Public debt and economic growth : a new assessment

El Mostafa Bentour

THÈSE

Pour obtenir le grade de

DOCTEUR DE L'UNIVERSITE GRENOBLE ALPES

Spécialité : **Sciences économiques**

Arrêté ministériel : 25 mai 2016

Présentée par

EL MOSTAFA BENTOUR

Thèse dirigée par **Cyriac Guillaumin** , Maître de Conférences (HDR) à l'Université Grenoble Alpes

Préparée au sein du laboratoire **Centre de Recherche en Economie de Grenoble (CREG, EA 4625)**
dans **l'École Doctorale Sciences Economiques (ED 300)**

Dette publique et croissance économique : Une nouvelle évaluation

Public Debt and Economic Growth : A new assessment

Thèse soutenue publiquement le **16 octobre 2020**,
devant le jury composé de :

M. Jean-Pierre ALLEGRET
Professeur à l'Université Côte d'Azur, président du jury
M. Cyriac GUILLAUMIN
Maître de Conférences (HDR) à l'Université Grenoble Alpes, directeur de thèse
Mme Florence HUART
Maître de Conférences (HDR) à l'Université de Lille, examinateur
Mme Valérie MIGNON
Professeur à l'Université Paris Nanterre, rapporteur
M. Patrick VILLIEU
Professeur à l'Université d'Orléans, rapporteur

UNIVERSITE GRENOBLE ALPES
ÉCOLE DOCTORALE DE SCIENCES ÉCONOMIQUES (ED 300)
CENTRE DE RECHERCHE EN ÉCONOMIE DE GRENOBLE (CREG, EA 4625)

THÈSE

Pour obtenir le grade de
Docteur de l'Université Grenoble Alpes
Discipline : Sciences Économiques

Présentée et soutenue par

El Mostafa Bentour

le 16 Octobre 2020

DETTE PUBLIQUE ET CROISSANCE ÉCONOMIQUE : UNE NOUVELLE ÉVALUATION

Directeur de thèse

M. Cyriac Guillaumin, Maître de Conférences, habilité à diriger des recherches (HDR), à l'Université Grenoble Alpes

Jury

M. Jean-Pierre ALLEGRET Professeur à l'Université Côte d'Azur	Président du Jury
M. Cyriac GUILLAUMIN Maître de Conférences (HDR) à l'Université Grenoble Alpes	Directeur de thèse
Mme Florence HUART Maître de Conférences (HDR) à l'Université de Lille	Examinateur
Mme Valérie MIGNON Professeur à l'Université Paris Nanterre	Rapporteur
M. Patrick VILLIEU Professeur à l'Université d'Orléans	Rapporteur

Remerciements

J’exprime, tout d’abord, ma profonde gratitude et mon entière reconnaissance à Cyriac Guillaumin, mon directeur de thèse, pour avoir accepté d’encadrer ce travail. Je le remercie pour sa grande disponibilité, ses conseils et suggestions utiles et ses encouragements précieux qu’il m’a prodigués tout au long de ma thèse.

Je présente, ensuite, mes plus sincères remerciements aux membres du jury, Jean-Pierre Allegret, Florence Huart, Valérie Mignon et Patrick Villieu, qui ont accepté d’évaluer et de donner leur opinion d’experts sur ma thèse.

Je souhaite également remercier les membres de mon comité de suivi individuel, Jean-Pierre Allegret, Olivier Bonroy et Faruk Ülgen, pour les discussions que nous avons eues et qui m’ont permis de mieux comprendre ce que je souhaitais moi-même (dé)montré dans mes travaux.

Mes travaux ont également bénéficié des échanges lors des conférences et séminaires auxquels j’ai participé. Je remercie particulièrement Christophe Bravard et Nadine Massard pour leurs précieux conseils.

Je tiens, enfin, à remercier tous les membres de ma famille pour leur soutien et leur patience ainsi que tous mes amis qui m’ont, de près ou de loin, aidé pour la réalisation de ce travail.

Que toutes ces personnes trouvent ici toute mon estime et toute ma considération.

L’Université Grenoble Alpes n’entend donner aucune approbation ou improbation aux opinions émises dans cette thèse. Ces opinions doivent être considérées comme propre à leur auteur.

Table of contents

Résumé de la thèse en français

Dette publique et croissance économique : une nouvelle évaluation

1. Introduction

Au cours de la dernière décennie, la dette publique est devenue de plus en plus élevée, atteignant des niveaux inquiétants, pour de nombreux pays avancés, en particulier dans la zone euro. Ces pays avaient mis en œuvre des mesures de relance budgétaire massives en 2009 en réponse aux graves ralentissements suite à la crise financière de 2008-2009. Deux ans après, les pays de la zone euro ont commencé à inverser le cours des expansions budgétaires, en s'orientant vers des consolidations fiscales, afin de stabiliser les ratios de déficit et d'endettement publics exacerbés par les stimuli budgétaires conjugués à une croissance en berne. En effet, les préoccupations quant aux défauts de paiement de la dette souveraine dans de nombreux pays, notamment de la périphérie de la zone euro, ont conduit aux mesures de consolidations budgétaires et d'austérité. Face à ces mesures, les pouvoirs publics et les économistes ont été partagés entre les effets de court terme des mesures d'assainissement budgétaire et les effets de long terme reliés notamment à l'impact de la dette publique sur la croissance économique.

Pour ce qui est des effets de long terme en particulier, les économistes semblent être au moins unanimes en théorie sur l'impact négatif de la dette publique sur la croissance économique à long terme. Ce constat est devenu tellement ancré dans l'esprit de tout un chacun qu'elle semble légitimer les affirmations quant à l'éventuelle existence d'un seuil de dette publique au-delà duquel la croissance économique serait altérée. C'est ainsi que deux économistes (Reinhart et Rogoff, 2010) ont déterminé, pour un échantillon de pays développés, l'existence d'un seuil de dette publique (rapportée au PIB) de 90%. À la suite de ce résultat, dont l'implication est forte en termes de politiques économiques, surtout parvenu en temps de crise où les finances publiques sont sous pression, un afflux incessant de travaux a émergé, examinant la relation entre la dette publique et la croissance économique et suscitant plusieurs controverses (Caner et al., 2010 ; Kumar et Woo, 2010 ; Reinhart et Rogoff, 2010 ; Lin, 2014 ; Bentour, 2018).

En ce qui concerne les effets de la dette publique à court terme, ils pourraient être appréciés dans un contexte de politique budgétaire en relation avec les multiplicateurs keynésiens. En effet, la dette publique est contractée pour faire face aux besoins de financement des déficits publics, lorsque les recettes publiques ne couvrent pas les dépenses publiques. Ainsi, les effets imminents de la dette publique sur la croissance sont aussi liés aux multiplicateurs de politique budgétaire, dont la valeur peut déterminer la capacité à générer la croissance économique aussi bien que les choix des politiques économiques (programme de *stimuli versus* austérité). En effet, une valeur élevée (faible) du multiplicateur de dépenses peut générer une croissance élevée (faible) pour une politique budgétaire expansionniste et ainsi réduire (augmenter) le poids de la dette. Étant donné

leur importance, les multiplicateurs budgétaires ont aussi fait l'objet d'échanges intenses dans les milieux académiques à la suite de la crise de 2008-2009. Ainsi, si Reinhart et Rogoff (2010) ont été les précurseurs de l'intense débat sur le seuil de la dette publique, c'est grâce à Auerbach et Gorodnichenko (2012) que le débat autour de la valeur des multiplicateurs notamment budgétaires a été déclenché. Ces auteurs ont révélé la sensibilité des multiplicateurs au cycle conjoncturel, notamment faibles en temps d'expansion et élevés en temps de récession économique. Dès lors, d'autres recherches furent publiées, ayant tendance à confirmer ce résultat et débattant davantage sur la dépendance des multiplicateurs à d'autres déterminants tels que le déficit public, l'endettement public, le régime de change, la politique monétaire, le degré d'ouverture, etc. (Romer et Romer, 2011 ; Ramey, 2011, 2018 ; Auerbach et Gorodnichenko, 2012, 2013 ; Delong et Summers, 2012 ; Farhi et al., 2017 ; Ramey et Zubairy, 2018).

En s'appuyant sur les limites économétriques des études précédentes, mises en évidence dans les différents débats à propos des effets de la dette publique sur la croissance économique depuis la crise de 2008-2009, cette thèse se propose d'analyser la pertinence des arguments en faveur et/ou en défaveur d'un seuil universel présenté *supra*, que la théorie économique ne semble pas signaler formellement. Nous montrons notamment, que l'existence d'un tel seuil, surtout commun à tous les pays, semble créer un clivage plutôt qu'un consensus au niveau des résultats empiriques. Ainsi, outre la revue de littérature théorique et empirique vigoureusement analysée, nous adoptons une démarche économétrique basée sur des arguments et des modèles économiques pour montrer que la relation entre la dette publique et la croissance économique est davantage un lien endogène émanant des canaux et variables par lesquelles les effets de la dette se transmettent à la croissance économique. De plus, nous montrons que ces canaux et effets qu'ils induisent diffèrent selon l'horizon temporel amenant à une distinction de traitement et de modélisation tenant compte des spécificités propres à chaque pays. Ceci a abouti à une formulation temporelle simulée de la limite de la dette (potentielle) en relation avec les performances de chaque pays en termes notamment de taux d'intérêt de long terme et de productivité potentielle du capital publique.

2. Contribution de la thèse à la littérature et débats des effets de la dette publique sur la croissance économique

Dans le volet consacré à la revue de littérature, la contribution de la thèse est large et diversifiée. La thèse est constituée de trois chapitres dont chacun assemble et analyse une revue de littérature autour des débats. Le chapitre 1 évoque les récents débats empiriques quant à l'existence d'un seuil de dette publique affaiblissant la croissance économique, sans omettre les différents débats théoriques sur les effets de la dette publique sur la croissance économique distinguant notamment la vision classique de long terme de la vision keynésienne de court terme. Partant de cette dernière, le chapitre 2 étale une riche littérature évaluant ainsi les effets de la dette publique sur la croissance économique à travers l'effet des multiplicateurs de dépenses publiques. La littérature à ce sujet est

essentiellement portée sur les différentes nouvelles contributions autour de la taille du multiplicateur qui s'est révélée sensible à une variété de déterminants dont notamment la position de l'économie dans le cycle et la situation fiscale (dette et déficit publics). Le chapitre 3 quant à lui se charge de présenter une revue de littérature très riche et contrastée des modèles évaluant les effets de la dette sur la croissance particulièrement dans l'optique de long terme, tout en résumant les avantages et les critiques à l'encontre de ces modèles.

2.1. Résumé du débat théorique sur les effets de la dette publique

En théorie, les effets de la dette sur la croissance économique ont été particulièrement débattus dans l'après-guerre suite à la forte augmentation de la dette publique des pays avancés. La littérature distingue particulièrement la vision keynésienne de court terme qui suppose que les dépenses publiques financées par la dette publique sont susceptibles de stimuler la demande globale dans un contexte de rigidité des prix et des salaires. Cependant, selon la vision classique dont la tendance est le long terme, la dette publique est susceptible de réduire le stock de capital et la productivité, puis de réduire la production.

Divers canaux sont cités pour expliquer les principales raisons de ces effets, comme le résume Hansen (1959). Une dette publique plus élevée peut déclencher une épargne privée plus élevée (effet Pigou), moins d'incitations à travailler et à investir en particulier pour les détenteurs des obligations d'État (effet Kaldor), un effet d'incitation négatif des impôts supplémentaires nécessaires pour financer le paiement des intérêts et des intérêts plus élevés défavorables pour contrer l'impact inflationniste de "l'effet Pigou". En outre, Modigliani (1961) a déclaré que la dette publique peut évincer l'investissement privé en réduisant le crédit à l'économie ou en augmentant les taux d'intérêt à long terme sur les emprunts publics. Les points de vue des keynésiens et des classiques sont résumés dans ce qui est appelée par la suite "l'analyse conventionnelle" des effets de la dette publique, reflétant le paradigme dominant des chercheurs (Elmendorf et Mankiw, 1999).

Une autre contribution théorique importante alimentant le débat sur les effets du financement par la dette publique est "l'équivalence ricardienne". L'idée attribuée à l'origine à Ricardo, affirme que la croissance économique peut être insensible à la dette publique, du fait que les consommateurs, supposés prospectifs (à anticipations rationnelles) peuvent réagir en réduisant leurs dépenses d'un montant équivalent à celui d'une augmentation des dépenses publiques. Ils anticipent en effet des impôts futurs finançant le déficit généré par les nouvelles dépenses publiques et par conséquent épargnent et renoncent à la dépense. Dans le même sens, Barro (1974) montre que les obligations d'État constituent un actif pour leurs propriétaires et un passif pour les contribuables. Dans l'ensemble, aucune richesse nette ne serait créée et l'effet serait nul. Les discussions entre économistes sur les effets de la dette publique dans l'optique de l'équivalence ricardienne, ont aussi invoqué les échanges quant à la redistribution de tels effets sur les générations successives. Cette redistribution est surtout reconsidérée dans le cadre des transferts

intergénérationnels dans des modèles à générations imbriquées (Diamond, 1965 ; Blanchard, 1985).

Quant au débat sur l'analyse à court terme, il se concentre en particulier sur la composition des dépenses publiques pour lesquelles les économistes (classiques et néoclassiques notamment) ont tendance à considérer que les dépenses en capital peuvent générer des effets positifs mais pas nécessairement les dépenses courantes. Ce point de vue est contrasté par les keynésiens qui soutiennent que les effets des dépenses sont toujours positifs, avec des différences en termes d'efficacité qui peuvent être plus élevées pour certains types que pour d'autres. Ces opinions opposées sont résumées dans Aschauer (2000) qui suppose que la relation à court terme entre la dette et la croissance pourrait être positive en raison de l'impact des dépenses d'investissement sur la croissance, tandis que la relation à long terme pourrait être inversée en raison de la prime de risque élevée, à la suite d'une dette publique élevée, augmentant ainsi le coût de la dette. Pour Blanchard (2006), l'association négative entre la dette et la croissance pourrait être attribuée au retard des politiques fiscales contracycliques, ce qui signifie que les pays en récession devraient adopter des politiques budgétaires expansionnistes pour stimuler la croissance et, en période d'expansion, des politiques restrictives pour réduire les niveaux d'endettement.

2.2. Résumé du débat empirique sur l'effet seuil de la dette publique sur la croissance économique

Dans les économies avancées, l'augmentation de la dette publique pendant la période précédant la crise a été accentuée par les mesures de relance budgétaire mises en œuvre en 2008-2009. Une année plus tard, Reinhart et Rogoff (2010) ont constaté que, pour un échantillon de 20 pays avancés, il existe un seuil commun de 90% du ratio de la dette publique au PIB au-delà duquel la croissance économique serait altérée. En particulier, ces deux auteurs ont observé que la corrélation entre la dette publique et la croissance est faible pour des niveaux d'endettement modérés et devient forte et négative lorsque le ratio de dette publique, mesuré par le rapport entre la dette publique et le PIB, dépasse 90%. Ils observent que les taux de croissance médian et moyen correspondant aux ratios d'endettement supérieurs à ce seuil diminuent respectivement de 1 et 4 points. Ce résultat, basé sur une approche statistique descriptive simple, a déclenché un afflux de recherches empiriques, utilisant différentes méthodes économétriques, dont la plupart des résultats ont suscité beaucoup de controverses.

Ainsi, certaines études ont tendance à confirmer l'existence d'un seuil de dette publique sans nécessairement parvenir à la valeur de 90% supposée par Reinhart et Rogoff (2010) (Caner et al., 2010 ; Checherita et Rother, 2010 ; Kumar et Woo, 2010 ; Lin, 2014). Néanmoins, le débat autour du seuil de la dette publique s'est intensifié, après que plusieurs auteurs aient contesté les conclusions de Reinhart et Rogoff (2010) comme, par exemple, Fergusson et Johnson (2011), Minea et Parent (2012), Baglan et Yoldas (2013), Pescatori et al. (2014), Egert (2015). Ces

contestations ont été notamment alimentées par la révélation de certaines erreurs de codification et de calcul dans l'article de Reinhart et Rogoff (2010) par Herndon et al. (2013).

Le résumé de ces résultats peut être regroupé en trois groupes :

- un premier groupe de recherches empiriques se concentrant principalement sur l'examen d'une relation concave non linéaire entre la dette publique et la croissance économique (Checherita et Rother, 2010 ; Kumar et Woo, 2010 ; Pescatori et al., 2014 ; Eberhardt et Presbitero, 2015 ; Chudik et al., 2017) ;

- un deuxième groupe intéressé par la causalité entre la dette publique et la croissance économique (Panizza et Presbitero, 2012, 2013 ; Di Sanzo et Bella, 2015 ; Gomez-Puig et Sosvilla-Rivero, 2015) ;

- un troisième groupe qui examine les effets d'autres variables institutionnelles et macroéconomiques interférant avec la relation entre la dette publique et la croissance économique (Greiner, 2011 ; Kourtellos et al., 2013 ; Pan et Wang, 2013 ; Sharpe, 2013 ; Marchionne et Parekh, 2015).

Les résultats de toutes ces recherches n'ont abouti à aucun consensus. Spécifiquement, certains chercheurs ont repris l'étude de la relation dette-croissance pour le même échantillon de 20 pays avancés utilisé par Reinhart et Rogoff (2010), adoptant différentes approches économétriques, et ont abouti à des résultats différents indiquant généralement de faibles niveaux de seuils d'endettement autour de 20 à 30% (Baglan et Yoldas, 2013 ; Egert, 2015 ; Lee et al., 2017). D'autres chercheurs ont utilisé différents échantillons et différentes périodes rejetant ainsi l'existence de tout seuil (Pescatori et al., 2014 ; Eberhardt et Presbitero, 2015 ; Chudik et al., 2017 ; Syssoyeva-Masson et De Sousa Andrade, 2017).

En règle générale, les évaluations des effets des politiques budgétaires sont quantifiées par les valeurs du multiplicateur budgétaire. L'efficacité des dépenses publiques dans l'analyse keynésienne/classique (comme mentionné au I.1) dépendant de la composition et du type de dépenses (courantes, en capital, de transferts, etc.) est empiriquement liée aux valeurs de leurs multiplicateurs. De ce côté, un volet important de recherches empiriques a été lancé au lendemain de la crise financière, révélant notamment davantage la sensibilité de ces multiplicateurs à de nombreux déterminants économiques et institutionnels.

2.3. Résumé du débat sur la valeur des multiplicateurs de dépenses publiques

Bien que la majorité des recherches précédentes (Section I.2) se concentrent sur l'étude du seuil de la dette publique et considèrent la relation dette-croissance à travers des formulations et modèles économétriques non linéaires, les canaux par lesquels les effets de la dette publique se matérialisent sont proprement liés aux effets des multiplicateurs de dépenses financées par une telle dette, en

particulier à court terme. L'évaluation des multiplicateurs budgétaires a été largement reconsidérée à la suite du développement des techniques économétriques. Depuis la crise financière de 2008, une littérature massive évaluant les multiplicateurs budgétaires est apparue (Romer et Romer, 2011 ; Ramey, 2011, 2018 ; Auerbach et Gorodnichenko, 2012, 2013 ; Delong et Summers, 2012 ; Farhi et al., 2017 ; Ramey et Zubairy, 2018).

Les principales conclusions de cette littérature révèlent de grandes différences dans la taille des multiplicateurs. En effet, la taille du multiplicateur s'est montrée sensible à une variété de déterminants qui n'étaient pas (ou rarement) considérés avant la crise de 2008-2009. Les multiplicateurs budgétaires sont particulièrement sensibles à la période d'estimation, propres à chaque pays, et à la méthode d'évaluation (Batini et al., 2012 ; Baum et al., 2012). En outre, les multiplicateurs budgétaires se sont révélés sensibles au cycle économique, en particulier, les multiplicateurs de dépenses budgétaires ont tendance à être plus importants dans les récessions que dans les périodes d'expansions (Auerbach et Gorodnichenko, 2012, 2013 ; Barro et Redlick, 2011 ; Parker, 2011 ; Corsetti et al., 2012 ; Caggiano et al., 2015 ; Fazzari et al., 2015 ; Glocker et al., 2019).

Par ailleurs, d'autres chercheurs conduisent à découvrir la vulnérabilité des multiplicateurs budgétaires à d'autres déterminants sans être nécessairement conditionnés par la cyclicité de l'économie. Ces déterminants sont la situation budgétaire mesurée par le niveau des ratios d'endettement et/ou des déficits (Corsetti et al., 2013 ; Huidrom et al., 2016), la politique monétaire contrainte soit par la tendance des taux d'intérêt à leur borne inférieure zéro (trappe à liquidité) ou par la perte de l'indépendance monétaire comme dans le cas d'un taux de change fixe ou d'une union monétaire (Hall, 2009 ; Cogan et al., 2010 ; Christiano et al., 2011 ; Delong et Summers, 2012 ; Farhi et Werning, 2017).[1]

Néanmoins, les travaux très récents de Ramey (2018) et Ramey et Zubairy (2018) considèrent que les multiplicateurs de dépenses publiques sont en moyenne inférieurs à l'unité. Cela contraste la tendance des études conduites après la crise de 2008-2009 et dont les résultats parviennent à des multiplicateurs plus importants, en temps de récessions, pouvant atteindre la valeur de 2. Cela va également dans le sens du même consensus sur les multiplicateurs de dépenses avant la récession de 2008-2009, considéré comme faible et que les effets de la politique budgétaire sont de très courte durée (Coenen et al., 2012). En particulier, les effets de celle-ci tenant compte de la situation budgétaire de l'économie mesurée par le niveau de la dette publique et/ou du déficit public sont fortement débattus au lendemain de la crise financière de 2008-2009 (Boussard et al., 2012 ; Corsetti et al ., 2012 ; Blot et al., 2014b ; Canzoneri et al., 2015 ; Bi et al., 2016 ; Huidrom et al.,

[1] Bentour (2020) a aussi trouvé la sensibilité des multiplicateurs de dépenses aux fluctuations des prix du pétrole pour un nombre de pays de la région MENA. En particulier, ces multiplicateurs sont positifs et très élevés (dépassant la valeur de 2) notamment pour les pays exportateurs de pétrole, pour des périodes de baisse du prix de pétrole, alors qu'ils sont faibles, voire négatifs pour certains pays, en période d'expansions des prix pétroliers.

2016 ; Perdichizzi, 2017 ; Poghosyan, 2017 ; Auerbach et Gorodnichenko, 2017 ; Afonso et Leal, 2018 ; Blanchard, 2019 ; Broner et al., 2019).

Très récemment, lors de la conférence présidentielle de l'*American Economic Association*, Blanchard (2019) a déclenché une nouvelle vague du débat sur la dette publique et la croissance économique liée au coût budgétaire d'une dette publique élevée ainsi qu'à son effet sur le bien-être. Il a particulièrement minimisé les inquiétudes concernant le coût de la dette publique pour l'économie américaine comme, historiquement, le taux d'intérêt nominal est resté toujours en moyenne inférieur au taux de croissance nominal, exception faite de certaines petites périodes autour des années 1980.

2.4. Résumé du débat sur les effets de la dette publique dans les modèles économiques

Pour évaluer les effets de la dette publique, de nombreux modèles de croissance théoriques ont été conçus. Le modèle de Ramsey (1928) était la base de la première classe des modèles d'agents à vie infinie (ILA). Plus tard, le débat entre économistes sur l'horizon de vie des agents et le type de liens de transferts opérationnels intergénérationnels entre eux a abouti au développement des modèles à générations imbriquées considérant l'existence/l'absence de continuité, entre les générations, assurée par ces liens (Samuelson, 1958 ; Diamond, 1965). Le débat a porté sur l'implication de l'altruisme entre les générations et le cycle de vie des agents pour déterminer l'existence d'effets de la dette publique sur les comportements des agents en termes d'épargne, d'accumulation du capital, d'utilité des consommateurs et du taux d'intérêt. Les contributions importantes dans ce sens remontent à Diamond (1965), Yaari (1965), Barro (1974), Blanchard (1985), Buiter (1988), Aiyagari (1985, 1987), Weil (1989) et Ni (1999).

Les effets redistributifs d'une génération à l'autre ont fait l'objet de nombreux débats dans l'après-guerre. Buchanan (1958) et Meade (1958), discutant des contributions de leurs prédécesseurs, notamment Lerner (1943), montrent que la dette publique ne constitue pas un fardeau pour les contribuables actuels. Ce fardeau est plutôt transféré partiellement ou totalement aux générations futures qui devront payer des impôts pour rembourser la dette (Bowen et al., 1960 ; Modigliani, 1961). Dans le même sens, les partisans de l'équivalence ricardienne montrent que la neutralité de la dette peut se produire en fonction notamment de l'existence de liens altruistes opérationnels entre générations (Barro, 1974). Ainsi, le débat a émergé modélisant les effets de la politique budgétaire, précisément l'échange (*swap*) de la dette et son effet sur l'utilité sociale et les taux d'intérêt. Cela a également déclenché un débat controversant entre les néoclassiques et les partisans de l'équivalence ricardienne (Barro, 1976 ; Feldstein, 1976 ; Cukierman et Meltzer, 1989).

Les effets sur la dette publique sont également pris en compte dans l'économie politique de la dette publique. À cet égard, deux approches ont été débattues. D'une part, l'approche normative où le gouvernement est considéré comme un planificateur social pour qui la priorité est de maximiser le bien-être social de ses individus (Barro, 1979 ; Lucas et Stockey, 1983 ; Aiyagari et al., 2002).

D'autre part, l'approche positive considérant la dette publique comme une variable d'État utilisée par chaque gouvernement comme une stratégie pour influencer les choix de son successeur ou comme un moyen de façonner les anticipations des agents économiques privés (Svensson et Persson, 1989 ; Alesina et Tabellini, 1990). Par conséquent, les idées les plus répandues étaient liées aux effets de la politique budgétaire sous des gouvernements qui suivent des règles d'engagement (*commitment*) contre des politiques discrétionnaires. En particulier, l'incohérence temporelle du gouvernement a un impact sur la façon dont les agents économiques forment leurs anticipations affectant ainsi leurs décisions économiques (Kydland et Prescott, 1977).

Les effets de la dette publique sont également examinés dans la classe des modèles de croissance endogène. Le développement de tels modèles a été essentiellement popularisé par Romer (1986), Lucas (1988) et Barro (1990). Ces modèles ont été proposés comme une alternative au modèle de croissance néoclassique de Solow (1956) et Swan (1956). Celui-ci n'a pas été en mesure d'expliquer les taux de croissance non nuls du PIB par tête persistant dans de nombreuses économies développées, et a donc été remis en cause pour avoir omis les déterminants de croissance à long terme. Ainsi, le cadre de croissance endogène englobe d'autres déterminants de la croissance à long terme, en particulier pour l'évaluation des politiques budgétaires, incorporant le secteur public dans le secteur productif (Lucas, 1988 ; Romer, 1989 ; Barro, 1990 ; Barro et Sala-i -Martin, 1992, 1995 ; Futagami, 1993 ; Jones, 1995, 2003 ; Corsetti et Roubini, 1996 ; Turnovsky, 1997 ; Greiner, 2007, 2012, 2016 ; Futagami et al., 2008 ; Maebayashi et al., 2017).

Récemment, la politique budgétaire, et en particulier la dette publique a également été modélisée dans la classe des modèles néo-keynésiens. Les travaux pionniers dans ce sens sont principalement dus à Christiano et al. (2005) et Smets et Wouters (2007). Ces derniers diffèrent des autres modèles en assumant des taxes générant des distorsions au lieu des taxes forfaitaires comme cela est particulièrement supposé dans les modèles à générations imbriquées. De plus, ils rejoignent la littérature de l'économie politique de la dette en discutant des politiques gouvernementales selon des règles d'engagement ou de discrétion. En particulier, certains auteurs considèrent que la dette publique optimale suivrait un processus de marche aléatoire chaque fois que le gouvernement peut atteindre un engagement politique incohérent dans le temps (Benigno et Woodford, 2003 ; Schmitt-Grohe et Uribe, 2004). D'importantes recherches empiriques sur ces modèles ont récemment prospéré (Leith et Wren-Lewis, 2013 ; Mayer et al., 2013).

Malgré les contributions importantes des modèles précédents dans l'évaluation de la dette publique et des effets de la politique budgétaire, les nouveaux modèles keynésiens ont été particulièrement critiqués par Mankiw (2000). Celui-ci a contribué par la théorie des "*Savings-Spenders*" qui a influencé de nombreuses recherches empiriques sur la politique budgétaire en essayant de considérer les comportements suivant des règles empiriques, en particulier dans les modèles d'inspiration de la nouvelle économie keynésienne. Par conséquent, Chari et al. (2009) montrent que cette classe de modèle n'est pas à présent utile pour l'analyse des politiques publiques. Ces auteurs se basent en particulier sur la critique du modèle de Smets et Wouters (2007) qui constitue

le noyau et la référence fondamentale pour de nombreuses contributions récentes adoptant le cadre d'analyse de la nouvelle économie keynésienne.

3. Contribution empirique de la thèse

Cette partie résume les principaux résultats empiriques et aboutissements de la thèse à la suite de l'évaluation économétrique des liens entre la dette publique et la croissance économique. Premièrement, nous présentons la contribution économétrique du chapitre 1 étudiant la forme non linéaire entre la dette publique et la croissance économique pour un échantillon de 20 pays avancés. Cette relation fait apparaître l'existence d'un point de retournement dans la relation pour chaque pays permettant de confirmer ou d'infirmer l'existence d'un seuil de dette à ne pas dépasser. Deuxièmement, nous détaillons les résultats du chapitre 2 relatifs à l'étude des multiplicateurs de dépenses publiques en fonction du cycle conjoncturel et le sens d'évolution du ratio d'endettement. Troisièmement, Nous résumons la contribution empirique du chapitre 3 reliant la dette publique à la croissance économique dans un cadre de croissance endogène, à travers la productivité du capital public.

Les principales conclusions de nos évaluations empiriques conduisent à rejeter le taux d'endettement commun qui s'applique à tous les pays. Nous montrons spécifiquement que la relation entre la dette publique et la croissance économique est plutôt sensible à la période d'analyse et surtout propre à chaque pays. En outre, dans un cadre à court terme, l'accumulation et la contraction de la dette publique ont un impact différent sur la croissance économique *via* l'effet des multiplicateurs de dépenses. Ces derniers se révèlent, notamment dans notre thèse, sensibles aux autres facteurs liés au cycle conjoncturel (expansion, récession), à l'évolution du taux d'endettement public (accumulation, contraction) et au croisement de ces facteurs. À long terme, la dette publique est liée, dans le cadre d'un modèle de croissance endogène, aux fondamentaux macroéconomiques des économies et à la productivité du capital public.

3.1. Présentation et choix de l'échantillon de pays

Compte tenu de l'endettement élevé des économies avancées, nous nous sommes concentrés sur un échantillon de 20 pays de l'OCDE, dont 11 sont membres de la zone euro, à savoir l'Australie, l'Autriche, la Belgique, le Canada, le Danemark, la France, l'Allemagne, la Grèce, l'Irlande, l'Italie, le Japon, les Pays-Bas, la Nouvelle-Zélande, la Norvège, le Portugal, l'Espagne, la Suède, la Suisse, le Royaume-Uni et les États-Unis[2]. Le choix de cet échantillon est justifié par de nombreuses raisons dont :

[2] Exception faite au chapitre 2 qui est restreint à 18 pays en omettant l'Australie et la Nouvelle Zélande suite au manque de données trimestrielles suffisantes pour ces pays.

- l'importance économique de ce groupe de pays avancés influençant les économies mondiales notamment du fait qu'ils pèsent sur le système économique et financier international (en termes de risque systémique) ;

- le niveau élevé de la dette publique par rapport au PIB accumulé pour la majorité de ces pays, dont plusieurs d'entre eux ont rencontré des problèmes de dette souveraine lors de la crise financière de 2008-2009, voire même avant ;

- l'échantillon est constitué des pays qui ont été très étudiés dans la littérature et dont les résultats sont débattus après la crise financière de 2008-2009 en termes de dette publique et de politique budgétaire, ce qui nous permet de confronter nos résultats à ceux de la littérature existante ;

- enfin, la disponibilité de séries de données longues, tant annuelles que trimestrielles pour la dette publique et la croissance économique.

3.2. Contribution empirique du Chapitre 1 : pas de seuil universel de dette publique

Malgré la diversité des méthodes économétriques utilisées pour étudier la relation croissance-dette, la plupart des analyses précédentes souffrent d'un biais d'échantillonnage (courtes périodes d'analyse). Presque toutes les méthodes économétriques avancées utilisées sont appliquées à des échantillons débutant dans les années 1970. Cette date coïncide avec la fin du système de Bretton Woods et le début de la libéralisation des marchés dans les pays développés. Pour remédier à ce biais, l'analyse a été étendue dans le chapitre 1 sur une longue période, 1880-2008, subdivisée en cinq sous-périodes correspondant aux changements majeurs survenus dans l'ordre monétaire et politique international (Rodrik, 2011 ; Obstfeld et Taylor, 2002). Ces changements pourraient affecter la stabilité des agrégats macroéconomiques et leurs interdépendances, dont éventuellement la relation dette-croissance. Notre analyse distingue les sous-périodes suivantes :

- 1880-1913 : cette période correspond à la fin de la première mondialisation ou la fin de l'ère du mercantilisme ;

- 1914-1945 : une période avec deux guerres dévastatrices et la grande dépression économique de 1929. L'ordre économique international a été marqué par le régime de l'étalon-or et le déclin de l'hégémonie britannique remplacé par la suprématie américaine ;

- 1946-1970 : le monde a connu une croissance et un développement solides au cours de cette période, notamment sous les accords de Bretton Woods et les régimes de taux de change fixes (centrés autour du dollar américain). Cette période de près de trois décennies de prospérité est désignée par le terme des trente-glorieuses ;

- 1971-1990 : ces deux décennies ont connu des événements économiques et politiques turbulents avec la fin de la convertibilité du dollar en 1971 et l'augmentation des régimes

de change flottants, les chocs pétroliers des années 1970 avec la coexistence du chômage et de l'inflation et la crise de la dette souveraine des années 1980 ;

- 1991-2008 : cette période a connu une large libéralisation financière conformément aux recommandations du Consensus de Washington, entraînant une instabilité financière et des crises pour la plupart des pays émergents. Au cours de cette même période, l'organisation mondiale du commerce (OMC) a été créée, les accords de libre-échange bilatéraux et multilatéraux ont proliféré et la zone euro a été établie.

D'abord, une analyse préliminaire descriptive variée par pays et en panel a été conduite. Puis, une forme quadratique de la croissance économique en fonction du ratio d'endettement sur toute la période 1880-2008 et les sous-périodes susmentionnées a été estimée[3]. La méthode d'estimation GMM a été utilisée corrigeant le problème d'endogénéité dû à la causalité inverse allant de la croissance au taux d'endettement. L'analyse descriptive par pays et par panel ainsi que les régressions ont révélé la sensibilité de la relation à la période et aux échantillons de pays et est altérée par l'hétérogénéité des pays. L'hétérogénéité diminue lorsque l'on omet des pays importants de l'échantillon et se manifeste moins dans l'échantillon des pays de la zone euro.

À la suite de cette hétérogénéité détectée, nous avons jugé primordial le recours à des régressions par pays, ce qui, à notre connaissance, était rarement mené dans les recherches empiriques précédentes. Ainsi, le chapitre a également étudié le lien entre la croissance et la dette publique en utilisant une nouvelle et innovante méthode appelée "*regression kink*" développée par Hansen (2017). Cette méthode a le pouvoir de détecter de manière endogène les points de tournure dans les relations économétriques étudiées. Appliquée à la relation dette et croissance pour chaque pays, elle met en évidence différentes formes de relations entre la dette publique et la croissance économique. Par conséquent, certains pays peuvent croître avec des ratios d'endettement public élevés, pendant que d'autres pourraient voir leur croissance se contracter par rapport à des ratios d'endettement même faibles, tandis que la croissance dans d'autres pays s'avère insensible à la dette publique. L'étude révèle également l'instabilité de la relation dans le temps. Chaque pays se distingue par des relations différentes selon les périodes d'estimation considérées, en particulier lorsque la transition se fait entre des périodes connues pour certains changements spécifiques du système monétaire international.

Tous ces résultats rejettent l'existence d'un seuil commun et sa valeur de 90% comme le prétendent Reinhart et Rogoff (2010). Néanmoins, il faut signaler que les travaux précédents n'adoptent pas généralement un cadre de modélisation impliquant d'autres équations et variables par lesquelles la dette publique interagit avec la croissance économique. Par conséquent, il convient d'étudier les effets de la dette publique sur la croissance économique considérant les caractéristiques propres à

[3] Cette méthode a été utilisée par Checherita et Rother (2010) pour un échantillon différent de pays et une période relativement courte comparée à celle de ce chapitre.

chaque pays, sans s'affranchir notamment des modèles théoriques pouvant expliquer les canaux de transmission des effets de la dette publique à la croissance économique.

3.3. Contribution empirique du Chapitre 2 : sensibilité du multiplicateur budgétaire aux variations de la dette publique et au cycle économique

Le deuxième chapitre est particulièrement consacré à approfondir la relation entre la dette publique et la croissance économique à court terme, notamment *via* l'évaluation des effets de la dette publique à travers les multiplicateurs de dépense. L'importance de cet exercice s'est inscrite dans le débat déclenché sur les multiplicateurs budgétaires par Auerbach et Gorodnichenko (2012), prouvant qu'ils sont plus élevés en période de récession et plus faibles en temps d'expansion. En conséquence, une grande littérature sur les multiplicateurs budgétaires a émergé en considérant des déterminants autres que le cycle économique, à savoir, les régimes de change, les politiques monétaires, le degré d'ouverture, etc. Ceci a conduit à des résultats suscitant plusieurs controverses entre économistes adoptant des méthodes différentes et/ou des échantillons de pays et des périodes différents.

L'une des méthodes fréquemment sollicitées pour évaluer les multiplicateurs sont les modèles VAR structurels (SVAR), également adoptés dans ce chapitre. Nous utilisons une panoplie de ces modèles pour estimer les multiplicateurs de dépenses à l'aide de données trimestrielles, pour un échantillon de 18 pays de l'OCDE. Nous avons contrôlé les effets du cycle économique et les effets des mouvements de ratio de la dette publique pour déduire les multiplicateurs de dépenses dans ces conditions.

Les résultats montrent que, en contrôlant les effets du cycle économique, les multiplicateurs de dépenses sont beaucoup plus élevés en période de récession qu'en période d'expansion. Ces résultats sont en conformité avec ce qui est observé dans la littérature récente sur les multiplicateurs budgétaires, qui sont importants en période de récession et faibles, voire négatifs en période d'expansion. Compte tenu de ces résultats, les politiques budgétaires devraient être contracycliques. Ces résultats vont également à l'encontre de toute consolidation budgétaire fondée sur une réduction des dépenses en période de récession, ce qui pourrait nuire à l'économie.

En outre, en contrôlant de manière exogène les mouvements de la dette publique, indépendamment du cycle économique, il a été révélé que les multiplicateurs de dépenses sont plus importants en période d'accumulation qu'en période de contraction de la dette. En plus, contrôlant conjointement pour les mouvements de la dette publique et du cycle conjoncturel, les multiplicateurs sont plus élevés sous l'accumulation de la dette dans les deux cas d'expansion et de récession. Cependant, l'endogénéisation de la variable dette publique au PIB dans un SVAR conduit à des multiplicateurs plus élevés en récession qu'en expansion.

De plus, un modèle plus élargi a été établi sur une longue période de données trimestrielles pour les États-Unis (1966q1-2019q2), pays disposant de longues séries chronologiques trimestrielles

d'un ensemble de six variables fiscales et monétaires prises en compte dans ce modèle. L'objectif de ce modèle était l'examen et l'explication des canaux de transmission des effets de la dette publique et des dépenses publiques sur la croissance économique en relation avec d'autres variables économiques en l'occurrence le taux d'intérêt, l'inflation et l'investissement privé. Les estimations de ce modèle ont été produites en considérant la variation du cycle conjoncturel.

Les principaux résultats de ce modèle montrent que les dépenses publiques ont des effets positifs mais de courte durée sur la croissance économique. En outre, la dette publique évince l'investissement privé "*crowding out*", entraînant une baisse du taux de croissance en période d'expansion, tandis qu'en période de récession, les effets de la dette publique sur la croissance sont positifs. Cet effet d'éviction peut jouer le rôle de relais sur les multiplicateurs de dépenses et pourrait expliquer, toutes choses égales par ailleurs, la faible taille des multiplicateurs de dépenses en expansion, alors qu'en période de récession, l'effet positif de la dette "*crowding in*" conduit à des multiplicateurs plus élevés.

Dans toute la panoplie des modèles SVAR examinés dans le deuxième chapitre, ceux-ci montrent clairement que pendant la période de récession, les effets sur les variables ont généralement tendance à persister. La convergence vers la trajectoire de long terme après les chocs se produit plus rapidement en période d'expansion qu'en période de récession. Cependant, malgré les principales conclusions du deuxième chapitre, l'approche SVAR, exigeant la stationnarité des variables comme condition nécessaire, est restreinte à l'évaluation notamment des effets de court terme des variables de la dette et des dépenses publiques. Cependant, compte tenu des effets théoriques de la dette publique à long terme, leur évaluation s'impose.

3.4. Contribution empirique du Chapitre 3 : Le ratio de dette publique potentiel à cibler à long terme est une fonction endogène de la productivité potentielle du capital public

En relation avec le sujet du seuil de dette publique discutée dans le chapitre 1, le troisième chapitre étend l'examen des effets de long terme de la dette publique dans le cadre des modèles théoriques, tenant compte des fondamentaux macroéconomiques propres à chaque pays. Par conséquent, un modèle de croissance endogène a été appliqué au même échantillon étudié dans le chapitre 1 constitué de 20 économies développées. Dans ce modèle, une formule paramétrée a été simulée pour une dette potentielle/limite qu'un pays pourrait cibler pour financer ses investissements productifs sans pour autant la dépasser. Ce potentiel, lié à la croissance économique et à la productivité du capital public ainsi qu'au taux d'intérêt, est dynamique, spécifique à chaque pays et dépendant du temps. De plus, celui-ci a tendance à évoluer à l'opposé de la dette publique réellement observée. Cela répond en particulier à la principale recommandation formulée dans le premier chapitre selon laquelle le seuil de la dette publique est propre à chaque pays et à la période et devrait être étudié compte tenu des fondamentaux économiques du pays. Il apporte notamment une contribution qui se distingue des limitations des recherches mises en évidence dans le premier

chapitre, et qui fixent et testent en particulier des valeurs de seuils particulièrement exogènes et atemporels.

De plus, les résultats du troisième chapitre montrent que la dette publique simulée est passée en dessous du niveau observé de la dette en temps de crise pour de nombreux pays avancés, notamment les plus touchés par la crise. Cela constitue un message clair de recommandation de politique économique montrant que les pays sont de plus en plus à l'abri du danger de la dette publique tant que la dette potentielle (simulée) reste supérieure à la dette publique observée. Les résultats montrent que de nombreux pays sont soumis à une pression de la dette publique, en particulier après la crise financière de 2008-2009. Pour certains pays comme l'Irlande, ce *stress* est de courte durée, et la dette potentielle est rapidement redevenue plus élevée que la dette observée à la suite du redressement de l'activité économique juste quelques années après la crise. Cependant, pour de nombreux autres pays, les effets sont plus prolongés. La dette potentielle a également révélé que des pays comme la Grèce, la Belgique et, dans une certaine mesure, l'Italie, avaient des problèmes de dette accumulée au cours des périodes même avant la crise de 2008.

Empiriquement, la moyenne de la dette potentielle simulée en pourcentage du PIB sur la période étudiée (1960-2015) est passée de valeurs plus élevées de 150% à 200% en Suisse, en Suède, au Danemark, en Norvège, aux États-Unis, en Autriche et aux Pays-Bas, à des valeurs moyennes de 80% à 120% enregistrées en France, en Allemagne, en Italie, en Espagne, au Portugal, au Royaume-Uni, en Australie et en Nouvelle-Zélande. Ces valeurs sont même réduites à environ 50% à 80% en temps de crise, notamment pour la Grèce (moins de 50%), le Royaume-Uni (60%), l'Italie et l'Espagne (50%) la France et l'Allemagne (80%) et la Belgique (environ 70%).

Ce chapitre a comme valeur ajoutée la modélisation de la limite d'endettement publique comme fonction endogène dépendante de la productivité du capital public, du taux d'intérêt de long terme et de la croissance économique. La série des dépenses publiques potentielles montre une tendance à la baisse dans le temps mais toujours plus élevée que celle observée dans de nombreux pays de l'échantillon. Cette évolution est due à la tendance générale à la baisse de la productivité du stock de capital public, en particulier pendant l'époque de la grande modération (1985-2015). Le message de politique économique est que l'accroissement de la dette potentielle cible, requière nécessairement l'amélioration de la productivité du capital public. D'où la nécessité de sélectionner les types de dépenses publiques susceptibles d'améliorer cette productivité. Pour reformuler la déclaration de Krugman (1994) sur l'importance de la productivité à long terme, "*la productivité n'est pas tout, mais à long terme, c'est presque tout*". L'amélioration de la productivité pourrait être réalisable par le choix de dépenses publiques plus productives, ce qui implique la sélection de projets ayant des multiplicateurs plus élevés.

4. Conclusion

Dans les trois chapitres, la thèse s'oppose à tout seuil d'endettement commun s'appliquant à tous les pays. Le sujet de la croissance économique et de la dette publique reste néanmoins l'un des sujets les plus débattus de la macroéconomie après la crise financière de 2008-2009. Cette importance sera maintenue et davantage de recherches à ce sujet sont anticipées à moyen et long terme pour de nombreux événements d'actualité. Effectivement, la crise sanitaire de 2020, en raison de mesures d'urgence rigoureuses et de confinement de la population, conduit à l'hibernation de presque tous les secteurs économiques pendant plusieurs mois. Par conséquent, tous les experts et institutions de prospection prévoient une inévitable récession, et même une dépression prolongée, dans presque toutes les économies mondiales. Toutes les mesures susceptibles d'aggraver les déficits et d'augmenter le niveau de la dette publique, combinées à une contraction du PIB, conduiraient à une flambée des ratios d'endettement public.

Au regard de ces mesures, certains économistes s'attendent à ce que ces ratios augmentent d'environ 20 à 40 points de PIB pour de nombreux pays. Selon Kose et al. (2020), des augmentations similaires ont été observées lors des crises précédentes. En effet, le ratio d'endettement a flambé de 31 et 35 points de pourcentage respectivement pour l'Indonésie et la Thaïlande lors de la crise financière de 1997, et de 27 et 38 points de pourcentage respectivement pour la Lettonie et l'Irlande lors de la crise de 2008-2009. La reprise de la croissance économique, incertaine, est conditionnée par la durée des mesures de confinement sujet à l'évolution de la pandémie Covid-19 et au développement d'un vaccin contre celle-ci.

Dans ces conditions, la politique budgétaire, longtemps subordonnée à la politique monétaire dans la grande modération (1986-2007), est désormais activement sollicitée. La crise sanitaire actuelle conduit notamment à une plus grande implication de la politique budgétaire, surtout que la politique monétaire conventionnelle a déjà atteint ses limites, en particulier dans de nombreuses économies avancées où les taux d'intérêt nominaux atteignent et franchissent pour certains la borne inférieure zéro. Bien que certains points de vue considèrent que la faiblesse des taux d'intérêt réduit le coût de la dette publique, ce qui peut amener à une trajectoire de la dette publique soutenable, la menace du redressement des taux d'intérêt en réponse à une inflation future anticipée, conjuguée à une croissance morose, pourrait prolonger les pays endettés dans des vagues de crise de la dette souveraine.

Par conséquent, les recherches sur la politique budgétaire et les problèmes de l'endettement et la croissance économique resteront désormais très actives. De nombreuses questions méritent notamment d'être soulevées au sujet de la dette publique et la croissance économique au cours de la crise économique actuelle à la suite des retombées économiques et sociales de la crise sanitaire de 2020. Il s'agit notamment d'étudier de nombreux objectifs, notamment conflictuels, de la politique budgétaire visant à sauver des emplois ainsi que des entreprises et secteurs économiques en difficultés d'une part en particulier à court terme, et relancer la croissance économique et ainsi

restaurer les recettes publiques, d'autre part à moyen terme. Ces deux objectifs sont inséparables de l'objectif de soutenir la croissance à long terme tout en considérant les effets ultérieurs de l'augmentation de la dette publique. En outre, la nature de la crise économique actuelle est susceptible de soulever de nombreux défis dans les politiques économiques. En particulier, cette crise est caractérisée par la coexistence des chocs négatifs d'offre et de demande, liés notamment aux mesures de confinement des populations et restrictions de mobilité internationale. Notamment, du côté offre, ceci a conduit à limiter les capacités de productions et d'exportations des entreprises et altérer les chaînes de valeurs globales pour certains secteurs. Du côté demande, les mesures du confinement ont limité la demande des ménages notamment en termes des services de voyages, transports, restaurations, ainsi que la demande en produits d'importations. Cette dualité du choc offre-demande pourrait avoir un impact important sur le cadre macroéconomique et particulièrement sur le cadre de la politique budgétaire. Il s'ensuit que la modélisation des effets de la politique budgétaire pourrait sortir du cadre traditionnel, notamment que cette crise ne semble pas ressembler aux crises économiques internationales vécues précédemment (de la grande dépression à la crise des *subprimes*). De plus, de nombreux défis nécessitant la coordination des politiques monétaires et budgétaires peuvent être à l'ordre du jour, dont les effets devront être évalués, en particulier dans la zone euro.

Public Debt and Economic Growth: A New Assessment

General Introduction

To finance their spending, governments generally have three options: first, they can raise taxes, second, they can create money and, third, they can borrow from domestic and/or foreign markets. The first option is politically not desirable and can even create economic downturns, harming economic growth and employment, especially for countries that have high tax burdens, which is the case for all developed countries. It also takes time to obtain a political consensus in a democratic system to raise taxes. The second option, the creation of money, whenever it is possible, can also cause significant damage to the economy by creating inflation and hence decreasing households' purchasing power. Furthermore, as the central banks in advanced countries are determined to gain and maintain their credibility vis-à-vis the private agents, the money-creation option is likely to alter such credibility. The third option, namely, raising funds through borrowing, remains the quick option for financing public deficit needs, particularly short-term needs. The choice of borrowing to finance public deficits also has its disadvantages, with doubtful negative effects for economic growth, especially when the borrowed money is destined for expenditure that is not necessarily pro-growth, and the accumulated public debt is higher. The capacity of a country to pay its debt is generally assessed by the level of its total debt reported to its national income (GDP).

Over the last decade, public debt has increasingly become a worrying issue for many advanced countries, especially in the euro area. These countries implemented massive fiscal stimuli in 2009 in response to the severe downturns of the 2008 financial crisis. In around 2011 countries started to reverse the course from fiscal expansion to fiscal consolidation to reduce deficit and debt ratios, which were exacerbated by those fiscal stimuli with slow recovery and long-lasting recession. The fear of a European sovereign debt default by many periphery euro area countries urged them to turn to fiscal consolidation and austerity measures in Europe. This was also fuelled by the triggered debate about the presumable existence of a public debt threshold hampering economic growth (Caner et al., 2010; Kumar and Woo, 2010; Reinhart and Rogoff, 2010; Lin, 2014; Bentour, 2018).

Following the recession and the fiscal stimuli programmes, almost all the euro area countries have overcome the rule of a 3% and 60% threshold stated in the European Monetary Union (EMU) Stability and Growth Pact (SGP). Consequently, rigorous austerity measures have been implemented to restore confidence, especially across the periphery of the euro area, whereas recessionary effects were more pronounced, and the economic growth rate was still negative. The negative short-term spillovers undermined the incomplete path of recovery, meaning the euro faced a dilemma of boosting economic growth while reducing public debt and deficit. The trade-off between boosting economic growth by fiscal stimuli to combat negative effects on social

welfare and employment, and reducing public debt and deficit through programmes of fiscal adjustment (austerity, consolidation), depends on the size of the fiscal multipliers in each action.

1. Historical facts of public debt and growth in advanced economies

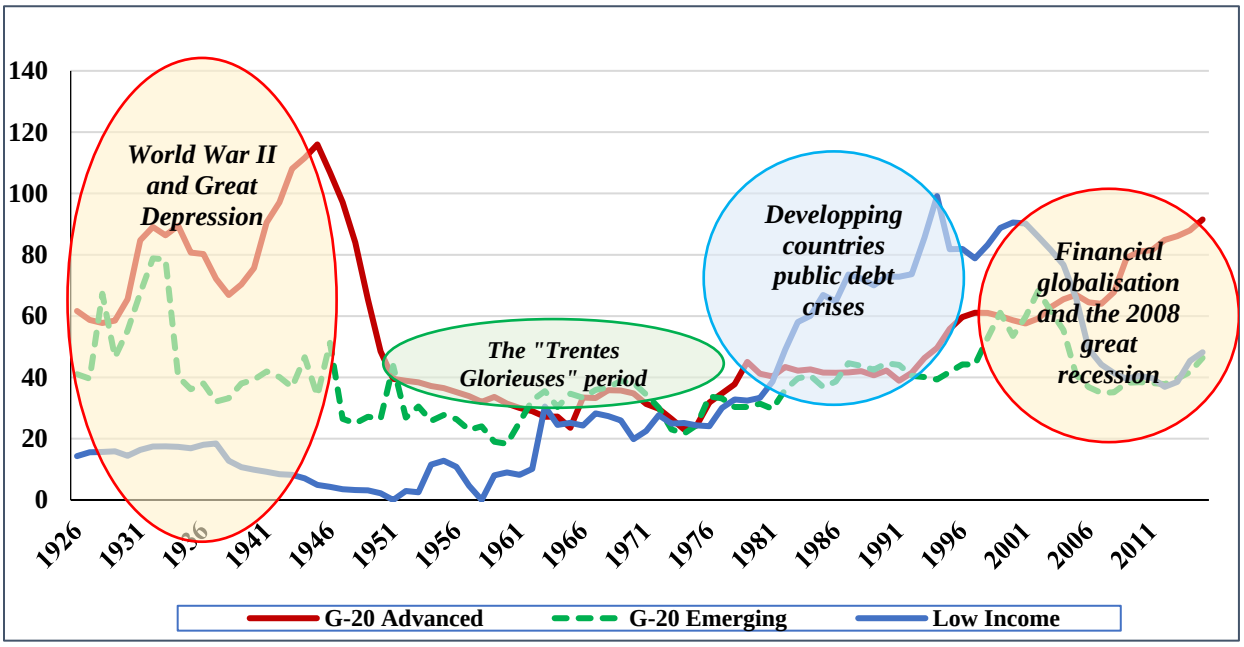
The history of public debt as a percentage of GDP in advanced economies shows that the period following the 2008 financial crisis has been, in terms of scale, approaching the period of the 1929 Great Depression and the devastating World War II era, where public debt ratios were abnormally high (Figure 1). What makes the difference between the two periods is that, in the recent period, public debt accumulated in peaceful periods of economic expansion and prosperity, which was worsened by the 2008 economic crisis, while the two aforementioned events (the 1929 Great Depression and World War II) were clearly the principal factors contributing to accumulating high public debt to GDP shares in that period.

Following the Great Depression and World War II period (1926–45), the public debt of advanced economies (the G20 advanced)[§] dropped down from a high average approaching 120% to very moderate levels ranging between 20% and 40%. This stable average was sustained for a period of around thirty years, labelled "*Les Trentes Glorieuses*" by the French economist Jean Fourastié. This prosperous period was characterized by strong economic growth under the stable Bretton Woods system of exchange rates. However, debt ratios started to rise, albeit not very high, from the mid-1970s, with the end of this system, but also as a result of the two 1970s oil price shocks. This period especially put pressure on the public finances of developing and low-income countries, for which the debt to GDP increased from an average of 24% in 1976 to 100% in 1994. This period is known as the developing countries' public debt crises.

Moreover, following a period of low interest rates and financial liberalization that started after the 1989 "Washington consensus", which contributed to lowering the cost of borrowing and encouraged access to the international financial market, contributing to appeasing the public debt of low-income and developing countries, the public debt to GDP of advanced countries once again started a sustained increase from an average of approximately 40% to more than 90% in 2015. The latter level of public debt ratio is considered by Reinhart and Rogoff (2010) to be an upper limit/threshold that, once passed, may reduce economic growth in advanced countries. This statement triggered an influx of empirical research studying the relationship between public debt ratios and economic growth, fundamentally based, for the majority, on these two variables alone.

[§] The G20 advanced economies here should be distinguished from the G20 group of countries set in 1999 and becoming active after the 2008 economic crisis. The latter contains the big emerging countries (China, India, Brazil, etc.) and the European Union countries block, while the former is only for the advanced OECD countries that have an available long history of public data, as reported in the IMF databases (Abbas et al., 2010; Mbaye et al., 2018).

Figure 1: Public debt as a percentage of GDP over the period 1926–2015

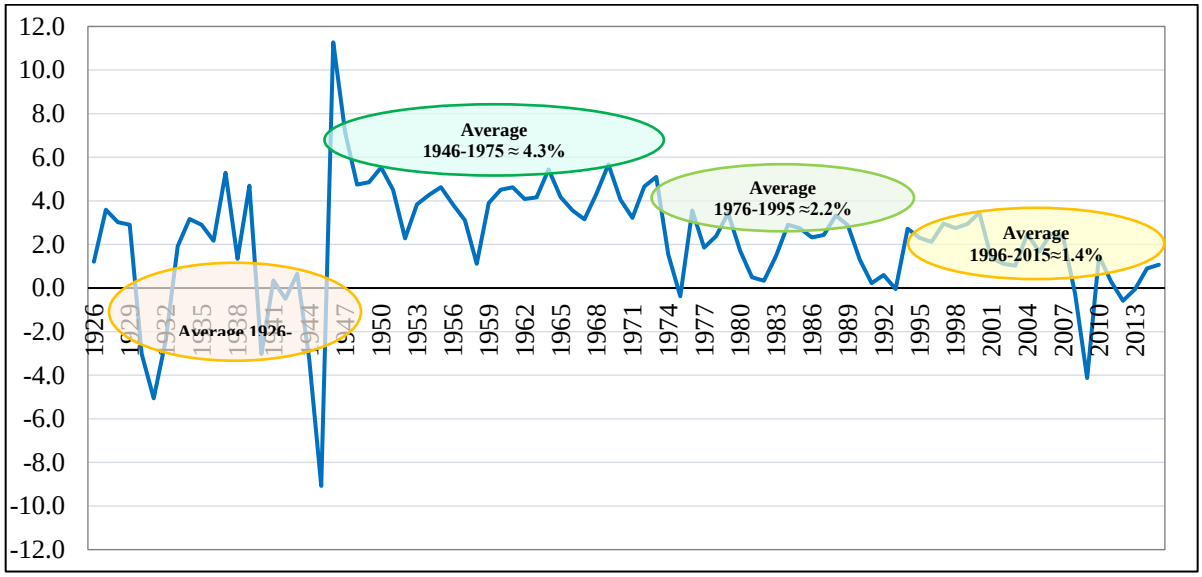


Source: Author's own construction using the IMF database (Mbaye et al., 2018).

The previously analysed debt to GDP ratio, representing the burden of public debt of a country normalized by its output, increases when the numerator (the debt in level) grows faster than the denominator (the GDP). From an accounting perspective, the growth rate of the debt in level is the nominal interest rate (the cost of borrowing), the latter is compared to the nominal growth rate of GDP (or to the real growth rate once deflated) from the famous sustainability public debt equation involving the primary deficit/surplus. Figure 2 shows an analysis of the average real growth rate over the same long period, as was done previously for the debt to GDP ratio, for the G20 advanced countries. We notice that the growth rate is weak for the two decades of the Great Depression and World War II (1926–45), averaging 0.4%. On the contrary, the "*Trente Glorieuses*" period recorded a high average of 4.3%, followed by a declining growth rate performance in the third and fourth periods of 1976–95 and 1996–2015, respectively, to an average of 2.2% and 1.4%. Apparently, this analysis shows that public debt accumulation in advanced economies is linked to the growth rate performances in these countries. This fact is endorsed by putting together GDP growth rate averages by decades and the public debt to GDP ratio in Figure 3. The latter shows that economic growth following the post-war period is a decreasing path from a high level of 5.4% in the decade of 1946–55 until reaching a low level of 0.5% in 2006–15. On the other hand, the public debt to GDP average over decades has increased, from 30.8% in the 1970s to 79% in the last decade. However, this analysis could not show, at high levels, which variable may cause the other, which has been highly debated in the recent literature: high public debt levels may cause

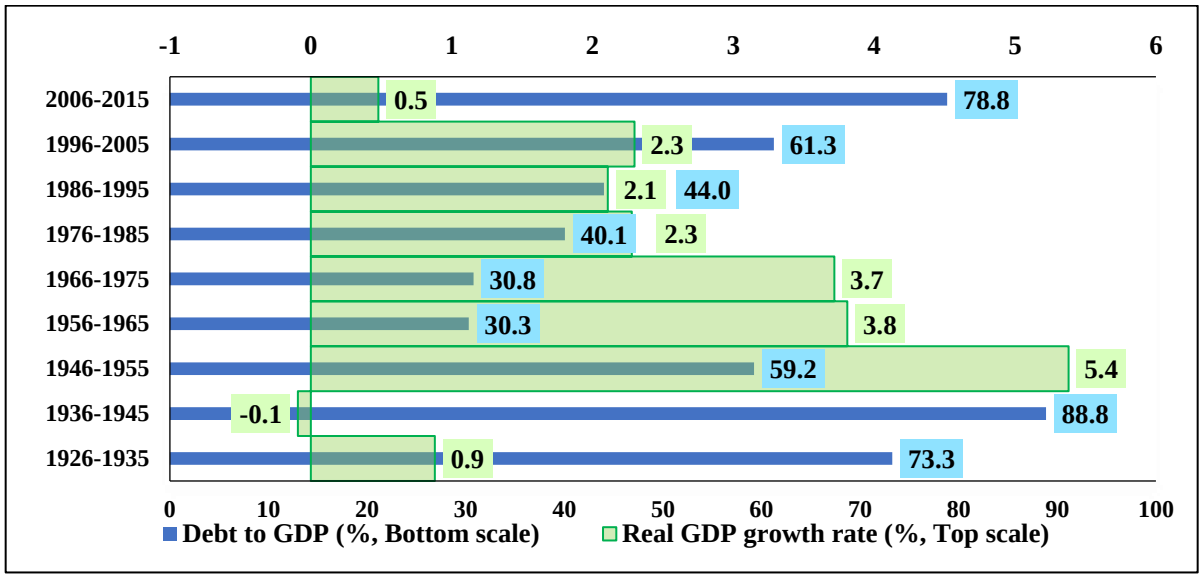
economic growth to slow down (Reinhart and Rogoff, 2010), especially in a time of peaceful economic expansion, as is the case for the period 1995–2007.

Figure 2: G20 Real GDP Growth Rate during 1926-2015 (%, Average)



Source: Author's own construction, calculating averages of GDP growth rates from Maddison database (https://www.rug.nl/ggdc/historicaldevelopment/maddison/).

Figure 3: Debt to GDP ratios and Real GDP Growth rate over decades for G20 advanced countries



Source: Author's own construction calculating period averages from the IMF database (Mbaye et al., 2018) for the public debt to GDP shares, and from the Maddison database for the real GDP growth rate (https://www.rug.nl/ggdc/historicaldevelopment/maddison/).

2. Debates about public debt effects on economic growth

2.1. The theoretical debate on the public debt effects

In theory, the effects of debt on economic growth were debated particularly in the post-war period following the surge in public debt of advanced countries. The literature distinguishes between the Keynesian short-term view, which assumes that government expenditure financed by public debt is more likely to stimulate the aggregate demand in the context of Keynesian prices and wage rigidities. However, according to the classical vision, which tends to focus on the long-term effects, government debt is likely to reduce capital stock and lower productivity, and then it reduces the output. Diverse channels are cited as the main reasons for these effects, especially as summarized by Hansen (1959). Higher public debt can trigger higher private saving (the Pigou effect), fewer incentives to work and invest, especially for owners of government bonds (the Kaldor effect), negative incentive effect of the additional taxes needed to finance the payment of interest and higher interest rates that are unfavourable to countering the inflationary impact of the "Pigou effect". Furthermore, Modigliani (1961) stated that public debt can crowd out private investment by reducing credit to the economy or by raising long-term interest rates on public borrowing. Both Keynesian and classical views are summarized in what is known as the "conventional analysis" of the effects of government debt, which reflects the dominant paradigm among economists and policy-makers (Elmendorf and Mankiw, 1999).

Another important theoretical contribution that fuels the debate about the public debt financing effects is the "Ricardian equivalence". The idea, originally attributed to Ricardo, states that economic growth can be insensitive to public debt, as consumers, assumed to be forward-looking (with rational expectations) can react by reducing their expenditure following a public expenditure increase by an equivalent amount. The reason is that they expect future taxes to finance the deficit generated by the new public expenditure. The equivalence is implied, as any public expenditure reducing public saving is assumed to be offset by an equivalent increase in private saving. This leads to unchanged total savings, and hence no effect is expected on other macroeconomic variables. Similarly, Barro (1974) shows that government bonds constitute an asset to their owners and a liability to taxpayers. Overall, no net wealth will be created, and the effect is null. The ideas of Ricardo-Barro effects of debt somehow invoke the redistribution of such effects across generations. They are especially discussed in the scope of intergenerational transfers and have been analysed in the first models of overlapping generations (Diamond, 1965; Blanchard, 1985).

The debate about the short-term analysis between economists (Keynesians, new Keynesians, classical and new classical) focuses on the composition of public spending, for which classical and neoclassical economists consider that capital expenditure, but not necessarily current expenditure, may have positive effects. This view is contrasted by Keynesians arguing that the effects of spending are always positive, with differences in terms of their efficiency, which may be higher for capital expenditure than other types of expenditure. These opposing views are gathered by

Aschauer (2000), who assumes that the short-term relationship between debt and growth could be positive as a result of the impact of financed capital expenditure on growth, while the long-term relationship could be reversed because of the high-risk premium following high public debt, raising the cost of debt. For Blanchard (2006), the negative association between debt and growth could be attributed to delayed counter-cyclical tax policies, which means that countries in recession are adopting expansionary fiscal policies to boost growth and, in times of expansion, restrictive policies to reduce debt levels. The relationship between debt and growth was debated further following the 2008 financial crisis in the wake of much recent empirical research.

2.2. The empirical debate on the public debt threshold effects on economic growth

In advanced economies, the trend of public debt in the period of pre-crisis was exacerbated by the fiscal stimulus implemented in the 2008–9 period of crisis. At that time, a controversial paper by Reinhart and Rogoff (2010) reported that, for a sample of 20 advanced countries, there is a 90% common threshold of the government debt to GDP ratio, over which debt has a negative effect on economic growth. This triggered an influx of research, creating an empirical debate with many controversial results about the existence of the public debt threshold, from which the debt–growth relationship changed its sign.

The empirical debate on the effects of public debt on economic growth is of particular importance, as its outcome has significant policy actions. In particular, if economic growth is revealed to be reduced by high levels of public debt, as assumed by Reinhart and Rogoff (2010) and other research supporting their results (Caner et al., 2010; Checherita and Rother, 2010; Kumar and Woo, 2010; Lin, 2014), expansionary fiscal policies that may have positive effects in the short term may reduce long-term economic growth, fully or partially offsetting the fiscal stimulus short-term effects.

The debate about the public debt threshold has intensified, as several authors have contested the Reinhart and Rogoff (2010) findings (Fergusson and Johnson, 2011; Minea and Parent, 2012; Baglan and Yoldas, 2013; Pescatori et al., 2014; Egert, 2015), especially after the revelation of some codification and calculation errors in the Reinhart and Rogoff (2010) article by Herndon et al. (2013). The summary of such results could be gathered under three groups: a first group of empirical research focusing mainly on the examination of a concave, non-linear relationship between debt and growth (Checherita and Rother, 2010; Kumar and Woo, 2010; Pescatori et al., 2014; Eberhardt and Presbitero, 2015; Chudik et al., 2017); a second group interested in the causality between debt and growth (Panizza and Presbitero, 2012, 2013; Di Sanzo and Bella, 2015; Gomez-Puig and Sosvilla-Rivero, 2015); and a third group of studies that examine the impacts of other institutional and macroeconomic variables interfering with the relationship between debt and growth (Greiner, 2011; Kourtellos et al., 2013; Pan and Wang, 2013; Sharpe, 2013; Marchionne and Parekh, 2015). The results of all this research did not lead to any confirmed consensus.

Generally, assessments of the effects of fiscal policies are quantified by the fiscal multiplier values. The distinction of public expenditure efficiency in Keynesian/classical analysis (as mentioned in the theoretical debate) by type (current, capital, defence, social, etc.) is empirically linked to their multipliers' estimates. In this vein, another important strand of empirical research was triggered in the aftermath of the financial crisis, revealing more about the sensitivity of such multipliers to many economic and institutional determinants.

2.3. The debate on the fiscal multiplier value

Despite the fact that the previous debate about the impact of government debt on economic growth considers the direct relationship between growth and public debt, the channels through which such effects materialize are related to the fiscal multiplier effects, particularly in the short term. The fiscal multiplier assessment has been extensively reconsidered following the development of econometrics and statistics. Since the 2008 financial crisis, a significant amount of literature assessing fiscal multipliers has emerged (Romer and Romer, 2011; Ramey, 2011, 2018; Auerbach and Gorodnichenko, 2012, 2013; Delong and Summers, 2012; Farhi et al., 2017; Ramey and Zubairy, 2018).

The main findings of this literature reveal key differences in the size of the multipliers. In fact, the multiplier's value showed sensitivity to a variety of determinants that were not (or rarely) considered before the 2008 crisis. Fiscal multipliers are especially time- and country-specific, and even sensitive to the assessment method (Batini et al., 2012; Baum et al., 2012). Furthermore, the fiscal multipliers are found to be sensitive to the business cycle; in particular, fiscal spending multipliers tend to be larger in recessions than in periods of expansion (Auerbach and Gorodnichenko, 2012, 2013; Barro and Redlick, 2011; Parker, 2011; Corsetti et al., 2012; Caggiano et al., 2015; Fazzari et al., 2015; Glocker et al., 2019). Other research has led to ascertaining the vulnerability of fiscal multipliers to other determinants and not necessarily conditioned by the state of the economy in the business cycle. These determinants are fiscal position measured by the level of debt ratios and/or deficits (Corsetti et al., 2013; Huidrom et al., 2016), the constrained monetary policy, either by the zero lower bound (ZLB) interest rate (liquidity trap) or by the loss of monetary independence, as in a pegged exchange rate or a monetary union (Hall, 2009; Cogan et al., 2010; Christiano et al., 2011; Delong and Summers, 2012; Farhi and Werning, 2017).

Nevertheless, the very recent works of Ramey (2018) and Ramey and Zubairy (2018) consider that government spending multipliers are, on average, lower than unity. This contrasts with the tendency of the post-2008 crisis research confirming larger multipliers, especially in recessions, which could reach the value of 2. This is also in line with the same consensus on spending multipliers before the 2008 recession, considered to be weak, and that fiscal policy effects are short-lived (Coenen et al., 2012). In particular, fiscal policy effects, taking into account the fiscal position of the economy, measured by the level of public debt and/or fiscal deficit, have been

highly debated in the aftermath of the 2008 financial crisis (Boussard et al., 2012; Corsetti et al., 2012; Blot et al., 2014b; Canzoneri et al., 2015; Bi et al., 2016; Huidrom et al., 2016; Perdichizzi, 2017; Poghosyan, 2017; Auerbach and Gorodnichenko, 2017; Afonso and Leal, 2018; Blanchard, 2019; Broner et al., 2019). These contrasting results about spending multipliers still make it interesting to reconsider studying fiscal multipliers and to contribute to this unsettled debate.

Very recently, in a presidential lecture of the American Economic Association, Blanchard (2019) triggered another wave of public debt and growth debate related to the fiscal cost of high public debt, as well as its effect on welfare. He particularly minimized worries about the public debt cost for the American economy as, in historical records, the nominal interest rate has remained, on average (except in some small periods around the 1980s), below the nominal growth rate.

2.4. The debate on the effects of public debt in economic models

To assess the effects of government debt, many theoretical growth models have been designed. Ramsey's (1928) model was the basis for the first class of the infinitely lived agents' models. Later, the debate between economists about agents' lifetime horizon, and the type of intergenerational operative transfer linkages between such agents, led to the concept of modes of overlapping generations (families/dynasties) being built to account for the existence or absence of continuity between generations provided by such linkages (Samuelson, 1958; Diamond, 1965). The debate was focused on the implications of the altruism between generations and the lifetime agents' horizon in determining the existence of government debt effects on agents' behaviour in terms of saving, capital accumulation, consumers' utility and interest rates. Important contributions in this sense are those of, for example, Diamond (1965), Yaari (1965), Barro (1974), Blanchard (1985), Buiter (1988), Aiyagari (1985, 1987), Weil (1989) and Ni (1999). The redistributive effects across generations have been much debated in the post-war period. Buchanan (1958) and Meade (1958), discussing the contributions of their predecessors, particularly Lerner (1943), show that public debt does not constitute any burden for the present taxpayers. The burden is instead transferred, partially or totally, to future generations that will have to pay taxes to service the debt (Bowen et al., 1960; Modigliani, 1961). Furthermore, advocates of the Ricardian equivalence show that debt neutrality could happen, depending particularly on the existence of operative altruistic links (bequests) between generations (Barro, 1974). In this way, the debate emerged, especially with useful contributions modelling fiscal policy insights, precisely the debt–tax swap and their effects on welfare utility and interest rates. This also created an intense debate between the neoclassicists and proponents of the Ricardian-equivalence conjecture (Barro, 1976; Feldstein, 1976; Cukierman and Meltzer, 1989).

The public debt effects are also considered in the political economy of public debt. In this regard, two approaches have been debated: the normative approach, where the government is a social planner for whom the priority is to maximize the social welfare of its individuals (Barro, 1979; Lucas and Stockey, 1983; Aiyagari et al., 2002); and the positive approach, which considers public

debt as a state variable used by each government as a strategy to influence its successor's choices or as a way to shape private economic agents' expectations (Svensson and Persson, 1989; Alesina and Tabellini, 1990). Hence, the most disseminated ideas were related to the effects of fiscal policy under governments following committed rules versus discretionary policies. In particular, the government time inconsistency has an impact on the way the economic agents form expectations affecting their economic decisions (Kydland and Prescott, 1977).

The public debt effects are also examined in the class of endogenous growth models. The development of such models was pioneered by Romer (1986), Lucas (1988) and Barro (1990). These models were brought as an alternative to the neoclassical growth model of Solow (1956) and Swan (1956), which was unable to explain the persistent per capita non-zero growth rates in many developed economies and was therefore highlighted for missing the determinants of long-term growth. Thus, the endogenous growth framework encompasses other determinants of long-term growth, particularly in assessing fiscal policies, by incorporating the public sector into the productive sector (Lucas, 1988; Romer, 1989; Barro, 1990; Barro and Sala-i-Martin, 1992, 1995; Futagami, 1993; Jones, 1995, 2003; Corsetti and Roubini, 1996; Turnovsky, 1997; Greiner, 2007, 2012, 2016; Futagami et al., 2008; Maebayashi et al., 2017).

Recently, fiscal policy, and particularly government debt, was also modelled under the class of the new Keynesian models. The pioneering works in the new Keynesian modelling framework are principally those of Christiano et al. (2005) and Smets and Wouters (2007). The latter differ from the models of the overlapping generations by assuming distortionary taxes instead of lump-sum taxes, as particularly assumed in the overlapping generation models. Furthermore, they join the literature of the political economy of debt by discussing government policies under commitment or discretion rules. In particular, some authors argue that optimal public debt would follow a random walk process whenever the government can achieve a time-inconsistent policy commitment (Benigno and Woodford, 2003; Schmitt-Grohe and Uribe, 2004). The important empirical research of these models has flourished recently (Leith and Wren-Lewis, 2013; Mayer et al., 2013).

Despite important contributions of the previous classes of models in assessing the effects of government debt and fiscal policy, the new Keynesian models have been subject, in particular, to Mankiw's criticism. Mankiw (2000) contributed by the "savers–spenders" theory, which has influenced much of the empirical research on fiscal policy, trying to consider the behaviour following the rule of thumb, especially in the New Keynesian models. In this way, Chari et al. (2009) show that this class of models is not yet useful for public policy analysis. In particular, they address their critics on the model of Smets and Wouters (2007), which constitutes the fundamental reference for many recent contributions and policy-makers using the new Keynesian analysis framework.

3. Interest of the thesis

Following the previous preliminary analysis showing the soaring levels of public debt in advanced economies, as well as the debates through the theoretical and empirical literature on the public debt effects on economic growth, the subject of public debt and economic growth linkages, which constitute the core of this thesis, deserves to be reconsidered among academicians, as well as policy-makers. Furthermore, the new reconsideration of fiscal policy effects assessments through fiscal multipliers, which were revealed to be sensitive to the business cycle, and particularly to the fiscal position represented by the public debt or deficit situations, as well as other economic and institutional determinants, adds more enthusiasm to this subject and justifies the choice of thesis subject.

Therefore, the current thesis builds on the very recent literature findings on the fiscal policy debates, particularly on the public debt threshold effects and fiscal multipliers, while also paying attention to the old literature on the public debt effects, which flourished in the post-war era (World War II) and constituted the theoretical core of many public debt effects and economic growth models. Moreover, it contributes empirically to the public debt and economic growth literature using a variety of economic and econometric models across all three chapters of this thesis.

Given the high indebtedness of the advanced economies, our focus was on a sample of advanced countries. It is constituted by 20 OECD advanced countries, of which 11 are euro area members, namely, Australia, Austria, Belgium, Canada, Denmark, France, Germany, Greece, Ireland, Italy, Japan, The Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom and the United States. The focus on this sample was justified for many reasons:

- The economic importance of this group of advanced countries influencing the world economies, and particularly that they weigh on the international economic and financial system (systemic risk).

- The high public debt to GDP accumulated for the majority of these countries, and many of these countries have encountered sovereign debt problems, either in the current financial crisis or previously.

- The sample is constituted by countries that have been highly studied and for which results have been debated in the post-2008 financial crisis in terms of public debt and fiscal policy issues, which allows us to turn our results into important findings in the literature.

- Finally, the availability of a long history of data, annually as well as quarterly, is also an important reason for the choice of this sample.

4. Plan of the thesis

The first chapter of this thesis, entitled "Public debt and economic growth: one size does not necessarily fit all", highlights the highly-debated issue in the empirical literature about the existence of a debt threshold inversing the relationship between public debt and economic growth from a positive relationship for low and moderate ratios of public debt to a negative one for higher public debt ratios. Our empirical application in the first chapter, applying panel polynomial equation regression, as in Checherita and Rother (2010) and many other papers that build on it, and a new method of kink regression by Hansen (2017), applied to individual countries, which searches endogenously the public debt ratio threshold, concludes that the turning point in the relationship between public debt and growth is rather a country- and time-specific one. Following these findings, we recommend in the first chapter studying the relationship between public debt and economic growth, taking into account countries' macroeconomic fundamentals, which should be captured by an appropriate theoretical modelling framework rather than a simple econometric relationship implying two main economic variables (public debt ratio and economic growth), as done by most of the empirical literature following the Reinhart and Rogoff (2010) paper.

As public debt is destined to finance public expenditure, we assess, especially in the short term, the effects and relationship of public debt on growth through the impact of government expenditure on the output. This impact is known as Keynesian multipliers. Therefore, the second chapter, "Short-term effects of public debt on growth: the spending multiplier *pass-through*", assesses the short-term effects of public debt, particularly through fiscal multipliers. As the body of literature studying the effects of (optimal) fiscal policy is substantial in size, our focus in this chapter, in the literature review and in our application, is dedicated to the fiscal policy effects through spending multipliers (no tax/income multipliers are considered).

Applying the methodology of a structural vector autoregressive (SVAR) model for each country, the results show that the expenditure multipliers are much higher in times of recession than in times of expansion. Moreover, it is observed that, generally, the idea of spending multipliers being weak, and even negative in recent decades compared to the 1960s, 1970s and 1980s, is not well supported by our findings. The previous results are in line with what is observed in the recent literature about fiscal multipliers, in advanced economies, being large in times of recession and weak or even negative in times of expansion.

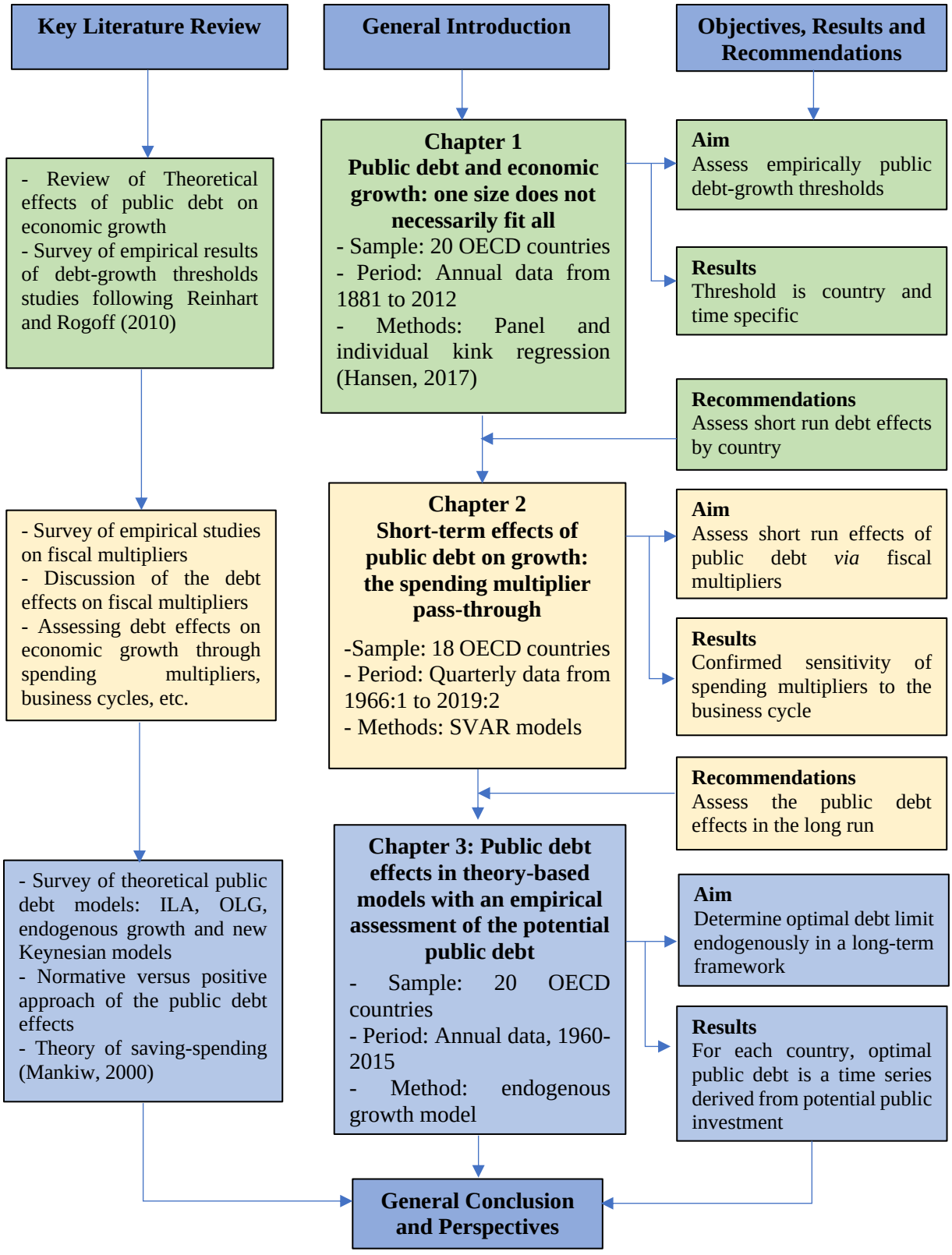
Furthermore, introducing endogenously the public debt to GDP variable in an SVAR model leads to higher multipliers in recession than expansion for each country of the sample. These results were checked by a large SVAR model conducted on a long history of quarterly data for the United States, as the country with long quarterly times series of six fiscal and monetary variables available, as considered in this model, namely, public debt, GDP, private investment, public expenditure, interest rates and inflation. The main results of this model show that government expenditure has positive but short-lived effects on economic growth. Furthermore, public debt

crowds out private investment, leading to a decreasing growth rate in times of expansion, while in times of recession the public debt effects on growth are positive. This crowding-out effect may play *pass-through* to the expenditure multipliers and could explain, *ceteris paribus*, the weak size of spending multipliers in times of recession, while the crowding-in effect leads to higher multipliers. Consequently, this chapter concludes on the fiscal policy effects and spending multipliers and contributes to the current economic literature.

The previous chapter considers a short-term approach, while public debt also has prolonged long-term effects, especially in the classical models. Therefore, the third chapter, entitled "Public debt effects in theory-based models with an empirical assessment of the potential public debt", undertakes the essence of the relationship between public debt and economic growth in all theoretical models, citing the over-lapping generations (OLG) models, the infinitely lived agents (ILA) models, the endogenous growth models and the new Keynesian models. For several considerations that were justified in this chapter, the endogenous growth model was chosen as a framework for our application to assess the long-term effects of public debt on economic growth. The main findings of this chapter are the ability to derive, for each country, an optimal potential endogenous government debt as a time series derived from potential public investment (the government gross fixed capital formation). This parametrized public debt, drawn from an economic model proper to each country, based on a Cobb-Douglas production function augmented by public and human capital, jointly with a public budget constraint equation, is an important result against vehiculating any exogenous threshold, therefore endorsing the conjecture of the first chapter that there is no specific threshold that fits all. Furthermore, for many advanced countries with high actual public debt, potential debt is overcome by actual debt in many periods, especially in times of crisis. Consequently, the third chapter closes with the effects of public debt and contributes to the debate about fiscal policy in the long term.

Figure 4 presents a graphical structure of the thesis, illustrating its main parts and describing its steps as well as the important findings and consequent recommendations.

Figure 4: Thesis Structure



Chapter 1

On the public debt and growth threshold: One size does not necessarily fit all

Chapter 1

On the public debt and growth threshold: One size does not necessarily fit all

Abstract: In a time of high debt and sluggish economic growth, the Reinhart and Rogoff (2010) conjecture of a common 90% debt threshold for advanced economies triggered a controversial debate among economists and policy-makers. We analyze the accuracy of this result for a sample of 20 advanced economies over the period of 1880-2010. Using a regression kink model with an unknown threshold proposed by Hansen (2017), we examine the relationship between public debt and economic growth. We show that the relationship between public debt and economic growth is time-varying and state-dependent and subject to data and country heterogeneities. The relationship is instable either by country, by group of countries or across periods of time and particularly sensitive to country size, government effectiveness and government expenditures. The kink regression method shows diverse curves for the debt-growth relationship. For a set of countries, growth slows starting from low debt levels over the postwar period. However, other countries start flourishing from low to medium levels of debt, while some countries show flat curves in the debt-growth relationship, especially over the long period of 1881-2010. These findings reject the existence of any common threshold fitting all countries and call for more theory-based models that take into account fundamentals that vary between countries and impact debt–growth interactions.

JEL classification: C13, C15, C23, H63, O57.

Keywords: Public debt, Economic growth, Regression kink, Non-linearity, Threshold effects.

1. Introduction

In 2010, the signs of a sovereign debt crisis in Europe and other advanced economies divided economists and policy-makers regarding the efficiency of the economic policies necessary to overcome the recession. Some are in favor of continuing the stimulus packages implemented at the beginning of the crisis, while others call for urgent fiscal consolidation and austerity policies to reduce the public deficit and debt levels. The former, believing in the role of Keynesian multipliers, make growth a priority to stabilize the deficit and debt ratios. The latter hold that high levels of debt hamper growth, which can be explained by a negative causality running from debt to economic growth. In both cases, the relationship between public debt and economic growth is at the forefront implying many controversies.

Thus, in what is an extremely controversial subject, Reinhart and Rogoff (2010) (RR (2010) hereafter) reported that, for a sample of 20 advanced countries, there is a 90% common threshold of the government debt-to-GDP ratio over which debt has a negative effect on economic growth. Several authors[5] have contested this result, especially after the revelation of some codification and calculation errors in RR's (2010) article.[6] This resulted in an influx of research using different methods to study a set of econometric properties likely to alter the link between economic growth and public debt.

The trend among emerging empirical literature has been the examination of a concave non-linear relationship between debt and growth, with some focusing on a variety of econometric issues, such as endogeneity, causality, and heterogeneity rather than using a proper theoretical modeling framework. Despite the use of a variety of econometric tools to overcome such issues, no consensus has been found on the robust existence of a single threshold that fit all and at which debt starts to alter growth. Moreover, despite most researchers agreeing on the negative correlation between high public debt and economic growth, it is difficult to agree on the direction of causality between debt and growth in the long term as suggested by the economic theory. Many economists warn against the hasty interpretation of this research and call for more investigation on this subject (Panizza and Presbitero, 2012; Minea and Parent, 2012). According to Minea and Parent (2012), institutions such as the OECD, the EU Commission and the French Report on Public Finance of April 2010 have a tendency to be influenced by the 90% threshold of RR (2010) in acting to reduce their public debt using austerity measures. The authors warn, in particular, against drawing conclusions based on considering exogenous thresholds instead of searching endogenously for such thresholds as the relationship between public debt and growth, which could be altered by complex non-linearities and sudden jumps around high debt thresholds. Their findings also suggest

[5] See, for example, Ferguson and Johnson (2011), Herndon et al. (2013), Baglan and Yoldas (2013), Pescatori et al. (2014), Egert (2015), Eberhardt and Presbitero (2015), and Chudik et al. (2017).
[6] See Herndon et al. (2013).

that there may be a regime in which very high public debt is positively correlated with economic growth, similarly to what is observed with low and moderate levels of public debt.

In theory, the effects of debt on economic growth are summarized by the "conventional analysis" which reflects the dominant views among economists and policymakers (Elmendorf and Mankiw, 1999). This approach adopts the deficit budget Keynesian view in the short term, assuming that a deficit financed by government bonds boosts economic activity. Government expenditures act as a stimulus for the aggregate demand in the context of Keynesian prices and wages rigidities. Nevertheless, for the short term, the debate is rather on the composition of public spending. The debt intended to finance the capital goods, would have positive short-term effects, which may become negative in the long run due to the induced risk premium following high debt (Aschauer, 2000). Keynesians report that the spending effect is positive for all expenditure types, and only differs in efficiency.

In the long term, the economy adheres to the classical vision, for which government debt reduces capital stock and lower productivity, hence, reducing the output. This goes through diverse channels as Hansen (1959) reported: higher debt can trigger higher private saving, less incentives to work and invest especially for the owners of the government bonds and negative incentive effect due to additional taxes needed to pay the debt service. Likewise, public debt can crowd out private investment by reducing credit to the economy or by raising long-term interest rates (Modigliani, 1961).

However, according to Barro (1974), economic growth can be insensitive to public debt. Under the assumption of perfect information, which assumes rational expectations, economic agents expect future taxes to finance the deficit generated by the new public spending and thus reduce their expenditures. This effect is known as Ricardian equivalence[7]: any public expenditure reducing public saving is assumed offset by an increase in private saving by an equivalent amount. Consequently, the national saving is unchanged and no effect is expected on other economic variables.

If theory suggests mainly a causality running from debt to economic growth, few papers examining empirically this issue have not reached any consensus about the direction of the causality (Panizza and Presbitero, 2012; Gomez-Puig and Sosvilla-Rivero, 2015 and Di Sanzo and Bella, 2015). The relationship between public debt and economic growth could also be eclipsed by the interference of other economic and institutional variables. Some authors criticized previous empirical works for the omission of such institutional variables in the debt growth analysis (Panizza, 2015; Kourtellos et al., 2013). Nevertheless, few researches tried to enrich the debt growth relationship

[7] The name Ricardian equivalence is due to Buchanan (1976) who found a similarity between the proposal of Barro (1974) and that of David Ricardo. Moreover, O'Driscoll (1977) notes that Barro's (1974) proposition contradicts Ricardo's conclusions that there is no equivalence of choice between financing a war by taxation or a debt and decides to call it "Ricardian non-equivalence". Barro's (1974) proposal is also referred to as modern Ricardian equivalence theorem (Ahiakpor, 2013).

by other macroeconomic and institutional variables (Sharpe, 2013, Pan and Wang, 2013; Greiner, 2011; Marchionne and Parekh, 2015).

Given the absence of consensus on a tolerable level of debt, questions still need to be asked: Does public debt that is too high reduce economic growth? Does the turning point in the relationship between growth and debt exist for all countries and at all times? What is its size? Does it fit all countries or is it a country-specific one?

The purpose of this article is to investigate the existence of the debt threshold effect, its size and whether it fits all countries or varies across countries and periods. The previous empirical studies have several limitations: some, using a long period of analysis as in RR (2010) suffer from methodological issues. They generally adopt simple descriptive statistical approaches to generalize for a common threshold that fits all. While those using different econometric tools could have a short time sample bias. Generally, their samples start after the 1970s. The main papers set exogenous thresholds to test. Furthermore, countries differ in their economic policies affecting the debt–growth relationship, and the panel approach adopted by all the previous empirical literature suffers from a high heterogeneity bias.

This paper adds to the existing literature by adopting a different approach. Unlike previous research that has examined the debt-growth thresholds across panels of countries, our methodology gives priority to country specific analysis. Surveying the previous empirical approaches and starting from their limitations, we use a novel econometric method proposed by Hansen (2017) that searches thresholds endogenously for individual countries. We undertake estimations using long time period of 1880-2010 and sub-periods depending on the World major economic and political events. We also run panel regressions by varying countries sample according to some sizeable countries, exchange rate regime and type of government expenditures and effectiveness.

The remainder of the paper is organized as follows. Section 2 reviews the existing literature. Section 3 describes the econometric methodology. Section 4 describes the data and descriptive statistics. Section 5 provides estimation results for country specific regressions. Section 6 presents estimation results for panel analysis. Section 7 concludes.

2. Literature review

The issue of the government debt threshold has been extensively studied since the 2010 debt crisis, provoking several controversies. Initiated by the early work of RR (2010), researchers have examined public debt thresholds for different panels of countries while correcting for econometric issues. Table 1 summarizes the main contributions.

Insert Table 1 about here

RR (2010) found that the correlation between public debt and growth is low for normal debt levels and becomes strong and negative when the debt-to-GDP ratio exceeds 90%. They observe that median and average growth rates corresponding to debt ratios over this threshold shrink by 1 and 4 points respectively. This result, based on a simple descriptive statistical approach, has given rise to much empirical research examining the relationship between debt and growth using increasingly econometric methods.

In a subsequent paper, Reinhart et al. (2012) emphasized their previous findings of the 90% threshold by analyzing periods of public debt overhangs for a sample of 22 advanced economies going back to the nineteenth century.[8] They defined a debt overhang period as a debt-to-GDP ratio of more than 90% lasting for at least five consecutive years. As a result, 26 periods were detected and 23 of these are associated with lower growth. On average, an annual growth lower by 1.2 percentage point than in periods of debt ratios less than 90%. However, from the 22 advanced countries, only 13 have episodes of debt overhang from which two countries (Italy and Greece) have both 8 periods of debt overhang (4 each). Therefore, the sample of countries, with different economic policy experiences, used to emphasize the 90% common rule is reduced. Furthermore, almost all episodes of high debt resulted from costly wars and the Great Depression and, only six countries have had a debt overhang in peacetime: Belgium, Canada, Greece, Ireland, Italy and Japan. So, should this small sample of heterogeneous countries in size, time sample and monetary sovereignty be sufficient for concluding about the common 90% threshold?

In fact, the conjecture of a common threshold does not seem to be accepted by many authors. For example, Ferguson and Johnson (2011) stated that RR (2009, 2010) "*jumble big and small countries together from different areas and different political choices. This makes induced policy lessons from such samples a likely misleading exercise*". They argue that *"political choices for smaller countries are frequently influenced by external factors, while big countries like United States and Japan are the principal players in the international system of which policies affect the rest of the world"*. Consequently, the authors opposed the idea of a common threshold debt arguing using historical counter-examples. Especially, the United Kingdom constitutes an interesting fact countering Reinhart and Rogoff claim showing that the British industrial revolution flourished while debt-to-GDP ratio exceeded 200% for decades.

Empirically, an important controversy came from Herndon et al. (2013). By replicating the exercise of RR (2010), these authors corrected some data processing errors. Consequently, the average growth rate of countries with government debt-to-GDP ratios of more than 90% is not dramatically different from that calculated for countries with moderate to high debt-to-GDP ratios. This paper triggered an influx of research examining debt thresholds using different econometric tools (Table 1).

[8] The time sample differs between countries depending on data availability. The United States have the largest dataset (1791-2011) while Ireland has the shortest sample (1924-2011).

A significant amount of research has replicated the same sample of 20 advanced countries used by RR (2010), finding different results that generally point to low levels of debt thresholds. Baglan and Yoldas (2013) used Bayesian inference and found a debt threshold of 20%. Egert (2015) used the Hansen (1999) method and found a debt threshold of 20 to 30%. Lee et al. (2017) examining the relationship between public debt and median GDP growth suggest that the debt threshold may exist around 30%. Surprisingly, Minea and Parent (2012), using panel smooth threshold regression (PSTR) models found a convex relationship between debt and growth where the effect is negative below a high debt threshold of 115% and positive above this threshold. However, these results are surrounded by more uncertainties and may result in dangerous consequences when translated into policy decisions.

Other researchers have used different samples and periods to study the long-term effects of debt on economic growth. For example, Pescatori et al. (2014) analyzed debt and growth data over long period, considering lead economic growth by 1, 5, 10 and 15 years to be affected by the current debt. Their analysis rejects any threshold from which economic growth is undermined. However, they found that high debt increases output volatility. They also found that countries with high but declining debt grow as fast as countries with lower growth. Eberhardt and Presbitero (2015) studied nonlinearity by correcting the heterogeneity of the debt-growth relationship across countries. Their results highlighted the negative non-robust relationship between public debt and long-term economic growth, but failed to determine a common debt threshold for all countries. Chudik et al. (2017) developed tests for threshold effects in the context of dynamic heterogeneous panel data models and found no evidence of a universally applicable threshold effect. Regardless of the threshold, they found significant negative long-run effects of public debt build-up on output growth. Furthermore, Syssoyeva-Masson and De Sousa Andrade (2017) highlight the long memory of public debt series and recommend studying the debt–growth relationship in a long-term framework.

Nevertheless, other researchers seem to support RR's (2010) findings, albeit not necessarily the 90% debt threshold. Caner et al. (2010) were the first to review the results of RR (2010) and confirm the negative link between public debt and economic growth above the 90% threshold. Kumar and Woo (2010) also highlighted a negative non-linear relationship for higher debt levels for a sample of advanced and emerging countries over the period of 1970-2007. Particularly, the per capita growth is 0.2% lower following a 10-percentage point increase in the debt ratio. Lin (2014) applied a threshold quantile Lasso regression to a sample of 62 cross-sections combining developing and developed countries over the period 1991-2005, and to individual countries for a subsample of data of 22 countries over the period 1961-2010. For cross-country analysis, he confirmed the 90% threshold for the median quintile as defended by RR (2010). However, for country-specific analysis, he demonstrated that tipping points range widely between 10% and 100% across countries. The widespread values of the threshold were emphasized in particular when controlling for macroeconomic and demographic changes. The existence and value of these thresholds increase by quintile, reflecting the asymmetric effects of debt on growth, and are more

common in developing than developed countries. Checherita and Rother (2010) found a significant polynomial term between public debt and per capita economic growth considering a sample of 12 eurozone countries over the period of 1970–2009. Unlike research that has pointed to a defined threshold, their paper indicates an interval (90–100%) from which public debt starts to hamper economic growth.

3. Econometric Methodology

Unlike the previous research that essentially examined panel groups despite the aforementioned heterogeneity,[9] we adopt a different approach in which we give more importance to country specific regressions. For this purpose, we first run an innovative methodology namely a regression kink recently developed by Hansen (2017). This method is more appropriate as it permit searching endogenously for unknown thresholds.

To support our results, we also run panel regressions in which we assume that economic growth is a non-linear[10] (quadratic) form of debt. Our aim, by this second approach, is to show that we could find thresholds in the relationship between debt and growth in heterogeneous panel groups as shown by partisans of RR (2010) results, but these are instable by time and countries sample as well as other institutional characteristics.

Our approach for panel regressions is different from the previous researches as it considers long period of analysis split according to the major events in the international economic and political order, as well as, varying sample by country size and level of public expenditures and government effectiveness. This approach complements the first one in results: while the individual regressions show different relationship curves by countries that are also instable over time, the panel regressions show that threshold is highly affected by country sample and time period. Both approaches argue against a unique threshold that fit all countries.

3.1. Country specific methodology

For the individual regressions, we use the kink regression method developed by Hansen (2017) that searches for endogenous thresholds.[11] The regression function is everywhere continuous

[9] Only fewer studies weakly investigated country specific regressions such as in Gomez-Puig and Sosvilla-Rivero (2017) that used time series regressions for 11 eurozone countries between 1961 and 2015 and draw conclusions based on thresholds that vary from a minimum of 21% in France to a maximum of 61% in Belgium.

[10] The example of debt-growth non-linear effect is becoming more used to test new econometric methods. See, for example, Egert (2015), Henderson et al. (2015) or Hansen (2017).

[11] The difference in countries in terms of institutions, governance, and economic policies, among others, contributes mainly to such endogeneity bias. In general, these variables are difficult to measure, and their effects could be better assessed in a theoretical model (such as endogenous growth model) rather than in a simple non-linear relationship for which the main goal here is to detect a turning point in the link between debt and growth simply from the data-generating process (DGP).

except on this threshold where the slope has a discontinuity. Instead of assuming exogenous known thresholds as in many previous empirical researches and by the traditional regression discontinuity models, this method considers that the threshold is unknown and should be estimated.

The recent regression kink with an unknown threshold constitutes an important advancement of the threshold regression models. The first class of such models used the regression discontinuity design (RDD), introduced early by Thistlethwaite and Campbell (1960) and recently enhanced by regression kink design (RKD) (Nielsen et al., 2010) and emphasized theoretically by Card et al. (2012). Both RDD and RKD are especially involved when a policy variable of interest (the outcome) is totally or partially determined by a known assignment rule of an observed treatment variable (covariate). Both methods become important for identifying causal effects in observations settings in many areas such as educational outcomes, election outcomes and unemployment, among others (Card et al., 2017).[12] The only difference is that RDD uses a "discontinuity" or a "jump" in level of a treatment status at a threshold of an assignment variable, while RKD examines discontinuities in derivatives (slope discontinuities) rather than the level (Athey and Imbens, 2017). Despite their important use, some authors warn that their results could be biased especially for smaller population size, and particularly in the presence of confounding nonlinearities between an assignment variable and an outcome variable (Ando, 2017).

As for Hansen's (2017) regression kink with an unknown threshold, it is the latest method to determine thresholds endogenously without the need for a treatment or an assignment variable as in the previous methods. The conventional regression kink design assumes that the threshold is known. This is suitable in many policy-oriented applications where the threshold is determined by policy (Hansen, 2017). Instead, we treat the threshold as an unknown to be estimated. This method is particularly appropriate when either the threshold is not set by the policy, or when one wishes to investigate the robustness of this assumption. The features of such regression correspond highly with our aim of examining endogenous thresholds from a direct relationship between economic growth and public debt. We aim to confirm or deny the existence of debt thresholds rather than to measure any policy effects, as the previous methods do. Hansen (2017)[13] developed an inference and estimation toolkit that tests for the presence of the threshold, estimation, and inference on the regression function and parameters.

Using $(a)_- = min[a, 0]$ and $(a)_+ = max[a, 0]$ to denote the "negative part" and "positive part" of a real number a, Hansen's regression kink model takes the following form:

$$g_t = \beta_1(d_t - \gamma)_- + \beta_2(d_t - \gamma)_+ + \beta_3' h_t + \varepsilon_t \quad (1)$$

[12] Other threshold models include a variety of autoregressive time series models with threshold, used particularly in financial applications (Chen et al., 2011).
[13] A theoretical generalization of Hansen's (2017) method to panel data appeared recently in Zhang (2017).

where (g_t, d_t, h_t) are, respectively, variables describing economic growth, public debt-to-GDP ratio, and a *k*-vector of other explanatory variables which includes an intercept. ε_t is the error term, which is independent and identically distributed with zero mean and constant variance $\left(\varepsilon_t \sim iid(0, \sigma_\varepsilon^2)\right)$. The variables (g_t, d_t, h_t) are observed for $t = 1, \dots, n$. The parameters to be estimated are the regression slopes β_i, with $i = 1,2,3$, and the parameter γ called the threshold or "kink point". In equation (1) the slope with respect to the variable *d* equals β_1 for values of d_t less than γ, and equals β_2 for values of d_t greater than γ; yet the regression function is continuous in variables d and h, except the slope with respect to d which is discontinuous at $d = \gamma$ (kink point). Equation (1) has $p = 3 + k$ parameters. $\beta = (\beta_1, \beta_2, \beta_3)$ are the regression slopes and are generally unconstrained so that $\beta \in R^{p-1}$. However, for the parameter γ, the model only makes sense if the threshold is in the interior of the support of the threshold variable d. We thus assume that $\gamma \in \Gamma$ where Γ is compact and strictly in the interior of the support of d.

To be applied to the debt growth relationship, we rewrite equation (1) with lagged independent variable d_{t-1} (so that this is plausibly pre-determined) and set $h_t = (g_{t-1}, 1)$ and then $\beta_3 = (\delta, c)$ so that the regression contains a lagged dependent variable to account for dynamic effects and minimize autocorrelations. Equation (1) becomes:

$$g_t = \beta_1(d_{t-1} - \gamma)_- + \beta_2(d_{t-1} - \gamma)_+ + \delta g_{t-1} + c + \varepsilon_t \qquad (2)$$

Equation (2) can be written as $g_t = \beta' x_t(\gamma) + \varepsilon_t$, where $x_t = ((d_t - \gamma)_-, (d_t - \gamma)_+, g_{t-1})'$ and the least squares criterion for estimation is:

$$S_n(\beta, \gamma) = \frac{1}{n}\sum_{t=1}^{n}\left(g_t - \beta' x_t(\gamma)\right)^2 \qquad (3)$$

Minimizing (3) yields the least squares estimator:

$$\left(\hat{\beta}, \hat{\gamma}\right) = arg \min_{\beta \in R^{k-1}, \gamma \in \Gamma} \{S_n(\beta, \gamma)\} \qquad (4)$$

The criterion $S_n(\beta, \gamma)$ is quadratic in β but non-convex in γ. Hansen (2017) uses a combination of concentration and grid search. Particularly, by concentration we write:

$$\hat{\gamma} = \arg \min_{\gamma \in \Gamma} \min_{\beta \in R^{k-1}} \{S_n(\beta, \gamma)\} = arg \min_{\gamma \in \Gamma} \left\{S_n\left(\hat{\beta}(\gamma), \gamma\right)\right\} = \frac{1}{n}\sum_{t=1}^{n}\left(g_t - \beta' x_t(\gamma)\right)^2 \qquad (5)$$

Where, for a given γ, the parameters $\hat{\beta}(\gamma)$ are the least squares coefficients from regressing g_t on $x_t(\gamma)$. The kink point $\hat{\gamma}$ is determined by a grid search over $\gamma \in \Gamma$, and once found, the parameters $\hat{\beta}$ are determined by standard least squares of g_t on $x_t(\hat{\gamma})$.

The deduced regression function is then:

$$g_t = \hat{\beta}' x_t(\hat{\gamma}) + \hat{e}_t \tag{6}$$

where $\hat{e}_t$ are residuals with an estimated error variance:

$$\hat{\sigma}^2 = \frac{1}{n}\sum_{t=1}^{n} \hat{e}_t^2 = S_n(\hat{\beta}(\gamma), \gamma) \tag{7}$$

In order to test for the unknown threshold, Hansen (2017) conducted an algorithm[14] to test the nested regression model (2) against the following linear model assuming $\beta_1 = \beta_2 = \beta_l$:

$$g_t = \beta_l d_{t-1} + \delta g_{t-1} + c + \varepsilon_t \tag{8}$$

3.2. Panel methodology

To investigate the existence of a threshold at which debt reduces growth, we proceed for the panel approach by the same way as in Checherita and Rother (2010).[15] We estimate the following equation:

$$g_{i,t+5} = \alpha d_{i,t} + \beta d_{i,t}^2 + \gamma_i + \varepsilon_{i,t} \tag{9}$$

where $g_{i,t+5}$ is the 5-years lead economic growth for country i; $d_{i,t}$ is the debt to GDP ratio for country i at time t, α and β are parameters associated with the debt and its square, γ_i is the constant term associated with each country i called fixed effect, and $\varepsilon_{i,t}$ is the error term with zero mean and constant variance ($\varepsilon_{i,t} \sim iid(0, \sigma_\varepsilon^2)$). The time lag of five years is assumed: the current debt will likely affect growth after 5 years. This is the case where debt is more negatively correlated with growth (Table 1.A).

This equation is analogous to many modelling curves in the economic literature: Mincer's (1974) earning equation, Laffer curve (tax rate, Government revenue) and Kuznets curve (income, inequality); where the dependent variable is a quadratic polynomial form of the explanatory variable and thus expected to have a turning point (negative slope of the quadratic term). Similarly, the non-linear term in (9) assumes that the rhythm by which debt affects growth changes from a specific turning point. For example, low public debt could have a positive effect on growth and starting from a certain threshold (high debt), the effect becomes negative.

[14] The algorithm is presented in the appendix C (algorithm 1).

[15] Our exercise is distinct from Checherita and Rother (2010) by adopting a longer span of time as well as different sample of countries and different instrumental variables. For example, these authors use Gross Capital Formation as instrument while it is rejected in our choice. The Pearson's correlations (Table A.3) reveal that this variable is weakly correlated with the explanatory variable.

Equation (9) changes its trend if it has a derivative null at a certain level of debt ratio. The debt threshold $\hat{d}$ is then deduced by deriving (9) according to the debt ratio:

$$\hat{d} = -\frac{\alpha}{2\beta} \tag{10}$$

Equation (9) is to be estimated using Generalized Least Squares (GLS) method. However, to remedy to the major problems raised by the literature in terms of endogeneity, which may be caused in particular by the omission of other explanatory variables or by reverse causality, we use the generalized method of moments (GMM) involving instrumental variables.

Thus, the equation to be estimated by GMM is:

$$g_{i,t+5} = \alpha d_{i,t} + \beta d_{i,t}^2 + \varphi Inst + \gamma_i + \varepsilon_{i,t} \tag{11}$$

where, $Inst$ are a set of instrumental variables and φ the set of their associated parameters. The threshold is deduced as in (10).

Another interesting method used previously by some authors is the PSTR models standing for panel smooth transition regression. Gonzalez et al. (2005) developed these models as an enhancement for the panel threshold regression (PTR) models of Hansen (1999). These models explain the dependent variable as a linear term of the independent variable augmented with non-linear terms as a multiplication of the same independent variable with an indicator function. This latter is modelled in the form of a logistic function which depends on a threshold variable. In case the threshold variable is the same as the dependent variable, this yields a polynomial form as in (9). Despite their popularity and advantages of accounting for fixed effects in the panel data, the PSTR do not allow lagged explained variables to be in the right-hand side of the specification (Colletaz and Hurlin, 2006). This means they do not allow for dynamic effects.

4. Data and preliminary analysis

In this section, we present the data sources and a preliminary analysis (as the Pearson's correlations and statistical heterogeneity tests) for the data generating process.

4.1 Data description

Regarding this work, we consider a sample of 20 developed countries over the period of 1880–2010 from the IMF database. This is the same sample of countries used by RR (2010), in addition to a significant amount of subsequent research. The methodology and description of the data are

published in Abbas et al. (2010).[16] The database reports the public debt-to-GDP ratio. The latter comes from the Maddison[17] data according to the Geary-Khamiss method, in international dollar. For consistency, the Maddison Project data is also used for GDP growth.

The 20 advanced countries are: Australia, Austria, Belgium, Canada, Denmark, France, Germany, Greece, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom and the United States.

4.2 Correlations and data heterogeneity tests

Table A.1 (appendix A) shows that Pearson's correlations tend to be negative, especially between current debt and 5-years lead growth. 13 out of 20 correlations are significantly negative over the period of 1950-2008. But, the weak correlations may suggest that the form of the relationship is not necessarily linear, since the Pearson correlations assume linearity. This seems to be revealed by scatter plots for individual countries.

An issue related to data and country samples is heterogeneity. The source of the heterogeneity could be unobserved characteristics as a result of other variables involving economic policies and institutions. The heterogeneity in country behaviors is known as the fixed effect in econometrics. Some of the previous works have warned against the high heterogeneity of countries as a result of differences in fiscal and monetary policies, country size, and quality of institutions.[18]

However, to the best of our knowledge, no paper has invoked the issue of data heterogeneity. We take the opportunity to study such heterogeneity. RR (2010), and other researchers, used descriptive statistics based on conditional means and medians to conclude, for all countries, the existence of a common debt threshold beyond which GDP growth slows. This assumes that the data generating process is homogenous for all countries. However, running appropriate statistical tests for the equality of means, equality of medians and equality of variances across countries, for the economic growth categorized by public debt, strongly rejects the null hypothesis of equality for such statistics. This means that the data generating process is highly heterogeneous across countries. Table A.2 presents the results of the equality tests for different periods. The source of variation is several times higher between countries than it is within countries. The heterogeneity seems to decrease as the period shortens. Specifically, over the period of 1991-2008, the null

[16] The database and the paper are drawn from www.imf.org/external/pubs/cat/longres.aspx?sk=24332.
[17] http://www.ggdc.net/maddison/maddison-project/data.htm.
[18] Despite its importance, we prefer not enriching equation (9) for panel data by a set of variables representing economic and monetary policies for two reasons. First, these variables are not necessarily observed over the same long period of debt and growth. Second, this could deviate the model from its assumed non-linear form leading to many ad-hoc relationships between variables. What we have done next is splitting the sample of the 20 countries and run our regressions on subsamples according to their levels in the main types of government expenditures. The level of expenditures should reflect to some extend the countries' economic governance.

hypothesis of equality of means and medians is accepted at 5% level and the test indicates variances homogeneity.

5. Country specific analysis

The aim of this section is to analyze the relationship between public debt and economic growth and investigate whether a unique debt turning point exists for all countries. Surveyed empirical studies have not reached any consensus about a clear relationship between debt and growth. Despite the diversity of methods, they showed sensitivity to different econometric problems and data samples shortness. Those using a long period of analysis as in Reinhart and Rogoff (2010, 2012) could have methodological issues, especially by adopting simple descriptive statistical approaches to generalize for a common rule that fits all. However, those using somehow advanced econometric analysis could have short time sample bias. Generally, their samples start after the 1970s. Our aim is to reconsider an investigation of the debt-growth relationship, starting from a data descriptive approach and ending to econometric estimations over a long period. We try to remedy to limitations of samples and econometric methods used in the previous literature by using both advanced recent econometric tools and rich statistical data analysis over long period for panel and country specific analyses.

5.1. Scatter plots analysis

Despite the diversity of the econometric methods used to study the growth-debt relationship, they are generally applied to samples starting from the seventies. This coincides with the end of the Bretton Woods system and the beginning of market liberalization in developed countries. To remedy this shortcoming, we extend the analysis to the long period of 1880-2008, split to five sub-periods corresponding to the main changes in the international economic and political order (Rodrik, 2011; Obstfeld and Taylor, 2002).[19] These world events may affect the stability of the macroeconomic aggregates and their interdependencies, hence the debt and growth linkages. We distinguish the following sub-periods:

- 1880-1913. This period fits with the end of the first globalization (mercantilism era);
- 1914-1945. A period with two devastating wars and the 1929 great depression. The international economic order was marked by the gold standard regime;

[19] Breakpoint tests based on Dickey-Fuller unit root test emphasized this partition around these dates. For example, break dates in debt series are 1918, 1941, 1964 and 2007 for the USA; 1915, 1950, 1969 and 1990 for the UK; 1906, 1944, 1975 and 1996 for Japan; 1896, 1960 and 1991 for France; 1902, 1937, 1974 and 1992 for Germany. Detailed results for all countries are available upon request from the author.

- 1946-1970. The world experienced strong growth and development during this period, notably with the Bretton Woods agreements and fixed exchange rate regimes;

- 1971-1990. A period of turbulent economic and political events with the end of the convertibility of the dollar in 1971 and the tendency to adopting floating exchange rates, as well as the oil shocks of the 1970s with the coexistence of unemployment and inflation, and the sovereign debt crises of the 1980s;

- 1991-2008. Countries underwent extensive financial liberalization under the Washington Consensus recommendations, resulting in financial instability for many emerging markets. The World Trade Organization (WTO) was created, bilateral and multilateral free trade agreements proliferated, and the Euro currency was launched.

We first conduct a scatter plots analysis for the relationship between public debt and growth for individual countries (Figures B.1 to B.9). The relationship is plotted over eight periods: the whole period 1880-2008, the five previous sub-periods, and two other periods (1946-2008 and 1971-2008). Scatter plots are organized for each period for individual countries. We draw scatter plots for 5-years[20] lead economic growth explained by the current public debt. The chart analysis is supported by the Pearson's correlations in Table A.1 for the debt and growth over different eras.

We tend to assume lag effect between debt and growth. We believe that a deficit financed by a government debt will act with a certain delay on economic growth either on the short-term or in the long-term. For example, capital expenditures, which assumed to affect economic growth more than any other type of expenditures are likely to impact growth with a delay. For example, a port or a road financed by bond issuance will make time to be constructed and begins to benefit to the community. Furthermore, other macroeconomic channels by which debt affects economic growth, such as interest rates, openness, population and others, are likely to react with a delay rather than immediately affecting growth. Our statistical data endorsed such assumed delay in the effect of debt on growth where current debt-to-GDP ratio is more correlated with lead growth than current growth (Table A.1).

Individual scatter plot analysis shows that the relationship form changes by countries and periods. We notably distinguish:

- Flat curves for the case of Austria (1991-2008 and 1880-2008), Denmark (1880-2008) and Portugal (1946-1970);

- Negative linear as in Germany (1880-2008 and 1880-1913), the Netherlands (1914-1945), Canada (1971-1990) and, Austria and Italy (1946-1990);

[20] The 5 years' lag is justified by the fact that the debt is supposed to affect growth over medium to long-run.

- Positive linear for Belgium (1880-2008), Australia and Portugal (1880-1913), Austria and Germany (1914-1945), France and Switzerland (1946-1970), Ireland and Portugal (1991-2008) and France (1946-1990);

- Convex relationship in Denmark and Norway (1880-1913), Germany and Greece (1946-1970), Italy and USA (1991-2008), Italy, Portugal, Greece, Sweden, the United Kingdom and Austria (1946-1970) and, Japan, Germany, the United States and Greece (1946-1990);

- Concave relationship as in France, Italy, Switzerland and New Zealand (1880-2013), Australia, Canada, Italy, Spain and the United Kingdom (1914-1945), the Netherlands, New Zealand and United Kingdom (1946-1970), Belgium, Denmark, France, Spain, Sweden and Switzerland (1971-1990), France, Norway and Sweden (1991-2008), Belgium, France, Spain and Denmark (1946-2008) and, Australia and Sweden (1946-1990).

Scatter plot analysis highlights that the form of the debt-growth relationship is country and time specific. The economic explanation is straightforward. We note especially differences across countries in the economic and political governance, the structure of debt (external or domestic, currency of denomination, maturity), the aging population (Germany and Japan versus Portugal and Spain), the degree of openness, the size of the economy (Greece and Ireland versus Japan and the United States), the structure of public expenditures, changeable economic policies and political and external environment as well as the level of the development in a country over time. Therefore, the fact that there is neither a unique economic policy, nor a comparable level of institutional and demographic variables across countries, makes less defendable the conjecture of "one size debt threshold that fits all".

5.2. Regression kink results

We use the kink regression method of Hansen (2017), allowing detecting unknown thresholds. Country specific regressions emphasized what is reported on country specific scatter plots. The regression kink with an unknown threshold shows a variety of forms for the growth-debt relationship. Tables 2 and 3 present the regression kink results for the whole and the postwar periods, respectively.

Furthermore, for better visualization of the results, we graph the summary of our findings across more than five landscape pages (Figures 1 to 5), where each page contains four countries' results for two periods: 1881–2010 and 1950–2010. For each figure, two panel charts are presented: the left-hand-side chart for the whole period, and the right-hand side for the post-war period. Each part contains a chart with three components: the first part (left) simply draws the debt ratio variable over time. This shows a mixture of high upward and downward sloping trends over time, indicating possible structural breaks. The second part (in the middle) shows kink regression plots, where the red point corresponds to the turning point (kink point or threshold), along with the regression line

corresponding to equation (2). The third part (on the right) presents the threshold parameter in axis with the F-statistic showing the minimum of the Fisher test that indicates the threshold. Asymptotic values (confidence intervals) are displayed in dashed blue lines.

The threshold F-statistic is calculated according to the test of the hypothesis $H_0: \gamma = \gamma_0$ against $H_0: \gamma \neq \gamma_0$. The criterion test is to reject for high values of the F-type statistic $F_n(\gamma_0)$, where $F_n(\gamma) = \frac{n(\hat{\sigma}^2(\gamma) - \hat{\sigma}^2)}{\hat{\sigma}^2}$, and $\hat{\sigma}^2 = \frac{1}{n}\sum_{t=1}^{n} \hat{e}_t^2$ is from equation (7). The threshold $\hat{\gamma}$ corresponds to the minimum of the threshold *F*-statistic which is also the minimum of the least squares criterion. Hansen (2017) presents an algorithm for the bootstrap confidence intervals for parameters and the *F*-statistic.[21]

Insert Tables 2 and 3 about here

Insert Figures 1 to 5 about here

According to these results, we can distinguish many cases depending on the sign and magnitude of parameters β_1 and β_2:

✓ Case 1: $\beta_2 > \beta_1 > 0$

The growth rate is always positively affected by debt and the effect becomes higher after the debt threshold. This case is only supported by Australia over the period 1956-2010.

✓ Case 2: $\beta_1 > \beta_2 > 0$

The effect of debt over growth is always positive but is reduced for debt values above the threshold compared to the effect of debt values below the threshold. This case is reported in countries such as Ireland (1929-2010) and Norway (1881-2010).

✓ Case 3: $\beta_2 > 0 > \beta_1$

The effect is negative for debt ratios below the kink point and then becomes positive after that point. This case is presented by Austria (1956-2010), Denmark, France, Italy, Spain, Sweden and Switzerland over the long period 1881-2010.

✓ Case 4: $\beta_1 > 0 > \beta_2$

The effect is positive and then becomes negative after the turning point. This case is presented by the United Kingdom (1956-2010), the United States (1791-2010), Austria (1956-2010), Germany (1881-2010) and the Netherlands (1956-2010).

[21] The algorithm is presented in the appendix C (algorithm 2).

✓ Case 5: $\beta_1 < \beta_2 < 0$

The effect is always negative but emphasized less after the turning point. This case is observed in Japan over both the long and short periods and Italy over the recent period.

✓ Case 6: $\beta_1 \cong 0$ (respectively $\beta_2 \cong 0$) and $\beta_2 \neq 0$ (respectively $\beta_1 \neq 0$)

Growth is insensitive to the debt ratio before the threshold (respectively after the threshold) and the effect has the sign of β_2 (respectively β_1). These special cases are shown by Ireland (1956-2010), Portugal (1881-2010 and 1956-2010) and Norway 1881-2010).

✓ Case 7: Flat curves

Debt neutrality is shown for the case of the United States and the United Kingdom (1881-2010), Australia (1910-2010), Canada (1881-2010), Denmark (1956-2010), Sweden (1881-2010) and Greece (1884-2010).

The kink regression method emphasizes the differences in the data-generating process of the debt–growth relationship across countries. It reveals that the thesis of a debt threshold is case-specific and changeable over time. It also suggests that there is no simple formula determining a specified debt threshold or even a range of it, considered a dangerous zone not to reach, just by considering the direct relationship between economic growth and the public debt-to-GDP ratio. This considers more theory-based models, taking into account country fundamentals that are different between countries and impact the debt–growth interactions.

6. Panel specification analysis

We present in this section, scatter plots analysis and estimation results for the panel groups.

6.1. Scatter plots analysis

Figures 6 and 7 present scatter plots for the panel analysis between the 5-year lead economic growth and the public debt ratio. Figures are presented in panel graphs by period for the whole and the euro zone sample. These scatter plots show that economic growth is weakly correlated with the public debt. The trend-line of the relationship is flat in almost all periods for both the whole sample and the eurozone. The relationship is only apparently negative for the whole sample over the period of 1950-2008 and the subsequent postwar period (1946-1970). For the euro zone sample, the analysis is nearly the same except a weak positive correlation over the period of 1991-2008.

Insert Figures 6 and 7 about here

6.2 Panel regressions

We first estimate equation (9) using GLS method. However, for the GMM method, a set of convenient instrumental variables is needed. The choice of instrumental variables for the GMM method can be challenging. In practice, these are chosen to be correlated with the explanatory variables and orthogonal to the error term before introducing instruments (error in equation (9)), which means weakly correlated to the dependent variable of the initial regression before considering such instruments. We choose a set of variables that can act as potential instruments based on the Pearson's correlations with the explained and explanatory variables (Table A.3). The following variables and their first and second lags are considered to be candidates: old people dependency ratio (ODR), shares to GDP of, respectively; exports (EX), imports (IM), government consumption (GC) and gross capital formation (GCF). The data source of the dependency ratio series is the World Development Indicators of the World Bank, while all other instruments are from the Penn World Tables (version 9.0), which provides data back to 1950 for all the countries of the sample adjusted for purchasing power parity (PPP).

Table A.3 shows first that, gross capital formation is weakly correlated with 5-years lead growth but also weakly correlated with debt. As a result, it is removed from the list of candidate instruments. Second, exports, imports, dependency ratio and government consumption are correlated with the debt variable and weakly correlated with growth. We also used the Sargan test which excluded the GCF at the estimation stage.[22]

Equation (9) is estimated over the periods of 1950-1970, 1971-1990, 1991-2008, 1971-2008 and 1950-2008. The periods of 1880-1913 and 1914-1945 were excluded as the debt series experienced breaks for several countries during these periods as a result of the great depression and the World wars. Similarly, estimations start from 1950 instead of 1946 as the debt of many advanced countries stands highly abnormal following World War II. Reinhart and Rogoff (2009) reported that defaults and restructuring debt in these times are among the highest in history.[23] For a similar reason, the recent financial crisis is not considered in estimation. The main argument is that these points at the end of the period could statistically distort the results in addition to the ambiguous character of the crisis on debt and growth.[24]

Equation (11) is estimated with the fixed effect[25] relative to each country γ_i. Some authors remove the fixed effect by differentiating their models. However, the fixed effect is important to keep in our case as it considers the heterogeneity of the panel. The fixed effect can be removed if the

[22] This statistic follows a χ^2_{r-k} distribution where r is the number of instruments and k is the number of estimated parameters (including the constant term).
[23] The GMM instruments are not observed before 1950.
[24] Baum et al. (2013) tested this effect for the euro area sample by introducing the years 2009-2010 and found a considerable upward effect on the threshold, especially in dynamic panel regression.
[25] The term fixed effects imply that although the intercept may differ across countries, it is time invariant. The fixed effects model allows for heterogeneity or individuality among countries.

heterogeneity is rejected. Furthermore, differencing the equation, in our case, will modify the assumed non-linear quadratic form and not allow to easily deduce the concavity of the relation and thus the value of the threshold according to the formula (10). We also run a variety of tests for no cross-section dependence[26] for the estimated panel model over all the periods. Table A.6 summarizes results for the 20 OECD sample of countries and the 10 Euro sample of countries. These tests strongly reject the null hypothesis of no cross-section dependence. Therefore, heterogeneity and cross-section dependence among other problems facing panel methodology support our approach considering studying growth-debt relationship for countries individually.[27]

Table 4 presents estimation results by GLS and GMM methods for the five periods of; 1950-1970, 1971-1990, 1991-2008, 1971-2008 and 1950-2008. The results are not significant for the GLS over all periods except the whole period 1950-2008 over which, the form of the equation is convex ($\beta > 0$).

However, the GMM method leads to significant results. For the fixed effects model, two thresholds result from the concavity of the relation ($\beta < 0$) over the two periods 1971-1990 and 1971-2008, with respective values of 47.5% and 46.5%. Assuming a model without fixed effects, the estimates are statistically significant over three periods: 1971-1990, 1991-2008 and 1971-2008, with respectively 49.4%, 80.1% and 62.8% thresholds. The *J* statistics shows the efficiency of the instruments considered in the regressions.

Insert Table 4 about here

These results emphasized the drawbacks from which the GLS method suffers. It reveals also that the relationship is affected by high heterogeneity behaviors across countries. We deal with the first issue by continuing the estimation using the GMM method. For the heterogeneity issue, we considered the size effect between countries and vary the sample by removing sizable countries namely Japan, the United Kingdom, and the United States. We also present the results for the sample of the euro area countries as a group of homogenous monetary and exchange rate regimes. Similarly, we filter countries according to a number of characteristics (government effectiveness and expenditure levels reflecting public economic governance).

For the fixed effects model (Table 5), the results of the estimates show a concave relationship between debt and growth for the periods of; 1950-1970, 1971-1990 and 1971-2008. The results do

[26] Testing for cross-sectional dependence is crucial for selecting the appropriate and efficient estimator. We use four tests: Lagrange multiplier (LM) test from Breusch and Pagan (1980), two tests of Pesaran (2004, 2006), one based on Lagrange multiplier and the other on pairwise correlation coefficients. The latter has a lower power when the population average pair-wise correlations are zero (Pesaran et al., 2008). The fourth test is proposed by Pesaran and al. (2008), which developed a bias-adjusted test that is a modified version of the LM test.

[27] For comparison purpose with the regression kink, we also run a dynamic quadratic form ($g_t = c + \alpha d_{t-1} + \beta d_{t-1}^2 + \delta g_{t-1} + \varepsilon_t$) estimation for each country using GLS method over 1880-2010 (no observed instruments on this period) and GMM method for 1950-2010. Results, available upon request from the author, are not significant.

not improve by excluding Japan alone. The two periods of 1971-2008 and 1950-2008 on which the relationship becomes significant shows, a convexity of the relationship. Excluding Japan and the United States, the model improves over the period 1950-1970 and the threshold over this period is around 78.4%. Adding the United Kingdom to the excluded countries, the results of the model remain substantially the same. The threshold varies from 40% over 1971-1990 to nearly 78% for the period 1950-1970. For the euro area, the relationship was concave and significant over the sub-periods of; 1950-1970, 1971-1990, 1991-2008 and 1971-2008. Estimates for the period of 1950-2008 are rejected. The threshold ranges from a minimum of 45% over the period 1971-2008 to a maximum of 94% over the period 1991-2008.

Insert table 5 about here

We generate fixed effect for this model in Table A.4. This reports the deviation of each country $(\gamma_i - \bar{\gamma})$ from the homogenous constant term (the average constant for the whole panel). These results emphasize high spreads across countries which makes it possible to conclude that the heterogeneity greatly affects the growth-debt linkages. This may explain the big differences in results across periods and samples. The threshold estimates are not tiny to consider as a claim for a one unique threshold for all countries in all times. On the contrary, this strongly suggests that the growth debt relationship is rather country specific than a common one. Furthermore, even when considering no fixed effects results (Table 6), no substantial improvement is found.

Insert Table 6 about here

For more investigation, we vary the samples by grouping countries according to their level of government effectiveness and expenditure levels reflecting good public economic governance. We split the sample into two groups of high and moderate level based on government effectiveness and shares to GDP of respectively: total final government consumption, military expenditures and, government transfers and subsidies. The first variable is from Worldwide Governance Indicators of the World Bank, while other variables are from the World Development Indicators of World Bank database. Countries are filtered form high to low values on average over time and the frontier between high and moderate groups is determined according to the average of countries averages. Therefore, the average government consumption to GDP over 1960-2008 ranges from 10.1% for Switzerland to 23.6% recorded for Sweden. The average of the sample is 17.7% and this value is used to split the two groups. Similarly, the government effectiveness index average over 1996-2016 ranges from 0.53 for Italy to 2.09 for Finland, and its average over the 20 countries is 1.58 which separates the group of countries with moderate governance from the one with high governance. The same approach was followed for the other variables.

Table A.5 summarizes the estimated thresholds by periods and country samples for the two groups of countries for each of the four considered variables. The estimation is done by GMM method. The results are fuzzy, and many non-significant thresholds are reported especially over the period

1951-2008. However, the recent period seems to point out to more homogeneity in countries behavior and significant thresholds, though different by sample, are reported. These results emphasize the idea of studying the debt-growth relationship on country by country case.

The investigation (both preliminary data analysis and estimation) revealed high heterogeneity in data and behaviors across countries. Despite that we could sometimes prove the existence of a debt threshold by advanced econometric methods, the heterogeneity suggests that this one tend to be rather country specific than common rule for all countries. Furthermore, when dealing with panel cross-section data, it is usually assumed that cross section errors in panel data models are independent, especially for large cross-section size. However, the presence of such cross-section dependence in estimation can result in serious problems of efficiency loss and inappropriate statistical tests.

7. Conclusion

In this paper, we studied the existence of possible threshold effects in the relationship between public debt and economic growth. We used two econometric approaches. The first method, applied individually to each country of the sample of 20 advanced countries, is the kink regression method developed by Hansen (2017), which searches endogenously for an unknown threshold. The second method is a technique that previously was explored by some authors especially Checherita and Rother (2010), which we applied to the panel of the previous countries.

Both methods clearly counter the claim of a common debt threshold that fit all countries. It reveals that the threshold, whenever it exists, is a country specific rather than a common rule to fit all. Unlike all the empirical literature examining the existence and values of debt thresholds on a cross-section data, our analysis undertakes the question on both cross-section and country-specific over a long data span. Country-specific analysis highlighted, in fact, diverse types of relationship between growth and public debt. Accordingly, some countries can grow with high debt to GDP ratios; others could see their growth shrink from even low debt ratios, while growth in some others is insensitive to public debt. The study also reveals the instability of the relationship over time: almost every country exhibits a different relationship by period, especially when considering the whole period (1880–2008) and the post-war period (1950–2008).

The results drawn from our study point to further interesting developments since several economic and institutional variables such as interest rate and governance could be integrated into the analysis as they could have some notable effects on the debt-growth nexus beyond the simple model developed here.

Chapter 1. Tables and Figures

Table 1. Empirical studies survey of the public debt and economic growth threshold

	Authors	Samples	Econometric methodologies	Debt thresholds	Other notes on methods and results
1	Reinhart and Rogoff (2010)	20 developed countries and 24 developing countries: 1946–2009	Growth mean and the median analysis according to pre-established thresholds	90% for advanced countries	Arbitrarily set thresholds: 30%, 60% and 90% and conclude that growth is altered from 90%
2	Caner et al. (2010)	26 developed and 75 developing countries: 1980–2008	Hansen's (2000) OLS threshold econometric estimate	77% and 64%	77% for the whole sample, 64% for developing countries
3	Herndon et al. (2013)	The 20 developed countries of RR (2010)	Replication of RR's (2010) work after correction of data errors	No threshold found	The relationship is sensitive to country and period
4	Kumar and Woo (2010)	38 countries, most of which are OECD countries: 1970–2007	Econometric estimation by various methods such as GMM	High level but not reported	Correction of problems of reverse causality, endogeneity and heterogeneity
5	Checherita and Rother (2010)	12 euro area countries: 1970–2009	Estimation of a polynomial form of growth explained by the debt ratio	Interval [70% to 100%]	The degree of the polynomial form is around 1.2 to 3
6	Checherita et al. (2014)	11 euro, 22 OECD and 14 EU countries: 1960–2010	Cobb-Douglas optimization augmented by public spending	65%: OECD; 63%: the EU; 50%: euro	The debt threshold is a non-linear function of the elasticity of the public expenditure/private capital ratio
7	Pescatori et al. (2014)	34 mainly developed countries: 1875–2011	Analysis of growth (t + k) and debt (t); k = {1,5,10,15} using a descriptive approach	No threshold found	High government debt tends to increase economic growth volatility
8	Chang and Chiang (2009)	15 OECD countries: 1990–2004	Threshold method for non-dynamic panel	32.3% and 66.25%	The relationship is positive over the three regimes delimited by the two thresholds
9	Cecchetti et al. (2011)	18 OECD countries: 1980–2010	Threshold method for non-dynamic panel	85%	Debt negatively influences growth above 85% threshold
10	Minea and Parent (2012)	20 developed countries of RR (2010) and Abbas et al. (2010) data	Estimation of econometric relationship with changing thresholds	60%, 90% and 115%	Between 90% and 115%, negative effect, between 60% and 90% and above 115% positive
11	Egert (2015)	The RR (2010) data and countries sample	Estimation and detection of endogenous thresholds (Hansen, 1999)	20%: central debt; 50%: general debt	Individual estimate confirms threshold for some countries around 30% (United States)
12	Baglan and Yoldas (2013)	20 developed countries of RR (2010): 1954–2008	Inference techniques to remedy endogeneity and heterogeneity issues	Between 18% and 53%	No robust threshold and subject to uncertainty
13	Baum et al. (2013)	12 euro countries: 1990–2010	Threshold method for dynamic and non-dynamic panel	67%	Study of short-term impact
14	Kourtellos et al. (2012)	Sample of 82 countries: 1980–2009	Threshold regressions using the Solow growth model	No threshold found	Heterogeneity and influence of institutional quality

Table 1 (continued)

	Authors	Samples	Econometric Methodologies	Debt thresholds	Other notes on methods and results
15	Eberhardt and Presbitero (2015)	Sample of 105 countries: 1970–2008	Techniques addressing heterogeneity and dependence in cross-sections	No common threshold	Estimation of dynamic and static non-linear models by GMM method
16	Panizza and Presbitero (2012)	17 OECD countries: 1981–2008	Estimation by GMM of linear and non-linear relationships	No threshold found	No negative effect of the debt on growth
17	Sharpe (2013)	12 euro countries: 1998–2011	Estimated relationship of debt and interest rate by GMM and TSLS	40% and 133%	Negative effect for debt ratios over 40%, emphasized above the 133% threshold
18	Pan and Wang (2013)	12 euro countries: 1970–2009	Bayesian analysis using dynamic factor models	Negative relationship	Common factors and shocks affect positive growth and negative debt
19	Gomez-Puig and Sosvilla-Rivero (2015)	11 euro countries: 1980–2013	Granger (1969) causality method	56% to 103%	Causality dependent on the country, the threshold found only for four countries
20	Di Sanzo and Bella (2015)	12 countries of the euro: 1970–2012	Studies of individual causality by non-parametric tests	Threshold not examined	Causality results vary across countries
21	Greiner (2011)	Long-term simulation for Italy, Germany and the eurozone	Simulated endogenous growth model	Threshold not examined	The impact of debt on growth is positive if the pace of debt remains lower than the pace of GDP
22	Marchionne and Parekh (2015)	Sample of 27 countries: 1994–2010	Estimation considering the GINI index	Non-linearity; no threshold reported	The results suggest non-linear link that depends on the income distribution
23	Lin (2014)	62 developing and developed countries: 1991–2005	Threshold quantile Lasso regression	Thresholds ranging from 10% to 100%	Thresholds vary by country and quintile and more common in developing than in developed countries
24	Lee et al. (2017)	RR (2010) database for 20 developed countries	Test for threshold effects by regressing growth median on public debt	Around 30%	The median real GDP growth falls abruptly above a debt-to-GDP ratio of 30%
25	Gomez-Puig and Sosvilla-Rivero (2017)	11 euro area countries: 1961–2015	Time-series regressions based on economic growth literature	Variable threshold from 21% to 61%	Threshold varies across countries from 21% in France to 61% in Belgium
26	Chudik (2017)	40 advanced and developing countries: 1965–2010	Test for thresholds in dynamic heterogeneous panel with cross-sectionally dependent errors	No evidence of any threshold	Significant negative long-term effects of public debt build-up on output growth
27	Syssoyeva-Masson and De Sousa Andrade (2017)	60 developed and developing countries, IMF data: 1970–2012	Panel regression using time-series cointegration and Hansen (1999)	Two regimes: 44% and 48%	Highlight the debt long-memory process and recommend long-term analysis

Table 2. Regression kink results over long periods

Specification	$g_t = \beta_1(d_{t-1} - \gamma)_- + \beta_2(d_{t-1} - \gamma)_+ + \delta g_{t-1} + c + e_t$					
Country	β_1	β_2	δ	c	γ	Period
Australia	0.002 (0.321)	1.719 (0.234)	0.49 (0.503)	1.11 (2.996)	134 (167.9)	1901-2010
Austria	0.070 (0.072)	-0.04 (0.039)	0.584 (0.085)	2.389 (1.335)	35.6 (6.4)	1881-2010
Belgium	0.000 (0.000)	0.088 (0.394)	0.214 (0.135)	1.487 (0.333)	173.4 (231.3)	1881-2010
Canada	1.016 (1.133)	0.002 (0.016)	0.314 (0.127)	1.471 (0.978)	22.7 (4.1)	1881-2010
Denmark	-0.067 (0.058)	0.048 (0.04)	0.016 (0.174)	0.679 (0.793)	33.4 (6.8)	1881-2010
France	-0.029 (0.01)	0.167 (0.064)	-0.203 (0.147)	-0.306 (1.22)	161 (20.4)	1881-2010
Germany	0.318 (0.127)	-0.051 (0.033)	0.459 (0.148)	2.587 (0.904)	20.1 (2.3)	1881-2010
Greece	-0.008 (0.016)	-2.063 (0.194)	0.027 (0.07)	1.172 (2.576)	215 (1.5)	1884-2010
Ireland	0.177 (0.191)	0.04 (0.016)	0.435 (0.15)	1.07 (0.829)	35.1 (7.9)	1929-2010
Italy	-0.058 (0.035)	0.053 (0.053)	0.371 (0.146)	0.001 (1.051)	66 (18.8)	1881-2010
Japan	-0.434 (0.159)	-0.006 (0.008)	-0.11 (0.104)	2.564 (0.671)	22.8 (4.9)	1881-2010
Netherlands	0.04 (1.806)	-0.009 (1.182)	0.233 (3.205)	3.235 (26.27)	110.9 (2439)	1881-2010
New Zealand	-0.005 (0.01)	0.074 (0.112)	-0.048 (0.107)	0.814 (0.973)	163.3 (78.2)	1881-2010
Norway	2.647 (0.87)	0.032 (0.028)	-0.123 (0.14)	2.501 (0.705)	14.6 (1.4)	1881-2010
Portugal	125.31 (17.9)	-0.069 (0.022)	-0.106 (0.137)	4.482 (0.954)	13.6 (0.0)	1881-2010
Spain	-0.059 (0.018)	0.017 (0.028)	0.014 (0.098)	0.399 (0.796)	74.6 (16.2)	1881-2010
Sweden	6.189 (0.01)	-0.001 (0.048)	0.109 (0.102)	2.092 (1.21)	13.4 (16.3)	1881-2010
Switzerland	-0.023 (0.016)	3.977 (0.595)	0.047 (0.119)	0.272 (0.63)	74.3 (0.6)	1899-2010
United Kingdom	-30.542 (0.02)	0.00 (0.235)	0.362 (0.067)	0.932 (1.571)	27.5 (55.0)	1881-2010
United States	34.306 (8.17)	-0.013 (0.02)	0.292 (0.107)	3.082 (0.936)	7.6 (0.1)	1881-2010

Note: Standard errors are given in parentheses.

Table 3. Regression kink results over the period 1956-2010

Specification	$g_t = \beta_1(d_{t-1} - \gamma)_- + \beta_2(d_{t-1} - \gamma)_+ + \delta g_{t-1} + c + e_t$				
Country	β_1	B_2	δ	c	γ
Australia	0.034 (0.033)	0.614 (0.155)	0.119 (0.167)	2.259 (0.697)	37.4 (1.1)
Austria	-0.086 (0.038)	0.039 (0.025)	-0.017 (0.141)	1.555 (0.517)	44.0 (7.7)
Belgium	51.31 (4.898)	-0.016 (0.024)	0.157 (0.107)	2.923 (0.694)	38.9 (3.8)
Canada	0.149 (0.238)	-0.006 (0.019)	0.328 (0.138)	1.587 (0.634)	52.7 (10.9)
Denmark	-36.619 (0.028)	-0.007 (0.095)	0.033 (0.024)	2.390 (1.191)	4.4 (15.4)
France	0.521 (0.478)	-0.024 (0.014)	0.476 (0.16)	1.705 (0.667)	16.1 (1.3)
Germany	-0.132 (0.061)	0.005 (0.033)	0.038 (0.183)	1.326 (0.817)	34.8 (7.7)
Greece	-0.058 (0.035)	0.053 (0.053)	0.371 (0.146)	0.001 (1.051)	66 (18.8)
Ireland	3.28 (1.227)	0.037 (0.015)	0.346 (0.128)	1.456 (0.667)	27.3 (1.0)
Italy	-0.053 (0.014)	0.091 (0.045)	0.100 (0.197)	0.502 (0.438)	105.4 (4.7)
Japan	-0.339 (2.241)	-0.011 (0.016)	0.299 (0.2)	2.171 (2.383)	18.1 (75.7)
Netherlands	0.083 (0.039)	-0.064 (0.113)	0.162 (0.179)	2.821 (0.962)	61.7 (10.2)
New Zealand	1.81 (0.055)	-0.014 (0.023)	-0.074 (0.169)	2.058 (0.771)	19.4 (0.4)
Norway	-0.037 (0.023)	0.793 (0.007)	0.337 (0.139)	0.926 (0.677)	57.9 (0.7)
Portugal	10.74 (2.203)	-0.066 (0.021)	0.377 (0.132)	3.998 (0.95)	14.5 (0.2)
Spain	-0.064 (0.078)	0.038 (0.026)	0.549 (0.126)	0.543 (0.841)	34.5 (18.7)
Sweden	-0.119 (0.044)	0.056 (0.025)	0.394 (0.156)	-0.198 (0.579)	40.2 (5.6)
Switzerland	-0.083 (0.036)	0.05 (0.037)	0.177 (0.144)	0.288 (0.492)	39.9 (8.8)
United Kingdom	0.124 (0.072)	-0.021 (0.019)	0.154 (0.18)	3.037 (0.873)	59 (8.5)
United States	1.892 (0.617)	-0.072 (0.028)	0.028 (0.156)	4.650 (0.800)	34.4 (0.7)

Note: Standard errors are given in parentheses.

Table 4. GLS and GMM panel estimation results

Regression by Generalized Least Squares method (GLS). Specification: $g_{i,t+5} = \alpha d_{i,t} + \beta d_{i,t}^2 + \gamma_i + \varepsilon_{i,t}$										
Model with fixed effects										
	1950-1970		1971-1990		1991-2008		1971-2008		1950-2008	
	Coef.	*prob.*	Coef.	*prob.*	Coef.	*prob.*	Coef.	*prob.*	Coef.	*prob.*
α	0.010	*0.647*	-0.017	*0.309*	0.049**	*0.030*	-0.003	*0.770*	-0.045***	*0.000*
β	0.000	*0.689*	0.000	*0.789*	0.000	*0.196*	0.000	*0.801*	0.000***	*0.000*
γ	3.296***	*0.000*	2.685***	*0.000*	-0.470	*0.620*	2.229***	*0.000*	4.206***	*0.000*
Threshold	NS		NS		NS		NS		123.3[a]	
Model without fixed effects										
	1950-1970		1971-1990		1991-2008		1971-2008		1950-2008	
	Coef.	*prob.*	Coef.	*prob.*	Coef.	*prob.*	Coef.	*prob.*	Coef.	*prob.*
α	-0.038***	*0.000*	-0.014	*0.307*	0.015	*0.234*	-0.005	*0.576*	-0.038***	*0.000*
β	0.000***	*0.007*	0.000	*0.546*	0.000	*0.251*	0.000	*0.841*	0.000***	*0.000*
γ	4.619***	*0.000*	2.411***	*0.000*	1.448***	*0.002*	2.165***	*0.000*	3.802***	*0.000*
Threshold	139.0[a]		NS		NS		NS		107.0[a]	
Regression by Generalized Method of Moments (GMM). Specification: $g_{i,t+5} = \alpha d_{i,t} + \beta d_{i,t}^2 + \varphi Inst + \gamma_i + \varepsilon_{i,t}$										
Model with fixed effects										
	1950-1970		1971-1990		1991-2008		1971-2008		1950-2008	
	Coef.	*prob.*	Coef.	*prob.*	Coef.	*prob.*	Coef.	*prob.*	Coef.	*prob.*
α	0.159	*0.671*	0.190**	*0.014*	-0.204	*0.592*	0.093**	*0.013*	0.060	*0.469*
β	-0.001	*0.733*	-0.002***	*0.006*	0.002	*0.389*	-0.001***	*0.004*	-0.001	*0.169*
γ	-0.444	*0.957*	-0.707	*0.625*	5.571	*0.690*	-0.014	*0.989*	3.290**	*0.019*
J-statistic[b]	2.755	*0.097*	3.923	*0.141*	10.774	*0.001*	0.334	*0.563*	3.692	*0.055*
Threshold	NS		47.5		NS		46.5		NS	
Model without fixed effects										
	1950-1970		1971-1990		1991-2008		1971-2008		1950-2008	
	Coef.	*prob.*	Coef.	*prob.*	Coef.	*prob.*	Coef.	*prob.*	Coef.	*prob.*
α	0.038	*0.808*	0.234*	*0.069*	0.161**	*0.043*	0.106**	*0.016*	0.566	*0.186*
β	-0.001	*0.529*	-0.002*	*0.081*	-0.001**	*0.034*	-0.001***	*0.005*	-0.006	*0.157*
γ	4.176*	*0.099*	-2.845	*0.277*	-3.684	*0.202*	-0.682	*0.616*	-6.376	*0.397*
J-statistic[b]	4.526	*0.339*	2.949	*0.399*	0.786	*0.675*	1.143	*0.565*	0.666	*0.717*
Threshold	NS		49.4		80.1		62.8		NS	

Notes: Significant at 1% (***), 5% (**) and 10% (*). NS is Non-Significant.

a: Coefficients are statistically significant, but the function is convex which means that the debt affects negatively growth for debt ratios below this threshold and positively above this threshold.

b: J-statistic is the value of the GMM objective function.

The threshold is calculated according to the formulae: $\hat{d} = -\frac{\alpha}{2\beta}$.

Table 5. GMM results for varying countries sample (fixed effects model)

Sample of 20 OECD countries										
	1950-1970		1971-1990		1991-2008		1971-2008		1950-2008	
	Coef.	*prob.*	Coef.	*prob.*	Coef.	*prob.*	Coef.	*prob.*	Coef.	*prob.*
α	0.159	*0.671*	0.190**	*0.014*	-0.204	*0.592*	0.093**	*0.013*	0.060	*0.469*
β	-0.001	*0.733*	-0.002***	*0.006*	0.002	*0.389*	-0.001***	*0.004*	-0.001	*0.169*
γ	-0.444	*0.957*	-0.707	*0.625*	5.571	*0.690*	-0.014	*0.989*	3.290**	*0.019*
J-statistic[b]	2.755	*0.097*	3.923	*0.141*	10.774	*0.001*	0.334	*0.563*	3.692	*0.055*
Threshold	NS		47.5		NS		46.5		NS	
Sample of 19 OECD countries (Japan excluded)										
	1950-1970		1971-1990		1991-2008		1971-2008		1950-2008	
	Coef.	*prob.*	Coef.	*prob.*	Coef.	*prob.*	Coef.	*prob.*	Coef.	*prob.*
α	0.137	*0.457*	0.184**	*0.015*	-0.981***	*0.007*	0.098**	*0.019*	-0.172***	*0.000*
β	-0.001	*0.579*	-0.002***	*0.008*	0.009***	*0.005*	-0.001***	*0.008*	0.001**	*0.013*
γ	-0.364	*0.932*	-0.764	*0.597*	23.638***	*0.007*	0.113	*0.912*	7.298***	*0.000*
J-statistic[b]	2.646	*0.104*	3.097	*0.213*	6.874	*0.009*	0.149	*0.700*	4.641	*0.098*
Threshold	NS		40.8		56.6[a]		51.5		75.5[a]	
Sample of 18 OECD countries (Japan and USA excluded)										
	1950-1970		1971-1990		1991-2008		1971-2008		1950-2008	
	Coef.	*prob.*	Coef.	*prob.*	Coef.	*prob.*	Coef.	*prob.*	Coef.	*prob.*
α	0.344**	*0.017*	0.186**	*0.015*	-0.731**	*0.018*	0.091**	*0.024*	-0.162***	*0.000*
β	-0.002**	*0.041*	-0.002***	*0.008*	0.007**	*0.012*	-0.001***	*0.010*	0.001**	*0.011*
γ	-4.910	*0.138*	-0.731	*0.609*	16.307**	*0.028*	0.296	*0.766*	7.139***	*0.000*
J-statistic[b]	5.375	*0.146*	2.402	*0.301*	11.895	*0.003*	0.372	*0.542*	3.692	*0.055*
Threshold	78.4		40.8		54.0[a]		51.0		79.3[a]	
Sample of 17 OECD countries (Japan, USA and UK excluded)										
	1950-1970		1971-1990		1991-2008		1971-2008		1950-2008	
	Coef.	*prob.*	Coef.	*prob.*	Coef.	*prob.*	Coef.	*prob.*	Coef.	*prob.*
α	0.296**	*0.033*	0.162**	*0.028*	-0.500*	*0.052*	0.070**	*0.047*	-0.172**	*0.011*
β	-0.002*	*0.074*	-0.002**	*0.013*	0.005**	*0.030*	-0.001**	*0.017*	0.001*	*0.075*
γ	-3.428	*0.269*	-0.256	*0.851*	10.658*	*0.088*	0.832	*0.333*	7.496***	*0.000*
J-statistic[b]	3.912	*0.418*	1.916	*0.384*	17.670	*0.000*	0.389	*0.823*	7.681	*0.021*
Threshold	76.5		40.1		51.9[a]		48.6		80.3[a]	
Sample of 10 Euro countries										
	1950-1970		1971-1990		1991-2008		1971-2008		1950-2008	
	Coef.	*prob.*	Coef.	*prob.*	Coef.	*prob.*	Coef.	*prob.*	Coef.	*prob.*
α	1.929*	*0.096*	0.100*	*0.057*	1.063**	*0.013*	0.064*	*0.071*	-0.123**	*0.019*
β	-0.014*	*0.095*	-0.001**	*0.027*	-0.006*	*0.092*	-0.001**	*0.021*	0.001	*0.126*
γ	-37.593	*0.136*	0.655	*0.557*	-41.709***	*0.006*	1.443*	*0.085*	6.689***	*0.000*
J-statistic[b]	2.191	*0.534*	3.652	*0.161*	4.996	*0.172*	0.765	*0.382*	4.387	*0.112*
Threshold	69.6		46.1		94.0		45.0		NS	

Notes: Significant at 1% (***), 5% (**) and 10% (*). NS is Non-Significant.

a: Coefficients are statistically significant, but the function is convex which means that the debt affects negatively growth for debt ratios below this threshold and positively above this threshold.

b: J-statistic is the value of the GMM objective function.

The threshold is calculated according to the formulae: $\hat{d} = -\frac{\alpha}{2\beta}$.

Table 6. GMM estimation results for reduced samples for model without fixed effects

Sample of 20 OECD countries										
	1950-1970		1971-1990		1991-2008		1971-2008		1950-2008	
	coef.	*prob.*	coef.	*prob.*	coef.	*prob.*	coef.	*prob.*	coef.	*prob.*
α	0.038	*0.808*	0.234*	*0.069*	0.161**	*0.043*	0.106**	*0.016*	0.566	*0.186*
β	-0.001	*0.529*	-0.002*	*0.081*	-0.001**	*0.034*	-0.001***	*0.005*	-0.006	*0.157*
γ	4.176*	*0.099*	-2.845	*0.277*	-3.684	*0.202*	-0.682	*0.616*	-6.376	*0.397*
J-statistic[b]	4.526	*0.339*	2.949	*0.399*	0.786	*0.675*	1.143	*0.565*	0.666	*0.717*
Threshold	NS		49.4		80.1		62.8		NS	
Sample of 19 OECD countries (Japan excluded)										
	1950-1970		1971-1990		1991-2008		1971-2008		1950-2008	
	coef.	*prob.*	coef.	*prob.*	coef.	*prob.*	coef.	*prob.*	coef.	*prob.*
α	0.054	*0.753*	0.291**	*0.037*	0.172*	*0.092*	0.136***	*0.003*	0.711	*0.357*
β	-0.001	*0.526*	-0.003**	*0.042*	-0.001*	*0.088*	-0.001***	*0.001*	-0.008	*0.322*
γ	3.657	*0.210*	-3.871	*0.166*	-3.976	*0.280*	-1.394	*0.304*	-9.868	*0.508*
J-statistic[b]	6.446	*0.168*	0.764	*0.858*	4.645	*0.326*	0.571	*0.752*	3.765	*0.152*
Threshold	NS		47.5		86.0		60.7		NS	
Sample of 18 OECD countries (Japan and United States excluded)										
	1950-1970		1971-1990		1991-2008		1971-2008		1950-2008	
	coef.	*prob.*	coef.	*prob.*	coef.	*prob.*	coef.	*prob.*	coef.	*prob.*
α	0.033	*0.799*	0.254**	*0.036*	0.162*	*0.074*	0.109***	*0.002*	0.270	*0.416*
β	-0.001	*0.502*	-0.003**	*0.039*	-0.001*	*0.063*	-0.001***	*0.001*	-0.004	*0.339*
γ	4.113**	*0.049*	-2.873	*0.220*	-3.160	*0.310*	-0.524	*0.592*	-0.656	*0.904*
J-statistic[b]	5.507	*0.239*	0.744	*0.863*	4.562	*0.335*	0.242	*0.886*	5.574	*0.062*
Threshold	NS		46.0		72.8		57.4		NS	
Sample of 17 OECD countries (Japan, United States and United Kingdom excluded)										
	1950-1970		1971-1990		1991-2008		1971-2008		1950-2008	
	coef.	*prob.*	coef.	*prob.*	coef.	*prob.*	coef.	*prob.*	coef.	*prob.*
α	0.247*	*0.096*	0.223*	*0.066*	0.415**	*0.021*	0.109***	*0.003*	0.249*	*0.069*
β	-0.003*	*0.055*	-0.002*	*0.063*	-0.003*	*0.051*	-0.001***	*0.001*	-0.003**	*0.045*
γ	0.104	*0.966*	-2.088	*0.364*	-12.292**	*0.021*	-0.601	*0.569*	-1.585	*0.541*
J-statistic[b]	2.873	*0.412*	0.386	*0.943*	0.319	*0.853*	0.594	*0.743*	7.465	*0.058*
Threshold	36.55		45.31		76.62		59.12		45.09	
Sample of 10 Euro zone countries										
	1950-1970		1971-1990		1991-2008		1971-2008		1950-2008	
	coef.	*prob.*	coef.	*prob.*	coef.	*prob.*	coef.	*prob.*	coef.	*prob.*
α	0.285*	*0.101*	0.226*	*0.061*	0.449**	*0.035*	0.074*	*0.065*	0.173	*0.214*
β	-0.004*	*0.091*	-0.002*	*0.053*	-0.002**	*0.041*	-0.001**	*0.041*	-0.003*	*0.098*
γ	0.148	*0.957*	-2.624	*0.339*	-16.135*	*0.057*	0.591	*0.544*	1.741	*0.423*
J-statistic[b]	4.306	*0.23*	0.971	*0.615*	0.843	*0.656*	2.066	*0.559*	12.577	*0.002*
Threshold	36.6		55.4		91.7		52.6		NS	

Notes: significant at 1% (***), 5% (**) and 10% (*). NS is Non-Significant.

b: J-statistic is the value of the GMM objective function.

The threshold is calculated according to the formulae: $\hat{d} = -\frac{\alpha}{2\beta}$.

Figure 1. Regression kink results for United States, Japan, United Kingdom and Australia

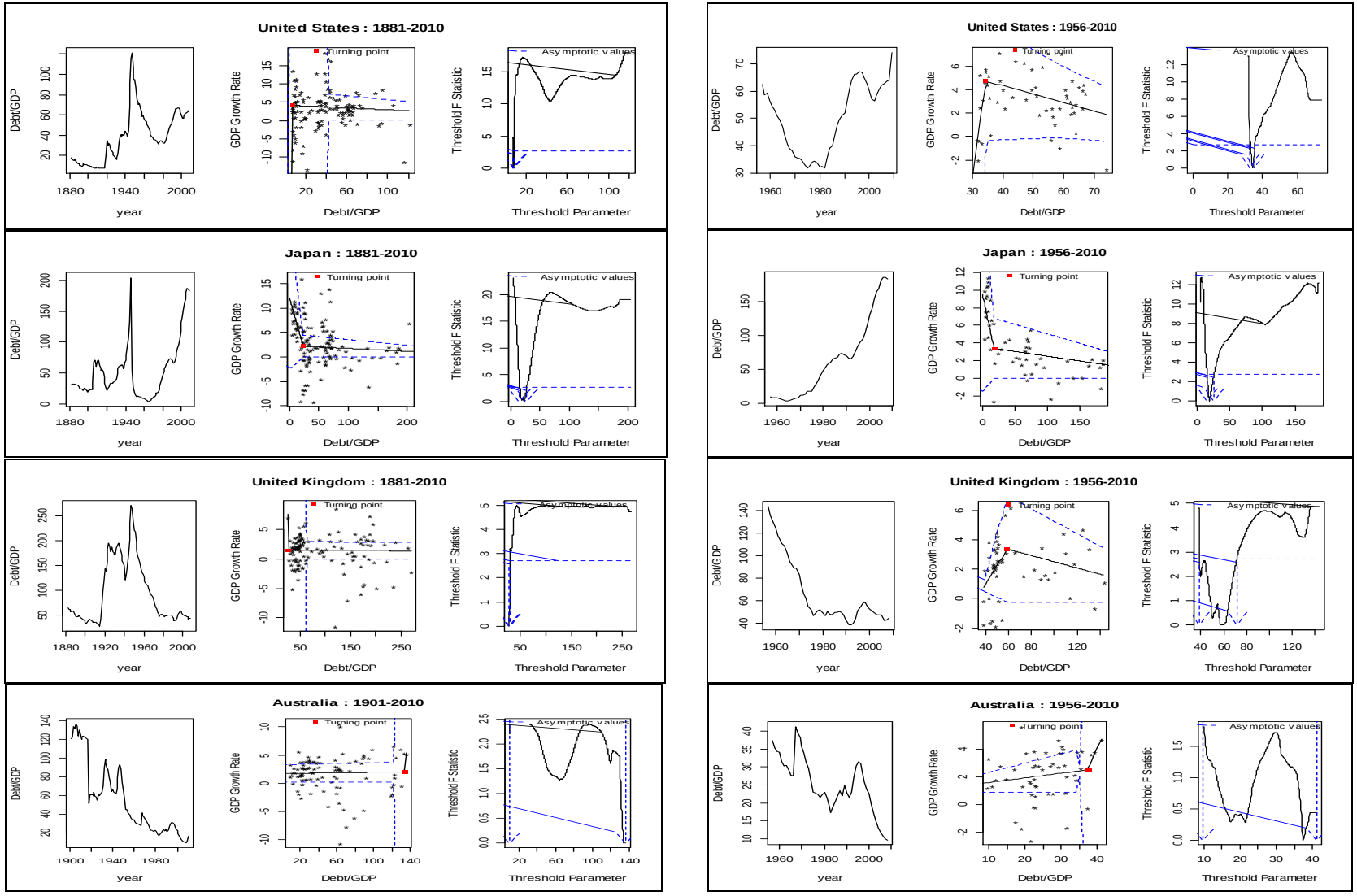


Figure 2. Regression kink results for Austria, Belgium, Canada and Denmark

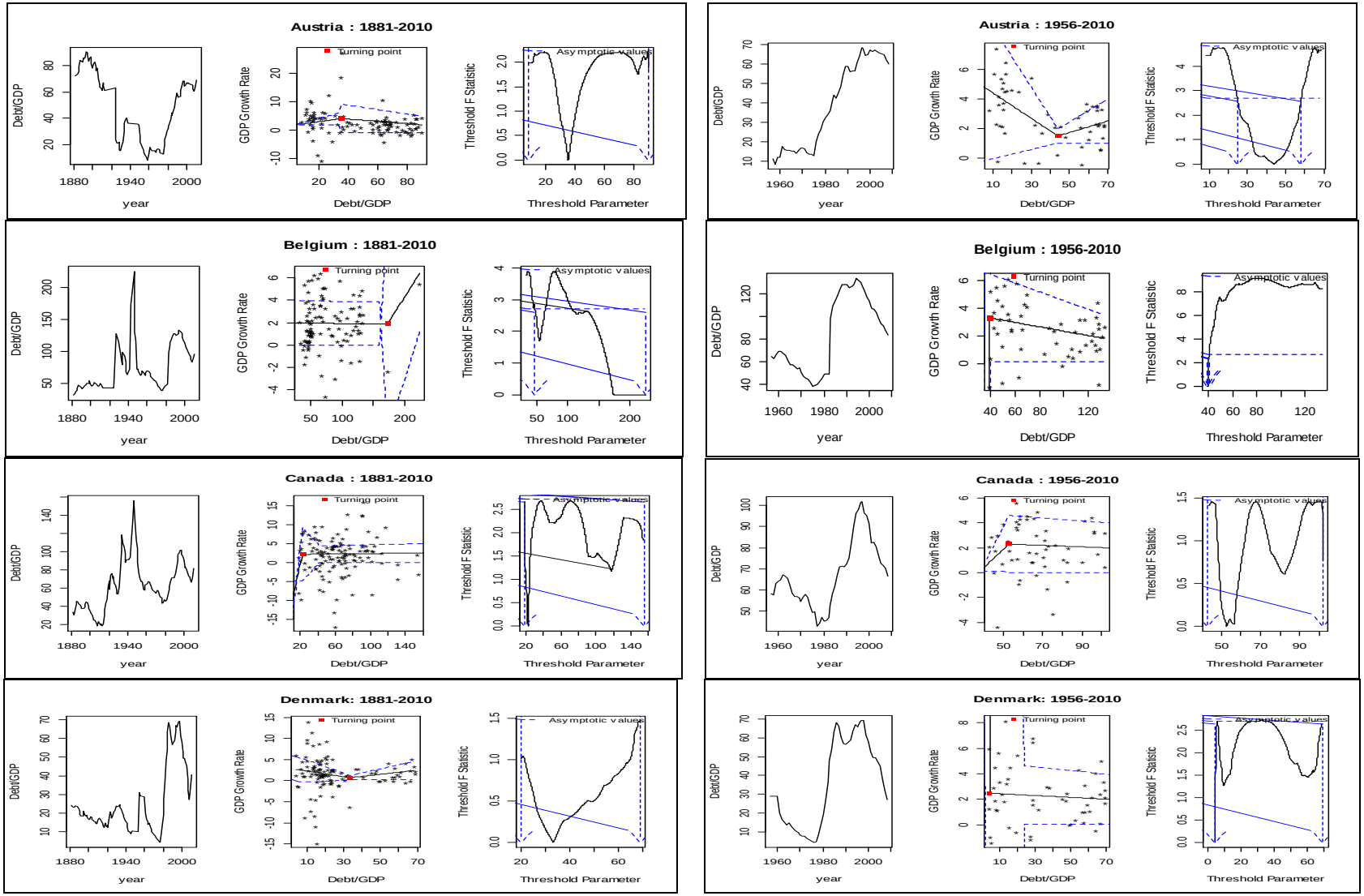


Figure 3. Regression kink results for France, Germany, Italy and Ireland

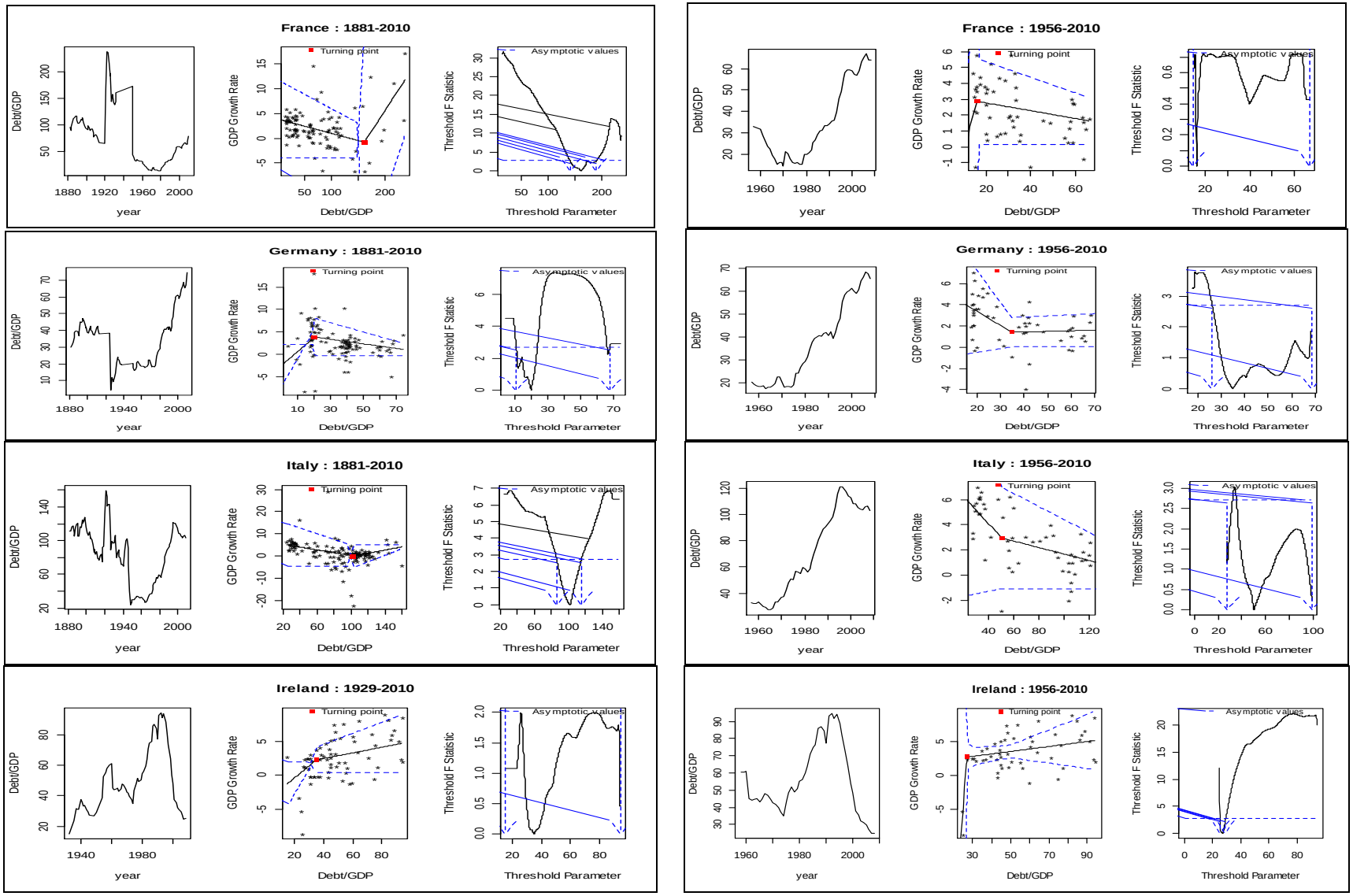


Figure 4. Regression kink results for Portugal, Spain, Sweden and Switzerland

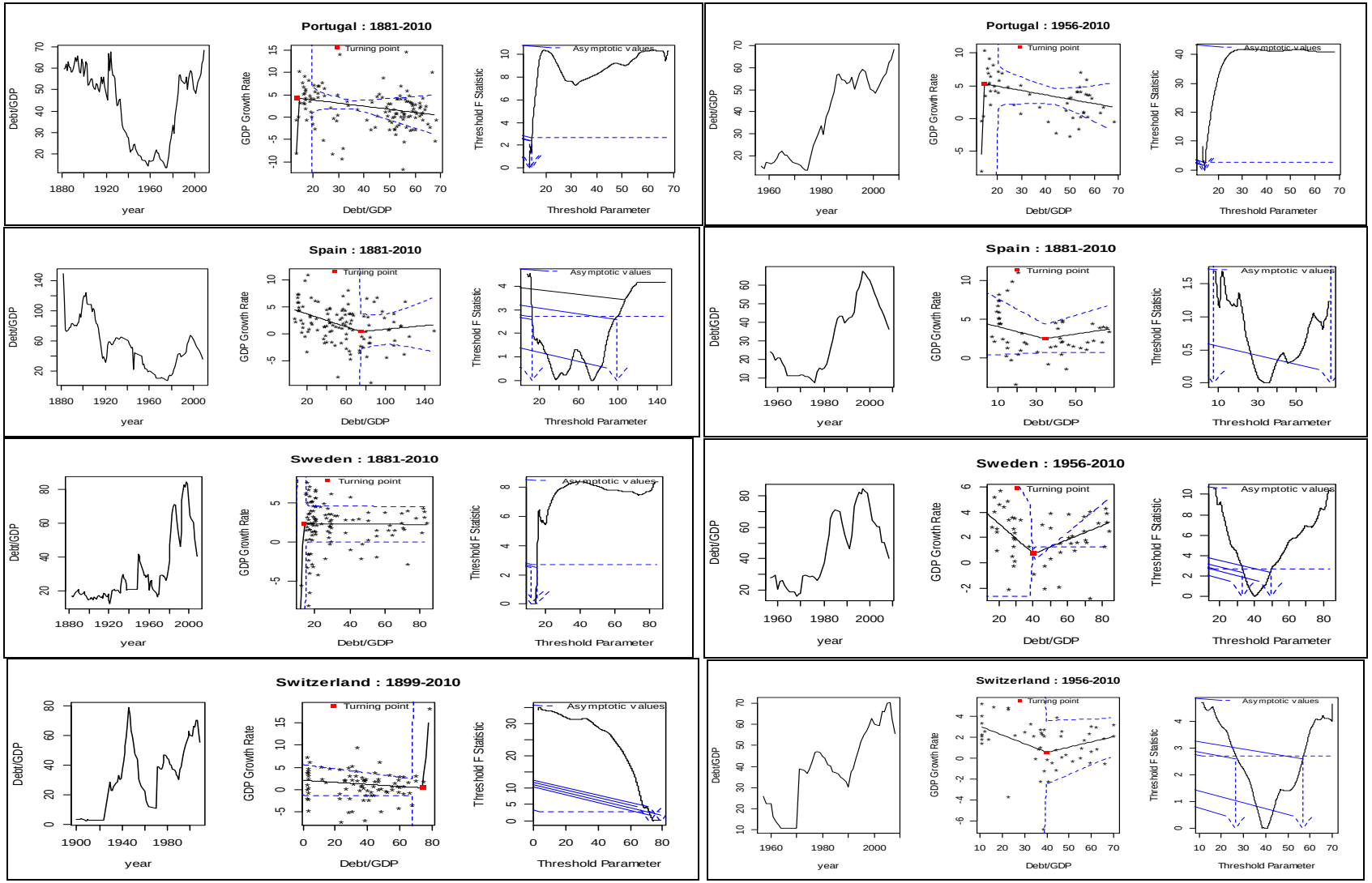


Figure 5. Regression kink results for New Zealand, Greece, Netherlands and Norway

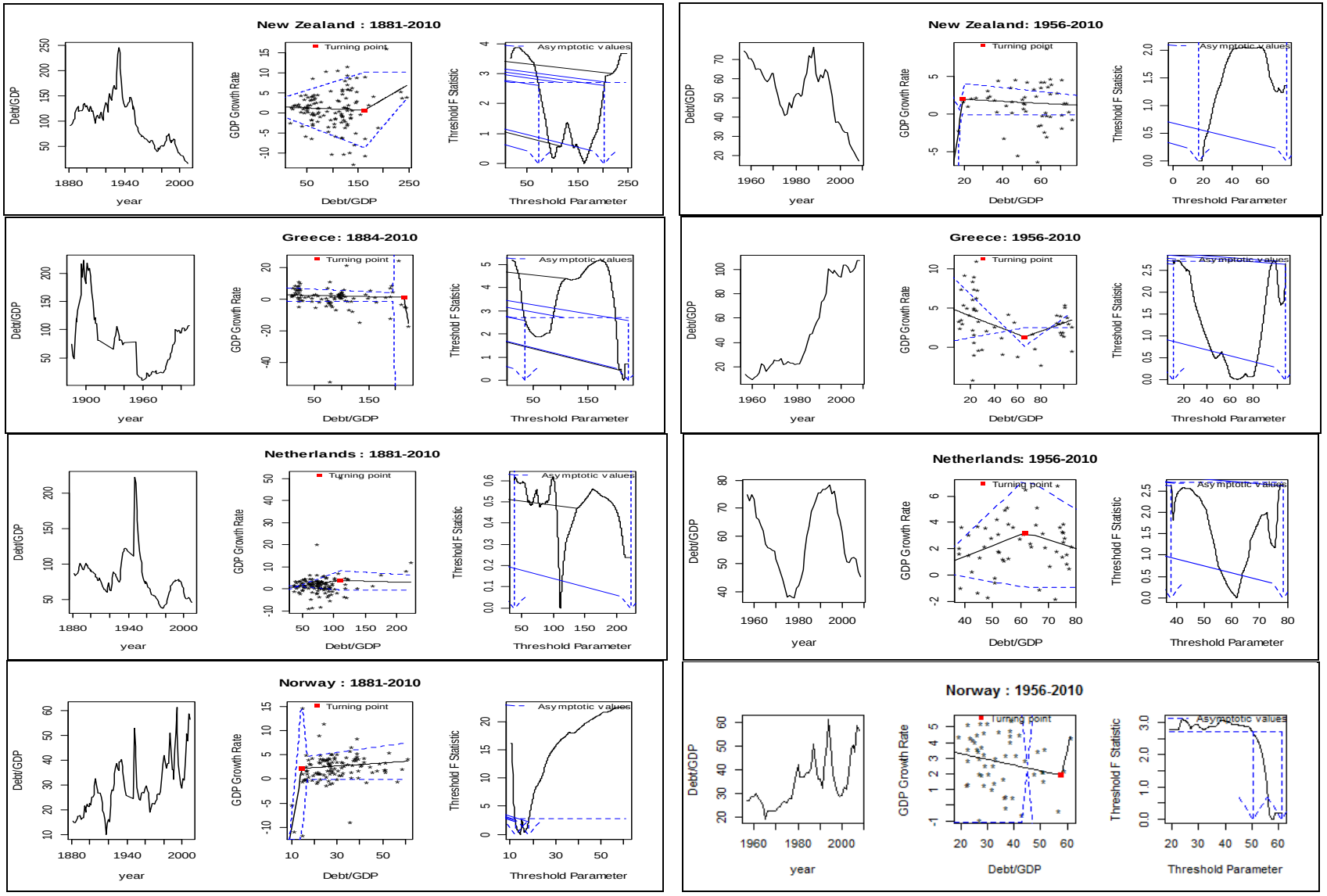


Figure 6. 5-year lead economic growth and public debt over different periods (panel of 20 advanced countries)

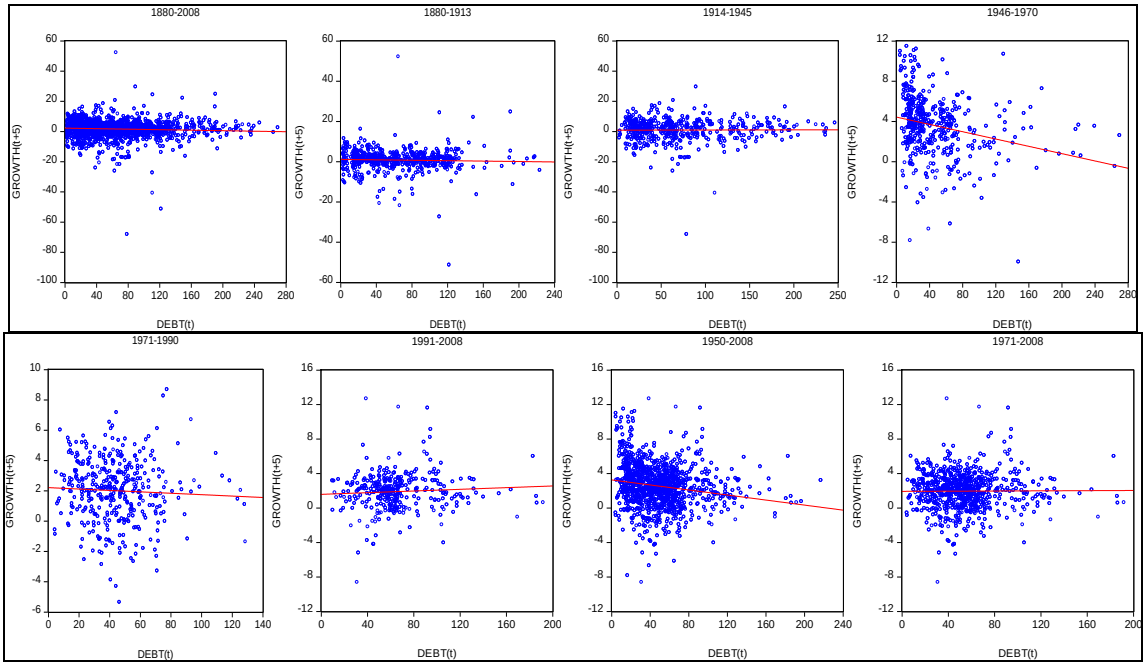
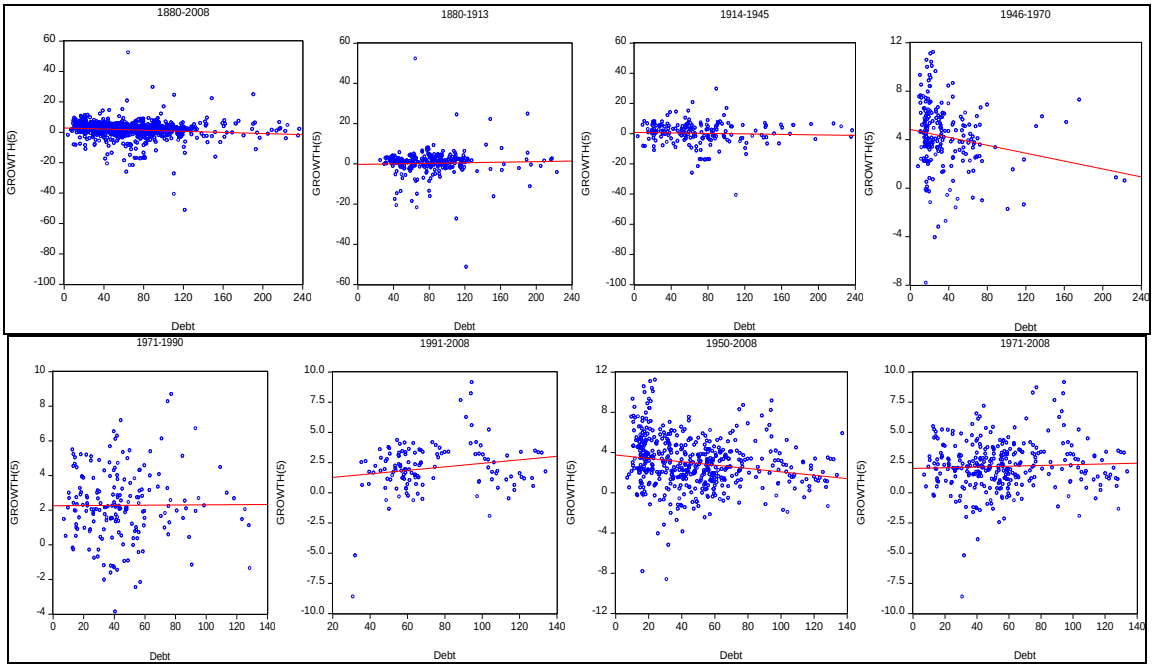


Figure 7. 5-year lead economic growth and public debt over different periods (panel of 10-euro countries)



Appendix A. Tables

Table A.1. Public debt and economic growth correlations by countries and periods

	Correlation of debt(t) and growth(t)					Correlation of debt(t) and growth(t+5)				
Countries	1950-2008	1950-1970	1971-1990	1991-2008	1971-2008	1950-2008	1950-1970	1971-1990	1991-2008	1971-2008
Australia	0.08	-0.25	0.26	0.14	0.13	-0.07	-0.11	-0.07	-0.44	-0.22
Austria	**-0.54*** **	0.20	-0.28	0.15	-0.3	**-0.51*** **	0.12	-0.52	0.39	**-0.38** **
Belgium	**-0.40** **	-0.30	-0.21	-0.19	**-0.28***	**-0.47*** **	-0.12	**-0.72** **	-0.17	**-0.44** **
Canada	-0.1	-0.02	-0.07	0.14	-0.10	**-0.37** **	-0.27	-0.34	-0.61	**-0.44** **
Denmark	-0.13	-0.26	0.08	0.25	0.08	**-0.28** **	-0.18	-0.06	0.27	-0.06
France	**-0.44*** **	-0.25	-0.12	0.21	**-0.28***	**-0.54*** **	-0.17	-0.49	0.31	-0.25
Germany	**-0.51*** **	-0.26	-0.29	-0.13	-0.19	**-0.57*** **	0.00	-0.21	-0.10	-0.30
Greece	**-0.30** **	0.30	-0.14	0.15	0.04	**-0.43** **	0.01	-0.11	**0.72** **	0.17
Ireland	**0.27** **	-0.22	0.13	**0.41***	**0.32** **	-0.22	0.16	-0.51	-0.31	**-0.36***
Italy	**-0.70*** **	0.09	0.00	0.25	**-0.38** **	**-0.66*** **	-0.22	-0.17	-0.16	-0.28
Japan	**-0.68*** **	-0.11	0.06	-0.03	**-0.44** **	**-0.75*** **	-0.05	-0.23	-0.24	**-0.55** **
Netherlands	0.06	-0.23	0.16	0.00	0.12	-0.21	-0.1	-0.41	-0.23	-0.21
New Zealand	0.11	0.22	-0.05	0.06	-0.08	-0.02	0.07	0.02	-0.40	-0.25
Norway	**-0.25***	-0.18	-0.22	-0.19	-0.30	**-0.47*** **	-0.22	**-0.69** **	**-0.74** **	**-0.74*** **
Portugal	**-0.35** **	0.21	-0.04	-0.28	-0.23	**-0.32** **	0.18	-0.26	-0.24	-0.21
Spain	**-0.29** **	-0.36	-0.14	**0.54** **	-0.16	**-0.50*** **	-0.3	**-0.85** **	-0.26	**-0.36***
Sweden	**-0.23***	0.04	0.16	0.01	0.11	**-0.52*** **	-0.23	-0.28	**-0.67***	**-0.43** **
Switzerland	**-0.28** **	**0.37***	-0.23	**0.58** **	0.04	-0.19	0.21	-0.03	**0.73** **	-0.02
United Kingdom	-0.04	-0.20	0.24	**0.55** **	0.36**	-0.14	-0.3	-0.09	-0.58	-0.42
United States	0.01	0.11	0.06	-0.17	-0.09	-0.1	0.03	-0.18	-0.35	-0.21
Total Sample	**-0.25***	-0.34	-0.02	-0.04	-0.07	**-0.29** **	-0.24	-0.14	-0.23	-0.11
Significant Correlations	*13/20*	*1/20*	*0/20*	*4/20*	*6/20*	*13/20*	*0/20*	*3/20*	*4/20*	*8/20*
Negatives correlations	*15/20*	*12/20*	*11/20*	*6/20*	*12/20*	*20/20*	*12/20*	*19/20*	*16/20*	*19/20*

Note: Significant at 1% (***), 5% (**) and 10% (*).

Table A.2. Data heterogeneity tests across sections and periods

Test for Equality of **means, medians and variances** of GROWTH Categorized by values of DEBT

Equality of **means**	Sample: 1881 2008			Sample: 1950 2008			Sample: 1971 2008			Sample: 1991 2008		
Method	df	Value	Prob.	df	Value	Prob.	df	Value	Prob.	df	Value	Prob.
Anova F-test	(2, 2248)	12.655	0.000	(4, 1119)	10.675	0.000	(3,	2.498	0.059	(3, 353)	2.365	0.071
Analysis of Variance												
Source of Variation	df	Sum of Sq.	Mean Sq.	df	Sum of Sq.	Mean Sq.	df	Sum of Sq.	Mean Sq.	df	Sum of Sq.	Mean Sq.
Between	2	470.52	235.26	4	281.74	70.44	3	34.26	11.42	3	25.42	8.47
Within	2248	41792.62	18.59	1119	7383.49	6.60	741	3387.23	4.57	353	1264.73	3.58
Total	2250	42263.14	18.78	1123	7665.23	6.83	744	3421.50	4.60	356	1290.15	3.62
Equality of **medians**	Sample: 1881 2008			Sample: 1950 2008			Sample: 1971 2008			Sample: 1991 2008		
Method	df	Value	Prob.	df	Value	Prob.	df	Value	Prob.	df	Value	Prob.
Med. Chi-square	2	22.29	0.000	4	35.61	0.000	3	13.44	0.004	3	6.76	0.080
Adj. Med. Chi-square	2	21.67	0.000	4	32.55	0.000	3	11.14	0.011	3	5.11	0.164
Kruskal-Wallis	2	26.97	0.000	4	49.99	0.000	3	10.88	0.012	3	7.77	0.051
Kruskal-Wallis (tie-adj.)	2	26.97	0.000	4	49.99	0.000	3	10.88	0.012	3	7.77	0.051
Van der Waerden	2	25.71	0.000	4	45.27	0.000	3	9.10	0.028	3	7.24	0.065
Equality of **variances**	Sample: 1881 2008			Sample: 1950 2008			Sample: 1971 2008			Sample: 1991 2008		
Method	df	Value	Prob.	df	Value	Prob.	df	Value	Prob.	df	Value	Prob.
Bartlett	2	143.47	0.000	4	34.49	0.000	3	22.05	0.000	3	5.82	0.121
Levene	(2, 2248)	36.73	0.000	(4, 1119)	5.66	0.000	(3,	2.95	0.032	(3, 353)	0.36	0.781
Brown-Forsythe	(2, 2248)	32.60	0.000	(4, 1119)	5.63	0.000	(3,	2.91	0.034	(3, 353)	0.38	0.771
Bartlett weighted standard deviation			4.31			2.57			2.14			1.89

Category statistics of debt

Debt	Sample: 1881 2008				Debt	Sample: 1950 2008				Sample: 1971 2008				Sample: 1991 2008			
	Count	Mean	Std. Dev.	Std. Err. of Mean		Count	Mean	Std. Dev.	Std. Err. of Mean	Count	Mean	Std. Dev.	Std. Err. of	Count	Mean	Std. Dev.	Std. Err. of Mean
[0, 100)	1928	2.256	4.062	0.093	[0, 50)	612	3.156	2.828	0.114	353	2.080	2.372	0.126	95	1.678	2.107	0.216
[100,	300	1.023	4.582	0.265	[50, 100)	434	2.278	2.235	0.107	334	2.204	1.946	0.106	211	2.025	1.847	0.127
[200,	23	3.918	12.991	2.709	[100, 150)	64	1.790	2.198	0.275	50	1.453	1.668	0.236	43	1.358	1.700	0.259
					[150, 250)	13	1.578	1.534	0.425	8	0.993	1.162	0.411	8	0.993	1.162	0.411
All	2251	2.109	4.334	0.091	All	1124	2.718	2.613	0.078	745	2.082	2.144	0.079	357	1.829	1.904	0.101

Notes: df is degrees of freedom. Prob. is the probability. Count is the number of observations. Sum of Sq. is the sum of square. Mean Sq. is the mean of square. Std. Dev. is the standard deviation. Std. Err. of mean is the standard error of mean.

Table A.3. Instruments correlations of public debt ratio and economic growth

	1950-2008		1950-1970		1971-1990		1991-2008		1971-2008	
Instrument	Growth (t+5)	Debt (t)	Growth (t+5)	Debt (t)	Growth (t+5)	Debt (t)	Growth (t+5)	Debt (t)	Growth (t+5)	Debt (t)
GC	-0.09	0.24	-0.12	0.23	0.05	**0.27****	0.14	0.14	0.07	0.14
GC(-1)	-0.09	0.27	-0.10	0.24	0.04	**0.32****	0.16	0.15	0.07	0.17
GC(-2)	-0.09	0.29	-0.11	0.23	0.03	**0.35****	0.18	0.15	0.07	0.20
IM	0.08	-	0.10	-0.36	-0.09	**-0.40****	-0.04	-0.39	-0.08	**-0.43****
IM(-1)	0.10	-	0.13	**-0.43***	-0.07	**-0.37****	-0.03	-0.38	-0.06	**-0.41****
IM(-2)	0.12	-	0.15	**-0.43***	-0.04	**-0.38****	-0.02	-0.37	-0.04	**-0.41****
EX	-0.14	**0.54****	-0.19	**0.55****	0.04	**0.55*****	-0.02	0.23	0.02	**0.46****
EX(-1)	-0.16	**0.54****	-0.22	**0.57****	0.01	**0.54*****	-0.05	0.23	-0.01	**0.46****
EX(-2)	-0.18	**0.54****	-0.25	**0.57****	-0.03	**0.54*****	-0.06	0.23	-0.03	**0.46****
GCF	-0.08	-0.11	-0.15	-0.02	0.00	-0.19	0.04	0.08	0.00	-0.19
GCF(-1)	-0.07	-0.08	-0.13	0.02	0.04	-0.21	0.06	0.08	0.04	-0.20
GCF(-2)	-0.09	-0.05	-0.13	0.04	0.03	-0.21	0.02	0.06	0.02	-0.18
ODR	**-0.23***	0.32	-0.17	-0.17	-0.01	0.02	-0.08	0.32	-0.02	0.28
ODR(-1)	**-0.23***	0.32	-0.18	-0.15	0.00	0.02	-0.07	0.30	-0.02	0.28
ODR(-2)	**-0.23***	0.33	-0.18	-0.13	0.00	0.04	-0.07	0.27	-0.01	0.27

Note: Significant at 1% (***), 5% (**) and 10% (*).

Table A.4. Fixed effects generated across countries and periods

Fixed effects for the quadratic form specification: the sample of 20 OECD countries					
Country	1950-2008	1950-1970	1971-2008	1971-1990	1991-2008
Australia	-1.78	-2.57	0.39	-0.65	15.10
Austria	-0.56	3.74	0.08	-0.05	-1.78
Belgium	2.79	-4.60	1.29	1.98	-4.19
Canada	0.45	-5.51	-0.50	-0.43	-5.90
Denmark	-1.22	2.08	-0.09	0.00	-0.93
France	-1.18	0.86	-0.31	-0.53	0.68
Germany	-1.44	2.14	-0.48	-0.47	0.21
Greece	1.04	4.70	0.59	-0.46	-4.92
Ireland	1.11	-3.46	1.13	2.14	1.11
Italy	1.46	0.29	0.19	1.00	-6.57
Japan	2.03	8.80	0.85	0.88	-2.14
Netherlands	0.40	-4.78	-0.50	-0.27	-1.92
New Zealand	-1.10	-6.50	-1.17	-1.10	4.62
Norway	-0.84	0.45	0.43	0.49	6.82
Portugal	-0.22	4.00	0.25	0.65	0.79
Spain	-0.12	4.60	0.37	0.00	0.40
Sweden	-0.57	0.88	-0.46	-0.99	-2.77
Swiss	-2.03	-0.73	-1.18	-1.45	0.01
United Kingdom	2.05	1.61	-0.25	-0.19	3.27
United States	-0.78	-5.06	-0.55	-0.37	-1.83
Fixed effects for the quadratic form specification: the sample of 10 Euro countries					
Austria	-0.80	8.13	-0.26	-0.23	-0.27
Belgium	1.78	-12.25	1.44	1.02	-6.01
France	-1.35	1.05	-0.77	-0.29	5.35
Germany	-1.53	4.48	-0.87	-0.58	4.48
Greece	0.60	7.66	0.41	-0.71	-7.76
Ireland	1.22	-9.45	0.97	1.13	4.67
Italy	0.99	-1.88	0.24	-0.12	-9.32
Netherlands	0.44	-12.01	-0.70	-1.10	-0.50
Portugal	-0.35	7.03	-0.13	0.43	5.32
Spain	-0.40	7.59	-0.08	0.27	4.00

Table A.5. Sensitivity of debt thresholds to government expenses and government effectiveness.

High Government effectiveness (13 countries): Finland, Denmark, Sweden, Norway, Netherlands, Canada, New Zealand, Austria, Australia, United Kingdom, Belgium, Germany and United States.					
	1951-1970	1971-1990	1991-2008	1971-2008	1951-2008
Model Without Fixed Effect	NS	NS	80.7***	73.8***	61.2***[a]
Model With Fixed Effect	114.7**	NS	95.4*	60.8**	92.8***[a]
Moderate Government effectiveness (7 countries): Ireland, France, Japan, Spain, Portugal, Greece and Italy.					
Model Without Fixed Effect	40.3**	41.6**	NS	49.3*	NS
Model With Fixed Effect	NS	NS	102.5***	NS	NS
High Government Final Consumption as % of GDP (9 countries): Sweden, Denmark, Netherlands, France, Canada, Belgium, Germany, United Kingdom and Norway.					
Model Without Fixed Effect	NS	NS	NS	72.2*	61.4***[a]
Model With Fixed Effect	NS	NS	NS	52.3**	101.4***[a]
Moderate Government Final Consumption as % of GDP (11 countries): New Zealand, Italy, Ireland, Austria, Australia, United States, Greece, Portugal, Japan, Spain and Switzerland.					
Model Without Fixed Effect	60.7**[a]	NS	NS	67.5***	NS
Model With Fixed Effect	NS	NS	91.5***	58.4*	NS
High Military Expenditures as % of GDP (9 countries): Unites States, United Kingdom, France, Greece, Portugal, Norway, Netherlands, Sweden and Australia.					
Model Without Fixed Effect	NS	NS	NS	45.2**	122.0*[a]
Model With Fixed Effect	NS	NS	65.3**	51.4**	118.9***[a]
Moderate Military Expenditures as % of GDP (11 countries): Belgium, Germany, Italy, New Zealand, Denmark, Spain, Canada, Switzerland, Ireland, Austria and Japan.					
Model Without Fixed Effect	46.0*[a]	NS	89.3**	NS	51.1***
Model With Fixed Effect	NS	NS	114.2**	NS	NS
High Government Transfers and Subsidies as % of GDP (7 countries): Belgium, Switzerland, Netherlands, Canada, Sweden, United States and Japan.					
Model Without Fixed Effect	53.4***	73.0*	93.0***	81.5***	NS
Model With Fixed Effect	NS	NS	NS	71.6***	NS
Moderate Government Transfers and Subsidies as % of GDP (13 countries):					
	1951-1970	1971-1990	1991-2008	1971-2008	1951-2008
Model Without Fixed Effect	NS	NS	NS	NS	NS
Model With Fixed Effect	126.7***	31.2*	NS	NS	NS

Notes: significant at 1% (***), 5% (**) and 10% (*). NS is Non-Significant. *a*: The form of Growth-debt link is convex meaning that the debt affects negatively growth for debt ratios below this threshold and positively above it.

Table A.6. Tests for cross-section dependence for the panel fixed effect model (Least Squares method)

Residual Cross-Section Dependence Test for the 20 OECD countries sample										
Degrees of freedom = 190	1950-2008		1950-1970		1971-2008		1971-1990		1991-2008	
Test	Stat.	Prob.	Stat.	Prob.	Stat.	Prob.	Stat.	Prob.	Stat.	Prob.
Breusch-Pagan LM	1362.7	0.000	474.0	0.000	855.2	0.000	539.0	0.000	671.4	0.000
Pesaran scaled LM	60.2	0.000	14.6	0.000	34.1	0.000	17.9	0.000	24.7	0.000
Bias-corrected scaled LM	60.0	0.000	14.1	0.000	33.8	0.000	17.4	0.000	23.9	0.000
Pesaran CD	32.3	0.000	15.9	0.000	23.6	0.000	17.2	0.000	22.2	0.000
Residual Cross-Section Dependence Test for the 10 Euro countries sample										
Degrees of freedom = 45	1950-2008		1950-1970		1971-2008		1971-1990		1991-2008	
Test	Stat.	Prob.	Stat.	Prob.	Stat.	Prob.	Stat.	Prob.	Stat.	Prob.
Breusch-Pagan LM	450.3	0.000	145.6	0.000	320.8	0.000	204.9	0.000	211.0	0.000
Pesaran scaled LM	42.7	0.000	10.6	0.000	29.1	0.000	16.9	0.000	17.5	0.000
Bias-corrected scaled LM	42.6	0.000	10.4	0.000	28.9	0.000	16.6	0.000	17.1	0.000
Pesaran CD	18.6	0.000	8.6	0.000	16.6	0.000	13.3	0.000	12.8	0.000

Notes: Null hypothesis: No cross-section dependence (correlation) in residuals. Test employs centered correlations computed from pairwise samples

Appendix B. Individual scatter plots for public debt and economic growth

Figure B.1. 5-year lead economic growth and current public debt, 1880 and 2008

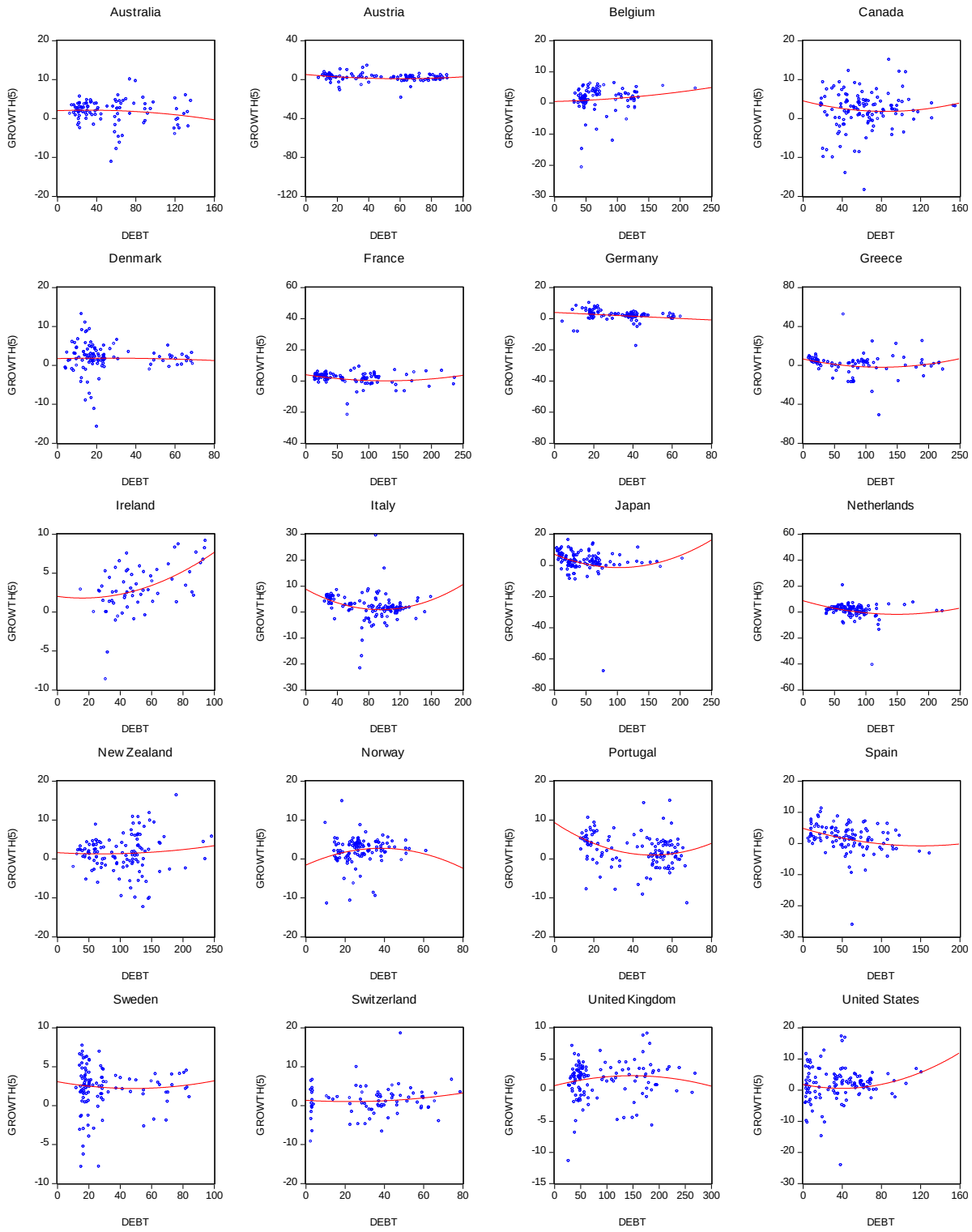


Figure B.2. 5-year lead economic growth and current public debt, 1880 and 1913

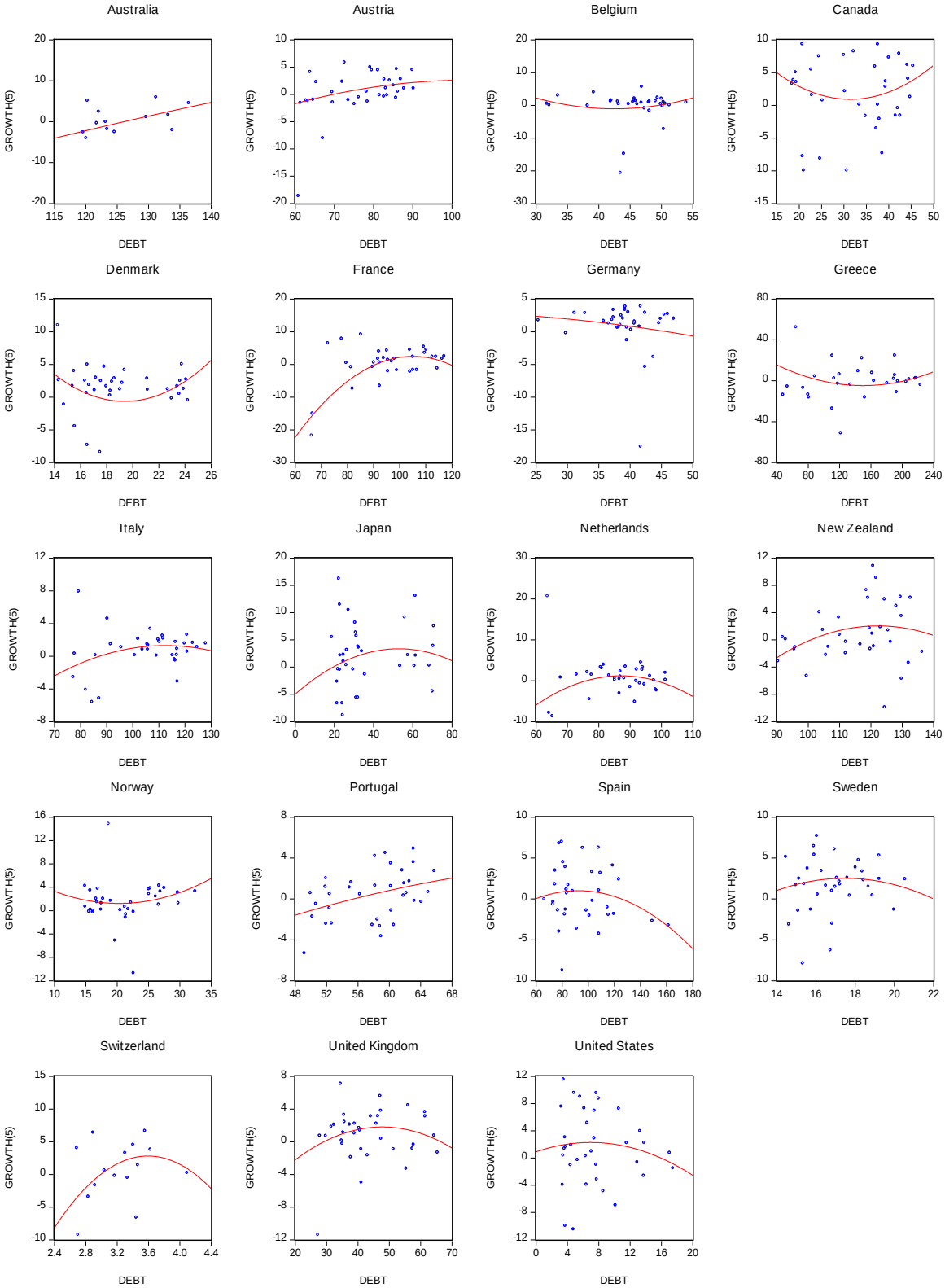


Figure B.3. 5-year lead economic growth and current public debt, 1914 and 1945

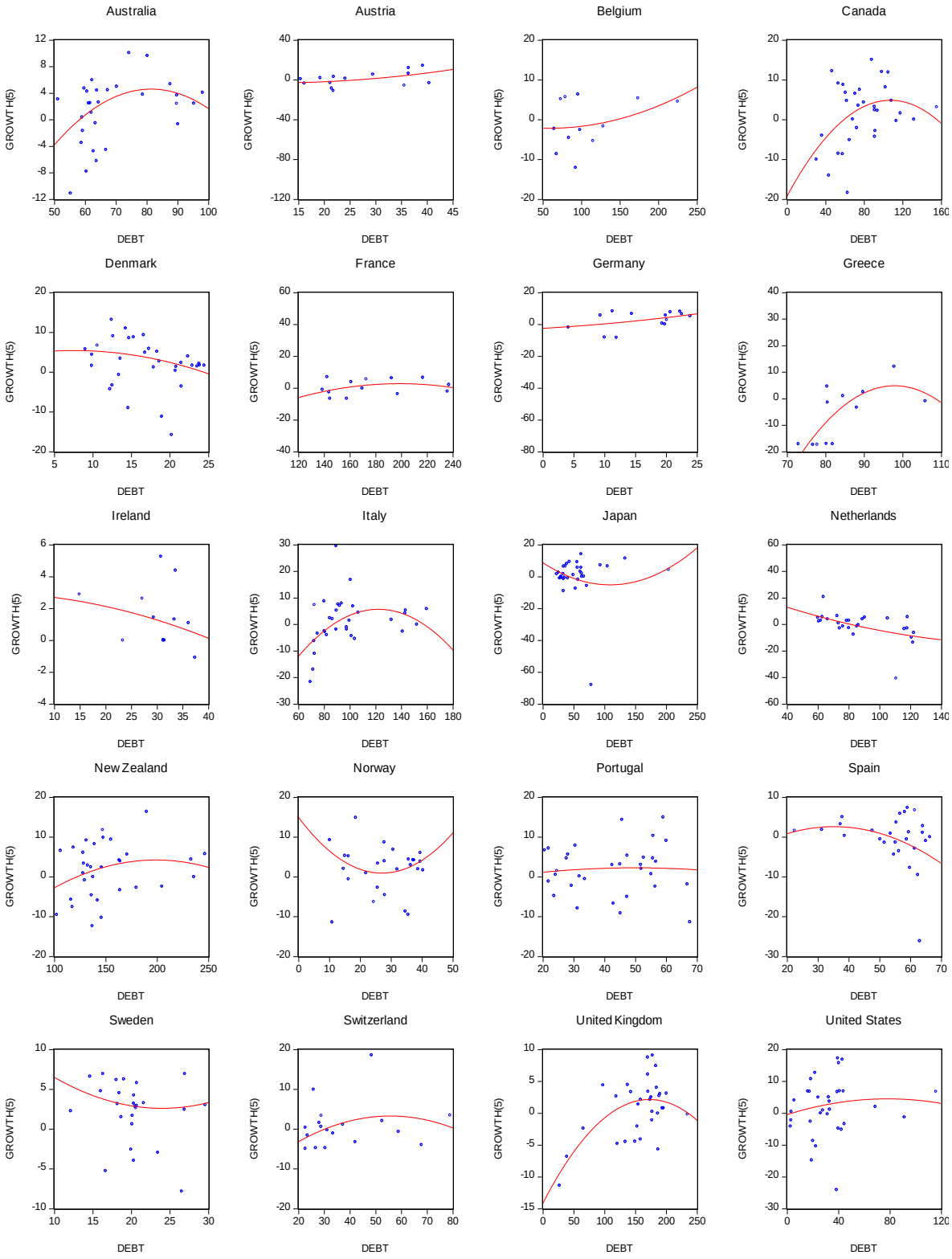


Figure B.4. 5-year lead economic growth and current public debt, 1946 and 1970

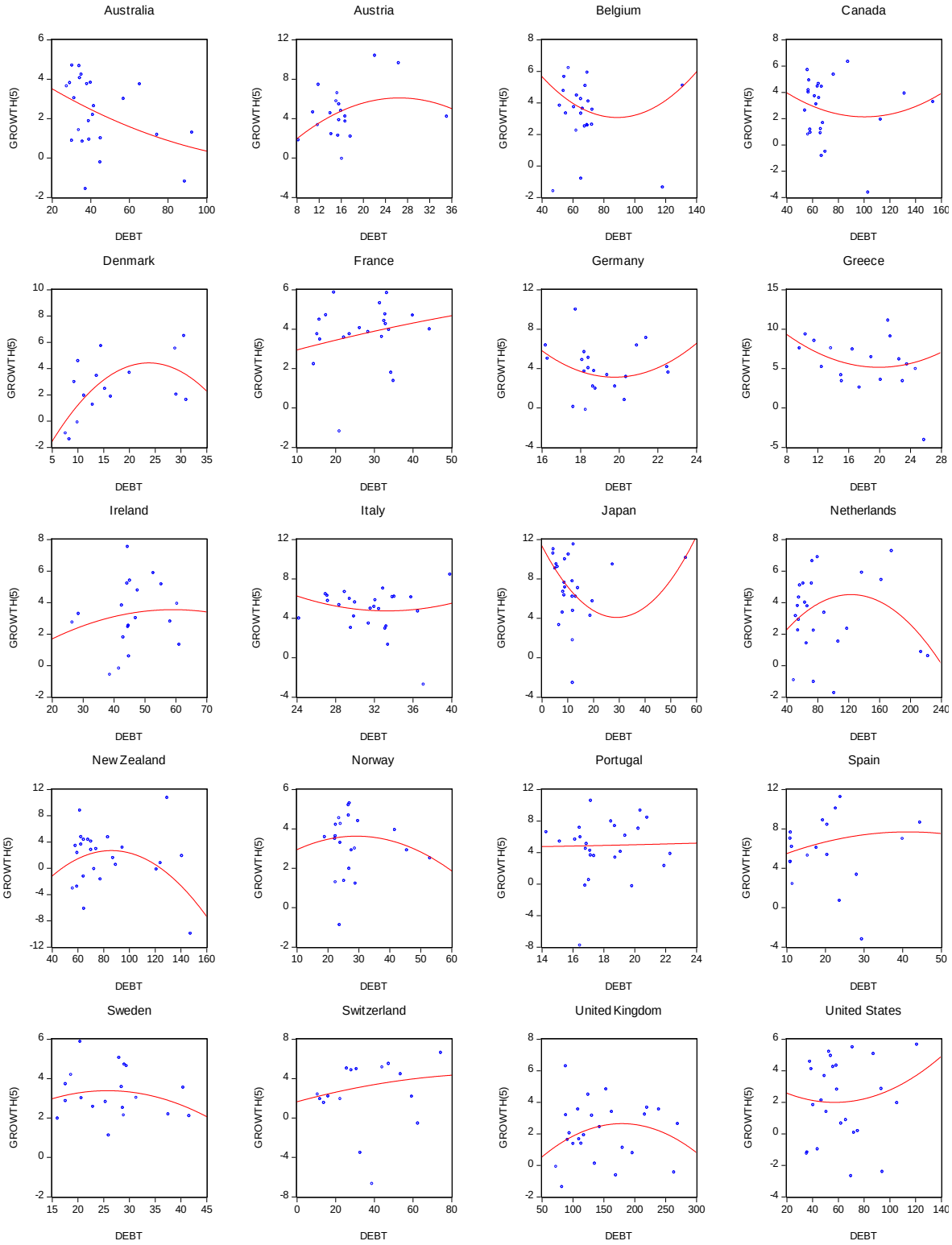


Figure B.5. 5-year lead economic growth and current public debt, 1971 and 1990

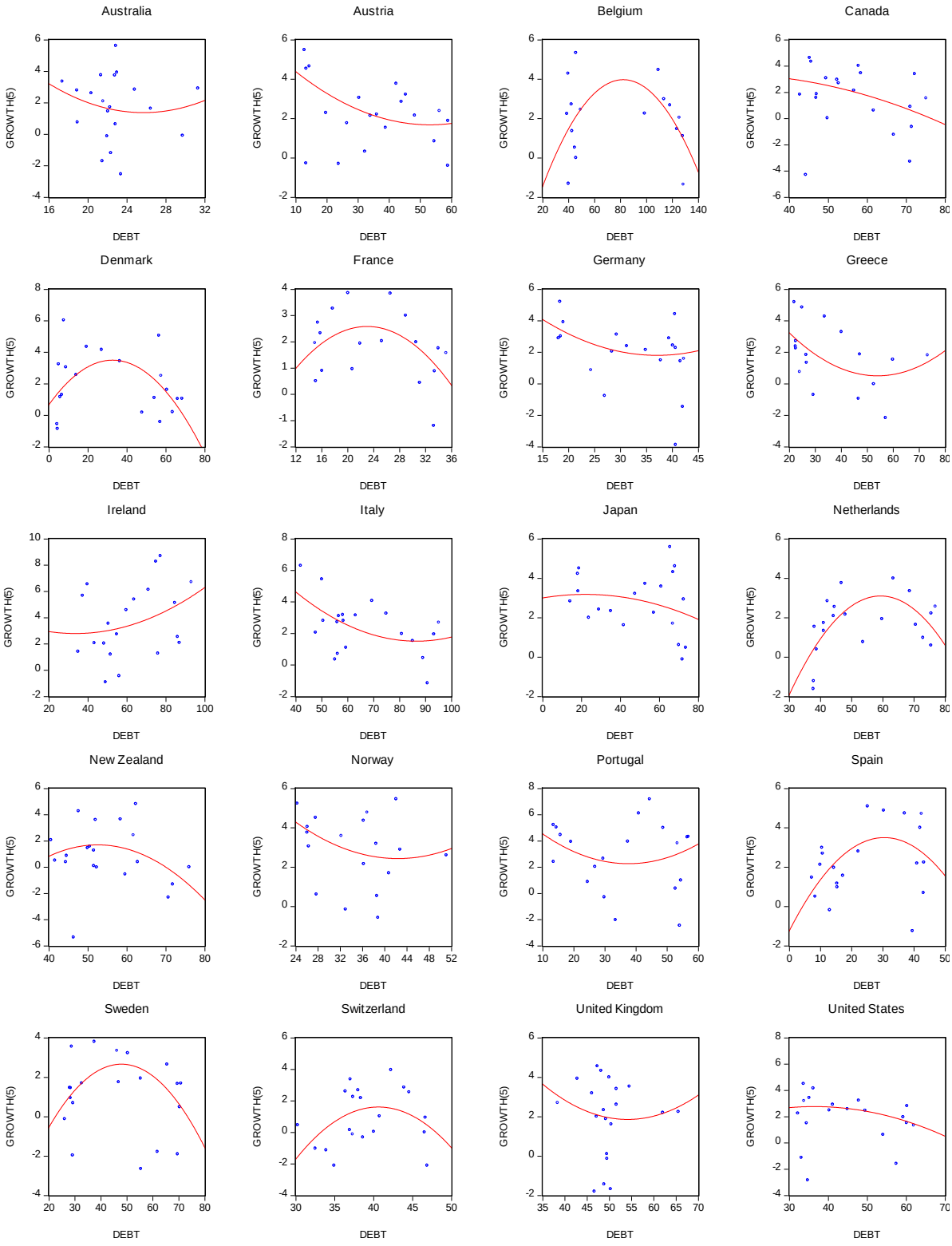


Figure B.6. 5-year lead economic growth and current public debt, 1991 and 2008

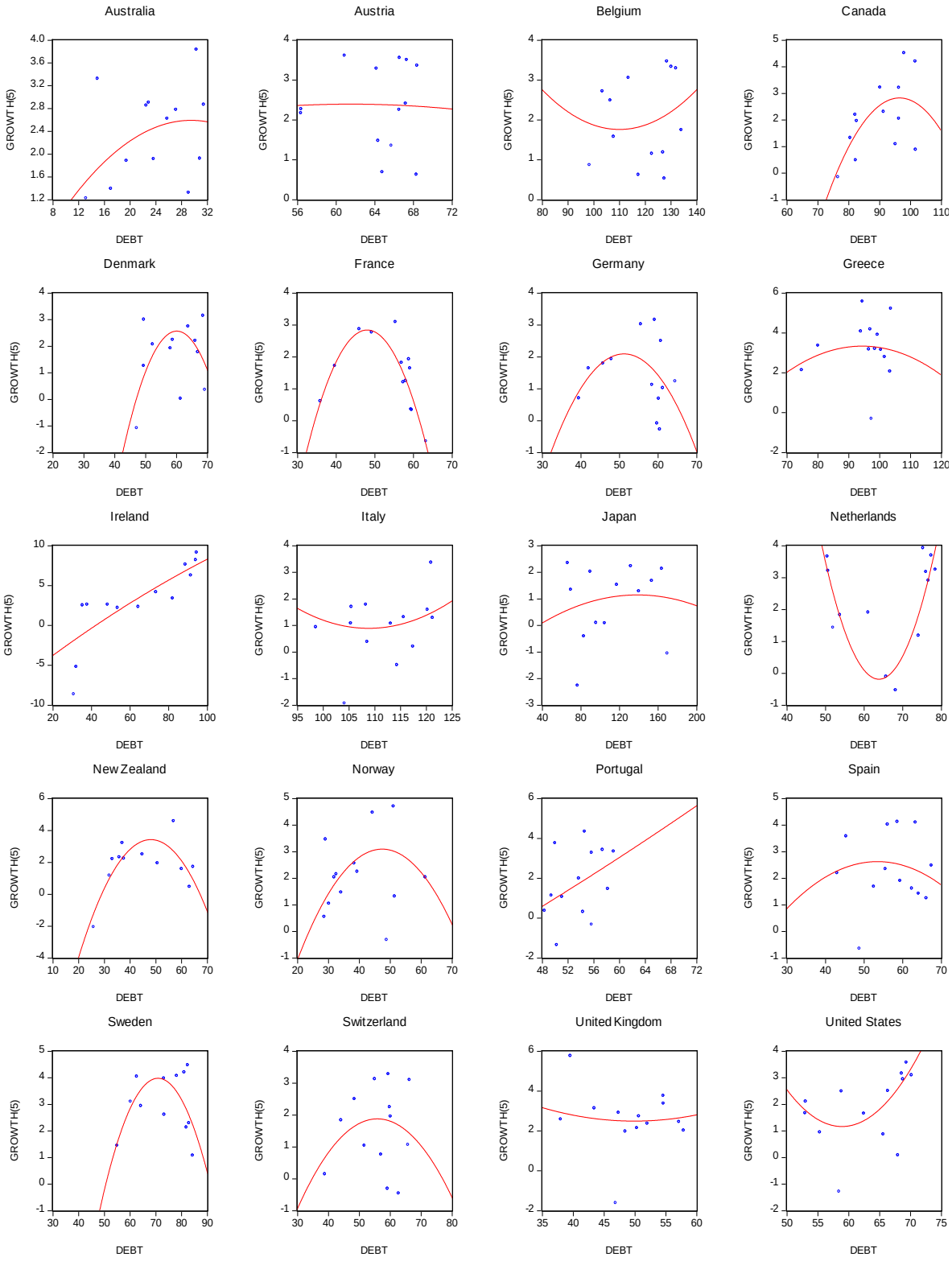


Figure B.7. 5-year lead economic growth and current public debt, 1971 and 2008

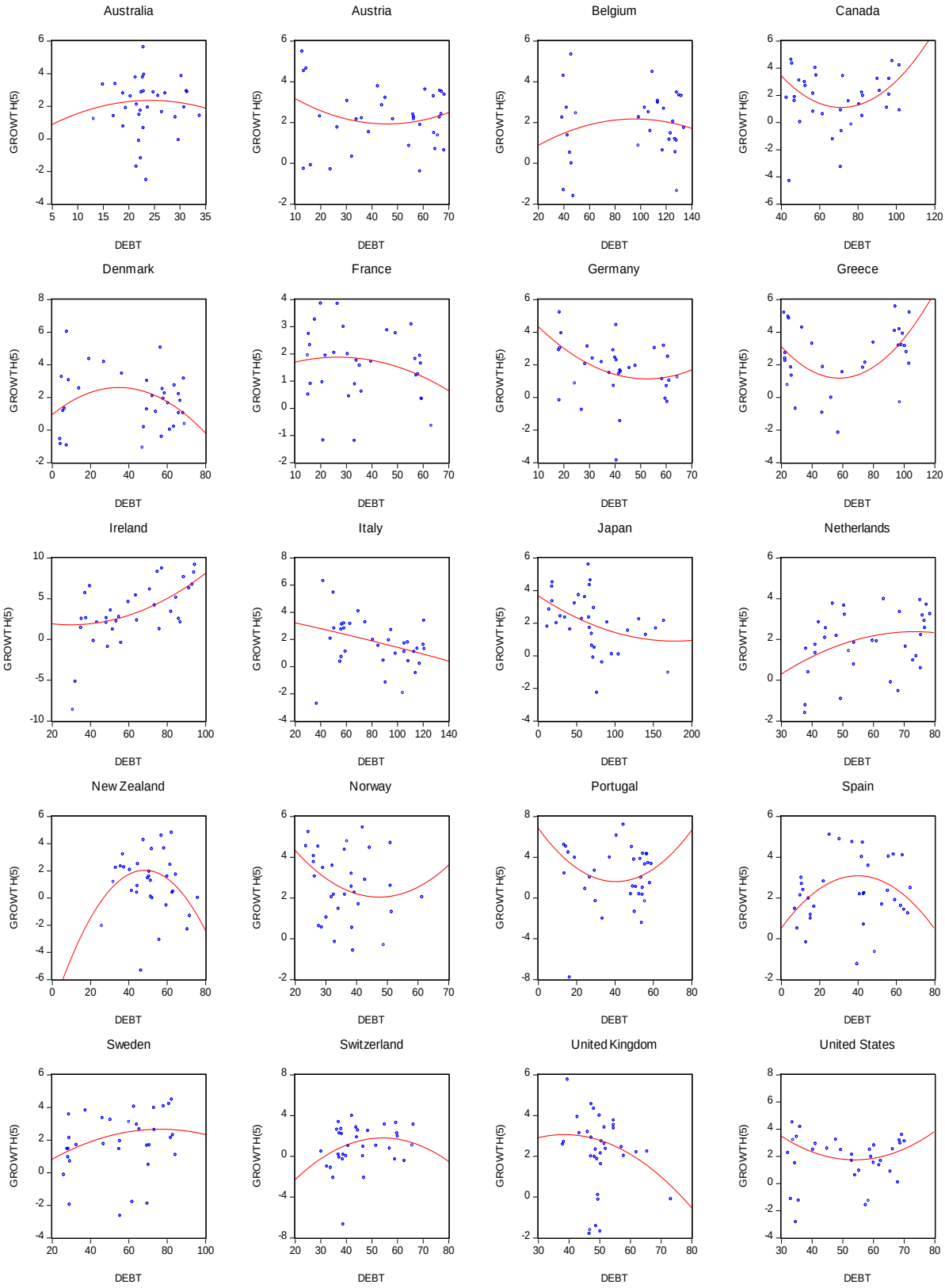


Figure B.8. 5-year lead economic growth and current public debt, 1946 and 2008

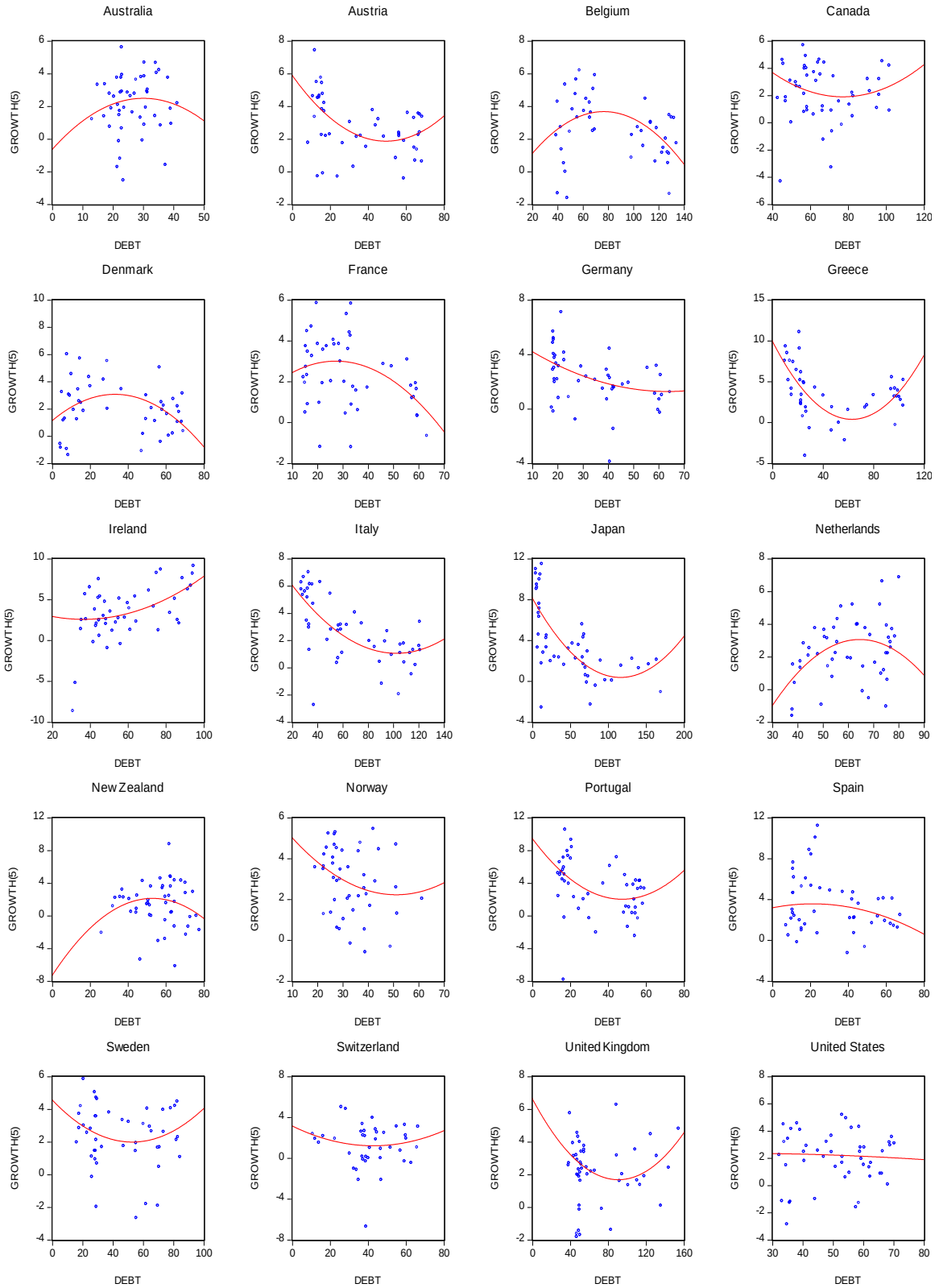
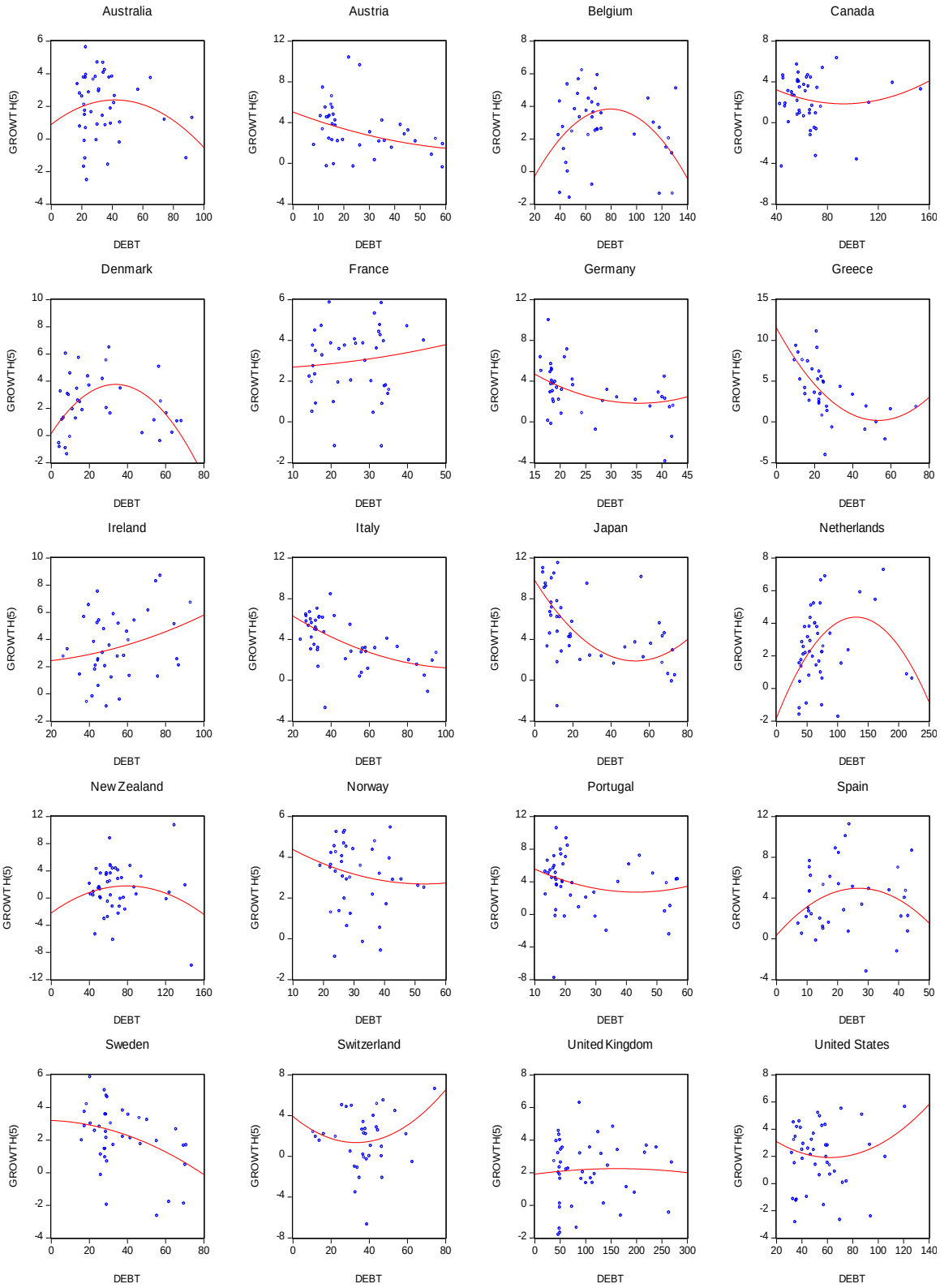


Figure B.9. 5-year lead economic growth and current public debt, 1946 and 1990



Appendix C. Hansen (2017) algorithms for the regression kink model

Algorithm 1: Testing for a Regression Kink with an Unknown Threshold.

1. Generate n *iid* draws u_t from the *N*(0,1) distribution.
2. Set $y_t^* = \widetilde{e_t} u_t$ where $\widetilde{e_t}$ are the OLS residuals from the fitted linear model (8).
3. Estimate the linear regression model (8) and the regression kink model (2), and compute the error variance estimates $\tilde{\sigma}^{*2}$ and $\hat{\sigma}^{*2}$ and the F statistic calculated as: $T_n^* = \frac{n(\tilde{\sigma}^{*2} - \hat{\sigma}^{*2})}{\hat{\sigma}^{*2}}$.
4. Repeat this *B* times to obtain a sample of simulated *F* statistic $\{T_n^*(b), b = 1..B\}$.
5. Compute the *p*-value as the percentage of simulated F statistics, which exceed the actual value: $p_n = \frac{1}{B}\sum_{b=1}^{B} 1(T_n^*(b) \geq F_n)$,
6. Compute the level α critical value c_α as the empirical $(1-\alpha)$ of the simulated F statistics $\{T_n^*(i), i = 1..B\}$.
7. Reject $H_{0(\beta_1 = \beta_2)}$ in favor of $H_{1\,(\beta_1 \neq \beta_2)}$ at significance α if $p_n < \alpha$, or equivalently if $T_n > c_\alpha$.

   The number of bootstrap replications *B* should set sufficiently large to ensure accuracy of the p-value. We keep the number *B*=10.000 in our case as reported by Hansen (2017). We also use $\Gamma = [\min(d_t), \max(d_t)]$ for each country and a grid search with the increments of 1. The number of grid points is then: $\lambda = \max(d_t) - \min(d_t) + 1$.

Algorithm 2: Wild Bootstrap confidence intervals for parameters

1. Generate n *iid* draws u_t from the *N*(0,1) distribution.
2. Set $e_t^* = \widehat{e_t} u_t$ where $\widehat{e_t}$ are the OLS residuals from the fitted regression kink model (2).
3. Set $g_t^* = \widehat{\beta}' x_t(\hat{\gamma}) + e_t^*$, where $(\hat{\beta}, \hat{\gamma})$ are the Least-Square estimates.
4. Using the observations $(g_t^*, g_{t-1}, d_{t-1})$, estimate the regression kink model (2), parameter estimates $(\widehat{\beta^*}, \widehat{\gamma^*})$ and $\hat{\sigma}^{*2} = \frac{1}{n}\sum_{t=1}^{n} \hat{e}_t^{*2}$ where $\hat{e}_t^* = g_t^* - \hat{\beta}^{*\prime} x_t(\hat{\gamma}^*)$.
5. Calculate the F-statistic for γ: $F_n^*(\hat{\gamma}) = \frac{n(\hat{\sigma}^{*2}(\hat{\gamma}) - \hat{\sigma}^{*2})}{\hat{\sigma}^{*2}}$; where $\hat{\sigma}^{*2} = \frac{1}{n}\sum_{t=1}^{n} \hat{e}_t^{*2}(\hat{\gamma})$ and $\hat{e}_t^*(\hat{\gamma}) = g_t^* - \hat{\beta}^{*\prime}(\hat{\gamma}) x_t(\hat{\gamma})$.
6. Repeat this *B* times to obtain a sample of simulated coefficient estimates $(\widehat{\beta^*}, \widehat{\gamma^*})$ and *F* statistics F_n^*.
7. Create $(1-\alpha)$ bootstrap confidence intervals for the coefficients $\beta = (\beta_1, \beta_2, \beta_3)$ by the symmetric percentile method: the coefficients plus and minus the $(1-\alpha)$ quantile of the absolute centered estimate bootstrap: for each coefficient $\beta_i;\ i = 1..3$, the interval is $\hat{\beta}_i \pm q_1^*$ where q_1^* is the $(1-\alpha)$ quintile of $|\beta_i^* - \hat{\beta}_i|$.
8. Calculate the $(1-\alpha)$ quantile $c_{1-\alpha}^*$ of the simulated *F* statistics F_n^*.
9. Create $(1-\alpha)$ bootstrap confidence interval for γ as the set of γ for which the empirical *F* statistics $F_n(\gamma)$ are smaller than the bootstrap critical value $c_{1-\alpha}^*$: $C_\gamma^* = \{\gamma : F_n(\gamma) \leq c_{1-\alpha}^*\}$

Chapter 2

Short-term effects of public debt on growth: The spending multiplier *pass-through*

Chapter 2

Short-term effects of public debt on growth: The spending multiplier *pass-through*

Abstract: We examine the relationship between public debt and economic growth in the short term, through spending multipliers. We study the impact of public debt accumulation on the size of the expenditure multipliers, as well as the effects of the business cycle. We adopt the structural vector autoregressive (SVAR) methodology, running a panoply of bi-variate and tri-variate SVAR models on quarterly data for a sample of 18 OECD countries. Furthermore, we estimate an SVAR with six fiscal and monetary variables for the United States to highlight the channels through which public debt affects economic growth. In all the above-mentioned SVAR models, we control for the business cycle and the public debt movement effects. The results show that expenditure multipliers are higher in times of recession than times of expansion, which is in line with the recent findings about fiscal multipliers in advanced economies, being larger in recessions than expansion periods. Moreover, controlling exogenously for public debt, the estimations revealed larger spending multipliers in debt accumulation than in debt contraction periods, independent of the business cycle effects. However, introducing endogenously the public debt ratio leads to higher multipliers in recessions than in expansions. Moreover, the results do not support any tendency for weak spending multipliers for the recent periods compared to older ones. Furthermore, the United States SVAR shows that public debt crowds out private investment, leading to a lower growth rate in times of expansion, while in times of recession the public debt effects on growth are positive. This crowding-out effect may play *pass-through* to the expenditure multipliers, which could explain, *ceteris paribus*, the weak size of spending multipliers, while the crowding-in effect in times of recession leads to higher multipliers. The results also revealed that government expenditure has a positive but short-lived impact on economic growth. Besides, the recession period has persistent effects on the responses of variables, for which convergence with the long-term path following the shock is achieved slower than with the expansion time. The policy implication is that fiscal stimulus effects could take time to materialize in recessions, while such effects could be short-lived in expansions, which is something that should be considered by policy-makers in their spending decisions.

JEL classification: C30, E62, H50, H60.

Keywords: Business cycle, Dynamic multiplier, Fiscal position, Government expenditure, SVAR.

1. Introduction

At the height of the 2008 financial crisis, fiscal policy was revived as the main and almost sole active government policy tool to cope with the financial crisis effects, after monetary policy was constrained in many advanced countries by the zero lower bound (ZLB) interest rate or by countries being affiliated to a monetary union, as is the case for eurozone countries (Romer, 2011). The fiscal policy is solicited in two "distinct" but subsequent events. The first, advanced countries, were urged to implement massive fiscal stimuli plans and bail-out programmes[28] (in 2009–10) designed to dampen the negative effects of the crisis on the private sectors and households at the beginning of the crisis, and therefore boosting growth (OECD, 2009; ILO, 2011). Consequently, this leads to exacerbating fiscal positions, with the deficit widening and a sharp increase in debt to GDP ratios, which were already high in the pre-crisis year (IMF, 2009; Taylor, 2018). This issue pushed policy-makers, especially in the eurozone, where the debt ratios climbed from the pre-crisis level in almost all countries by 20 percentage points (European Commission, 2012), supported by advisors and economists' views from international institutions and think thank institutes (International Monetary Fund, World Bank, European Central Bank, OECD, G20) and other economists from academia, to reverse the track of the fiscal policy from stimuli programmes to fiscal consolidation. The argument of those economists stands for the modest results obtained from the assessment of fiscal stimuli programmes,[29] as reported by many studies (Baldacci et al., 2009; Freedman et al., 2010; Taylor, 2011; Coenen et al., 2012; Cogan and Taylor, 2012; Mian and Sufi, 2012; Phelps, 2018), and the likely negative impact of high public debt on economic growth, which triggered a large open debate between economists.[30]

However, the prolonged negative impacts of the financial crisis, under the two consequent programmes (fiscal stimulus and fiscal consolidation), have put the focus on another issue related to the role of fiscal multipliers in those programmes, namely, trying to find answers to the weak GDP recovery despite massive fiscal stimuli from one side and the persistent high debt ratios and deficits despite fiscal consolidation from the other. This triggered a permanent influx of empirical studies (re)-assessing the values of the multipliers and reviewing their determinants.

One research strand involves assessing the size of the multipliers due to positive fiscal shocks corresponding to the stimuli programmes (an important list of sample studies and their main

[28] Although these fiscal stimuli seem to be large in absolute size, approximately US$ 2 trillion in the G20 countries (ILO, 2011), some authors qualified these fiscal stimuli by insufficient and timid programmes (Aizenman and Pasricha, 2011; Stiglitz, 2018), especially compared to emerging countries in Asia and the Pacific, not including Japan and the Republic of Korea, where the average stimuli programmes were around 9.1% of GDP compared to just 3.4% of GDP in advanced economies (ILO, 2011).

[29] The two important fiscal stimuli that were reviewed are the ARRA programme (the American Recovery and Reinvestment Act), implemented in the United States, and the EERP programme (the European Economic Recovery Plan), implemented in Europe. A very large list of studies, reproduced in Table 1.A. in the appendix, on fiscal stimulus measures and their main findings from the ILO (2011), shows very mixed results, especially on the ARRA programme. Among 47 studies and reports of this list, 22 reported mixed effects, 21 positive effects and 4 negative effects.

[30] More details about this debate are presented in Chapter 1. See also Bentour (2018).

findings about the effects of fiscal stimuli around 2008–10 is reproduced in Table 1.A in the appendix), while the other strand goes the opposite way, evaluating and designing strategies for successful fiscal consolidation[31] and austerity measures (Abbas et al., 2010; OECD, 2011, 2012; Molnár, 2012; Cogan et al., 2013; Estevão and Samake, 2013; Blot et al., 2014a; Alesina et al., 2015). In fiscal stimuli programmes, the fiscal instruments used are either related to the increase in spending programmes (and fiscal transfers to households and bail-out programmes) or based on tax cuts for households and investors to boost consumption and investment – or a mixture of the two. However, in fiscal consolidation, which directly aims, *ceteris paribus*, to sustain and improve the government's fiscal position (reducing debt and deficit) by increasing revenue and rationalizing expenditure, the course of the fiscal instruments is reversed, as in this case, where taxes should be increased and expenditure cut.[32]

Since the 2008 financial crisis, a significant body of literature assessing fiscal multipliers has flourished (Romer and Romer, 2010; Auerbach and Gorodnichenko, 2012, 2013; Delong and Summers, 2012; Farhi and Werning, 2017; Ramey, 2011; Ramey and Zubairy, 2018).[33] Although the story of fiscal multipliers was remounted at the edge of the Keynesian era following the 1929 Great Depression, their empirical assessment has recently been extensively revived as a result of the development of econometrics and statistics. Nevertheless, the renewed importance of fiscal multipliers showed large discrepancies in their values (whether in absolute values or sometimes even in algebraic signs), especially in the recent financial crisis (Ramey, 2018). These values are time- and country-specific and even sensitive to the assessment method (Baum et al., 2012; Batini et al., 2014).

Indeed, in explaining the values of fiscal multipliers, some authors have found those multipliers to be sensitive to the business cycle. In particular, fiscal spending multipliers were revealed to be larger in recessions than expansion periods. Auerbach and Gorodnichenko (2012, 2013) were the first to emphasize the tendency of fiscal multipliers to be large in recessions (potentially reaching more than 2) compared to expansions. Consequently, many other researchers confirmed their results, differentiating between fiscal multipliers in recessions and expansions (Barro and Redlick, 2011; Parker, 2011;[34] Corsetti et al., 2012; Caggiano et al., 2015; Fazzari et al., 2015; Glocker et al., 2019). This also pushed some researchers who were not totally convinced, or with opposing results, to refine their analysis, leading to finding out the vulnerability of fiscal multipliers to other determinants and not necessarily conditioned by the state of the economy in the business cycle.

[31] See the World of Work Report (2010) for a list of detailed consolidation and austerity measures for advanced countries.

[32] We should be cautious when the values of multipliers deducted from fiscal stimulus, for example, are used to draw conclusions and policy advice on fiscal consolidations, and vice versa, as there is no revealed symmetry of effects in the instrument changes: an increase/decrease in expenditure could have an effect that is not necessarily the same in absolute value for a similar decrease/increase in expenditure. Few authors cared about this issue (see Section 2.4).

[33] See, for example, Ramey (2018) for a recent and large literature review.

[34] Parker (2011) built on earlier versions of Auerbach and Gorodnichenko (2012, 2013) (as did some other authors), which are issued, respectively, as NBER working papers in 2010 (No. 16311) and 2011 (No. 17447).

Therefore, fiscal multipliers were revealed to be dependent on the fiscal position measured by the level of debt ratios and deficits (Corsetti et al., 2013; Huidrom et al., 2016), on the monetary policy stance (Hall, 2009), particularly the constrained monetary policy, either by the ZLB interest rate (liquidity trap) or by the loss of monetary independence, as in the pegged exchange rate or monetary union (Cogan et al., 2010; Christiano et al., 2011; Delong and Summers, 2012; Farhi and Werning, 2017).

However, the recent works of Ramey (2018) and Ramey and Zubairy (2018) consider that government spending multipliers are, on average, lower than unity. This contrasts with the tendency of the post-2008 crisis researchers to confirm larger multipliers, especially in recessions. This also aligns with the consensus on spending multipliers before the last recession, considered to be weak, and that fiscal policy effects are short-lived (Coenen et al., 2012). Furthermore, the debate about the impact of government debt on economic growth (studied in Chapter 1) is directly related and assessed via the multiplier's effects. In particular, fiscal policy effects, taking into account the fiscal position of the economy, measured by the level of public debt and/or the fiscal deficit, have been highly debated in the aftermath of the 2008 financial crisis (Boussard et al., 2012; Corsetti et al., 2012; Blot et al. 2014b; Canzoneri et al., 2015; Bi et al., 2016; Huidrom et al., 2016; Perdichizzi, 2017; Poghosyan, 2017; Afonso and Leal, 2018; Auerbach and Gorodnichenko, 2017; Blanchard, 2019; Broner et al., 2019). Very recently, in a presidential lecture of the American Economic Association, Blanchard (2019) triggered another wave of public debt and growth debate related to the fiscal cost of high public debt, as well as its effect on welfare, minimizing worries about the public debt costs for the American economy, as, in historical records, the nominal interest rate has remained, on average (except for some small periods around the 1980s), below the nominal growth rate. These contrasting results about spending multipliers make it interesting to reconsider studying fiscal multipliers and contributing to this unsettled debate.

The remainder of this chapter is as follows. Section 2 presents the literature review on fiscal multipliers, focusing particularly on the fiscal spending multipliers and their determinants, especially for highly indebted countries and constrained monetary policies. Section 3 presents a methodology for assessing spending multipliers according to the way the public debt ratio is evolving. Section 4 presents the empirical results. Section 5 concludes.

2. Literature review

A fiscal multiplier is defined as the output change in response to an (exogenous) change in a fiscal variable in reference to their baseline levels (Spilimbergo et al., 2009; Coenen et al., 2012).[35] The concept of multiplier is generally associated with the *general theory* of John Maynard Keynes

[35] If Y_t and Z_t denote, respectively, the output and the fiscal instrument at time t, the fiscal multiplier is simply expressed as $\frac{dY_t}{dZ_t}$. Or, while the effects come with different lag times, the cumulative fiscal multiplier is expressed as $\frac{\sum_{j=0}^{j=n} dY_{t+j}}{\sum_{j=0}^{j=n} dZ_{t+j}}$ (Chinn, 2013).

(1936).[36] The idea behind fiscal stimulus is that the fiscal multiplier, as the measure of the policy instrument effect, is de facto a Keynesian one, which means that the value of such a fiscal multiplier is larger than unity, making it rewardable/beneficial to go for such fiscal stimulus. In the Keynesian structural models, the simplest way to compute a spending multiplier is via the marginal propensity to consume.[37] The spending multiplier in the Keynesian framework decreases with the marginal propensity to import, as well as the rise in interest rates and increases with the rise of investment due to the expansion of GDP (the accelerator effects). In a vector autoregression (VAR) approach, spending multipliers are determined using the impulse response function and the methodology of identification proposed by Blanchard and Perotti (2002).

Despite a continuously growing body of empirical literature on fiscal multipliers in recent years, these tend to bring more confusion than forming a consensus about the size of the fiscal multiplier. There are many reasons why the size of the fiscal multiplier changes. Besides the proper characteristics of the studied economy, which are obviously due to macroeconomic fundamentals, as well as the institutional environment, the difference of methods and the accuracy of data make an important contribution to these differences. This section surveys the main important contributions of the literature on fiscal multiplier determinants, as well as the challenging issues presented by the methods used to gauge fiscal multipliers.

Recent researchers have mainly been interested in explaining why the recovery slowed in many advanced countries and fiscal consolidation is hurting many others. In this line of research, the frontier is not clear. For some, fiscal consolidation hurts in times of crisis, as fiscal multipliers are larger in recessions than expansions. If this is the case, a legitimate question to consider is why the large size of these multipliers in a time of crisis did not help fiscal stimuli to recover, especially in the eurozone countries. This may be because of the asymmetric effects of the two cases (fiscal stimulus versus austerity). To our best knowledge, very few studies have undertaken the issue of asymmetry. Our investigation of the recent empirical literature found only two papers with contrasting results (Baum and Koester, 2011; Riera-Crichton et al., 2014), while some papers draw conclusions without paying attention to the asymmetry issue (Ramey, 2018; Ramey and Zubairy, 2018). More details about these papers are provided in Section 2.5.

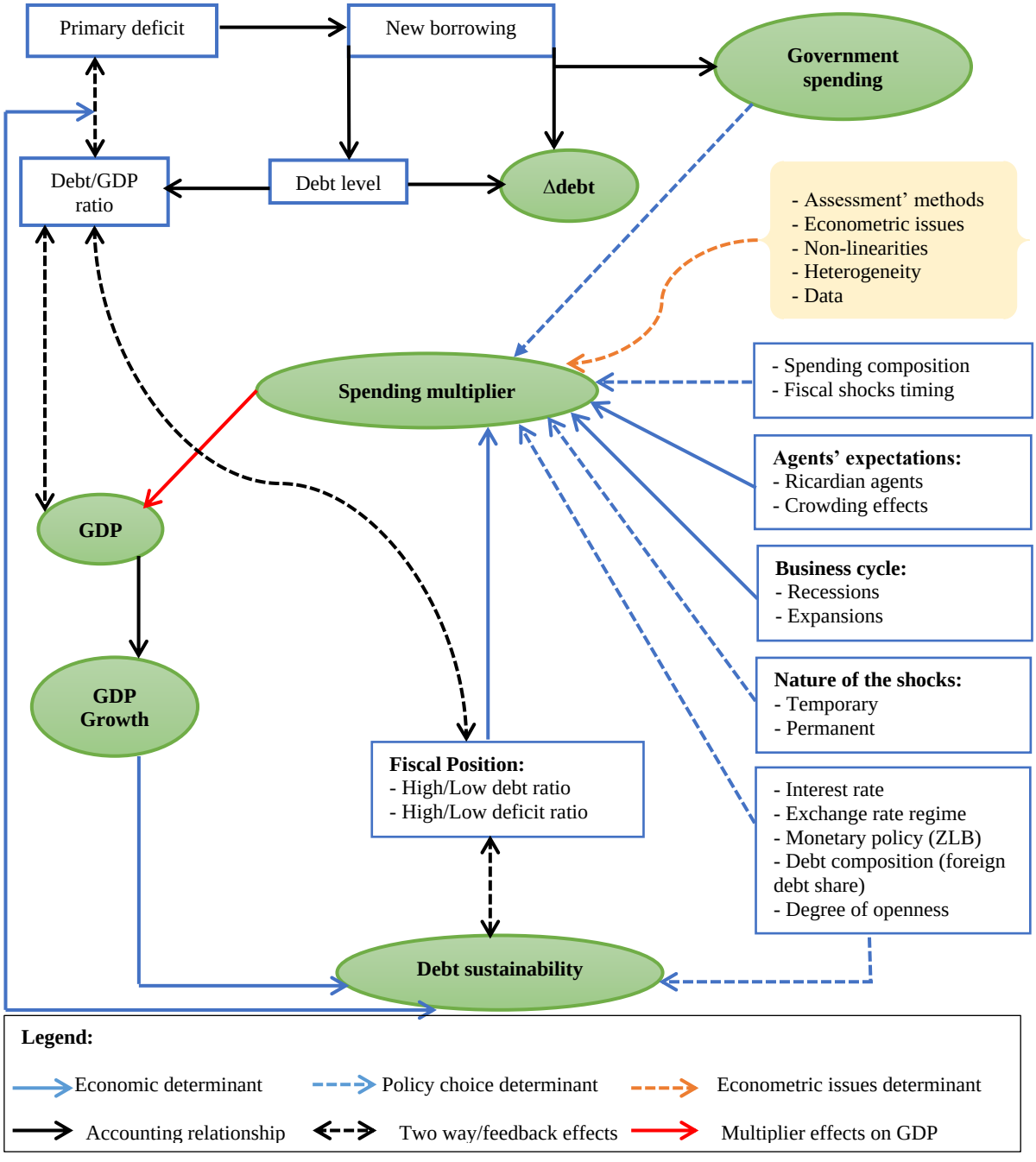
This also triggered much research exploring the factors determining fiscal multipliers and concentrating on the economic and institutional fundamentals of advanced economies. Researchers in this way studied the effects of fiscal position related to the level of debt and deficit ratios, the exchange rate regime (monetary unions), the degree of openness, agents' expectations (foresight fiscal policy), the constrained monetary policy at the ZLB interest rate and hand-to-mouth consumers, among other things. Some have also found contrasting results while trying to explain

[36] Historically, according to Hegeland (1954), the concept of fiscal multiplier goes back at least to the "*Tableau Economique*" of François Quesnay (1758), as mentioned by some authors (Mustea, 2015).

[37] The government spending multiplier for a closed economy under a fixed interest rate is given by: $1/(1-mpc)$ with mpc the marginal propensity to consume.

the reasons for the failure of fiscal stimuli to deliver a fast recovery. Figure 1 presents the debated determinants impacting the fiscal expenditure multiplier and its relationship with public debt and economic growth linkages.

Figure 1: Fiscal spending multiplier determinants and the link to government debt and GDP growth



Source: Author's own construction.

In what follows, as the literature on fiscal multipliers is somehow very rich and large and still evolving, with many different results, we try to highlight some important contributions without pretending to cover all of the literature, particularly the recent works related to the determinants impacting the size of the spending multipliers.

2.1. The state dependency of fiscal multipliers on the business cycle

Some works studied fiscal policy in the pre-crisis of 2008 and proved the linkages between fiscal policy and state dependence. The more recent example is the paper of Tagkalakis (2008),[38] who found, for OECD countries, larger effects of fiscal policy in recessions than expansions, with more emphasized effects in countries with less-developed consumer credit markets.[39] However, since the works of Auerbach and Gorodnichenko (2012), research assessing the effects of fiscal policy, considering the state dependency of the economy, have flourished, especially in the period of the 2008 financial crisis. Among these are the works of Bachmann and Sims (2012), Batini et al. (2012), Baum et al. (2012), Riera-Crichton et al. (2014), Caggiano et al. (2015), Canzoneri et al. (2015). The main result of these papers is confirmation of the dependency of spending multipliers on the business cycle, which is larger during recessions than expansions.

The contributions of Auerbach and Gorodnichenko (2012), which triggered a series of works studying fiscal multipliers during recessions and expansions, use a regime-switching structural vector autoregression (SVAR) methodology to assess fiscal multipliers in relation to the business cycle. They find large size of spending multipliers in recessions than in expansions, making expansionary fiscal policy more effective in times of recession than expansion. Moreover, at the disaggregated level, expenditure shows large differences in fiscal multipliers, with military spending having the largest multiplier. They also show that multipliers tend to increase once the real-time predictions of fiscal variables are controlled.

Also, focusing on the United States case, Caggiano et al. (2015) estimate a non-linear VAR model to assess fiscal multipliers. They show two important results related to fiscal spending multipliers. First, fiscal spending multipliers are greater than 1 in recessions, and, second, they are not necessarily different from, or larger than, those in expansions. The second result opposes the main findings of the previous research, which confirmed that fiscal multipliers are larger in times of recession than expansion. Another important result raised by the authors is related to the non-linearity effects on fiscal spending multipliers, which seem to be emphasized in extreme events manifested by deep recessions or strong expansionary periods. Auerbach and Gorodnichenko (2013) extend the same methodology of Auerbach and Gorodnichenko (2012) to a panel of OECD countries and confirm their earlier results on the average of studied countries.

[38] The author used a panel of 19 OECD countries over the period 1970–2002 to assess the effects of fiscal policy changes on private consumption during recessions and expansions.

[39] This is explained by the presence of individuals facing binding liquidity constraints in a recession that will consume the additional income generated by the fiscal stimulus.

However, considering the discrepancies between countries in terms of the structure and behaviour of the economies, the fiscal adjustments and policy responses and private agents' expectations, and the impacts of all these factors on the multipliers' size, the results of the papers studying a single country or averaging a group of countries could not be transposed to other countries and remain debatable.

In this regard, Batini et al. (2012) and Baum et al. (2012) also confirm that fiscal multipliers tend to be larger in recessions than expansions, but importantly they differ substantially across groups of advanced countries, calling for a fit of fiscal policies and country-by-country assessment of fiscal multipliers. The two papers employ the same methodology of non-linear threshold VAR (TVAR) model. The only difference is that the threshold is endogenously determined by the sign of the output gap in the first paper, and output growth in the second paper. Data is split according to the threshold that separates expansions (positive output gap/growth) and recessions (negative output gap/growth), chosen to maximize the fit of the model and hence allowing different regression slopes for the explanatory fiscal variable. Using the output gap as the threshold variable is argued by the fact that excess capacities are available in the economy under a negative output gap, which reduces the crowding-out effects of private investment in response to government expenditure shocks. Besides, the share of credit-constrained households, adjusting spending in response to a change in disposable income, is higher in recessions. Other studies use output growth or its moving average (Auerbach and Gorodnichenko, 2012). Moreover, according to Bachmann and Sims (2012), the role played by household and firm confidence in the transmission of fiscal policy shocks into economic activity is significant, which emphasizes the evidence of country-specific properties that should be considered when studying the effects of fiscal policy.

Canzoneri et al. (2015), using a model of costly financial intermediation based on Curdia and Woodford (2016),[40] provide evidence of strong state-dependent fiscal multipliers that can exceed the value of 2 in times of recession and may fall below unity during times of expansion. Furthermore, the size of the fiscal multiplier is inversely dependent on the size of the fiscal stimulus, with a smaller amount of fiscal intervention leading to a larger size of fiscal multiplier, and vice versa. According to the author, "*The reason large fiscal interventions are less effective than smaller ones is that the negative marginal wealth effect due to the higher tax liabilities is increasing with the size of the fiscal intervention while the positive marginal effect on the borrowers, from the reduction in the finance premium, is decreasing with the size of the fiscal expansion*" (Canzoneri et al., 2015). Using a regime-switching framework, Arin et al. (2015) also confirmed large spending multipliers for the United States over the period 1949Q1–2006Q4 during

[40] The model is a simple extension of the basic-representative-household new Keynesian model (as developed in Woodford, 2003) of the monetary transmission mechanism, allowing for a time-varying wedge between the interest rate available to households on their savings and the interest rate available to borrowers. This model introduces credit frictions and financial intermediation for the allocation of resources due to the introduction of heterogeneity in the spending opportunities currently available to different households.

economic slowdown, while tax multipliers seem to be larger during periods of economic expansion.

The problem of large multipliers is challenging for fiscal consolidation and austerity measures intending, in times of high public debt, to reduce the latter. In this regard, some papers focus on studying the effects of fiscal consolidation on the public debt ratios, particularly in the short term. For example, Eyraud and Weber (2013) analyse the short-term fiscal multipliers considered to be the key linkages between instruments of fiscal consolidation, economic growth and public debt reduction. They find that, for many advanced countries, fiscal short-term multipliers in the recent financial crisis have been close to 1, judged to be larger than the average of the short-term multipliers observed before the 2008 recession. With the crisis environment of constrained monetary policy, constrained credit agents and depressed external demand, these are likely to raise the debt ratio in the short term under fiscal consolidation, and this could be emphasized if financial markets react negatively to this short-term behaviour of public debt.

Along the same lines, Egron (2018) estimate a threshold VAR for France, confirming the higher value of spending multipliers in recessions than expansions, and therefore warning about the dangerous effects of fiscal consolidation, particularly in the short term, leading to an increase, rather than reduction, in the government debt to GDP ratio. Nevertheless, the above results should be considered carefully with regard to the likely asymmetric effects of an increase versus a decrease in fiscal instruments (more details on this point in Section 2.5).

Furthermore, using an SVAR model for several MENA countries, Bentour (2020) assessed spending multipliers considering the oil price fluctuations. The spending multipliers found to be sensitive to the oil price movements especially for oil exporting countries, being large (more than 2) in time of oil price decrease and weak in time of oil price increase.

With regard to the researchers tending to confirm larger multipliers in times of economic downturn compared to economic booms, some researchers contrast these results (Barro and Redlick, 2011; Ramey, 2011; Owyang et al., 2013). For example, Owyang et al. (2013) find multipliers to be smaller and less than 1. The authors use a large constructed quarterly data set for the United States (1980 to 2010) and Canada (1921 to 2011) and the unemployment rate as a measure of slack considering thresholds of 6.5% and 7% for, respectively, the United States and Canada. For a linear model (no threshold of unemployment considered), either in the United States or Canada, spending multipliers are all below unity and slightly larger in the United States than in Canada. However, in periods of high unemployment (period of slack), multipliers are slightly higher than those in Canada and lower than those in low unemployment rates. For the United States, spending multipliers are always less than 1 and comparable across all regimes.

These clashing results about fiscal multipliers have pushed other economists to dig deeper and control for features related to the economic and institutional regimes of the countries, such as fiscal position, monetary policy stance and exchange rate regimes.

2.2. Fiscal multipliers' dependency on the fiscal position

Since the first wave of studies triggered by the public debt and economic growth threshold idea of Reinhart and Rogoff (2010), fiscal policy effects have also been revised distinguishing the presence of high debt and deficit impacts on fiscal multipliers. Until now, the results of these studies have continued to fuel the debate about such a subject.

Consequently, using a panel of 17 OECD countries (Australia, Austria, Belgium, Canada, Denmark, Finland, France, Ireland, Italy, Japan, The Netherlands, Norway, Portugal, Spain, Sweden, the United Kingdom and the United States), Corsetti et al. (2012) find that output and consumption multipliers are high during times of financial crisis. In particular, for weak public finances corresponding to "*government debt in excess of 100 percent of GDP or net government borrowing above 6 percent of GDP (each lagged once)*", they find that government spending responds negatively to a weak fiscal position, thereby contributing to stabilizing public debt.

Depending on the fiscal position, especially with the presence of high public debt, Bi et al. (2016), adopting a real business cycle (RBC) framework, find that the fiscal multiplier is generally smaller in a high-debt than a low-debt state when general income tax rates serve as an adjustment instrument, but the difference shrinks as the wealth effect on labour becomes strong. Furthermore, uncertainties involving household reactions to the timing and magnitude of the shock, as well as the debt target of fiscal consolidation, also matter. Expecting a higher debt target is not always expansionary, especially when households perceive consolidation to be implemented via adjusting labour tax rates, and expecting a higher debt target produces a positive wealth effect, which reduces the current hours worked and thus offsets positive government spending effects (Bi et al., 2016).

The previous results are in accordance with the findings of Huidrom et al. (2016), which confirm that fiscal multipliers are state-dependent of the fiscal position and tend to be systematically smaller when government debt and deficit are high (weak fiscal position). The authors also show that the fiscal multipliers' dependency on the fiscal position is independent of the business cycle effects. In particular, while the size of the fiscal multiplier tends to be larger in recessions and weaker in expansions, the effects of the fiscal position (weak/strong) apply independently of the economy being in recession or expansion.

In relation to fiscal consolidation under high public debt, Boussard et al. (2012) and Berti et al. (2013) tend to confirm the large effect of fiscal multipliers in times of crisis, which push the debt ratio to increase in response to fiscal consolidation, particularly in the short to medium term. However, these undesired effects on the debt dynamics are judged to be short-lived unless these large multipliers persist over time, which may be caused by non-credible fiscal adjustments and the very high (abnormal) impact on interest rates and sovereign yield. These two publications report "critical" fiscal multipliers, defined as "*multipliers that can then be defined as the value of the multiplier for which a fiscal shock would leave the public debt ratio unchanged (while a multiplier higher than the critical value would entail a short-term increase in the debt ratio)*".

They show that these multipliers are inversely correlated to the change in debt ratio. According to the authors, the true fiscal multiplier could be higher than the critical multipliers, especially for a group of highly indebted countries, namely, Belgium, Bulgaria, the Czech Republic, Ireland, Greece, Spain, France, Italy, Cyprus, Lithuania, Hungary, Portugal, Slovenia and the United Kingdom.

Moreover, Blot et al. (2014b) simulate the dynamic path of public debt and output, under fiscal consolidation, using a simple macroeconomic model for 11 eurozone countries and considering time-varying fiscal multipliers. They analyse the ability of EMU countries to reach public debt ratios below the threshold of 60% in 2032 to comply with the new fiscal rules of the EMU Stability and Growth Pact. The revised Stability and Growth Pact, which was signed in 2012, outlines converging (from an average level of debt ratios of around 80% across the eurozone in 2012) to a 60% debt to GDP ratio, by 1/20th of the adjustment yearly, which allows until 2032 to achieve the target. In this way, Aussilloux et al. (2018) make an exercise of simulation on public expenditure reduction for France, expecting that the public debt to GDP ratio could decrease by 25 points from 100% currently to 75% in 2040 for a best-case scenario of fiscal consolidation.

Canzoneri et al. (2015) and Broner et al. (2019) consider studying the type of financing spending to impact fiscal multipliers in times of economic downturn. Canzoneri et al. (2015) find that either tax-financed or debt-financed spending leads to multipliers that are higher than those in recessions, with the multipliers being much larger for debt-financed than tax-financed spending. According to the authors, "*The reason is that while higher government spending sets in motion the financial accelerator, higher taxes partly counter this by reducing the quantity of funds available to financially constrained individuals*". Broner et al. (2019) study fiscal multipliers, considering the portfolio of foreign public debt for a panel of 17 advanced countries from 1980 to 2014. In this case, they reveal that fiscal multipliers are stronger when the expenditure is financed by foreign resources. Their size increases, in particular, with the share of foreign public debt and is larger than unity in periods and countries with a high foreign share of public debt (as in the United States and Ireland today) and smaller than those in the opposite case (as in the United States in the 1950s and 1960s, and Japan today).

Moreover, Poghosyan (2017) studies the way that the public debt cycles interact with financial cycles for 57 advanced and emerging economies over the period 1960–2014. He finds that public debt cycles are asymmetrically linked to financial cycles in the way that public debt expansions that are preceded by fuelling in credit and financial markets are longer than any other expansions, while there is no substantial association between public debt contractions and financial cycles.

Afonso and Leal (2018) compute fiscal multipliers for government expenditure in the eurozone for quarterly data over the period 2001–16, using a structural VAR model. They consider the state of the economy, particularly the reaction to the public debt level, the pace of economic growth and the output gap. Government expenditure multipliers accumulate to less than 1 over a year (0.64

yearly and 1.1 after two years), while tax multipliers are negative. Moreover, expenditure multipliers are larger for countries with higher public debt levels during recessions (compared to low public debt levels where the multiplier is close to 0) and in countries showing positive output gaps.

In contrast to the previous findings about the effects of fiscal position on fiscal multipliers, very recently some new studies have minimized the effects of the fiscal position on fiscal multipliers and then minimized the effects of high public debt on reducing the benefits of fiscal expansion in advanced economies (Auerbach and Gorodnichenko, 2017; Perdichizzi, 2017; Blanchard, 2019). For example, using a non-linear panel VAR model controlling for the macroeconomic properties of 12 eurozone countries over 1985–2015, Perdichizzi (2017) find that fiscal spending multipliers are insensitive to the level of government debt. Furthermore, these multipliers are larger in times of recession for countries with low degrees of trade openness, high deficit and fixed exchange rate regime, compared to countries with high degrees of trade openness, low deficits and flexible exchange rate regime.

Auerbach and Gorodnichenko (2017) also produce interesting results on this issue for 17 OECD countries. First, the government spending shock effects depend on a country's position in the business cycle, with the fiscal multipliers being larger in times of bad economic conditions than good ones. Second, fiscal expansion while the economy's fiscal position is weak is likely to boost economic output and reduce the debt to GDP ratio, as well as appeasing interest rates and CDS spreads on government debt. Consequently, these findings suggest that fiscal stimulus under a weak fiscal position is likely to boost the economy without worrying about the associated modest cost. However, these results should be considered with caution, as the authors themselves argue, based on the asymmetric effects of fiscal policy shocks (see discussion in Section 2.4).[41] The authors call for more detailed research on this issue using more frequent and variable data on public debt and more disaggregated categories of government spending, as well as structural models for clearer policy recommendations. Besides, Alichi et al. (2019) consider the size of the country and focus on estimating government spending effects for 23 small countries across the world. They conclude that fiscal policy in small countries using government primary spending is ineffective at stimulating the level of GDP over the medium term compared to government spending. However, in the short term, multipliers for government current primary spending are higher and sensitive to the level of government debt, the position of the economy in the business cycle, as well as imports as a share of GDP, among other factors.

[41] These results should be interpreted with caution, as the authors argue themselves, because of the problem of asymmetric effects "*… we recode fiscal shocks series so that the sign of the shocks is negative whenever the shocks take a nonzero value and thus estimated impulse responses show dynamics after an increase in government spending. This recording may be problematic since the effects of government spending cuts are not necessarily symmetric to the effects of government spending increase… thus one should bear in mind the caveat that, although we interpret results as showing responses to increases in government spending, the estimated responses are only based on cuts in government spending*" (Auerbach and Gorodnichenko, 2017).

Along the same lines, in analysing the fiscal and welfare costs of higher debt with reference to the United States, where the safe interest rate[42] is less than the growth rate, Blanchard (2019) argues that both the fiscal and welfare costs of debt may be smaller than assumed in current policy debates. Blanchard (2019) seems likely to draw the same conclusions for European economies. His results have triggered a debate, which have been contained until now in economist blogs and some media. This new paper about debt cost nevertheless warns that the cost of austerity measures driven by the fear of high debt is likely to hurt more than the cost of debt build-up, since actual data shows that the interest rate differential/gap growth rate minus interest rate is positive enough to stabilize the public debt ratio while maintaining a small primary deficit. In this case, two important points are worth mentioning. First, the Committee of a Responsible Federal Budget (CRFB), in response to Krugman's "misinterpretation" of Blanchard's (2019)' conclusions, outlined that Blanchard's (2019) conclusions are correct if the primary balance in the United States is small, but the American economy is running a huge primary deficit.[43]

The second point highlights some arguments and counter-arguments of potential debt finance. The arguments that Blanchard (2019) reports in favour of potential debt finance (standing against fiscal consolidation) are: revised large multipliers, debt hysteresis, higher marginal product of public capital and necessary budget deficits to stimulate demand in the context of constrained monetary policy. Alternatively, the counter-arguments about the potential costs of public debt are as follows: the safe interest rate may be artificially lower than the observed one (which could happen in the case of liquidity discount); the future may be different to the past because of many factors related to total factor productivity (TFP) and an ageing population; and the last counter-argument relies on the existence of multiple equilibria.

However, while some enthusiastic supporters of fiscal stimulus welcome the message of this paper (Krugman, 2019),[44] this has not been commonly agreed by other economists, as historical data showed the opposite for the most important European economies (Mazza, 2019; Philippon, 2019).[45] This paper, while minimizing the effects of high public debt when the safe interest rate is below the nominal GDP growth (which is the case for many advanced economies), is likely to re-fuel the debate about public debt effects, and Blanchard (2019) himself argues that this should not be taken as an invitation for more debt rollover and calls for more investigation on this issue.

[42] Blanchard (2019) uses the terminology "safe interest rate" to describe, depending on the situation: the risk-adjusted rate of return on capital or the interest rate on nominal bonds (assuming no default).
[43] See http://www.crfb.org/sites/default/files/CRFB_DoNotMischaracterizeBlanchard.pdf.
[44] https://www.nytimes.com/2019/01/09/opinion/melting-snowballs-and-the-winter-of-debt.html.
[45] http://bruegel.org/2019/01/is-public-debt-a-cheap-lunch/ and https://www.stern.nyu.edu/experience-stern/faculty-research/true-cost-public-debt.

2.3. Fiscal multipliers in a constrained monetary policy and exchange rate regime

Just before the financial crisis, economists seemed to agree on the powerful role of monetary policy as a stabilization instrument, eclipsing, to some extent, the role of fiscal policy. However, conventional monetary policy effectiveness is impaired when the interest rate hits the ZLB rate or when it loses its independence because of a currency pegged to another country.[46] In these cases, fiscal policy is more desirable.[47] In assessing the effects of fiscal policy in the case where monetary policy is constrained by the ZLB interest rate (also called the liquidity trap), or by the fixed exchange rate, as when the country participates in a monetary union, the new Keynesian modelling framework is more desirable than other forms of modelling in assessing the effects of fiscal policy.[48]

Previous important contributions on the effects of zero interest rates have been conducted by many authors in the context of new Keynesian dynamic stochastic general equilibrium (DSGE) models, which have their basis in the real business cycle (RBC). Therefore, Eggertsson and Woodford (2003) and Eggertsson (2011) conduct simulations of an economy with a zero interest rate and find a large effect of temporarily increasing government spending in this situation, much larger than under normal circumstances. Numerical evidence conducted by Eggertsson (2011) suggests a spending multiplier that could attain five times the spending multiplier in normal circumstances.

In the same scope of new Keynesian models[49] used in analysing monetary stabilization policy, Woodford (2011) finds that under the severe conditions of a great depression and a lower interest rate, near 0, these models are likely to report larger multipliers, higher than 1, which, to some extent, may also increase welfare. In this situation, an increase in government spending could have a powerful effect, such as offsetting the negative output gap. However, in less severe circumstances, the fiscal policy through expenditure tool is less powerful, even in the case of a binding constraint of a zero interest rate, especially when the disturbance implying it to bind is expected to be transitory. In such a case, although the spending multiplier could stand above unity in such circumstances, it is viewed as insufficient to eliminate the negative output gap. Similarly, Christiano et al. (2011) base their analysis on a new Keynesian DSGE model to argue that the

[46] Before the financial crisis of 2008, researchers studying the constraint of the zero interest rate policy were inspired by the real situation of the Japanese economy, where the interest rate has nearly touched zero since 1995, accompanied by anaemic economic growth (Eggertsson and Woodford, 2003).

[47] Farhi et al. (2013) show that both a uniform increase in import tariff and export subsidy, and a VAT tax increase and uniform payroll tax reduction, can play a role equivalent to exchange rate devaluation (which is mentioned as fiscal devaluation). However, when these policies are anticipated by economic agents, they need to be supported by consumption tax reduction and income tax increases.

[48] For example, Correia et al. (2012) use a standard new Keynesian model to assess the fiscal policy when the conventional monetary policy is constrained by the ZLB nominal interest rate. They show that tax policy (distortionary taxes) can deliver similar expected benefits to the monetary policy (being constrained in this case).

[49] Woodford (2011) reviews the benchmark of the neoclassical models, assuming perfect flexibility of prices and wages, leading generally to spending multipliers of less than 1. The author also inferred cases under which the new Keynesian DSGE models could lead to spending multipliers greater than, equal to or below unity.

government-spending multiplier can be large when the ZLB on nominal interest rates binds, except when the central bank is committed to a Taylor rule, in which case the spending multiplier is smaller than 1. Likewise, in the ZLB, the value of the multiplier is positively related to both the fraction of government spending, as well as the expected duration of the zero bound constraint. Consequently, efficient government spending should fall in line with the state of the ZLB interest rate.

For countries participating in a monetary union, Kilponen et al. (2015) simulate fiscal consolidation effects for 15 structural models from national central banks (NCBs) in the euro area and the ECB (of which 14 out of 15 have a new-Keynesian dynamic general equilibrium framework). They find that short-term multipliers are, in general, negative and smaller than 1 in absolute value, independent of the fiscal instrument, the studied country and the duration of the fiscal shock, with tax multipliers typically smaller in absolute value than government consumption multipliers. However, for permanent fiscal shocks, the short and long-term effects depend on the fiscal instrument, which acts endogenously to stabilize the long-term public debt path. Furthermore, the simulated short-term multipliers seem to be insensitive to the ZLB exchange rates, except when simultaneous fiscal consolidation is implemented across the euro area as a whole.[50] In this case, short-term government consumption multipliers become larger than 1. This result stays valid for non-euro area countries, for which monetary policy is independent and domestically determined.

Furthermore, Farhi and Werning (2017) differentiate between the fiscal multipliers resulting from liquidity traps from the ZLB interest rate and those arising from the currency union, using a standard new Keynesian model but also considering Ricardian and non-Ricardian (hand-to-mouth) agents. They particularly highlight the differences in fiscal multiplier values in the ZLB case and those in the situation of a monetary union. In the first case (the liquidity trap due to the ZLB interest rate), in the standard Ricardian model (generally assuming Ricardian agents), fiscal multipliers are always larger than 1 in liquidity traps. According to the authors, the mechanism is insured through inflation: higher government spending during liquidity traps stimulates inflation, and with a fixed nominal interest rate the real interest rate is reduced, which increases current household consumption. However, for a country in a monetary union, in the standard Ricardian model, assuming price flexibility, the crowding-out effects of government spending on private consumption, as well as domestic inflation spurred by government spending, which induces a loss of competitiveness and depresses private investment, drags down the multiplier to less than unity.[51]

[50] As the aim of fiscal devaluation is improving competitiveness when the monetary policy is constrained to do that via the exchange rate devaluation (as in the case of monetary union), and while the competitiveness of a country is enhanced at the expense of the other countries, simultaneous fiscal reforms targeting fiscal devaluation are likely to cancel/compensate the effects of fiscal devaluation between countries (European Commission, 2013).

[51] According to Farhi and Werning (2017), "*the liquidity trap analysis implicitly combines a shock to government spending with a one-off devaluation. The positive response of consumption relies entirely on this devaluation. A currency union rules out such devaluation, explaining the difference in the response of consumption*".

In contrast to the previous results, Glocker et al. (2019) do not find the fiscal spending multipliers to be affected by the ZLB interest rate. They only report, using a time-varying parameter factor augmented vector autoregressive (TVP-FAVAR) framework for the United Kingdom, that fiscal multipliers are timely and cyclically variant: in particular, they are larger in times of recession (more than unity) and lower in times of expansion (less than unity). Moreover, and contrary to research showing "non-Keynesian multipliers" (i.e. inferior to 1) for countries participating in a currency union, Combes et al. (2014) use panel VAR (PVAR) on quarterly data over the period 1999–2012 to assess the effect of fiscal multipliers on European countries. They reveal that spending multipliers can be larger than 1, especially for countries that are members of the eurozone, or for those expecting to join it. Furthermore, these multipliers tend to be higher in the group of euro countries affected by the 2008 crisis compared to the benchmark of the eurozone countries.

As previously revealed in Section 2.2, spending multipliers are also sensitive to the way they are financed. Spending multipliers are much larger when they are debt-financed compared to when they are tax-financed (Canzoneri et al., 2015), and they are also much higher when they are financed by foreign rather than domestic debt (Broner et al., 2019). Along the same lines, and within a monetary union, (local) fiscal multipliers are also sensitive to the transfers from outside regions/countries for a country participating in a monetary union. Particularly, fiscal multipliers seem to be large (and may even be larger than 1) when there are fiscal transfers from outside regions or countries (Farhi and Werning, 2017; Auerbach et al., 2019).[52]

The degree of openness also plays an important role in this issue, with more closed economies having larger fiscal multipliers than more open ones. This happens particularly in the short term and incomplete financial markets, as prices that are not fully adjusted push up demand for home goods, which stimulates output. Furthermore, the persistency of the fiscal shocks increasing the magnitude of the fiscal multipliers is due to the agents' willingness to save more from foreign fiscal transfers in temporary shocks expecting future lower periods of transfers. Previous to Farhi and Werning's (2017) work on regional multipliers, Nakamura and Steinsson (2014) find that regional fiscal multipliers in the United States, related to military expenditure, are strongly dependent on the business cycle. Using data on military procurement spending across US regions, they estimate a government spending multiplier in a monetary union of approximately 1.5. Erceg and Linde (2012) use a new Keynesian DSGE model for a relatively small open economy to study the effects of fiscal consolidation for a monetary policy constrained either by a monetary union affiliation or by the ZLB on policy rates (for a country with an independent monetary policy). The

[52] Farhi and Werning (2017) distinguish between local fiscal multipliers due to local government spending only and the overall fiscal multipliers, which consider in the model not only local government transfers but also the possibility of transfers from other countries or regions in the currency area (for example, in the US, federal military spending allocated to each state is financed by the federal budget). This may explain, in part, the difference between the Unites States' relatively fast recovery compared to the eurozone countries, as these fiscal transfers are almost absent between eurozone countries. The allocated federal budget is roughly 1% in the eurozone, while it is around 20% in the United States (Feyrer and Sacerdote, 2013).

impacts of fiscal consolidation differ between the two cases, with differences depending particularly on the persistency time of the ZLB (generally more than two years) and on the inflation responsiveness to output gap. Principally, for a sensitive inflation to output gap, fiscal consolidation is more contractionary under the ZLB rate than under currency union.

2.4. The impact of the assessment methods

Despite the growing body of literature on fiscal multipliers, their estimation remains very challenging. Generally, methods mostly employed for assessing fiscal multipliers are of three types: first, structural macro-econometric models; second, the multivariate time series, especially the standard vector autoregressive model and its derivatives of linear and non-linear types (structural VAR, threshold VAR, etc.); and, third, the new Keynesian DSGE models.

Macroeconomic structural models were thoroughly developed by public and government institutions, as well as academicians, in the post-war period and are still largely used in fiscal policy analysis.[53] These are based on works associated with the Cowles Commission programme, based on Keynes' general theory and the relative consensus around the IS-LM framework and econometric tools to estimate the structural parameters. Large-scale models were developed following the first attempts to model the United States economy by Tinbergen (1939), Klein (1950) and Klein and Goldberger (1955).[54] These kinds of model, however, were exposed to two important critiques by Lucas (1976) and Sims (1972, 1980).[55] Lucas highlighted in his critique the inability of econometric models to catch structural breaks in the behaviour of economic agents vis-à-vis monetary policy changes. He expressed this critique as follows: "*Given that the structure of an econometric model consists of optimal decision rules of economic agents, and that optimal decision rules vary systematically with change in the structure of series relevant to the decision maker, it follows that any change in policy will systematically alter the structure of econometric models*" (Lucas, 1976).

Sims' (1972, 1980) critique is directed at exogeneity, causality issues, parameter identification and hypotheses testing. The contributions of the VAR approach to economics science are well

[53] For example, Coenen et al. (2012) simulate government spending multipliers under seven structural models from six institutions, namely, the European Commission (QUEST), the International Monetary Fund (GIMF), the Board of Governors of the Federal Reserve System (with two models, FRB-US and SIGMA), the Bank of Canada (BoC-GEM), the European Central Bank (NAWM) and the OECD (OECD Fiscal). The models tend to produce sizeable output multipliers of expenditure and targeted transfers, especially under accommodative monetary policies, although permanent fiscal stimulus can significantly lower such multipliers.

[54] See also, for example, Fox (1956) and Chinn (2013) for a complete literature review.

[55] The Lucas critique has revolutionized macroeconomics science by developing many theories such as the theory of rational expectations, which won him the 1995 Nobel Prize, the development of the "time inconsistency" problem by Kydland and Prescott (both Nobel Prize winners in 2004) and the important contribution of Thomas Sargent over the credibility of economic policies. Thomas Sargent also contributed to much empirical research in line with Cristopher Sims, with whom he shared the 2011 Nobel Prize for their contribution to cause and effect in macroeconomics.

summarized and synthesized, for example, in Hoover el al. (2008) or Gossé and Guillaumin (2013).

Following these critiques, Sims (1980) brought the vector autoregressive (VAR) models and their utilization to diverse applications as an alternative to the macroeconomic structural models. Their strength resides in their simplicity and robust application, especially in forecasting, compared to structural models. However, these models have also attracted many critics, especially the famous Lucas (1976) critique. The third type of models based on the real business cycle (RBC) neoclassical model, are the new Keynesian DSGE models (due to the new synthesis theory), largely developed and used in recent years by central banks and monetary institutions. Kydland and Prescott (1982) first confronted the theory with data through the application of calibration methods to real business cycle (RBC) models, avoiding the option of fully econometric estimation, as did the pioneer of structural models.

All these methods have been criticized for caveats on their technical and conceptual design in analysing fiscal policy effects. For example, Cogan et al. (2010) highlighted the role played by the quantitative models in evaluating fiscal policy. In particular, government spending multipliers in the recently used new Keynesian models tend to be much smaller than in the old Keynesian ones. This conclusion came after simulating a new Keynesian model based on the core model of Smets and Wouters (2007) for the United States and comparing its results to those of Romer and Bernstein (2009), which are based on an old Keynesian model for the same country. They conclude that the models used to assess fiscal policy effects lack robustness and consensus in their results, in which there are stark differences. Their new Keynesian model showed fiscal multipliers and job impact six times smaller than those found by Romer and Bernstein's (2009) old Keynesian model. The principal challenges remain in many differences in assumption, economic issues, as well as econometric and statistical aspects. Generally, the drawbacks and caveats of the new Keynesian models have been discussed in the recent literature, as reported in Chapter 3 (Section 2.4).[56]

The difference in assumptions, as well as their structure, greatly impacts the size of the multipliers between these three classes of models. Changing assumptions in the same class of models may also lead to a sizeable change in fiscal multipliers. For example, assuming complementarities between public and private capital in the neoclassical RBC models leads to higher spending multipliers than the modest values without this assumption (Baxter and King, 1993). Under its standard framework, the new Keynesian DSGE model leads to smaller spending multipliers, while relaxing some assumptions, such as the presence of the ZLB interest (Christiano et al., 2018; Galí, 2018), or the relaxation of the Ricardian equivalence assumption in favour of "hand-to-mouth" agents (Farhi and Werning, 2017), leading to an increase in spending multipliers.

[56] In addition, a section of Chapter 3 (in the literature review) also summarizes the critiques of the neoclassical models (overlapping generation models and infinitely lived agents), as well as the new Keynesian models (DSGE models).

From an economic perspective, agents' expectations ("fiscal foresight") about future spending and tax policies, the monetary policy reaction, the exchange rate regime, the degree of openness, the state of the economy and the fiscal position (high/low public debt and deficit) are examples of the economic determinants making it difficult to deduce the fiscal multiplier, especially given that, remembering the definition, the fiscal multiplier measures the effects of an exogenous distortionary fiscal instrument on the level of the output. From an econometric and statistical perspective, many problems arise when calculating fiscal multipliers. Important issues are the endogeneity of government spending and non-linearities created by extreme changes, especially in times of extreme events (high expansions or severe downturns). The accuracy of the data and its availability on a disaggregated level is also an important determinant of the correct multipliers' size (Ramey, 2018).

For example, Parker (2011) warned against the impact of the methods and the lack of accurate data used to gauge the effects of fiscal policies through multipliers, especially the use of linear dynamic forms represented by the vector autoregression models and linearized dynamic stochastic general equilibrium models. Accordingly, ignoring the state of the economy (the business cycle) leads to multipliers representing a weighted average of the phases of the cycles over the studied period, which is lower than those estimated in recessions and higher in those emanating from expansions. These caveats can be resolved, according to the author, by considering partial-equilibrium response estimations on a microeconomic level rather than macro and aggregated data. Along the same lines, Canzoneri et al. (2015) highlighted that studies assessing fiscal multipliers, without distinguishing between recessions and expansions, lead to spending multipliers around unity, while these multipliers could reach more than 2 during recessions and only around 0.5 during expansions.

The new Keynesian models have been criticized for assessing the fiscal multipliers (see also the critiques of this type of model for their assessment of debt effects in Chapter 3, Section 2.4). The new Keynesian DSGE models rely principally on many assumptions that are hard to realize in reality, for example, the assumption about the behaviour of agents generally supposed to be Ricardian, with rational expectations, as well as their poor performance in the recent crisis (Chatelain and Ralf, 2012; Wieland et al., 2012; Blot et al., 2014b). Furthermore, these models are unable to deal with non-linearities of fiscal multipliers over the business cycle (Blot et al., 2014b).

Furthermore, modelling behaviour is not straightforward. The heterogeneity of economic agents' behaviour adds complexity to the adopted modelling approach conditioning the fiscal policy assessment. For example, Farhi and Werning (2017) distinguish between Ricardian and non-Ricardian consumers that could affect the size of the fiscal multipliers. Particularly, in a non-Ricardian model where "hand-to-mouth" consumers are considered, marginal propensities to consume are different between Ricardian and non-Ricardian groups of agents. This leads to additional effects of government spending increasing output, whether in a liquidity trap or in a currency union, due to the incidence of taxes, the timing of taxation (on the non-Ricardian agents)

and redistribution from Ricardian agents with low marginal propensity to consume permanent-income to non-Ricardian agents with high marginal propensity to consume. Accordingly, this may raise the multipliers above 1 for a country within a currency union (Farhi and Werning, 2017).

Another issue that is mentioned in the literature belongs to the "fiscal foresight" policy shocks (Forni and Gambetti, 2010; Mertens and Ravn, 2010; Leeper et al., 2012, 2013). The standard VAR models assess the effects of fiscal policy shocks from current and past information from the data of fiscal variables involved, and they are unable to embed/incorporate the so-called information on "fiscal foresight" policy shocks, that is, shocks related to agents' anticipations/expectations on government fiscal policy spending (Caggiano et al., 2015). For example, Caggiano et al. (2015) address this issue by considering state-dependent fiscal multipliers, taking explicit information on such expectations using a measure of anticipated information ("news") on fiscal spending shocks and a group of macro-fiscal variables from the Survey of Professional Forecasters.

For the non-linear effects and behaviour of fiscal relationships, Fotiou (2019) uses a mix of the two methodologies of Auerbach and Gorodrichenko (2012) of the STVAR[57] model and the methodology of Nickel and Tudyka (2014)[58] to study non-linear effects on fiscal multipliers for a panel of 13 countries during 1980–2014. According to the author, non-linearities arise from, first, the state of the economy (recessions versus expansions), second, the composition of the fiscal policy, and, third, the government's fiscal position (high debt ratio versus low debt ratio). He finds that the initial level of debt and the composition of the fiscal adjustments are the most relevant sources of non-linearities. Furthermore, for this author, tax-based consolidation tends to be self-defeating whenever debt is high. Casalis (2017) also studies the effects of non-linearities controlling for public debt and financial cycles. He reports that non-linearities produce more queries than answers for policy advice and that comparing results is likely to be misleading in this environment.

2.5. Do we need a consensus about a unique fiscal multiplier size for all countries?

Despite the important flux of studies about fiscal multipliers, these studies show more uncertainties than certitude about their size. The differences in methods, as well as samples of countries and time periods, play an important role in this issue. Recently, Ramey (2018) summarized the main research outcome on fiscal policy since the 2008 financial crisis. According to the author, average fiscal spending multipliers vary in a narrow range between 0.6 and 1. However, there are economic circumstances where spending multipliers lie outside this range, as well as the impact of approaches used to assess those multipliers. In particular, this range may widen if country

[57] STVAR stands for smooth transition vector autoregressive, which uses a regime-switching model.
[58] Nickel and Tudyka (2014) consider fiscal position in assessing fiscal multipliers by incorporating debt ratio as an interaction term in the panel VAR, which is indicated as interacted panel VAR (IPVAR).

characteristics, such as the exchange rate regime, and the type of government spending are considered.

Along the same lines, Parraga Rodriguez (2018), following an SVAR framework, finds that government spending multipliers and income transfers multipliers in the United States are by far below 1 in the short term (approximatively 0.2). However, compared to government fiscal income transfers multipliers that can reach more than 1 in the long term, the spending multipliers cumulate only to 1 in the long term. Ramey and Zubairy (2018), focusing again on the case of the United States, as the single country case for which multipliers are most evaluated in the literature, examine whether the government spending multipliers are sensitive to the zero bound interest rate and the business cycle in the economy.

For Ramey (2018), concluding that the average of fiscal multipliers (spending) reported in the previous literature is low and ranges between 0.6 and 1, averaging fiscal multipliers without distinguishing between the sign of the fiscal shocks[59] is misleading. Indeed, and surprisingly, to our best knowledge, this flux of very recent studies does not seem to distinguish between multipliers drawn from negative shocks and those from positive shocks, leading us to understand that the effects are similar in the two situations. For example, some studies may draw conclusions on the effect of fiscal multipliers, from fiscal austerity and fiscal consolidation, as if they were the same as in fiscal stimulus, thereby admitting the symmetrical effects in the two opposed shocks. One of these studies, Ramey and Zubairy (2018), draws the following conclusion "*... If multipliers are indeed this low, they suggest that increases in government purchases do not stimulate private activity and that fiscal consolidations based on reducing government purchases are unlikely to do much harm to the private sector*". Ramey (2018) also does not seem to distinguish between these situations (fiscal consolidation and fiscal stimuli) in averaging the fiscal multipliers reported in the previous studies. Another study, by Blot and al. (2014b), concludes that "*... Recent mainstream literature has emphasized that fiscal multipliers may notably be higher in time of crisis. Then, not only would fiscal consolidation drag down growth more severely, but it could even be self-defeating*".

In line with the literature studying fiscal multipliers' dependency on the business cycle, Ramey and Zubairy (2018) study the state dependency of fiscal multipliers, involving, at the same time, the zero lower bound for the United States. They contrast the findings of the previous research in line with Auerbach and Gorodnichenko (2012; 2013) and report multipliers ranging in a narrow band between 0.6 and 1. The higher magnitude of the fiscal multipliers in the zero lower bound is also of little evidence in Ramey and Zubairy (2018).

[59] For example, the distinction should be made between positive expenditure shocks (fiscal stimulus) and negative shocks (austerity measures). The outcome of the fiscal policy is different under the two scenarios and depends on the economic environment and countries' economic fundamentals.

Ramey and Zubairy's (2018) results should be considered with caution, especially with regards to their data set. Indeed, while they have the advantage of pointing to their long history and more frequent data for the United States (sample between 1889 and 2013), half of the period sample is constructed for the World War periods and before (1889–1946) and interpolated using different methods in four different sub-periods.[60] This quarterly constructed data could imply serious problems of accuracy and may have serious problems for the calculated multipliers. This may explain the difference between results where the multipliers seem to be larger in the post-war period when omitting the initial period (although they suggest that these multipliers are not statistically strongly significant). Furthermore, Ramey and Zubairy (2018) use narrative methods to extend Ramey's (2011) defence news series in order to identify shocks that are unanticipated and exogenous to the state of the economy.[61]

Important exceptions to these papers are Baum and Koester (2011) and Riera-Crichton et al. (2014), who mention that government spending is not necessarily acting counter-cyclically (going up in times of recessions); rather, it could be, as is the case in many industrial economies, pro-cyclical (decreasing). In this paper, the authors control for the sign of fiscal shocks (increase or decrease in government spending), as well as the size of the fiscal intervention, rather than distinguishing only between recessions and expansions. Their analysis reveals that fiscal expansions are much more expansionary in recession periods than in expansion periods. Using a threshold SVAR (TSVAR) to account for non-linearities, Riera-Crichton et al. (2014) find that the long-term multiplier for bad times and an increase in government spending is around 2.3 higher than the value of 1.3 if we control for recession only and expansion is considered. However, using the same methodology of threshold VAR, Baum and Koester (2011) find that public expenditure multipliers vary depending on the size of the shock, its sign and the level of the output gap. Consequently, a positive fiscal shock (increase in government expenditure) in crisis periods leads to a higher spending multiplier, and the latter increases with the size of the fiscal shock. However, in good times, multipliers are lower and seem to behave more linearly.

To sum up this section, the wide spread of results about the size of spending multipliers leads us to conclude that these multipliers, despite their simple definition, reflect:

1- The difference of methods and models used to assess these multipliers: with the same data, and on a single country (the United States, for example), researchers find different results whether the used model is a structural model, a new Keynesian DSGE model or a (non-)

[60] The time series are the real GDP, the GDP deflator, government purchases, federal government receipts, population, the unemployment rate, interest rates and defence news. The time series data is interpolated using different techniques depending on the series over the period 1889–1946 and its sub-periods. They follow Gordon and Krenn (2010) by using various higher-frequency series to interpolate existing annual series. Generally, the proportional Denton (1971) procedure, resulting in series that average up to the annual series, is used in the interpolation. This method is robust (Chen, 2007) and recommended in IMF or Federal Reserve Bank publications (Liu et al., 2011; Woo et al., 2013).

[61] The news series is linked to government spending due to political and military events and is likely to be independent of the business cycle. This is an important difference from and other papers using the output gap and economic growth as the instrument variable to determine the turning points of the business Auerbach and Gorodnichenko (2019) cycle.

linear VAR/SVAR model. The assumptions and features, as well as the methods of solving the three types of model, vary widely.

2- The difference in macroeconomic fundamentals of the studied countries, although the most advanced countries share, to some extent, the same level of development and qualified institutions, fiscal policies effects may differ regarding the difference of monetary policy and exchange rate regimes, as well as economic conditions (the business and/or the financial cycle), as represented by the levels of debt and deficit, for example. Other determinants could play an important role as the degree of openness.

3- Consequently, all the differences in empirical results should not be seen as an incongruity between economists. It is a fact rather than a general theory that should apply to all countries. In this regard, a good way to study the effects of fiscal policy is to avoid considering the empirical results of one country or a group of countries as a universal benchmark for all countries. Therefore, studies of fiscal multipliers should be undertaken at country level and avoid drawing conclusions from a single country such as the United States, Japan, the United Kingdom or Germany. When it comes to assessing things empirically, each country's data set represents its own model of economic development and experience across a period of that country, and if this is not even valid to reproduce the future of this economy itself, it is hardly transposable to a different country.

Whether in fiscal stimuli or fiscal consolidation, accurately estimating fiscal multipliers by type of expenditure helps policy-makers to know what categories of spending they should increase (in fiscal stimuli) or cut (in consolidation). The next section undertakes calculations of government spending multipliers in a sample of advanced countries.

3. Methodology

In our empirical investigation, we use a sample of 18 advanced countries over different periods of time, a panoply of structural vector autoregressive (SVAR) models to assess the fiscal expenditure impacts on the output. We especially test how the business cycle could affect expenditure multipliers, as well as the way accumulating public debt and reducing public debt are impacting the size of the expenditure multipliers. In what follows, we display, first, a detailed methodology of an SVAR model, particularly, its formulation, lag selection and identification of shocks. Second, we discuss the identification restrictions for the considered VAR models linking government expenditure with GDP, augmented exogenously by a dummy variable that controls for the business cycle (expansion/recession) and the public debt evolution (accumulation/decumulation), hence noted an SVAR-X. We also endogenize the public debt variable instead of its exogeneous effects, making a tri-variate VAR of government expenditure, debt and GDP. This model is also controlled for the business cycle impacts.

3.1. The general methodology of a VAR/SVAR model

The vector autoregressive (VAR) methodology was popularized by the works of Sims (1972, 1980) following the debate between monetarists and Keynesians on exogeneity and causality issues. In particular, Sims (1980) points out that the structural models of the Cowles Commission have too many theoretical hypotheses that have not been empirically tested, and he presents the VAR models as an alternative to these models. However, the standard VAR models, which are reduced forms, do not integrate the structural model's simultaneity where there is instantaneous feedback between two endogenous variables (Desai, 1981). In particular, conditional correlations assimilated with a causal order in the case of the standard VAR can only be justified under determined hypotheses that could not be tested in the absence of a priori restrictions derived from economic theory (Cooley and LeRoy, 1985). To overcome this issue and interpret canonical innovations as exogenous economic policy shocks, Sims transforms the VAR model into a structural VAR (SVAR). Furthermore, to justify the identification restrictions imposed on innovations, Sims refers to Wold's (1954) notion of causal chain.

3.1.1 VAR formulation

A system of N equations linking linearly N endogenous variables through their past values to a certain level p, representing the optimal/maximum lag, is called a standard vector autoregressive with lag p, $VAR(p)$. It is expressed by Equation (1):

$$Y_t = \Phi_0 + \sum_{i=1}^{p} (\Phi_i \, Y_{t-i}) + \epsilon_t \qquad (1)$$

Where; $Y_t = \begin{bmatrix} y_{1t} \\ \vdots \\ y_{Nt} \end{bmatrix}$, $\Phi_0 = \begin{bmatrix} a_1^0 \\ \vdots \\ a_N^0 \end{bmatrix}$ and $\epsilon_t = \begin{bmatrix} \varepsilon_{1t} \\ \vdots \\ \varepsilon_{Nt} \end{bmatrix}$ are vector columns of respectively; endogenous variables $y_{1t} \dots y_{Nt}$, constant terms and corresponding errors, also called innovations, shocks, of each equation in the VAR, and $\Phi_p = \begin{bmatrix} a_{1p}^1 & a_{1p}^2 & \cdots & a_{1p}^N \\ \vdots & \vdots & \vdots & \vdots \\ a_{Np}^1 & a_{Np}^1 & \cdots & a_{Np}^1 \end{bmatrix}$ is the matrix of coefficients associated with lagged terms.

Defining lag time operator L as $LX_t = X_{t-1}$, Equation (1) can be written as:

$$Y_t\left(I - \sum_{i=1}^{p} \Phi_i \, L^i\right) = \Phi_0 + \epsilon_t \qquad (2)$$

Or equivalently also, $\Phi(L)Y_t = \Phi_0 + \epsilon_t$, with I as the matrix identity and $\Phi(L) = I - \sum_{i=1}^{p} \Phi_i \, L^i$

3.1.2. Lag selection procedure

To determine the optimal lag p to be introduced in the VAR, there is a set of methods commonly used in the economic literature, which select the optimal lag based on the information criteria. The most well known in the literature are Akaike information criterion (AIC) and Schwarz information criterion (SC). However, other tests are also solicited such as sequential modified LR test statistic (LR test), final prediction error (FPE test) and Hannan-Quinn information criterion (HQ). The methodology of these criteria is based on selecting the model that minimizes a defined function.

The methodology consists of estimating the $VAR(p)$ for lags ranging from 0 to a maximum h_{max}, where the latter is the maximum number of lags included in the VAR model based on a defined economic theory, a referenced academic article or even sometimes on a simple economic intuition (Gossé and Guillaumin, 2013). We then retain the number p of lags, which minimizes the AIC and SC criteria defined by the following parametrized functions:

$$AIC(p) = \ln\left[\det\left(\widehat{\Omega}\right)\right] + 2\frac{pk^2}{T} \tag{3}$$

$$SC(p) = \ln\left[\det\left(\widehat{\Omega}\right)\right] + 2\frac{pk^2\ln(T)}{T} \tag{4}$$

where T is the number of observations, k the number of variables in the VAR model and $\widehat{\Omega}$ the estimated variance–covariance of the residuals.

3.1.3. Identification and analysis of shocks

The reduced form is seen as a "black box", as it is difficult to interpret the reduced form parameters based on an economic theory. Therefore, the structural VAR (SVAR) was developed in the mid-1980s to overcome this issue and allow economic agents' behaviour to be described by the VAR methodology. Since then, many authors have proceeded by including shocks grounded in the economic theory in relation to economic policies, such as supply and demand shocks (Shapiro and Watson, 1988; Blanchard and Quah, 1989), monetary shocks (Sims, 1986) or fiscal shocks (Blanchard and Perotti, 2002). The *pass-through* from canonical shocks of the reduced form of the equation (1), namely, ϵ_t, to structural shocks (based on economic behaviour), ω_t, requires the existence of a matrix *P* such as:

$$\epsilon_t = P\omega_t \tag{5}$$

Consequently, identification of structural shocks insured once matrix *P* has been estimated yields:

$$\widehat{\omega}_t = P^{-1}\hat{\epsilon}_t \tag{6}$$

The initial method of identification of shocks, initially suggested by Sims (1980), is based on a recursive Cholesky decomposition. Meanwhile, the standard VAR as a reduced form (without any economic theory) requires the variables of the VAR system to be ordered considering the degree of exogeneity/endogeneity of these variables; the order must go from the most exogenous variable to the least exogenous (the most endogenous) one.

However, for a structural VAR, SVAR, the identification method is based on restrictions over structural terms that are not necessarily recursive. The restrictions can be in the short term, as in Bernanke (1986) and Sims (1986), as well as the long term, as pioneered by Blanchard and Quah (1989). A combination of the two types (short- and long-term restrictions) was developed by Galí (1992). Recently, restrictions have also targeted specific structural terms, annulling the coefficients associated with these or imposing specific signs. This is done regarding the economic theory (Faust, 1998; Canova and De Nicolo, 2002; Blanchard and Perotti, 2002; Uhlig, 2005).

To analyse the shocks of a VAR model, a vector moving average (VMA) (also called Wold decomposition) is required. According to Wold's theorem, every stationary system can be expressed as a weighted average sum to infinity of white noise terms. Considering a stationary $VAR(p)$ of Equation (1), and supposing that the variables are centralized around the mean (i.e. $\Phi_0 = 0$), Equation (1) can be written in the form of vector moving average, noted $VMA(\infty)$ as:

$$Y_t = \sum_{j=0}^{\infty} \psi_j \, \epsilon_{t-j} = \Psi(L)\epsilon_t \tag{7}$$

with $\Psi(L) = \sum_{j=0}^{\infty} \psi_j \, L^j$, $\psi_0 = I$ and ϵ_t as the vector of innovations (shocks). The impact of these shocks (innovations) over endogenous variables is determined by dynamic impacts defined from Equation (3) as:

$$\psi_{ij,s} = \frac{\partial Y_{i,t+s}}{\partial \varepsilon_{j,s}} \tag{8}$$

where $\psi_{ij,s}$ measures the impact of ε_j in time t over the endogenous variable Y_i following s periods of time. For $s = 0$, this is called immediate impact or instantaneous effect (which can also be assimilated to short-term effect).

Considering (6) and rewriting (7), we can deduct:

$$Y_t = \sum_{j=0}^{\infty} (\psi_j \, P)\left(P^{-1}\epsilon_{t-j}\right) = \sum_{j=0}^{\infty} \Phi_j \, \omega_{t-j} \tag{9}$$

Equation (9) yields responses to a structural dynamic impact following a structural shock ω_t:

$$\Phi_{ij,s} = \frac{\partial Y_{i,t+s}}{\partial \omega_{j,s}} \tag{10}$$

Furthermore, the structural VAR form (SVAR) can be derived from the reduced form as:

$$Y_t = \sum_{j=0}^{\infty} A_j Y_{t-j} + \omega_t \tag{11}$$

where matrices A_j and the structural residual variances of ω_t are estimated by multiplying the estimated reduced form terms of Equation (1) by $\hat{P}^{-1}$; $I - A_0 = \hat{P}^{-1}$; $\hat{A}_j = \hat{P}^{-1}\hat{\Phi}_j$ for $1 \leq j \leq p$ and $Var(\omega_t) = \hat{P}^{-1}\Omega(\hat{P}^{-1})'$. Consequently, the estimation of SVAR is assured once matrix *P* has been estimated. This matrix represents n^2 unknown parameters comprising $n(n-1)/2$ identifying constraints mandatory to estimate the SVAR model. These constraints must be imposed a priori for the estimation of the model.

3.2. Application

For our application, we run a bivariate SVAR linking government expenditure to the GDP to study the effects/multipliers of government consumption on the output. In order to control exogenously for the business cycle (expansion versus recession), debt to GDP evolution (accumulation versus reduction) and the existence of both debt accumulation/reduction under expansion/recession, the SVAR is augmented by variable dummies corresponding to each of the previous prescribed states, hence becoming an SVAR-X (X for exogenous).

Following the previous general methodology, the SVAR, in our case, linking two endogenous stationary variables describing, respectively, the relationship between government expenditure (g_t) and GDP (y_t) for each country, is formulated as:

$$\begin{cases} g_t + \beta_{1,2} y_t = c_{1,0} + c_{1,1} g_{t-1} + c_{1,2} y_{t-1} + \varepsilon_{g,t} \\ y_t + \beta_{2,1} g_t = c_{2,0} + c_{2,1} g_{t-1} + c_{2,2} y_{t-1} + \varepsilon_{y,t} \end{cases} \tag{12}$$[62]

where $\varepsilon_{g,t}$ and $\varepsilon_{y,t}$ are, respectively, the structural shocks/innovations of the first and second variables in this bivariate SVAR, and could be formulated as:

$$\begin{pmatrix} \varepsilon_{g,t} \\ \varepsilon_{y,t} \end{pmatrix} = \varepsilon_t \approx i.i.d.\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_g & 0 \\ 0 & \sigma_y \end{pmatrix} \right) \tag{13}$$

The real government consumption/expenditure and the real output (GDP) are considered in log differentiated natural logarithm, hence designing the growth rate of the corresponding variables and allowing direct interpretation of simultaneous parameters as elasticities assigned to these variables in the SVAR equations (i.e. $\begin{pmatrix} \beta_{1,2} \\ \beta_{2,1} \end{pmatrix} = \beta$). Thus, Equation (1) can be formulated as:

[62] The lag order adopted is 1, which is confirmed in the results section by the appropriate tests discussed in the general methodology.

$$\begin{bmatrix} 1 & \beta_{1,2} \\ \beta_{2,1} & 1 \end{bmatrix} \begin{bmatrix} g_t \\ y_t \end{bmatrix} = \begin{bmatrix} c_{1,0} \\ c_{2,0} \end{bmatrix} + \begin{bmatrix} c_{1,1} & c_{1,2} \\ c_{2,1} & c_{2,2} \end{bmatrix} \begin{bmatrix} g_{t-1} \\ y_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{g,t} \\ \varepsilon_{y,t} \end{bmatrix} \quad (14)$$

which could be also expressed in the form of:

$$Bv_t = C_0 + Cv_{t-1} + \varepsilon_t \quad (15)$$

We deduce the reduced form of the SVAR, called a standard VAR model, by multiplying equation (15) by the inverted matrix B^{-1}, assuming it exists, and solving for v_t in terms of v_{t-1} and ε_t:

$$v_t = B^{-1}C_0 + B^{-1}Cv_{t-1} + B^{-1}\varepsilon_t = a_0 + Av_{t-1} + u_t \quad (16)$$

Or equivalently, $A_1(L)v_t = a_0 + u_t$ with $A_1(L) = I - AL$.

We can easily deduce the residuals u_t as a linear combination of the structural errors ε_t:

$$u_t = B^{-1}\varepsilon_t = \frac{1}{(1-\beta_{1,2}\beta_{2,1})} \begin{bmatrix} \varepsilon_{g,t} - \beta_{1,2}\varepsilon_{y,t} \\ \varepsilon_{y,t} - \beta_{2,1}\varepsilon_{g,t} \end{bmatrix} \quad (17)$$

Thus:

$$v_t = \lambda + \Psi(\mathrm{L})u_t \quad (18)$$

The structural moving average (SMA) representation of v_t is based on an infinite moving average of the structural innovations ε_t, deduced by substituting $u_t = B^{-1}\varepsilon_t$ into equation (18), which leads to:

$$v_t = \lambda + \Psi(L)B^{-1}\varepsilon_t = \mu + \Phi(L)\varepsilon_t \quad (19)$$

where $\Phi(L) = \sum_{k=0}^{\infty} \varphi_k L^k$.

In order to solve an SVAR, the parameters must be identified, which requires some restrictions to be imposed. Typical identifying restrictions include either assuming no simultaneous equations effects from one variable to another in the SVAR (for example, $\beta_{1,2} = 0$ or $\beta_{2,1} = 0$) or linear restrictions on the elements of the matrix (for example, $\beta_{1,2} + \beta_{2,1} = 0$). In our case, we follow the methodology of Blanchard and Perotti (2002) by identifying government spending shocks using a Cholesky decomposition, ordering government spending first as the variable that is clearly the most exogenous compared to GDP.[63] For our case, we are only interested in government multipliers, and no tax multipliers are considered in the current chapter. As explained in the general methodology, the number of restrictions needed is determined by the number n of endogenous

[63] Contrary to our bi-variate case, the Blanchard and Perotti (2002) is a tri-variate SVAR linking three variables: tax revenue, government expenditure and GDP.

variables of the VAR by the formulae, $n(n-1)/2$. Thus, for a bi-variate model, the number of restrictions is only 1 $(2(2-1)/2)$. Then, the matrix of shocks after restrictions is $\begin{bmatrix} c_{1,1} & 0 \\ c_{2,1} & c_{2,2} \end{bmatrix}$.

In our restriction, we especially consider that the response of government expenditure to the output comes with a lag, which means no contemporaneous effects of GDP to government expenditure. Thus, the coefficient $\beta_{1,2} = 0$. This is also interesting, as the reverse instantaneous causality from GDP to expenditure may alter, deducing the effect, *ceteris paribus*, of government expenditure on GDP (fiscal multiplier).

In order to draw fiscal multipliers, the formulae of impulse response functions are required. For the bivariate SVAR model, taking the structural moving average (SMA) representation in Equation (18) at the horizon time $t+h$, we have:

$$\begin{bmatrix} g_{t+h} \\ y_{t+h} \end{bmatrix} = \begin{bmatrix} c_{1,1} & c_{1,2} \\ c_{2,1} & c_{2,2} \end{bmatrix} \begin{bmatrix} g_{t-1} \\ y_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{g,t} \\ \varepsilon_{y,t} \end{bmatrix} \tag{20}$$

Fiscal multipliers are drawn from structural shocks assigned to each variable; in particular, we are interested in the effect of structural fiscal (expenditure) shocks on GDP in this case. For this purpose, we consider the structural moving average (SMA) representation of the SVAR. At the horizon time $t+h$, the SMA representation is:

$$\begin{bmatrix} g_{t+h} \\ y_{t+h} \end{bmatrix} = \begin{bmatrix} \varphi_{1.1}^{0} & \varphi_{1.2}^{0} \\ \varphi_{2.1}^{0} & \varphi_{2.2}^{0} \end{bmatrix} \begin{bmatrix} \varepsilon_{g,t+h} \\ \varepsilon_{y,t+h} \end{bmatrix} + \cdots + \begin{bmatrix} \varphi_{1.1}^{h} & \varphi_{1.2}^{h} \\ \varphi_{2.1}^{h} & \varphi_{2.2}^{h} \end{bmatrix} \begin{bmatrix} \varepsilon_{g,t} \\ \varepsilon_{y,t} \end{bmatrix} + \cdots \tag{21}$$

Then the structural dynamic multipliers are:

$$\frac{\partial g_{t+h}}{\partial \varepsilon_{g,t}} = \varphi_{1.1}^{h} \tag{22.a}$$

$$\frac{\partial y_{t+h}}{\partial \varepsilon_{y,t}} = \varphi_{2.2}^{h} \tag{22.b}$$

$$\frac{\partial g_{t+h}}{\partial \varepsilon_{y,t}} = \varphi_{1.2}^{h} \tag{22.c}$$

$$\frac{\partial y_{t+h}}{\partial \varepsilon_{g,t}} = \varphi_{2.1}^{h} \tag{22.d}$$

The structural dynamic multipliers/impacts measure how a unit impulse of the structural shocks at time t affects the level of endogenous variables at the horizon time $t+h$. In particular, the two first equations (22.a and 22.b) represent the response of, respectively, government expenditure and GDP growth rates to their proper innovations. The two other equations (22.c and 22.d) assess the crossing effects of the structural innovations between the endogenous variables of the SVAR. In particular, Equation (22.d) represents the response of the GDP growth rate to a structural unit

shock of government expenditure, which will be our emphasis in this application. Drawing the structural dynamic impacts $\varphi_{i.j}^{h}$ for the shocks $(i,j) = (1,2)$ allows us to visualize such dynamic impacts in what is referred to as the impulse response functions (IRFs). For the cumulative effects of the structural shock impacts, since the SVAR is designed to be stationary, which means that the effects $\varphi_{i.j}^{h}$ fade away in the long term (i.e. $\lim_{h\to\infty} \varphi_{i.j}^{h} = 0$), the long-term cumulative impact of the structural shocks is captured by the instant IFRs to infinity, which means:

$$\emptyset = \sum_{h=0}^{\infty} \varphi_{i.j}^{h}; (i,j) = (1,2) \tag{23}$$

The structural dynamic multipliers (short-term or long-term cumulative) defined above are different from the Keynesian concept of the fiscal multiplier, generally associated with the general theory of John Maynard Keynes (1936). The latter is defined as the output change in response to a (exogenous) change in a fiscal variable in reference to their baseline levels (Spilimbergo et al., 2009; Coenen et al., 2012). Hence, for G_t and Y_t denoting, respectively, the fiscal instrument (government expenditure here) and the output at time t, the Keynesian or simply fiscal multiplier is expressed as $\frac{\Delta Y_t}{\Delta G_t}$. Or, while the effects come with different lag times, the cumulative fiscal multiplier to the time horizon h is expressed by: $\frac{\sum_{j=0}^{j=h} \Delta Y_{t+j}}{\sum_{j=0}^{j=h} \Delta G_{t+j}}$ (Chinn, 2013).

To compare our results with the findings in the literature and across countries, an exercise of mapping the IRF impacts to Keynesian fiscal multipliers is required. In the explicit SVAR, the government expenditure variable, as well as GDP, are introduced in per cent of first differences of the natural logarithm for the corresponding levels of the variables (i.e. the growth rates in per cent). The unit root augmented Dickey-Fuller and Phillips-Perron tests show that these variables are integrated of order one in levels. Thus, using the first difference of logarithms ensures stationarity of such variables. Furthermore, introducing the variables in logarithms allows us to draw the Keynesian multipliers directly from the effects of elasticities. Letting $\mu_{Y/G}$ define the elasticity of GDP to government expenditure,[64] we have:

$$\mu_{Y/G} = \frac{dlog(Yt)}{dlog(Gt)} = \frac{\Delta Yt}{\Delta Gt} \times \frac{Gt}{Yt} = k\frac{Gt}{Yt} \tag{24}$$

The Keynesian multiplier $k = \frac{\Delta Yt}{\Delta Gt,}$ measuring government expenditure effect on GDP, is then deduced as the elasticity of GDP to government expenditure scaled by $\overline{G_t/Y_t}$ representing the averaged share of government expenditure in GDP (or multiplied by $(\overline{Y_t/G_t})$) (Gonzales-Garcia et al., 2013; Ilzetzki et al., 2013; Barnichon and Matthes, 2017; Priftis and Zimic, 2018; Glocker et al., 2019). However, with the latter references, even though they scale their impact IRFs by share

[64] Razzak and Bentour (2013) use this approach to deduce foreign direct investment return from estimated elasticities of the Cobb-Douglas production function.

of consumption, the results are meaningful in terms of size only if the structural shock is expressed in percentage units. The reason for this is that the structural innovations, especially when using Cholesky innovations in an SVAR, are expressed in standard deviation units. Therefore, in practice, for accuracy of results, the impacts should also be scaled by a standard deviation σ_g of the fiscal variable (government expenditure), as in Combes et al. (2014). Following this precision, an adjustment coefficient is defined to deduce the short-term (immediate) fiscal (Keynesian) multiplier from the corresponding Cholesky impact multiplier, as:

$$k^{sr} = IM^{sr} \times \frac{\frac{\overline{Y}}{\overline{G}}}{\sigma_g} \tag{25}$$

where, from Equation (22.d), $IM^{sr} = \frac{\partial y_t}{\partial \varepsilon_{g,0}} = \varphi_{2.1}^0$ is the immediate effects of government expenditure Cholesky innovations. For the accumulated (long-term) expenditure multipliers k^{lr}, they are deducted in the same way as:

$$k^{lr} = IM^{lr} * \frac{\overline{Y}}{G} / \sigma_g = (\sum_{h=0}^{\infty} \varphi_{2.1}^h) * \overline{Y/G} / \sigma_g \tag{26}$$[65]

In the previous bivariate SVAR, the effect of public debt on the expenditure multipliers is exogenously tested by a dummy representing the way the public debt ratio is evolving. In the second case, we endogenize the public debt effects and introduce the public debt to GDP ratio in a tri-variate SVAR linking government consumption, GDP and government debt ratio. For the identification in this tri-variate model, two other restrictions are needed. These are simply imposed by assuming that both government consumption and GDP do not have an immediate (simultaneous) effect on the public debt ratio. Thus, the only structural coefficients assumed to be non-null are those capturing the public debt effects on the other variables in the model, while the opposite effects (feedback effects) are delayed by at least one quarter. For the formulations (equations, IRFs, etc.), the methodology is the same as for the previous bi-variate, or as described by the general methodology.

4. Data

4.1. Data source

We first solicited the database of the Federal Reserve Bank of Saint Louis for the quarterly data on real government consumption, GDP and public debt, displayed on their website free of charge, and downloaded country by country, where data is seasonally adjusted. We noticed that this data,

[65] Other authors used formulae without mentioning any normalization with reference to the volatility of the fiscal instrument (σ_g) (Ilzetzki et al., 2013; Priftis and Zimic, 2018).

which was not available for all the 18 sample countries, has the OECD database as its main source. We therefore avoided the Federal Reserve Bank of Saint Louis data for the two first models and downloaded constructed national accounts of the 18 countries displayed in the OECD database. For the last model applied to the United States and requiring a long history, data was found and downloaded for all variables from the Federal Reserve Bank of Saint Louis website.

Compared to annual data, high-frequency data, especially quarterly data, is considered to be the most important for assessing fiscal policy effects (Ilzetzki et al., 2013). However, some issues also arise when using such data. The availability of the observed quarterly national account in many of the advanced countries is recent and goes back to the 1990s. Although the data is displayed for the general government consumption and the GDP back to the 1960s, these are estimations rather than observations going back to pre-1990s, as indicated in the OECD database comments. The exception is the United States, the United Kingdom, Canada, Norway and France, where data goes back to before 1990 (Table 1.C in the appendix). Table 2.C presents descriptive statistics for the economic growth rate and government expenditure. The same issue of observed sample data is encountered with government debt, where the observed data starts. for the majority, in the late 1990s (Table 3.C in the appendix), but for the latter variable, there is no estimation back in time. This constrained our estimations for these countries to the corresponding period (except for the United States), where the quarterly public debt is available when the latter is considered an estimation, whether as an exogenous variable or as an endogenous one.

4.2. Preliminary analysis of some previous fiscal multipliers with relation to public debt

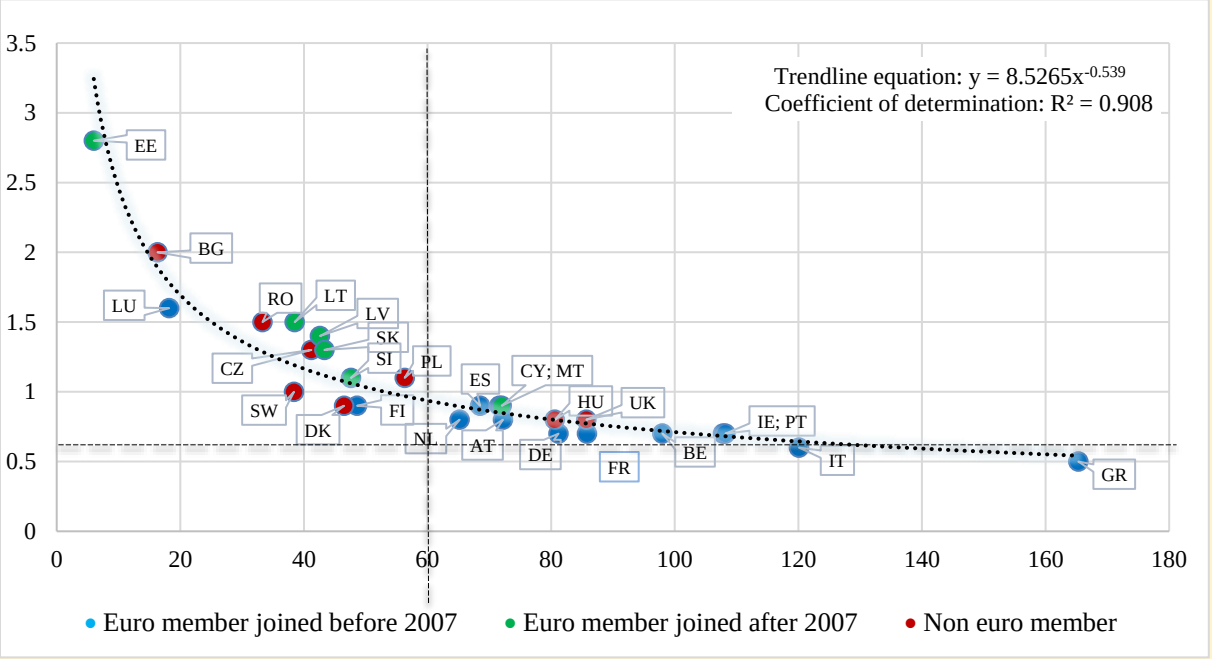
In this sub-section, we undertake an exercise analysing some previous expenditure multipliers in links with public debt ratios, from previous works for 27 European countries. We especially investigate the calculations and results of Boussard et al. (2012) and Berti et al. (2013). We draw scatter plots showing short-term expenditure critical multipliers (first year) and public debt to GDP ratios in 2011 and 2012 (Figures 2 and 3) for the 27 European Union countries. The calculations are simulated under fixed interest rates. The 27 countries are Belgium (BE), Bulgaria (BG), Cyprus (CY), the Czech Republic (CZ), Denmark (DK), Estonia (EE), Finland (FI), France (FR), Germany (DE), Greece (EL), Hungary (HU), Ireland (IE), Italy (IT), Latvia (LV), Lithuania (LT), Luxembourg (LU), Malta (MT), The Netherlands (NL), Poland (PL), Portugal (PT), Romania (RO), Slovakia (SK), Slovenia (SI), Spain (ES), Sweden (SE) and the United Kingdom (UK).

The fiscal multipliers decrease exponentially with public debt to GDP ratios with an "elasticity/country" of -0.539 and -0.597 in 2011 and 2012, respectively. The trendline of the scatter plot is compatible with a negative power curve, with a high coefficient of determination of around 90.8% and 92.6% for the two figures, respectively. We highlight the countries not affiliated with the eurozone countries (with red dots), as well those that joined the eurozone recently (green dots) and the 12 euro core member countries that joined before 2007 (blue dots). The latter group

of countries is more concerned with high public debt and lower fiscal multipliers of less than 1, except for the case of Luxembourg. Figures 2 and 3 show clearly that all countries with a public debt to GDP ratio exceeding 60% have fiscal multipliers lower than 1.

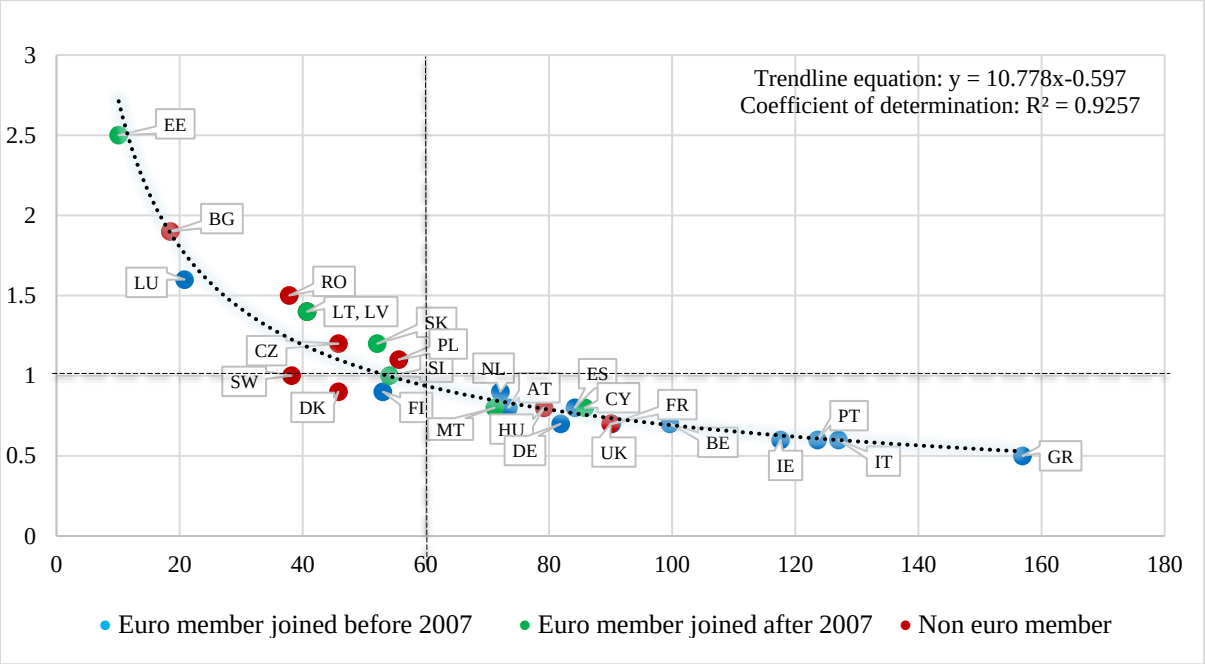
These figures clearly show a quite different message to the conclusion of the two papers, namely, that large, short-term multipliers are likely to increase debt ratios under initial high public debt. It shows an picture of which high public debt is associated with low spending multipliers, which also raises a legitimate question. On the one hand, could high public debt also have led to lower fiscal multipliers (crowding-out effects, for example)? And it raises a similar debate to the one detailed in Chapter 1 between public debt and economic growth feedback effects (reverse causality). On the other hand, according to these results, fiscal expansion, as opposed to fiscal consolidation, is expected to be less effective under high public debt levels, particularly as the multipliers assumed to be calculated from an exercise of positive fiscal shocks are lower than unity for highly indebted countries (thus assuming assymetry –this issue is discussed in Section 2.4).

Figure 2. Critical multipliers for EU member states versus the public debt to GDP ratios – year 2011



Source: Constructed from results of the European Commission working papers reported in Bouassard et al. (2012) – Table 3 – and Berti et al. (2013) – Table 2.

Figure 3. Critical multipliers for EU member states versus the public debt to GDP ratios – year 2012



Source: Constructed from results of the European Commission working papers reported in Bouassard et al. (2012) – Table 3 – and Berti et al. (2013) – Table 2.

5. Results

In this section, we display the results of the models discussed in the methodology section and argue our results with a robustness check based on the United States data set using a more detailed SVAR with six endogenous (including monetary and fiscal) variables.

We used unit-root tests (augmented Dicky-Fuller and Phillips-Peron) for the stability of the variables, which confirmed that all the variables are integrated of order 1. A summary of the stationarity tests is presented in Table 4.C in the appendix for the three variables of GDP, government consumption and public debt to GDP ratios. Thus, we introduced all the variables in the three models in first differences of the natural logarithm of such variables, except for prices (the interest rate and inflation). The sample of countries that was considered comprises 18 advanced countries, of which the majority are eurozone member countries, namely: Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, The Netherlands, Norway, Portugal, Spain, Sweden, the United Kingdom and the United States. Furthermore, following Blanchard and Perotti (2002), we chose not to test for any long-term cointegration relationship, as this might also complicate the exercises of SVAR methodology, especially the way of resolving identification issues, and might deviate from comparing our results to the leading literature and the model results adopting the Blanchard and Perotti (2002) approach.

Although some pioneer researchers did not test for the number of lags to introduce in their SVAR, simply adopting an SVAR with one lag, we ran the exercise of the determination of such a lag for each country and each model (Table 5.C in the appendix for models with no control of exogenous effects of business cycle or debt movements). We found that 15 out of 18 countries have at least one criterion that indicates that the optimal lag is 1 (more likely indicated by Schwarz information criterion, SC). The three countries are Denmark, Greece and Japan. When controlling, for example, for the business cycle, Greece, Japan and Spain have an order of lags superior to 1 for models in times of recession, while in times of expansion, Austria, Japan, Portugal and Italy have order lags of 2 to 3. As a result of the multiplicity of the exercises undertaken here for each country individually (control for the business cycle, debt movements, etc.), and based on the higher number of countries pointing to only one lag, we preferred to follow the same approach as other researchers who fixed the model for all the countries to a unique optimal minimum lag equal to 1.

5.1. The effects of the time periods

Do fiscal multipliers tend to be lower in recent periods than those of the previous decades of the 1960s and 1970s?

There are a set of determinants revealed in the economic literature that may work in reducing the size of the fiscal multipliers. First, there is the increase in trade openness: more closed economies tend to have higher multipliers (Barrell et al., 2012; Ilzetzki et al., 2013; Batini et al., 2014). Second, there is labour market flexibility: the more flexible the labour market is, the larger the fiscal multiplier. For example, based on this, it is expected that Europe will show higher multipliers than the United States, as the market in the former tends to be rigid, with the presence of stronger labour syndicates and unions. Rigidities play against wage flexibility, which tend to reduce the response of output to demand shocks (Cole and Ohanian, 2004; Gorodnichenko et al., 2012; Batini et al., 2014). Third, there is the size of automatic stabilizers: larger automatic stabilizers tend to reduce fiscal multipliers, by offsetting part of the initial fiscal shock (Dolls et al., 2012). Fourth, the flexibility of the exchange rate regime tends to lower the multiplier size, as the movements of the exchange rate may cushion the effects of fiscal policy actions (Born et al., 2013; Ilzetzki et al., 2013). Fifth, the fiscal position, with high public debt and fiscal deficit widening, reduce the size of the multipliers (Ilzetzki et al., 2013; Bi et al., 2016; Huidrom et al., 2016; Kirchner et al., 2010). Sixth, there is the effect of the active monetary accommodation to fiscal shocks, where expansionary monetary policy can offset the impact of fiscal contraction on demand.

Based on this, fiscal multipliers are likely to be smaller in recent decades, known as the “Great Moderation Era”, especially the period 1986–2007, than the pre-1986 period. The reason for this is that, in this period, all the factors previously cited have been strengthened. The degree of openness has increased with the proliferation of the free trade agreements and increased international financial and economic integration. Many exchange rate systems have been switched to greater flexibility, except for countries that have adopted monetary unions. The monetary policy

has been more active in fulfilling its role in stabilizing economies, among other things. All this leads us to think that fiscal multipliers may have a smaller size in the recent period than previously.

To examine these facts, we split our sample data for each country, 1966Q1–2019Q2, into two balanced sub-samples, 1966Q1–1991Q4 and 1992Q1–2019Q2, with, respectively, 104 and 110 observations each. We ran a bivariate stationary SVAR with differentiated logarithm of government expenditure and GDP (i.e. growth rates, in per cent) for all 18 countries for the 2 periods.

The results of the impulse response functions[66] (the structural dynamic impacts) are drawn for this exercise in Figures 1.B.a to 1.B.c in Appendix B. These results are also summarized in Table 3.A, which shows that the main sample of countries (12 out of 18) tends to confirm that the expenditure impacts are weak and substantially smaller in the first period than the second one. However, some exceptions were recorded, especially for small-sized economies such as Finland, Greece, Ireland and, to some extent, Italy, Portugal and Spain, particularly in the long term, which reported opposite results: fiscal multipliers tend to be higher in recent periods than previously. This may be in contrast to the idea that more openness decreases fiscal multipliers as the propensity to import increases. However, not only the degree of openness that acts on the size of the multipliers, but also other determinants, could play against the increase of fiscal multipliers, such as the monetary policy accommodation and the exchange rate regimes (Batini et al., 2014). For a few other countries, the impacts are even negative in the second period, namely, Canada, Denmark and Germany in the long term, and France and the United States in the short and long terms. Overall, for the first period, the multipliers average for the sample is around 0.96 (the impact is 0.18) for the first quarter, 1.5 (0.26) for the accumulated fourth quarter (first year) and 1.57 for the accumulated five years. However, for the second period (1992q1–2019q2), the corresponding multipliers are reduced by more than half, recording on average in the sample 0.47, 0.54 and 0.66, respectively for the first, the accumulated 4 and the accumulated 20 quarters (last row in Table 3.A).

Nevertheless, these results should be considered with caution for several reasons. The first, related to the data construction method, is that the quarterly national accounts data for the government expenditure variable, as well as for the GDP aggregate, is for many countries an estimation, rather than an observation, in the first period. OECD data downloaded for the purpose of this exercise displays a comment on each Excel cell data indicating whether the data cell is an observation or estimation. We noticed that for all the countries' samples – except for Canada, the United Kingdom and the United States, for which data is observed from the first quarter of 1966, and Norway and

[66] In all our applications, we reported the accumulated structural Cholesky IRFs, as defined in the methodology section, deduced from Equation 8 (the first impact is $\emptyset_0 = \varphi_{i.j}^0$; the second accumulated impact $\emptyset_2 = \sum_{h=0}^{2} \varphi_{i.j}^h$; …; until the long-term accumulated impact to time horizon q; $\emptyset_q = \sum_{h=0}^{\mathrm{q}} \varphi_{i.j}^h$). In all our applications, we considered $q = 20$, which corresponds to five years. The latter accumulated multiplier defined as the sum of effects to 20 quarters is to be differentiated from what some authors reported as the maximum multiplier; namely, the peak of the effects attained in a specific point of time.

France, for which the data observed starts in 1978 and 1980, respectively – the observed data starts after the 1990s (mainly in 1995Q1 for the majority; see Table 1.C in the appendix). The quarterly national account could be estimated using mechanical/statistical methods without any fiscal policy feedback or any business cycle impacts on the data, which may deviate any fiscal policy assessment from accurate outcomes.

The second reason, which is related to the values rather than the method of construction, is that although the Cholesky impact multipliers are higher in the first period than in the period of openness and financial globalization, the fiscal multipliers could be reduced or amplified between the two periods. The trick resides in the coefficient of adjustment enabling the expenditure multipliers to be obtained from the Cholesky impact multipliers. This coefficient has two components, the first being the share of government consumption to GDP, and the second the standard error of the growth rate of government consumption. The common tendency for all advanced economies is for the shares of government consumption to grow as countries prosper and the welfare state is enhanced. Direct factors of this are also related to an ageing population, especially in Japan and many European countries. The increasing/decreasing shares of government consumption could reduce/amplify the fiscal multipliers. The same is true for the second component, which is the standard error of government consumption, which seems to be lower in the second period than the first one (as opposed to the growing of the first component). Variables are less volatile in the second period (the Great Moderation Era). The product of the two components, which correct the Cholesky impacts to get spending multipliers, could then be higher, less or approximately the same for each country between the two periods. Calculus on the countries' data shows that the adjusting coefficient (Table 2.A) is higher for all countries except Ireland, Norway, Portugal and Spain, which may lead to a reduced gap (gap impacts shown by the Cholesky innovations) in government consumption multipliers between the two periods.

A third issue is related to the method of rescaling by the average of the share of government consumption to GDP ($\overline{G_t/Y_t}$). This method, issued from the elasticity of the output of the fiscal instrument, as explained in Equations (24), (25) and (26) and used by many authors (Ilzetzki et al., 2013; Gonzales-Garcia et al., 2013; Priftis and Zimic, 2018; Glocker et al., 2019), may lead to overestimated fiscal multipliers, which is the case here for many countries in periods of recession and long-term accumulated cases. This fact is valid for our results in the current section and subsequent sections, where some countries that have higher expenditure multipliers in the long term under a recession could attain more than five (examples are France, Spain, Portugal). The issue is because Y/G can display large movements over the sample period (Ramey and Zubairy, 2018). To dampen this effect, some authors use an *ex ante* conversion approach (Gordon and Krenn, 2010; Ramey, 2016; Barnichon and Matthes, 2017), which consists of re-scaling all the variables by an estimated "potential output" Y_t^p. Thus, the variables reconsidered for these authors are Y_t/Y_t^p, G_t/Y_t^p, and so on; for our case, we did not consider this issue and rather focused our analysis on comparing changes in both structural impacts and multipliers, among the considered

cases (first period versus second period, expansion versus recession, debt accumulation versus debt reduction, etc.), rather than focusing on the size of the fiscal multipliers.

5.2. The effect of the business cycle

We ran the same SVAR controlling for the business cycle in the current case. Some authors have used the output gap to control for the business cycle position (Batini et al., 2012). For our case, we used the growth of GDP, as used by Baum et al. (2012), noted ggr_t, instead of the output gap, and we defined a dummy variable for the business cycle, as follows: $bcd_t = \begin{cases} 1 \; if \; ggr_t > 0 \\ 0 \; if \; ggr_t \leq 0 \end{cases}$. The business cycle dummy indicates expansion, while its complement to unity is a proxy for recession. The SVAR model is augmented by this variable exogenously (SVAR-X) for considering the effects of the expansion periods only and its complement to unity to account for recessions.

The results of this exercise are displayed in Table 4.A, while the IRFs are plotted in Figures 2.B.a to 2.B.c in Appendix B. The table reporting short-term (first quarter) and long-term (five years) impacts, and their corresponding Keynesian multipliers, shows that these multipliers are either positive and very low or negative and very low (in absolute value) for many countries in the sample in times of expansion (exceptions are recorded for Greece and Ireland, where short-term multipliers are, respectively, 0.92 and 1.02, corresponding to impacts of, respectively, 0.42 and 0.55). However, in times of recession, these impacts are all positive and amplified in size. The maximum of the short-term Cholesky impact is recorded in Ireland by 1.53, corresponding to a multiplier of (1.02),[67] and in Norway by 0.82 (with a multiplier of 2.4). These higher impacts yield multipliers greater than 1 for many countries (11 countries) and approaching unity for the rest (between 0.52 and 0.92). On average, expenditure multipliers in the short term are near 0 (0.09) in times of expansion, while they are more than 1 in recessions (1.55). The long-term accumulated are negative in expansions (-0.24) and very high in recessions (4.8). Our results confirm the conjecture of the higher expenditure multipliers in periods of recession than in those of economic expansion, as revealed by the aftermath of the 2008 crisis literature, especially by Auerbach and Gorodnichenko (2012, 2013). Another important point is that, from the IRF plots, the effects are more persistent in times of recession than expansion, as convergence to the long term is more quickly achievable in the latter than in the former (Figures 2.B.a to 2.B.c).

For a general view with relation to the effects of government debt, we plot the impact multipliers, associated with the business cycle, versus debt ratios in Figure 3.B. It seems that these impacts are slightly negatively associated with higher public debt ratios in recessions, while in expansions, the opposite is observed, particularly for the long term. This means that higher debt may weigh on expenditure multipliers in recession periods.

[67] Although the Cholesky impact is higher, the multiplier is reduced by, in particular, the second component of the adjusted parameter used as pass-through to fiscal multipliers in Table 2.A. Indeed, government consumption volatility is higher (exceeding 2) for this country in the period of estimation.

5.3. The exogenous effect of the public debt accumulation/reduction

To control exogenously for the effect of public debt, we ran the previous bivariate SVAR, where the accumulation is proxied by a dummy variable equal to 1 whenever the growth rate of public debt to GDP ratio is positive, non-null and zero elsewhere. The public debt reduction case is controlled in the SVARX by the complement of the debt accumulation dummy to unity. The dummy variable for the debt ratio accumulation is defined according to the sign of the debt ratio growth rate (dgr_t): $dad_t = \begin{cases} 1 \; if \; dgr_t > 0 \\ 0 \; if \; dgr_t \leq 0 \end{cases}$, where dad_t is the dummy indicating debt increase of the debt to GDP ratio (accumulation), and its complement to unity is a proxy for debt reduction. We do not care whether the public debt ratio is reduced by the high performance of GDP (the denominator) or accumulated because of weak GDP. In both situations, it is the ratio that is important, reflecting the capacity to repay or not based on the performances of the economy.

Table 5.A shows the Cholesky impacts and their corresponding values of expenditure multipliers under public debt movements: in the case where debt to GDP ratio is consequently accumulated; or in the opposite case, where debt is reduced. Overall, the multipliers (impacts) tend to be higher in times of debt accumulation than in times of reduction, except in a few countries, where the two cases are approximately the same, namely, in Finland, Italy, Japan and Norway. The latter has even larger multipliers in debt reduction cases than in debt accumulation. Convergence to the long-term accumulated multiplier varies across countries, where it is fast in more than half of cases, medium in around a third of cases and slow in a few cases (France, Spain and the UK). The convergence is defined as fast if the accumulated long-term multiplier is approximately attained in fewer than five quarters, medium if it is attained in between six and nine quarters, and slow when it is above ten quarters. The size of the expenditure multipliers varies considerably between countries.

The effects of the way the debt is moving, on multipliers, tends not to be different from the business cycle effects, especially if we assume that, generally, the public debt ratio increases in times of recession, which sounds more realistic, due to the double effects of GDP shrinking and the debt level accumulation in times of recession. For further examination of this, an exercise combining the business cycle effects jointly with the public debt movements was run. Table 6.A shows the results. The main conclusion is that, under expansion, multipliers are very low for some countries and negative for most countries, almost independently from the way the debt ratio is evolving. By contrast, under recessions, multipliers are higher and could be larger than unity even in the short term, as is the case for Belgium, Canada, Denmark, Greece, Ireland, Italy, Norway, Spain, Sweden, the United Kingdom and the United States.

To obtain an overall view of the public debt effects on multipliers, we display, for the sample of 18 countries, scatter plots for the average public debt and the short- and long-term multiplier values, under debt accumulation and debt recession cases, as illustrated in four charts presented in Figure 4.B. It seems that, under debt accumulation, there is no clear association between the

average of the debt ratio (over the time period) and the multipliers' size. However, a positive correlation (albeit less strong) is observed in the case of debt reduction, which means that expenditure multipliers are higher for high debt ratios conditioned with the case where the debt is decumulated.

5.4. The effect of the public debt ratio movements jointly with the business cycle

Controlling for the business cycle effects and the public debt ratio movements is captured by augmenting the SVAR by the product of the two corresponding dummies bcd_t and dad_t yielding the following four situations:

1- The effect of public debt accumulation under expansion, captured by ($bcd_t.dad_t$*),*

2- The effect of public debt accumulation under recession, captured by ($(1 - bcd_t).dad_t$,

3- The effect of public debt reduction under expansion, captured by ($(1 - dad_t).bcd_t$,

4- The effect of public debt reduction under recession, captured by ($(1 - bcd_t).(1 - dad_t)$.

The results of the structural dynamic impacts (Cholesky IRFs), as well as the corresponding multipliers, are presented in Table 6.A. The latter are deduced from Equation (13) for the short-term (first) multiplier and Equation (14) for the long-term multiplier, as explained in the methodology section. For the graphical IRFs, they are presented for each country by case of debt movements under the business cycle. Therefore, Figures 6.B.a to 6.B.c present the impulse response functions for the case of debt accumulation and the two business cycle cases. Similarly, Figures 7.B.a to 7.B.c show the impulse response functions for the case of debt contraction and the two business cycle cases.

From the results summarized for the short- and long-term impacts and multipliers in Table 6.A, we observe that the effects are negative or positive but near 0 for many of the countries in times of expansion, regardless of the debt development. Exceptions are recorded for Greece, Ireland and Italy. However, in times of recession, all 18 countries have positive important multipliers, whether under debt accumulation or debt reduction, except for The Netherlands and Portugal, which have weak negative multipliers only in the case of debt reduction under recession. Under recession and debt accumulation, many countries have expenditure multipliers higher than 1 in the short term, namely, Belgium, Canada, Denmark, Greece, Ireland, Italy, Norway, Spain, Sweden, the United Kingdom and the United States. However, under recession and debt reduction, the number of countries with multipliers greater than 1 reduced to six countries, namely, Belgium, Italy, Japan, Norway, Spain and the United States.

In order to visualize the previous results in a global view, we scattered the multipliers obtained for these cases against the averages of the debt ratio (Figure 8.B). In two cases of joint expansion with debt accumulation (the first two scatter plots for the short and long terms) and the recession with

debt reduction (the last two scatter plots), we observe a positive association of the fiscal multipliers with the average of the debt to GDP ratio. However, there is no clear association for the cases of expansion and debt reduction or recession and debt accumulation. This means that multipliers tend to be higher for countries with high debt to GDP ratios, either in times of expansion, and the debt being accumulated, or times of recession, and the debt ratio being reduced.

5.5. The endogenous effect of public debt

Controlling for the business cycle effects, and considering the endogenous public debt ratio, by the tri-variate SVAR model, the results confirm the previous results of the large multipliers under recession, while reporting weak or even negative multipliers in periods of expansion. Tables 7.A and 8.A present, respectively, the dynamic structural impacts and the associated expenditure multipliers for the first quarter (short term), first year, second year and fifth year (long term). The IRFs of these results are shown in Figures 9.B.a to 9.B.c. These results tend to confirm those reported for the case of the bi-variate model, while controlling exogenously for government debt. Furthermore, for the short- and long-term impacts, a positive association with the average of the debt to GDP ratios is noticed in expansion cases, as reported in the scatter plots in Figure 10.B.

We can conclude generally from the previous results of the bi-variate and tri-variate models that: in times of recession, multipliers tend to be higher than in times of expansion, but they tend to decrease with debt reduction rather than debt accumulation in times of recession. This may lead us to consider the self-defeating effects of austerity aimed at reducing public debt and based on expenditure cuts, as it tends to reduce the higher multipliers recorded in times of recession and high public debt.

5.6. Robustness check: the public debt crowding-in/out effects

In order to examine why spending multipliers are lower in times of expansion than in recessions, a more disaggregated model containing behavioural equations is required. For this purpose, we chose to study, in particular, whether the crowding-out effect that might be behind lowering spending multipliers originates from public debt. We particularly consider an SVAR with six fiscal and monetary variables for the United States.

In this section, we present the SVAR with six endogenous variables applied to the United Sates only, as the country with a large quarterly data set available (1966Q1–2019Q2). This SVAR is intended to explain and check the robustness of the previous models' outputs, where other variables representing monetary policy aggregates and private-sector investment are introduced, leading to more interactions catching economic behaviour. The endogenous variables considered are the interest rate, the public debt ratio, prices, output, government expenditure and private investment. In this model, we follow nearly the same approach as in Sims (1986). The difference from Sims's model is that the latter considered money supply equation (which is an interest rate

equation explained by money demand), money demand, output, price, unemployment and investment demand equations (the model is detailed in Sims (1986)).

In our case, we modified the model to include fiscal variables that are of interest to us for studying the spending multipliers via the impact of expenditure and public debt. Moreover, in order to assess what is happening on the private demand side, especially the possibility of crowding-in/out effects of government spending and/or debt to private agent decisions, we kept the private investment equation. Private consumption could also be considered but we decided to reduce the size of this model into six variables to gain more degrees of freedom for the quality purpose estimation. The monetary policy action is presented by the equation of interest rate, and the dynamic of prices is captured by the inflation equation.

For the interest rate equation, we used the policy variable, which is the effective federal funds rate. Assuming that the feds follows a conventional monetary policy based on Taylor's rule, it seems suitable to assume that the feds policy rate (r_t) is determined by innovations (e_3, e_4) corresponding, respectively, to GDP growth rate (y_t) and inflation (π_t). GDP is a best proxy for the output gap, as we do not consider the output gap in this model. The second equation is related to public debt (d_t). For this equation, three variables are important from the classical debt sustainability rule; we could realistically assume that the public debt ratio is determined by the innovations (e_3, e_4, e_1) corresponding, respectively, to innovations from the GDP growth rate, the inflation rate and the interest rate.[68] The third equation is the output assumed to rely on innovations, e_5, e_6 and e_2, from, respectively, private investment (i_t), government expenditure (g_t) (three options are tested: total, current and capital expenditure) and public debt. For the fourth equation of the system corresponding to inflation, the latter is assumed to be determined by the interest rate's innovations (e_1) and the investment private innovations (e_5). The private investment is assumed to be determined in the fifth equation as the function of innovations coming from the output (e_3) and the interest rate (e_1) (the accelerator equation). The last equation is an error term corresponding to government expenditure determined by its proper structural innovations (e_6). This means that the government expenditure variable does not react simultaneously to the other endogenous variables in this model, but its reaction comes with a delay. We considered the following formulations for the equations of this model, such as:

$$\begin{cases} r_t = f(y_t, \pi_t, e_{1t}); & interest\ rate\ equation & (1) \\ d_t = f(y_t, \pi_t, r_t, e_{2t}); & government\ debt\ ratio\ equation & (2) \\ y_t = f(i_t, g_t, d_t, e_{4t}); & output\ \ equation & (3) \\ \pi_t = f(r_t, i_t, e_{5t}); & inflation\ equation & (4) \\ i_t = f(y_t, r_t); & private\ invesment\ equation & (5) \\ g_t = f(e_{3t}); & government\ expenditure\ \ equation & (6) \end{cases}$$

[68] It is possible to provide an SVAR with identities equations such as Taylor's rule for the interest rate and the debt sustainability equation. However, the structural shocks associated with those identities would be zero, and the situation is more complex if the identity is dynamic (Cherif and Hasanov, 2017; Ouliaris et al., 2018). As assessment of the effects of fiscal and monetary policy structural innovations (shocks) on the other endogenous variables is our requirement, we keep such identities as functional structural equations.

Explicitly, the six simultaneous equations of the current model are formulated in the following system, with all the variables log-differentiated:

$$\begin{cases} r_t = c(1)y_t + c(2)\pi_t + e_{1t}; & interest\ rate\ equation & (1) \\ d_t = c(3)y_t + c(4)\pi_t + c(5)r_t + e_{2t}; & government\ debt\ ratio\ equation & (2) \\ y_t = c(6)i_t + c(7)\pi_t + c(8)r_t + e_{4t}; & output\ \ equation & (3) \\ \pi_t = c(9)r_t + c(10)i_t + e_{5t}; & inflation\ equation & (4) \\ i_t = c(11)y_t + c(12)r_t + e_{6t}; & private\ invesment\ equation & (5) \\ g_t = e_{3t}; & government\ expenditure\ \ equation & (6) \end{cases}$$

In this exercise, all the variables are made stationary by differentiated natural logarithms, and hence the variables are all in growth rates. The variables, which will appear in outputs and figures, are LGDP for GDP growth rate (y_t), LGE for government consumption expenditure, total, current and capital ($g_t = LGE = dlog(GOVEXP)$), LPRC for inflation (GDP deflator inflation, $\pi_t = LPRC = dlog(GDPdeflator)$), LDR for log differentiated of the debt ratio ($d_t = dlog(debtratio)$), LPINV for the real private investment growth rate ($i_t = LPINV = dlog(rpinv)$) and RINTR for the interest rate ($r_t = RINTR = ffr$).

We test the SVAR model with six endogenous variables applied to the United Sates only, as the country with a large quarterly data set. The data set covers, for many variables of this model, a long-observed history of quarterly data going back to 1953. However, the public debt quarterly data starts at 1996. Hence, the model is estimated over the period 1966Q1–2019Q2. This SVAR is intended to check the robustness of the previous models' outputs, where other variables representing monetary policy aggregates and private-sector investment are introduced, leading to more interactions catching economic behaviour. The model functional equations' determinants are discussed in the methodology section. The considered endogenous variables are interest rate, public debt ratio, prices, output, government expenditure and private investment.

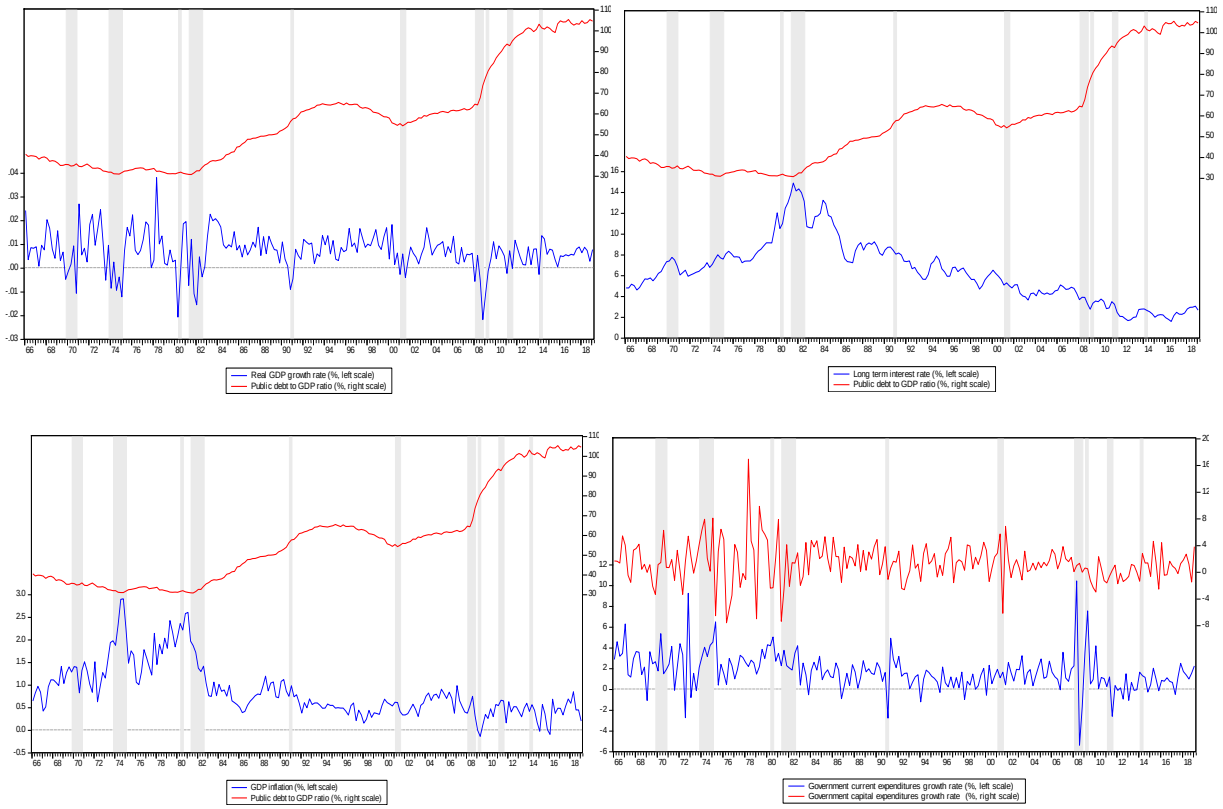
In this SVAR we control exogenously for the business cycle and debt movements by introducing as exogenous the dummies controlling for expansion/recession and debt accumulation/reduction, as defined for the previous bivariate model. We also produce the cases where debt movements and business cycle are jointly considered (four cases).

Figure 8 presents a panel of charts showing quarterly data over 1966Q1–2019Q2, by row order and column, from left to right, the public debt ratio development and output growth, the long-term interest rate and the inflation rate for the three first charts. The last chart shows the composition of the total government expenditure, capital and current expenditure growth rates. The dashed grey areas in all four charts of Figure 8 indicate the recession periods where the quarterly negative growth is recorded.

The public debt of the United States stands at around US$ 20.42 trillion at the end of June 2019, from which: 1) about 66% is long-term liabilities, 2) more than 83% is denominated in domestic currency and 7% in foreign currency, and the rest is not allocated (see Table 6.C). For evolution

over a long history (Figure 8), we observe that the growth rate is more volatile in the 1966–84 period, but with the public debt ratio in a downward trend. Staring around 1985, the real growth rate becomes less volatile than previously, while the public debt ratio reverses track to generally increase. For the relationship between public debt and interest rate, although the golden rule of public debt and economic growth stipulates that public debt is accumulated whenever the real interest rate is higher than economic growth, the public debt ratio and interest rate are evolving the opposite way. From the 1960s to early 1980s, the interest rate takes an upward trend, while the public debt to GDP ratio is on a downward trend. Starting from the 1980s up to 2019 the interest rate records a sustained decrease, while the public debt ratio reverses its path to a general upward trend (except 1996 until 2001, where it decreases). The same facts are observed when comparing the trend of inflation and GDP growth rate. The period starting from 1986 is known by economists as the "Great Moderation Era". In this period, we can conclude from the previous analysis that public debt in the United States has accumulated over this period of sustained growth and moderate inflation and interest rates, which is the case for many advanced countries in our sample. For the last chart in Figure 8, capital expenditure is less volatile in the second period (1986–2019) than the first period (1966–85), compared to current expenditure, which means that current expenditure is more mobilized in times of crisis in recent periods than in the decades of the 1960s and 1970s.

Figure 4. Evolution of some SVAR variables vis-à-vis public debt for the United States



Note: The shaded area corresponds to recession periods (two consecutive negative quarterly economic growth).
Source: Author's own construction

The estimation of the structural model (the block of equations described in the methodology by Equations (1) to (6)), controlling for expansion and recession, yields the following table. Standard errors of the estimated coefficients are displayed between parentheses below the estimated values of those coefficients.

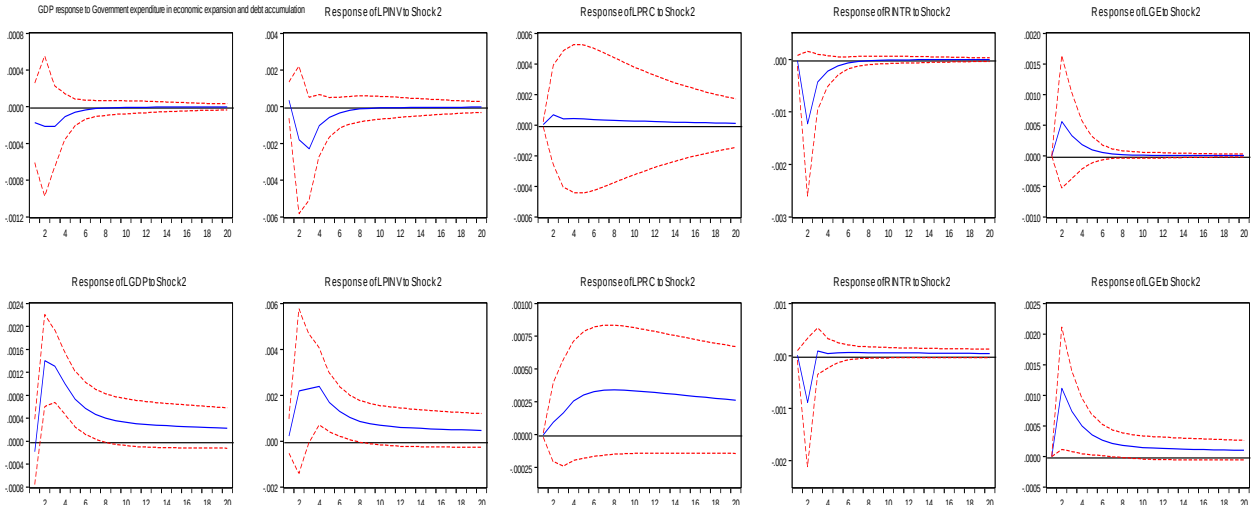
Model's estimation controlling for expansion	Model's estimation controlling for recession
$r_t = \underset{(.256)}{.129}\, y_t + \underset{(.287)}{.311}\pi_t + e_{1t}$	$r_t = -\underset{(.192)}{.071}\, y_t + \underset{(.279)}{.383}\pi_t + e_{1t}$
$d_t = \underset{(.174)}{-1.05} y_t \underset{(.355)}{-1.12}\pi_t \underset{(.087)}{-.308} r_t + e_{2t}$	$d_t = \underset{(.181)}{-.639} y_t \underset{(.354)}{-1.20}\pi_t \underset{(.088)}{-.269} r_t + e_{2t}$
$y_t = \underset{(.018)}{.167} i_t + \underset{(.029)}{.209}\pi_t - \underset{(.020)}{.017} r_t + e_{4t}$	$y_t = \underset{(.021)}{.163} i_t + \underset{(.032)}{.245}\pi_t - \underset{(.024)}{.016} r_t + e_{4t}$
$\pi_t = \underset{(.030)}{-.024} r_t \underset{(.021)}{-.005} i_t + e_{5t}$	$\pi_t = \underset{(.031)}{-.022} r_t \underset{(.021)}{-.009} i_t + e_{5t}$
$i_t = \underset{(.605)}{-.636} y_t \underset{(2.07)}{-2.13} r_t + e_{6t}$	$i_t = \underset{(.368)}{.378} y_t \underset{(1.25)}{-1.15} r_t + e_{6t}$
$g_t = e_{3t}$	$g_t = e_{3t}$
(…) are standard errors	(…) are standard errors

From the previous estimations, we notice significant differences in some estimated elasticities between the two models (expansion versus recession). We also observe that some signs are inverted from positive to negative, or vice versa, between two situations in the equation of interest rate and private investment. This shows that some behaviour is changing over the business cycle, which could explain the differences in fiscal multipliers between periods of expansion and recession. For the rest of the application, we produce the impulse response functions to structural shocks of the interest rate (shock1), public debt variable (shock2), private investment (shock3) and public expenditure (shock6) for the variables output, investment, inflation, interest rate and debt. We produce these IRFs for eight cases: two for the business cycle periods (expansion versus recession), two for debt ratio movements (accumulation versus reduction) and four for the joint business cycle and debt movements (expansion and debt accumulation/reduction and recession and debt accumulation/reduction). These outputs are displayed by the eight figures in Appendix B (Figures 11.B.a to 11.B.h).

To shed more light on the effects of fiscal variables on output, inflation and private investment, we prefer to focus on the corresponding IRFs, which we reproduce in this section. For the effects of the innovations of public debt (shock2) on output, private investment and inflation, Figure 9 clearly shows in the first row corresponding to the expansion model's IRFs that public debt increase has a deflationary effect on the other variables by reducing economic growth, especially through crowding out private investment in the United States, and inducing an increase in government expenditure. However, in times of recession (the second row of Figure 5), an increase in public debt is likely to increase growth by even stimulating inflation and private investment while keeping the interest rate reduced in the second quarter and pushing up government expenditure. We also observe that the effects are generally happening with a delay of one quarter and are at their peaks in the second or third quarter, while fading away (or stabilizing at their long-

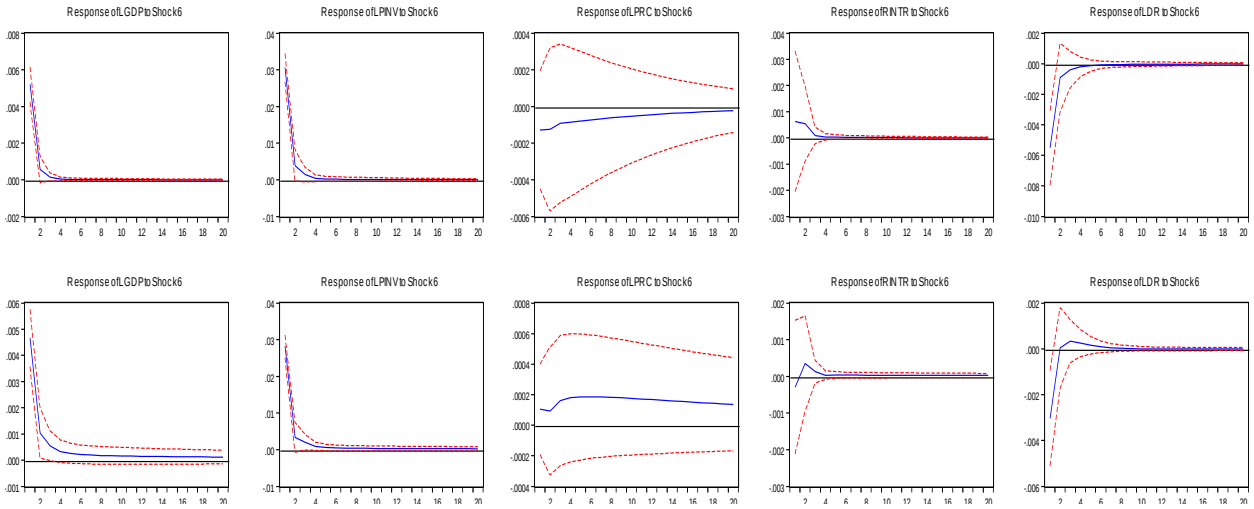
term path) at the fourth or sixth quarter, except for inflation, which has a persistent long-term response.

Figure 5. Responses to a structural shock of the government public debt ratio (shock2) in times of expansion (first row of charts) and recession (second row of charts)



For the effects of the structural innovations of total government expenditure (shock6, in Figure 6) in periods of expansion and recession, we note that the effect is immediate and high (in the first quarter), especially for the response of GDP, private investment and the public debt ratio. The effects of government expenditure are generally independent of the business cycle effects, except for the inflation variable being reduced in times of expansion and pushed up in times of recession. For the periods of expansion and recession as well, an increase in government expenditure is likely to immediately increase the output and then reduce the public debt ratio, while inducing an increase in the interest rate, especially in the second quarter, to counter the inflationary effects, albeit less important, in times of recession. However, this reduction of the public debt ratio could be a consequence of an algebraic computation of the increase of GDP being the denominator of the debt ratio variable. An important point is that all the responses are very short-lived (the effects occur and fade way within the first year), except for the reaction of the prices. In concordance with the public debt and government expenditure effects, we can conclude that expenditure multipliers are mainly weakened in times of expansion and increased in times of recession (as found in the previous results) by the effects of the public debt that crowd out the private agent decisions of investing, while the effects of fiscal policy (by expenditure side) are positive and short-lived, independent of the business cycle.

Figure 6. Responses to a structural shock of government expenditure (shock6) in times of expansion (first row of charts) and recession (second row of charts)



For the effects of debt movements (Figures 7 and 8), we observe almost the same findings about the reactions of the variables as those observed for the business cycle, except for prices (inflation and interest rates). A structural innovation of the public debt ratio is likely to reduce output by crowding out investment and may have a deflationary effect when debt is accumulated. However, in times of decumulating public debt, the effects of the public debt increase on output, investment and prices are positive (Figure 7). For the effects of government expenditure, they are positive on output and investment, while reducing public debt. The prices' reactions are slightly different for debt accumulation and debt reduction cases.

Figure 7. Responses to a structural shock of the public debt ratio (shock2) in periods of debt accumulation (first row of charts) and debt contraction (second row of charts)

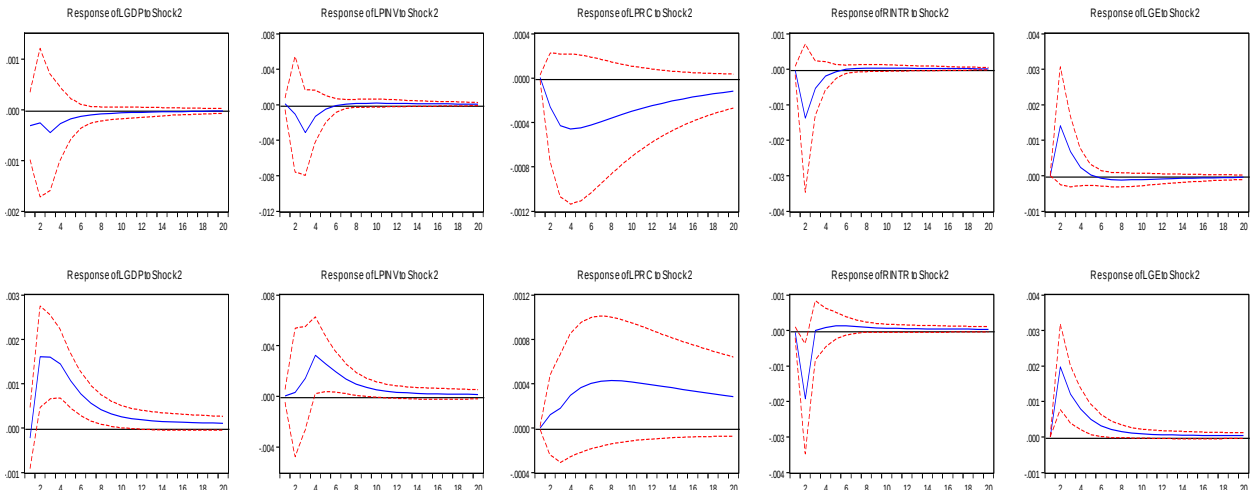
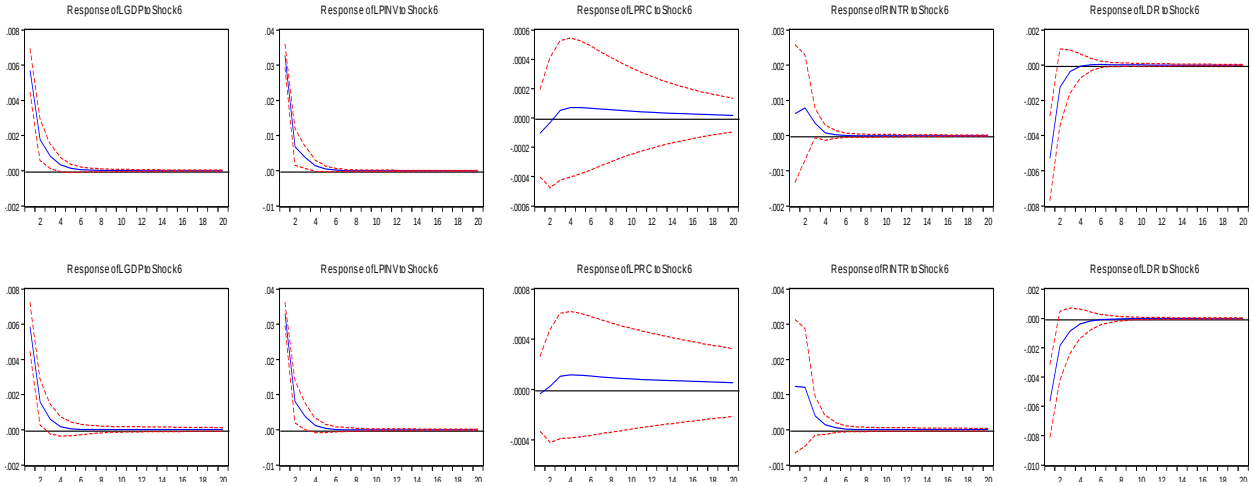


Figure 8. Responses to a structural shock of government expenditure (shock6) in periods of debt accumulation (first row of charts) and debt contraction (second row of charts)



For the effects of the business cycle and debt movements, we produce the four cases (in Figures 9 to 12). A structural innovation of the debt in periods of debt accumulation and expansion decreases simultaneously the GDP, investment and prices (inflation and interest rate), while increasing government expenditure (first row of the panel in Figure 9). For periods of debt accumulation in recession periods (second row of Figure 9), the effects are opposite (positive) on the first three variables, while the reaction of the interest rate and government expenditure have almost the same shape as in the first case. For the effects of government expenditure (Figure 10), they are short-lived and almost the same, independent of the two considered cases.

Figure 9. Responses to a structural shock of the government debt ratio (shock2) in periods of debt accumulation and expansion (first row of charts) and debt accumulation and recession (second row of charts)

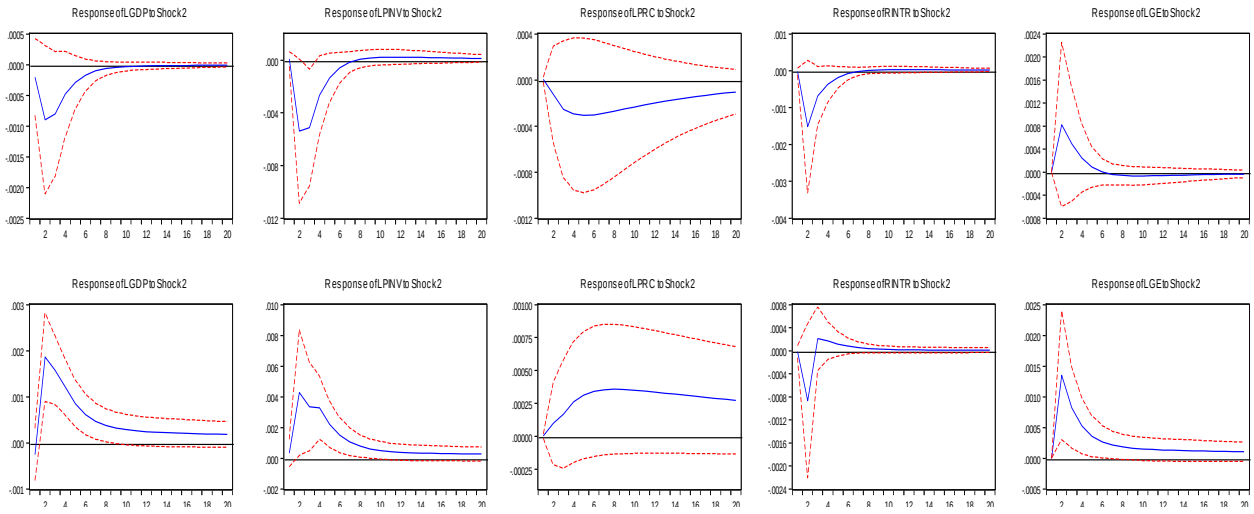
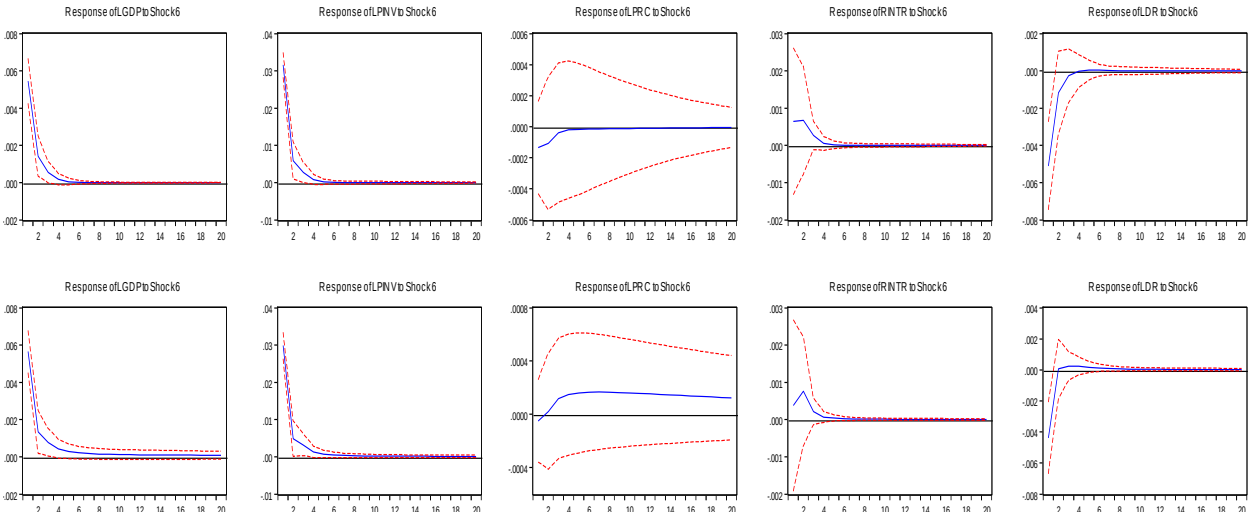


Figure 10. Responses to a structural shock of government expenditure (shock6) in periods of debt accumulation and expansion (first row of charts) and debt accumulation and recession (second row of charts)



For the government debt reduction case, jointly with the business cycle, unlike the case where debt is accumulated, the responses to the public debt structural shock are slightly different over the business cycle for private investment and interest rate, while they seem to behave the same way for the other variables, between the two situations. In particular, the output, investment and inflation are positively affected in the first year with persistent effects for inflation.

Figure 11. Responses to a structural shock of the government debt ratio (shock2) in periods of debt reduction and expansion (first row of charts) and debt reduction and recession (second row of charts)

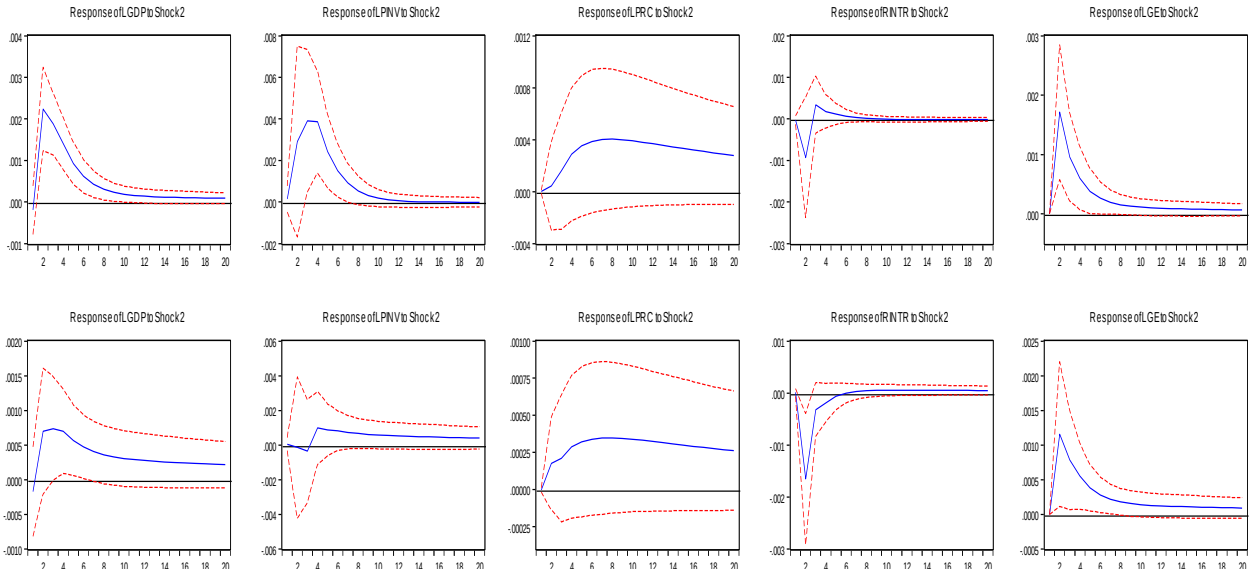
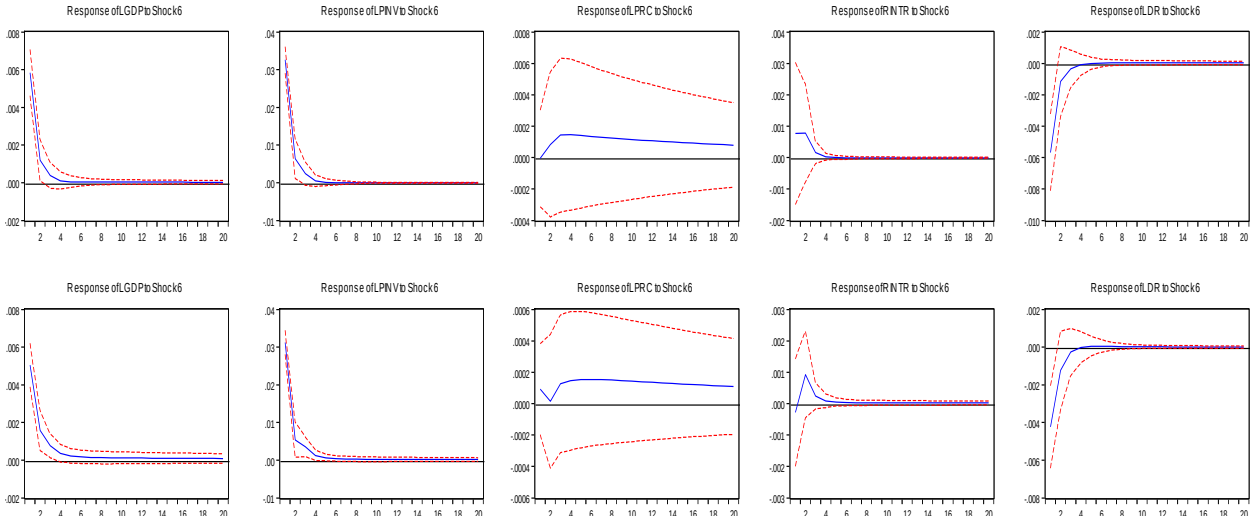


Figure 12. Responses to a structural shock of government expenditure (shock6) in periods of debt reduction and expansion (first row of charts) and debt reduction and recession (second row of charts)



This model, containing fiscal and monetary variables, sought to explain why the fiscal multipliers are weaker, or even negative, in times of expansion than recession. In times of high public debt, and particularly expansion, an increase in public debt ratio crowds out private investment, hence reducing output. By contrast, the government expenditure effects on output are all positive in the short term, independent of the public debt evolution (accumulation or decumulation) and business cycle. These results align with what we observed in a preliminary analysis (Section 4.2) of the works of Bouassard et al. (2012) and Berti et al. (2013) for 27 European countries, in which we highlighted the apparent decreasing relationship between expenditure multipliers' size and public debt ratio.

6. Conclusion

In this chapter, we used the methodology of a structural vector autoregressive model (SVAR), augmented by exogenous dummies variables controlling for the business cycle (expansion/recession) and public debt movements (accumulation/reduction). We applied this approach to assess the expenditure multipliers for a sample of 18 OECD countries (Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, The Netherlands, Norway, Portugal, Spain, Sweden, the United Kingdom and the United States) with different exchange rate regimes, monetary policies and degrees of openness.

The results show that, controlling for the business cycle effects, the expenditure multipliers are much higher in times of recession than times of expansion, and could attain, in recessions, more than 1 for many countries in the sample, in the short term, while going beyond the value of 2 in the long term. Moreover, it is noted that, generally, the idea of spending multipliers being weak,

and even negative in recent decades, compared to the 1960s, 1970s and 1980s, is not well supported by our findings. The previous results are in line with what was observed in the recent literature about fiscal multipliers, in advanced economies, being large in times of recession but weak, or even negative, in times of expansion.

Considering these results, the fiscal policy in advanced countries should be designed according to business cycle fluctuations. In particular, fiscal policies should be designed to counter the business cyclicality. In times of recession, it is the role of the government sector to stimulate the economy, while public intervention in times of expansion seems to alter economic growth (as the multipliers are weak or negative for many countries) and less beneficial to the economy than in times of recession. These results also run contrary to any fiscal consolidation based on cutting expenditure in times of recession, which could harm the economy.

Controlling exogenously for the public debt movements, independent of the business cycle, it is revealed that spending multipliers are larger in periods of debt accumulation than in debt reduction periods. Furthermore, controlling jointly for debt movements exogenously and the business cycle reveals the previous tendency, that is, multipliers are higher under debt accumulation in cases of expansion and recession. However, introducing endogenously the public debt to GDP variable in an SVAR leads to higher multipliers in recessions than expansions.

Furthermore, a robustness check of the previous results was conducted on a long history of quarterly data for the United States, as the country with long quarterly time series of the six fiscal and monetary variables considered in this model, namely, public debt, GDP, private investment, public expenditure, interest rate and inflation. The period of estimation covers the range 1966q1–2019q2. The main results of this model show that government expenditure has positive but short-lived effects on economic growth. Furthermore, public debt crowds out private investment, leading to lowering growth rates in times of expansion, while in times of recession, the public debt effects on growth are positive. This crowding-out effect may play *pass-through* to the expenditure multipliers and could explain, *ceteris paribus*, the weak size of spending multipliers, while in times of recession the crowing-in effect leads to higher multipliers.

In all our models the recession period generally has a persistent effect on variables for which convergence to the long-term path following the shock is achieved faster in times of expansion than recession. The policy implication of this, for highly indebted countries, is that fiscal stimulus effects could take time to materialize in times of depressed economies, while the effects are short-lived in times of expansion, which should be considered by policy-makers in their spending decisions.

Appendix A. Tables

Table 1.A: Sample of studies on the effectiveness of stimulus measures

Author(s)	Countries/Periods	Effects	Main Findings
Verick and Islam (2010)	60 countries (2008-2009)	Positive	Fiscal stimuli have proven more effective in creating jobs when they focus on capital expenditures for employment-intensive infrastructure and labour market measures. The US in 2009 enacted ARRA to restore employment mostly through tax cuts with a goal to create 3.5 million jobs by Q4 2010. By Q3 2009, 300,000-1.5 million jobs were made; 8.4 million jobs were lost since 2007.
Van Doorn, Suri, and Gooptu (2010)	20 countries (1995-2010)	Mixed	A nation's original fiscal stance determines how it can respond during a crisis. Hungary, for example, now has greater foreign exchange risks because its external debt surpassed its domestic debt prior to the crisis. Brazil, India, and Egypt have less risky exchange rates by accumulating more domestic debt than external debt before the economic downturn hit.
UNESCAP (2010)	37 countries (1990s – 2009)	Positive	Between 7 and 11 million jobs were saved due to the G20's 2009 fiscal policies, representing 29-43 per cent of the G20's total unemployment in the first half of 2009. In comparison, the Asian region's policies were successful overall in offsetting the loss of exports and kept regional 2009 GDP dropping at 4.2 per cent instead of 7.8 per cent, a possible outcome had the fiscal policies not been enacted.
IMF (2010a)	186 countries (1970-2010)	Mixed	Fiscal stimuli have provided an essential impetus for recovery in developed and developing countries alike. Following a decline of 0.5 per cent in 2009, the world output is projected to increase by 4.25 per cent in 2010. However, growth and recovery in the job market have varied across countries of different socio-economic levels, even with similar fiscal responses.
Arpaia and Curci (2010)	27 EU countries (1980s-2009)	Positive	During the crisis, many EU countries implemented reforms to combat the discouraged worker effect and keep workers in the labour market, such as decreasing the average hours worked per week. This made the early reduction in economic activity less drastic than originally projected.
EEAG (2010)	27 countries (1990s-2009)	Mixed	The EU's stimulus measures succeeded in curbing deflation and preventing a second depression. As example, Germany see its investment and domestic demand recover by the end of Q2/2009; however, consumption and GDP drop after an initial increase brought about by fiscal stimulus measures.
ILO (2010a)	EU (2006-2009)	Mixed	Mixed As a result of the European Globalization Adjustment Fund (EGAF) component of the European Economic Recovery Plan (EERP), 25,000 people received support in the form of skills training, job and career search help, promotion of entrepreneurship, and training for self-employment. This allowed many EU citizens to find jobs after losing work due to outsourcing.
Wyplosz (2010)	Eurozone – 16 countries (1996-2009)	Negative	Fiscal policies played a small role in Eurozone's recovery, due to the pre-existing Stability and Growth Pact and 3 per cent public deficit ceiling limiting their use. Budget balances as a percentage of GDP were less in France, Germany, and Italy compared to the UK and US, implying that less government funds went towards fiscal stimuli in the former three countries than the latter two.
Kandil and Morsy (2010)	34 emerging countries (1970-2009)	Positive	The presence of international reserves allowed emerging economies to be in a good position to weather the economic crisis and have their stimulus measures succeed, while at the same time avoiding a crowding-out effect. For example, China and Brazil have managed to weather the crisis well due to a rapid increase in export prices, robust demand, and constant capital inflows.
World Bank (2010a)	14 emerging countries (Mid-1980s-2009)	Positive	Due to China's economic activity, its monetary and fiscal stimuli, and its inflow of foreign capital, the East Asia and the Pacific region overall has recovered from the crisis and had its employment, exports, and output return to pre-crisis levels. The region is doing so well that many national governments are beginning to end support policies.
ADB (2010)	32 countries	Positive	Asia, the first region to recover from the global financial crisis, (1990s-2010) experienced a strong and fast V-shaped recovery due to large monetary and fiscal stimulus packages. These heavily increased the demand for goods and services and promoted growth, which is projected to reach 7.5 per cent in 2010, which is up from 5.2 per cent in 2009.
Bhaskaran and Ghosh (2010)	3 countries (1981-2009)	Mixed	Indonesia, the Philippines, and Thailand were resilient during the global recession thanks to timely stimulus measures. For example, starting in 2008 Indonesia injected RP 1 trillion into its economy, which successfully increased liquidity and prevented a dramatic depreciation of its currency.
IDB (2010a)	4 Latin American countries	Positive	Decreased economic activity, employment, tax rates, and export prices brought about due to the downturn ended Latin America's period of expansion that began in 2002-03 and thus decreased its fiscal surplus. MERCUSOR was still able to respond by implementing measures that showed positive impacts, such as increased government spending, tax cuts, and infrastructure investment.
IMF (2010b)	28 North and South America States (1970-2010)	Mixed	The North American and Latin American regions experienced different outcomes due to their fiscal stimuli. The recoveries in the US and Canada are propelled by fiscal stimuli, giving the former a 5.6 per cent GDP increase by Q4 2009 and the latter resilient fiscal credibility, increased demand, and 3 per cent growth in 2010. In most of Latin America, government fiscal stimuli had small multipliers that did not contribute much to growth.
Kucera, Roncolato, and Uexkull (2010)	India and South Africa (19602010)	Negative	Fiscal stimuli did not contribute much to GDP or job growth in India or South Africa. India's employment growth rate was 1.7% in Q4/2009 but only 0.2% in Q1/2010. South Africa experienced 3 negative quarters of growth in 2009 and observed positive growth in Q4/2009 (0.7%), but growth decreased again in Q1/2010 (-1.3%). Employment declined by 770,000, 833,000, and 870,000 in Q3/2009, Q4/2009, and Q1/2010 respectively.

Table 1.A continued: Sample of studies on the effectiveness of stimulus measures

Author(s)	Countries/Periods	Effects	Main Findings
Kasekende, Ndikumana and Brixova (2010)	56 African countries (Mid-1980s–2009)	Mixed	Most of Africa had favourable pre-crisis macroeconomic standings. Thus, much of the region was able to deliver well-timed, domestic demand and supply-side focused countercyclical stimuli that promoted a better business environment. However, due to their lack of resources, they should look internationally for support to coordinate and establish a long-term mutually-beneficial outcome.
Ndikumana, el al. (2010)	41 countries (1986-2009)	Positive	Even with short supply of national resources, African nations enacted a variety of well-timed and targeted policies. Some nations were successful in stimulating domestic demand while offsetting declining exports and supporting local businesses.
World Bank (2010b)	18 countries (1980-2010)	Positive	Most Middle Eastern nations improved their near and long-term outlooks. Others, such as Egypt and Tunisia, spent stimulus money on infrastructure and support for SMEs to create new jobs. Unlike the public sector, the private sector has received less support and it is uncertain whether this sector will continue to recover when Saudi Arabia's 400 billion dollar stimulus package expires in 5 years.
ILO (2010b)	Germany	Positive	Germany's labour market-targeted measures left favourable (2006-2009) impacts on employment. Germany's Kurzarbeit reduced working hour program had 1.43 million participants by mid-2009. Working time reduced on average by 30.5 per cent, which counted for 432,000 fulltime jobs. If these job losses had occurred, Germany's unemployment rate would have risen by 1 percentage point.
IMF (2010c)	Germany (mid-1970s2010)	Mixed	The economic downturn was contained in Germany by the government's automatic stabilizers and fiscal stimulus. Additionally, Germany's extensive labour market programmes, such as the Kurzarbeit short-term subsidy programme, which compensated employers for retaining workers during the crisis, successfully encouraged many employers to refrain from layoffs.
ILO (2010c)	Russia (1992-2010)	Negative	Despite the rapid pace at which stimulus packages were adopted, hiring has yet to catch up. In September 2009, Russian public employment services have placed 61,300 out of 328,300 employees in public sector jobs, a 50 per cent increase from 2009 target. However, the ratio of unemployed to 100 labour market vacancies stands at 212.
Park and Lommen (2010)	China (2008-2010)	Mixed	China's timely and effective fiscal stimuli allowed it to experience a stronger and faster V-shaped recovery than expected. However, pressing national issues remain for China to solve in the medium-run, such as aging population, lack of domestic growth, absence of effective social protection, inflexible exchange rates, and unbalanced growth sources, all of which need stimuli.
Yongding (2009)	China (1978-2008)	Mixed	In 2008, the Chinese government issued a RMB 4 trillion stimulus package and RMB 200 billion worth of local government bonds. While succeeding in reviving and stabilizing the economy and keeping growth positive, these actions have not insured China against long-term consequences, such as investment overdrive, decreased efficiency, and slow infrastructure investment.
Zhu and Orton (2010)	China (2003-2010)	Positive	Chinese fiscal policy responses were effective in curbing the negative impacts of the global financial crisis. The GDP growth maintained high during the crisis, reaching levels of 9 per cent in 2008, 8.7 per cent in 2009, and 8 per cent in 2010. On the labour side, 97 per cent of 150.7 million migrant workers from rural China found jobs in urban areas.
Shimizu and Orton (2010)	Japan (1985-2010)	Positive	Japan implemented effective labour market stimuli. Japan's crisis response employment measures created 90,000 new local government jobs and granted 2.34 million workers wage subsidies by July 2009. Furthermore, 2.55 million temporary Japanese workers were covered under the unemployment insurance by April 2010.
ILO (2010d)	Republic of Korea (2006-2009)	Mixed	Korea's stimulus helped retain jobs and allowed new labour market entrants to find employment. It raised SME subsidies from 2/3 to 3/4 of wages and gave large enterprises a subsidy increase from 1/2 to 2/3 of wages. 30 per cent of workplaces with 100 or more employees participated, which saved at least 90,000 jobs. Internship programmes at public institutions and SMEs gave employment to 90,000 young Koreans, 80 per cent of whom went on to work fulltime.
OECD (2010)	Korea (1996-2010)	Positive	Korea's fiscal stimulus package from 2009 greatly increased national consumption and decreased unemployment levels. By the end of 2009, this measure created at least 300,000 jobs in the public sector.
ACTU (2009)	Australia (2008-2009)	Mixed	Australia's fiscal labour market measures had mixed results on employment. Its fiscal stimulus package was successful in decreasing national unemployment down to 5.7 per cent by late 2009. However, over 140,000 job-seeking Australians remain out of work. Therefore, the economic stimulus and infrastructure investment should not end.
Commonwealth of Australia	Australia (1980s-2009)	Positive	By the end of Q2 2009, the Australian stimulus package had succeeded in stabilizing the national market and minimizing (2009) the rise in unemployment. The unemployment rate was 5.8%, 1.9 points higher than in Feb 2008. However, without the stimulus, the Treasury estimated that an additional 210,000 jobs would have be lost.
ILO (2010e)	Australia (2007-2010)	Positive	Australia's fiscal stimulus measures increased national growth levels and strengthened the labour market. It increased GDP by 1% between 2008 and 2009 and unemployment declined by 0.5% from a high level in July 2009 (5.8%) to a lower mark in February 2010 (5.3%), as a result of the stimulus.
ILO (2010f)	Indonesia (2006-2010)	Positive	Of the IDR 12.2 trillion infrastructure package, IDR 6.6 trillion went to the Department of Public Works for the creation of water systems, sanitation systems, and roads. IDR 1.5 trillion devoted to water systems alone was responsible for creating 250,000 jobs in 2009.

Table 1.A continued: Sample of studies on the effectiveness of stimulus measures

Author(s)	Countries/Periods	Effects	Main Findings
ILO (2010g)	Argentina (1996-2009)	Positive	Argentina's measure to reduce tax credits for capital goods, infrastructure firms, and SMEs in an effort to temporarily reduce their tax and social security burden succeeded in retaining 330,547 employees of those 169,000 employers that registered for the program.
Zandi (2010)	United States (2008-2009)	Positive	The ARRA has dampened the negative impact of the recession on GDP and employment. The most economic activity per federal dollar spent has come from the extension of unemployment insurance benefits and social programs like food stamps and work-share as well as infrastructure spending.
Taylor (2009)	United States (2006-2008)	Negative	The US government's early response to the 2007 crisis worsened the situation by focusing on liquidity and bank credit market problems rather than risk, providing no help to other than banks and creditors. Measures such as term auction facilities, cash infusions, and interest rate cuts failed to substantially increase consumption, but it increased dollar inflation and raised oil prices.
Burtless (2010)	United States (2007-2010)	Mixed	The ARRA was successful in allowing most state governments to maintain pre-crisis levels of employment in government and educational institutions, in spite of the massive decrease in tax revenue. This did come at the cost of decreased wages and working hours though. The bill also gave a 9-month subsidy for the unemployed that covered 65 per cent of former employers' healthcare.
US Government (2010)	United States (1940s – 2009)	Mixed	Due to US stimulus packages, the decline in national GDP slowed from -6.4% in Q1/2009 to -0.7% in Q2/2009, and then turned around to 2.2 and 5.7% in Q3 and Q4 of 2009. The rate of job losses also has been reduced substantially, from a high of 691,000 in Q1/2009 to a low of only 69,000 in Q4/2009.
Council of Economic Advisors (2010)	United States (2007-2009)	Positive	The ARRA was able to slow down the rate of job and output loss while also returning GDP to positive levels. In Q2 2009, 2-3% was added to GDP, and in Q4/2009, 1.5-3% was added to GDP. Employment significantly increased under the ARRA, specifically between 1.5-2 million jobs by the end of 2009.
Joint Eco. Committee -US Congress (2010)	United States (1950s-2010)	Mixed	By Q1 2010, the ARRA increased GDP by 1.7 to 4.2 per cent and decreased the national unemployment rate by 0.7 to 1.5 percentage points. This resulted in the creation of 1.2-2.8 million jobs since the ARRA was enacted a year prior.
Mishel and Shierholz (2010)	United States (2007-2010)	Positive	Unemployment insurance should not be reduced, as it both creates jobs and aids those without one. The unemployment insurance measures in the ARRA retained 1.7 million current jobs and created 1.2 million new jobs by July 2010.
Weller (2010)	United States (1950s-2010)	Mixed	The ARRA allowed the private sector to start recovering prior losses in investment, production, and hiring. The US in Q2 2010 experienced a 2.4% growth rate and gained 630,000 new private sector jobs in the first 7 months of 2010, but unemployment still high and 7.7 million jobs lost since 2007.
Flaherty (2010)	Canada (2000-2010)	Positive	As a result of Canada's stimulus package, in 2009 both aggregate employment and GDP levels increased. Since its inception in July 2009, the Canada Action Plan has created 135,000 jobs out of its target of 225,000. The GDP increased by 0.9 per cent in Q3 of 2009 and by 5 per cent in Q4 of 2009. Canada also experienced the smallest decline in GDP out of all G7 nations, since the crisis began.
ILO (2010g)	Canada (20072010)	Positive	The earnings protection and work sharing components of Canada's Action Plan were successful in saving many Canadian jobs during the crisis. In 2009, 13,500 workers received C$3,323 in financial assistance for unpaid wages due to company closures and termination. Also, in 2009, 6,000 work sharing agreements were signed by Canadian employees, securing the employment of 167,410.
Asian Development Bank, ADB (2010)	Asia (4 G20 members and 10 other developing countries)	Positive	The countries in developing Asia rolled out the stimulus measures quickly and decisively in general, proactively using fiscal policy for countercyclical purposes during the global developing crisis. The stimulus packages are tilted toward higher countries) spending, in particular infrastructure investments, consistent with the region's long-standing pro-growth orientation. Partly helped by the healthy public finances' situation in the initial stage, evidences suggest that the stimulus efforts to boost sagging demand have been effective and contributed to the region's remarkable recovery.
The Brookings Institution (2009)	G-20 Countries (2008-2009)	Positive	The article finds that fiscal stimulus played a crucial role in stabilizing the world economy, especially in the G-20 economies. It suggests that while the effectiveness of fiscal stimulus is questioned, the world economy would have been even worse had there not been stimulus packages.
NBER (2010)	22 high income +24 developing countries (1960:Q1 -2007:Q4)	Mixed	Using the panel SVAR methods, the research finds that the effect of government consumption is very small on impact, with estimates clustered close to zero. It supports the notion that fiscal policy may be rather slow in impacting economic activity, raising questions as to the usefulness of discretionary fiscal policy for short-run stabilization purposes. The medium- to long-run effects of increases in government consumption vary considerably depending on the level of development, exchange rate flexibility, openness to trade, and debt of the central government.
OECD Economic Outlook, Interim Report (2009)	34 OECD Countries (2008-2010)	Mixed	The report verifies the use of fiscal stimulus in virtually all OECD countries. As for the effectiveness of fiscal stimulus, the report suggests after its own review of relevant literatures that the fiscal multipliers are around unity for government spending under normal circumstances. The report suggests that the multipliers may be reduced in the current conjuncture as the propensity of households/businesses to save is likely to increase reducing tax cuts multipliers.
OECD Economic Outlook, Volume 2010 Issue 1	34 OECD Countries (2008-2010)	Mixed	Noting that most OECD countries introduced fiscal packages during the recent crisis, the report recognizes the potentially important role of discretionary fiscal policy during a large and protracted shock. Meanwhile, the report warns that implementing fiscal stimulus may be slow and may result in a pro-cyclical rather than counter-cyclical. Looking at past experience, estimates of discretionary fiscal policy show pronounced counter-cyclicality only in Australia, Canada, Denmark, and the US, while policy has been generally pro-cyclical in Austria, Belgium, Hungary, the Netherlands, Poland, Portugal, and the UK. Also, fiscal policy was poorly prepared to deal with the crisis as countries were financially constrained prior to the outbreak of the crisis.

Source: International Labour Organization (2011).

Table 2.A: Coefficient of correction to get fiscal multipliers from Cholesky impacts innovations by periods and countries samples

	Government consumption growth rate standard error (σ_g)			Average of GDP to government consumption ($\overline{Y/G}$)			$\overline{Y/G}/\sigma_g$		
Countries	1966Q1/ 2019Q2	1966Q1/ 1991Q4	1992Q1/ 2019Q4	1966Q1/ 2019Q2	1966Q1/ 1991Q4	1992Q1/ 2019Q4	1966Q1/ 2019Q2	1966Q1/ 1991Q4	1992Q1/ 2019Q4
Austria	0.721	0.469	0.882	4.796	4.575	5.002	6.65	9.75	5.67
Belgium	0.679	0.700	0.599	3.877	3.643	4.096	5.71	5.20	6.84
Canada	1.056	1.288	0.704	4.091	3.616	4.536	3.88	2.81	6.45
Denmark	0.821	0.850	0.751	4.156	4.215	4.101	5.06	4.96	5.46
Finland	1.800	1.809	1.724	3.818	3.605	4.018	2.12	1.99	2.33
France	0.468	0.498	0.291	4.275	4.298	4.253	9.14	8.62	14.63
Germany	1.178	1.459	0.823	5.179	5.103	5.251	4.40	3.50	6.38
Greece	1.827	1.026	2.272	5.558	5.967	5.174	3.04	5.82	2.28
Ireland	1.898	1.116	2.415	5.002	3.717	6.205	2.64	3.33	2.57
Italy	0.706	0.456	0.713	5.050	4.829	5.257	7.15	10.58	7.38
Japan	0.928	1.119	0.576	5.758	6.067	5.469	6.20	5.42	9.49
Netherlands	1.415	1.821	0.884	4.165	4.163	4.167	2.94	2.29	4.71
Norway	1.423	1.444	1.350	4.590	4.756	4.435	3.22	3.29	3.28
Portugal	1.096	1.010	0.671	6.890	8.262	5.606	6.28	8.18	8.35
Spain	1.035	1.060	0.912	6.842	8.128	5.638	6.61	7.67	6.18
Sweden	0.923	1.013	0.749	3.236	2.994	3.463	3.51	2.96	4.62
United Kingdom	1.101	1.162	1.046	4.727	4.251	5.173	4.29	3.66	4.95
United States	0.830	0.952	0.680	5.298	4.400	6.139	6.38	4.62	9.03

Table 3.A. Sensitivity of government expenditure Cholesky impacts and the corresponding multipliers to different periods of time

	1966Q1-1991Q4						1992Q1-2019Q2					
	first Quarter		Fourth Quarter (one year)		20th Quarter (5 years)		first Quarter		Fourth Quarter (one year)		20th Quarter (5 years)	
Countries	Impact	Multiplier	Impact	Multiplier	Impact	Multiplier	Impact	Multiplier	Impact	Multiplier	Impact	Multiplier
Austria	0.27	2.59	0.34	3.31	0.34	3.35	0.03	0.17	0.03	0.19	0.03	0.20
Belgium	0.02	0.13	0.32	1.68	0.49	2.53	0.07	0.48	0.17	1.17	0.18	1.21
Canada	0.27	0.76	0.13	0.36	0.13	0.35	0.04	0.24	-0.09	-0.57	-0.11	-0.68
Denmark	0.24	1.20	0.47	2.35	0.50	2.46	0.10	0.53	-0.05	-0.28	-0.05	-0.28
Finland	-0.08	-0.16	0.01	0.02	0.01	0.01	0.25	0.58	0.44	1.03	0.44	1.03
France	-0.07	-0.58	0.18	1.53	0.18	1.53	-0.17	-2.42	-0.46	-6.73	-0.61	-8.85
Germany	0.26	0.91	0.21	0.73	0.21	0.73	0.02	0.14	-0.13	-0.83	-0.13	-0.84
Greece	-0.14	-0.82	0.16	0.96	0.70	4.05	0.66	1.50	0.97	2.20	0.97	2.21
Ireland	0.33	1.09	0.85	2.83	0.11	0.36	0.79	2.03	0.77	1.98	0.77	1.97
Italy	0.12	1.27	0.30	3.20	0.33	3.49	0.21	1.55	0.46	3.37	0.51	3.80
Japan	0.11	0.61	0.00	0.03	0.00	0.02	0.01	0.10	0.06	0.60	0.06	0.60
Netherlands	0.24	0.55	0.17	0.38	0.17	0.39	-0.01	-0.02	0.14	0.65	0.15	0.71
Norway	0.27	0.89	0.30	1.00	0.30	0.99	0.23	0.75	-0.04	-0.14	0.01	0.02
Portugal	0.72	5.92	0.79	6.47	0.70	5.72	0.20	1.68	0.61	5.11	0.87	7.30
Spain	0.22	1.71	0.22	1.67	0.22	1.66	0.27	1.65	0.77	4.74	1.09	6.74
Sweden	0.34	1.00	0.29	0.85	0.29	0.85	-0.01	-0.03	-0.06	-0.30	-0.07	-0.31
United Kingdom	0.00	-0.01	-0.04	-0.13	-0.04	-0.13	0.06	0.31	0.03	0.16	0.03	0.13
United States	0.03	0.16	-0.02	-0.10	-0.02	-0.12	-0.08	-0.72	-0.30	-2.72	-0.33	-3.02
Average	0.18	0.96	0.26	1.51	0.26	1.57	0.15	0.47	0.18	0.54	0.21	0.66

Note: Impact multipliers (*IM*) are adjusted by the corresponding adjustment coefficient from table 2.A to obtain fiscal multipliers (*FM*) according to the formulae $FM = IM * \overline{Y/G}/\sigma_g$.

Table 4.A: Business cycle effects on government expenditure short run and long run multipliers

1992Q1-2019Q2	Short run impact (1st quarter)		Long run accumulated impact (5 years)		Short run multiplier (1st quarter)		Long run accumulated multiplier (5 years)		Short run multiplier (Recession ***Minus*** Expansion)	Long run accumulated multiplier (Recession ***Minus*** Expansion)
Country	Expansion	Recession	Expansion	Recession	Expansion	Recession	Expansion	Recession		
Austria	-0.029	0.375	-0.085	1.292	-0.137	1.793	-0.404	6.175	1.93	6.58
Belgium	-0.014	0.276	0.025	1.196	-0.071	1.429	0.131	6.201	1.50	6.07
Canada	-0.027	0.383	-0.239	1.413	-0.137	1.907	-1.190	7.043	2.04	8.23
Denmark	0.009	0.419	-0.158	0.814	0.033	1.506	-0.570	2.929	1.47	3.50
Finland	0.071	0.366	0.108	0.752	0.141	0.728	0.215	1.498	0.59	1.28
France	-0.080	0.153	-0.461	1.428	-0.318	0.611	-1.835	5.689	0.93	7.52
Germany	-0.104	0.359	-0.307	0.805	-0.500	1.723	-1.474	3.861	2.22	5.33
Greece	0.423	0.514	0.457	0.603	0.917	1.113	0.990	1.308	0.20	0.32
Ireland	0.550	1.533	0.486	2.165	1.022	2.846	0.903	4.019	1.82	3.12
Italy	0.112	0.195	0.213	0.515	0.641	1.120	1.226	2.956	0.48	1.73
Japan	-0.085	0.322	-0.240	0.915	-0.461	1.745	-1.302	4.953	2.21	6.25
Netherlands	-0.065	0.279	-0.069	1.538	-0.246	1.051	-0.261	5.796	1.30	6.06
Norway	0.145	0.819	-0.004	0.906	0.427	2.405	-0.011	2.659	1.98	2.67
Portugal	0.109	0.234	0.295	1.623	0.488	1.051	1.323	7.280	0.56	5.96
Spain	0.085	0.407	0.087	1.481	0.396	1.893	0.406	6.895	1.50	6.49
Sweden	-0.099	0.377	-0.200	1.012	-0.303	1.158	-0.614	3.109	1.46	3.72
UK	-0.014	0.346	-0.117	1.414	-0.065	1.588	-0.535	6.488	1.65	7.02
USA	-0.024	0.310	-0.181	1.060	-0.174	2.224	-1.298	7.608	2.40	8.91
Average	0.05	0.43	-0.02	1.16	0.09	1.55	-0.24	4.80	1.46	5.04

Table 5.A. Short run and long run government expenditure multipliers under debt accumulation and debt reduction

	Cholesky impacts				Multipliers impacts				Convergence to long run multiplier	
	Under debt accumulation		Under debt reduction		Under debt accumulation		Under debt reduction			
Country	Short run	Long run	Short run	Long run	Short run	Long run	Short run	Long run	Under debt accumulation	Under debt reduction
Austria	0.19	0.38	0.14	0.24	0.90	1.80	0.65	1.15	Fast	Fast
Belgium	0.34	1.23	0.21	0.48	1.76	6.36	1.11	2.48	Medium	Medium
Canada	0.31	0.85	0.10	0.03	1.54	4.21	0.51	0.13	Medium	Medium
Denmark	0.31	0.34	0.14	0.08	1.12	1.22	0.50	0.28	Fast	Fast
Finland	0.14	0.22	0.15	0.20	0.28	0.44	0.30	0.39	Fast	Fast
France	0.09	0.63	0.03	0.40	0.35	2.49	0.13	1.60	Medium	Slow
Germany	0.18	0.38	0.07	0.10	0.87	1.81	0.32	0.47	Fast	Fast
Greece	0.77	1.20	0.67	1.01	1.67	2.61	1.44	2.18	Fast	Fast
Ireland	1.48	1.70	0.38	0.14	2.75	3.16	0.70	0.27	Fast	Fast
Italy	0.35	0.90	0.31	0.74	1.99	5.19	1.79	4.22	Medium	Medium
Japan	0.09	0.16	0.07	0.21	0.48	0.89	0.37	1.12	Fast	Fast
Netherlands	0.12	0.88	-0.06	0.09	0.45	3.32	-0.23	0.35	Medium	Fast
Norway	0.52	0.30	0.62	0.50	1.54	0.89	1.83	1.48	Fast	Fast
Portugal	0.20	0.70	0.04	0.31	0.88	3.16	0.20	1.38	Medium	Medium
Spain	0.33	2.95	0.26	1.25	1.55	13.72	1.20	5.81	Slow	Slow
Sweden	0.32	0.75	0.04	0.04	1.00	2.30	0.12	0.13	Fast	Fast
UK	0.36	1.43	0.21	0.47	1.65	6.58	0.95	2.16	Slow	medium
USA	0.15	0.28	0.03	-0.11	1.09	2.02	0.22	-0.76	Medium	Fast
Average	0.35	0.85	0.19	0.34	1.22	3.45	0.67	1.38	--	--

Notes: Impact multipliers (*IM*) are adjusted by the corresponding adjustment coefficient from table 2.A to obtain fiscal multipliers (*FM*) according to the formulae $FM = IM * \overline{Y/G}/\sigma_g$. Convergence to the long run is fast if it is approximately attained in less than 5 quarters, medium between 6 and 9 quarters and slow in case it is reached in more than 10 quarters (this is clearly visible from the GDP responses charts).

Table 6.A.: The mutually effects of the business cycle and public debt (accumulation/reduction)

	Cholesky impacts								Multipliers impacts							
	Expansion				Recession				Expansion				Recession			
	Under debt accumulation		Under debt reduction		Under debt accumulation		Under debt reduction		Under debt accumulation		Under debt reduction		Under debt accumulation		Under debt reduction	
Country	Short run	Long run	Short run	Long run	Short run	Long run	Short run	Long run	Short run	Long run	Short run	Long run	Short run	Long run	Short run	Long run
Austria	-0.06	-0.12	-0.08	-0.16	0.13	0.23	0.15	0.27	-0.30	-0.59	-0.38	-0.76	0.64	1.09	0.72	1.30
Belgium	0.04	-0.04	0.01	-0.11	0.31	1.08	0.23	0.58	0.21	-0.22	0.06	-0.58	1.60	5.58	1.21	2.98
Canada	-0.01	-0.18	-0.05	-0.28	0.28	0.83	0.19	0.36	-0.05	-0.91	-0.26	-1.38	1.41	4.12	0.94	1.79
Denmark	0.01	-0.12	0.00	-0.15	0.31	0.55	0.15	0.22	0.04	-0.43	0.02	-0.52	1.11	1.98	0.52	0.78
Finland	-0.01	-0.07	-0.04	-0.08	0.11	0.18	0.15	0.17	-0.03	-0.14	-0.08	-0.17	0.22	0.35	0.30	0.33
France	-0.09	-0.31	-0.11	-0.46	0.13	0.73	0.12	0.73	-0.35	-1.22	-0.44	-1.84	0.53	2.90	0.47	2.89
Germany	-0.19	-0.38	-0.23	-0.42	0.16	0.46	0.10	0.18	-0.89	-1.84	-1.09	-2.00	0.75	2.21	0.47	0.88
Greece	0.28	0.35	0.59	0.81	0.57	0.74	0.31	0.39	0.62	0.75	1.27	1.75	1.23	1.60	0.68	0.85
Ireland	0.35	0.16	0.25	0.07	1.48	1.91	0.34	0.12	0.64	0.31	0.46	0.12	2.75	3.55	0.64	0.23
Italy	0.21	0.36	0.19	0.40	0.25	0.66	0.25	0.52	1.18	2.09	1.10	2.30	1.45	3.81	1.41	2.97
Japan	-0.04	-0.11	-0.18	-0.44	0.12	0.17	0.22	0.54	-0.22	-0.60	-0.97	-2.37	0.63	0.93	1.22	2.93
Netherlands	-0.13	-0.12	-0.14	-0.12	0.11	0.78	-0.04	0.13	-0.51	-0.45	-0.54	-0.44	0.40	2.94	-0.15	0.51
Norway	0.15	0.05	0.20	0.09	0.56	0.51	0.60	0.72	0.45	0.14	0.58	0.27	1.63	1.49	1.77	2.10
Portugal	-0.02	0.06	0.06	0.12	0.17	0.46	-0.01	0.20	-0.07	0.27	0.26	0.54	0.78	2.06	-0.03	0.89
Spain	0.05	0.03	0.09	0.17	0.30	2.14	0.23	0.95	0.25	0.12	0.44	0.77	1.38	9.95	1.08	4.44
Sweden	-0.11	-0.16	-0.14	-0.22	0.34	0.85	0.10	0.23	-0.35	-0.50	-0.44	-0.68	1.03	2.62	0.31	0.70
UK	0.00	-0.07	-0.01	-0.11	0.28	0.86	0.20	0.50	-0.01	-0.33	-0.04	-0.52	1.31	3.95	0.93	2.27
USA	0.02	-0.09	0.00	-0.13	0.25	0.61	0.26	0.60	0.15	-0.66	-0.01	-0.96	1.82	4.35	1.87	4.30
Average	0.03	-0.04	0.02	-0.06	0.33	0.76	0.20	0.41	0.04	-0.23	0.00	-0.36	1.15	3.08	0.80	1.84

Note: Impact multipliers (*IM*) are adjusted by the corresponding adjustment coefficient from table 2.A to obtain fiscal multipliers (*FM*) according to the formulae $FM = IM * \overline{Y/G}/\sigma_g$.

Table 7.A. Short run and long run GDP response to a structural government expenditure innovation from an SVAR with endogenous public debt

		Short run Impact (1st quarter)		Impact in one year		Impact in two years		Long run impact (5 years)		Convergence to the long run	
Country	Sample	Expansion	Recession	Expansion	Recession	Expansion	Recession	Expansion	Recession	Expansion	Recession
Austria	2000:1-2019:2	-0.05	0.29	-0.12	0.63	-0.12	0.69	-0.12	0.70	Fast	Medium
Belgium	1995:4-2019:2	0.03	0.17	-0.07	0.62	-0.08	0.84	-0.08	0.95	Fast	Slow
Canada	1990:1-2019:2	-0.02	0.29	-0.20	0.89	-0.22	1.16	-0.22	1.24	Fast	Medium
Denmark	2000:1-2019:2	0.09	0.30	-0.07	0.56	-0.07	0.58	-0.07	0.58	Fast	Fast
Finland	2000:1-2019:2	-0.05	0.23	-0.10	0.38	-0.10	0.38	-0.10	0.38	Fast	Fast
France	1998:4-2019:2	0.03	0.21	-0.08	0.70	-0.12	1.02	-0.13	1.22	Medium	Slow
Germany	1998:1-2019:2	-0.16	0.20	-0.35	0.68	-0.35	0.72	-0.35	0.72	Fast	Fast
Greece	1997:4-2019:2	0.45	0.57	0.60	0.82	0.60	0.83	0.60	0.83	Fast	Fast
Ireland	2000:1-2019:2	0.08	0.28	-0.05	0.61	-0.05	0.62	-0.05	0.62	Fast	Fast
Italy	1995:4-2019:2	0.11	0.19	0.23	0.54	0.24	0.59	0.24	0.59	Fast	Fast
Japan	1997:4-2019:2	0.00	0.24	-0.11	0.41	-0.12	0.42	-0.13	0.42	Fast	Fast
Netherlands	1999:4-2019:2	-0.11	-0.02	-0.06	0.33	-0.05	0.45	-0.05	0.48	Fast	Medium
Norway	1995:4-2019:2	0.13	0.70	0.02	0.83	0.03	0.82	0.03	0.82	Fast	Fast
Portugal	1999:4-2019:2	-0.04	0.12	-0.07	0.33	-0.10	0.39	-0.10	0.40	Medium	Medium
Spain	1995:4-2019:2	0.03	0.06	0.04	0.53	0.04	0.96	0.04	1.51	Medium	Slow
Sweden	1995:4-2019:2	-0.10	0.36	-0.18	0.97	-0.18	1.10	-0.18	1.11	Fast	Medium
UK	1995:1-2019:2	0.04	0.35	-0.02	1.07	-0.03	1.47	-0.03	1.68	Fast	Slow
USA	1995:1-2019:2	0.05	0.42	-0.06	1.17	-0.06	1.41	-0.06	1.46	Fast	Medium
Average		0.03	0.28	-0.04	0.67	-0.04	0.80	-0.04	0.87	--	--

Note: Convergence to the long run is fast if it is approximately attained in less than 5 quarters, medium between 6 and 9 quarters and slow in case it is reached in more than 10 quarters (this is clearly visible from the GDP responses charts).

Table 8.A. Short run and long run government expenditure multipliers from an SVAR with endogenous public debt

		Short run multiplier (1st quarter)		1st year multiplier		2nd year multiplier		Long run multiplier (5 years)	
Country	Sample	Expansion	Recession	Expansion	Recession	Expansion	Recession	Expansion	Recession
Austria	2000:1-2019:2	-0.25	1.40	-0.58	3.01	-0.57	3.31	-0.57	3.35
Belgium	1995:4-2019:2	0.16	0.90	-0.37	3.21	-0.41	4.37	-0.41	4.91
Canada	1990:1-2019:2	-0.11	1.44	-0.98	4.45	-1.08	5.79	-1.09	6.20
Denmark	2000:1-2019:2	0.33	1.06	-0.25	2.02	-0.25	2.07	-0.25	2.07
Finland	2000:1-2019:2	-0.10	0.47	-0.21	0.75	-0.20	0.76	-0.20	0.76
France	1998:4-2019:2	0.13	0.84	-0.32	2.78	-0.47	4.07	-0.51	4.84
Germany	1998:1-2019:2	-0.77	0.96	-1.69	3.25	-1.68	3.44	-1.68	3.44
Greece	1997:4-2019:2	0.98	1.23	1.31	1.78	1.31	1.80	1.31	1.80
Ireland	2000:1-2019:2	0.15	0.52	-0.10	1.14	-0.09	1.15	-0.09	1.15
Italy	1995:4-2019:2	0.65	1.11	1.31	3.09	1.36	3.39	1.36	3.41
Japan	1997:4-2019:2	0.00	1.30	-0.62	2.23	-0.67	2.25	-0.68	2.25
Netherlands	1999:4-2019:2	-0.42	-0.07	-0.21	1.23	-0.20	1.70	-0.20	1.79
Norway	1995:4-2019:2	0.39	2.04	0.07	2.44	0.08	2.42	0.08	2.42
Portugal	1999:4-2019:2	-0.18	0.54	-0.31	1.46	-0.45	1.74	-0.46	1.78
Spain	1995:4-2019:2	0.15	0.27	0.19	2.47	0.17	4.47	0.17	7.02
Sweden	1995:4-2019:2	-0.31	1.09	-0.55	2.99	-0.55	3.37	-0.55	3.41
United Kingdom	1995:1-2019:2	0.17	1.60	-0.09	4.90	-0.11	6.73	-0.12	7.69
United States	1966:1-2019:2	0.23	1.86	-0.25	5.15	-0.27	6.22	-0.27	6.43
Average		-0.25	1.40	-0.58	3.01	-0.57	3.31	-0.57	3.35

Note: Impact multipliers (*IM*) are adjusted by the corresponding adjustment coefficient from table 2.A to obtain fiscal multipliers (*FM*) according to the formulae $FM = IM * \overline{Y/G}/\sigma_g$.

Appendix B. Figures

Figure 1.B.a: Sensitivity of GDP responses to expenditures impact multipliers by period of time (1st set of countries)

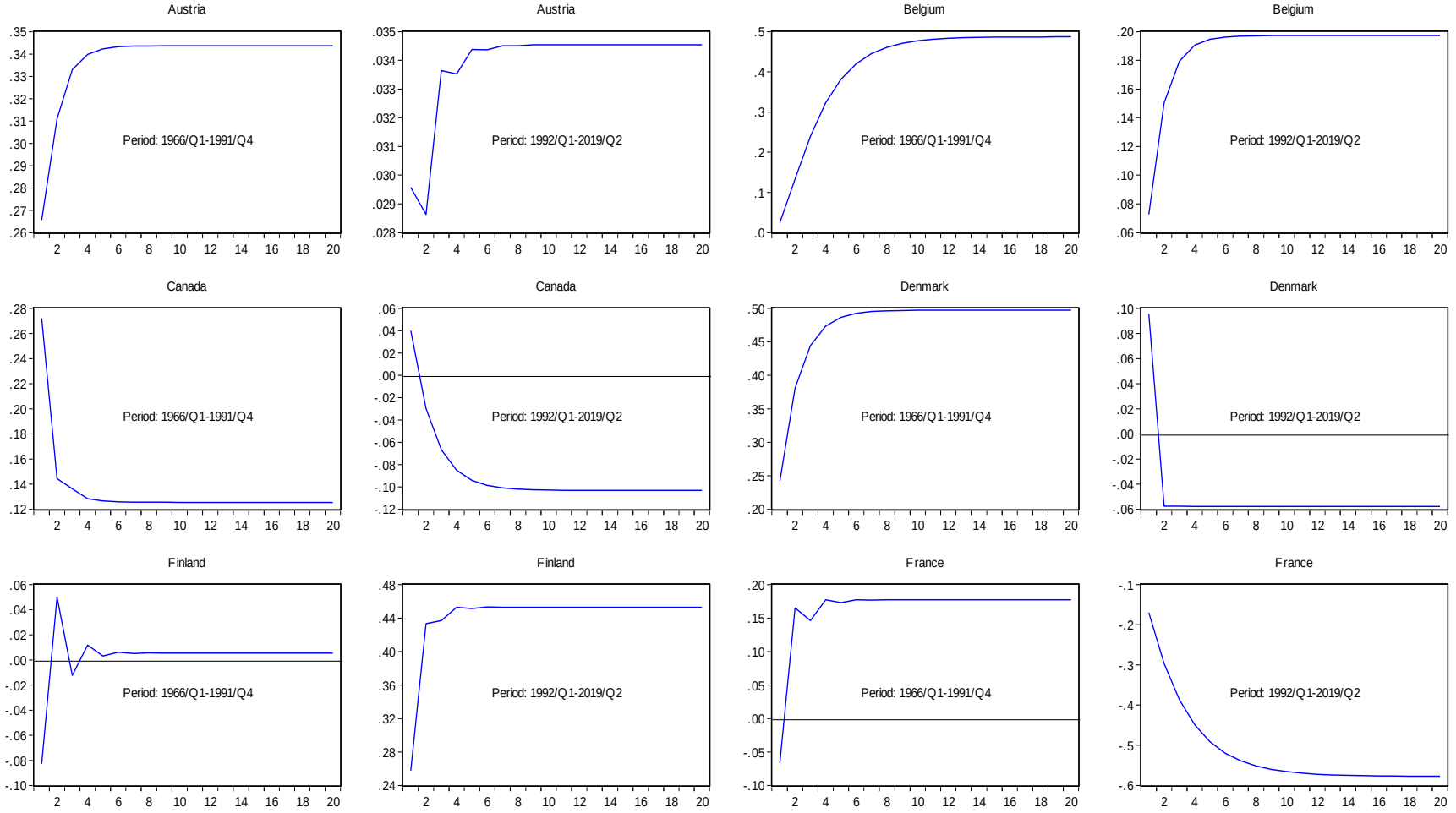


Figure 1B.b: Sensitivity of GDP responses to expenditures impact multipliers by period of time (2nd set of countries)

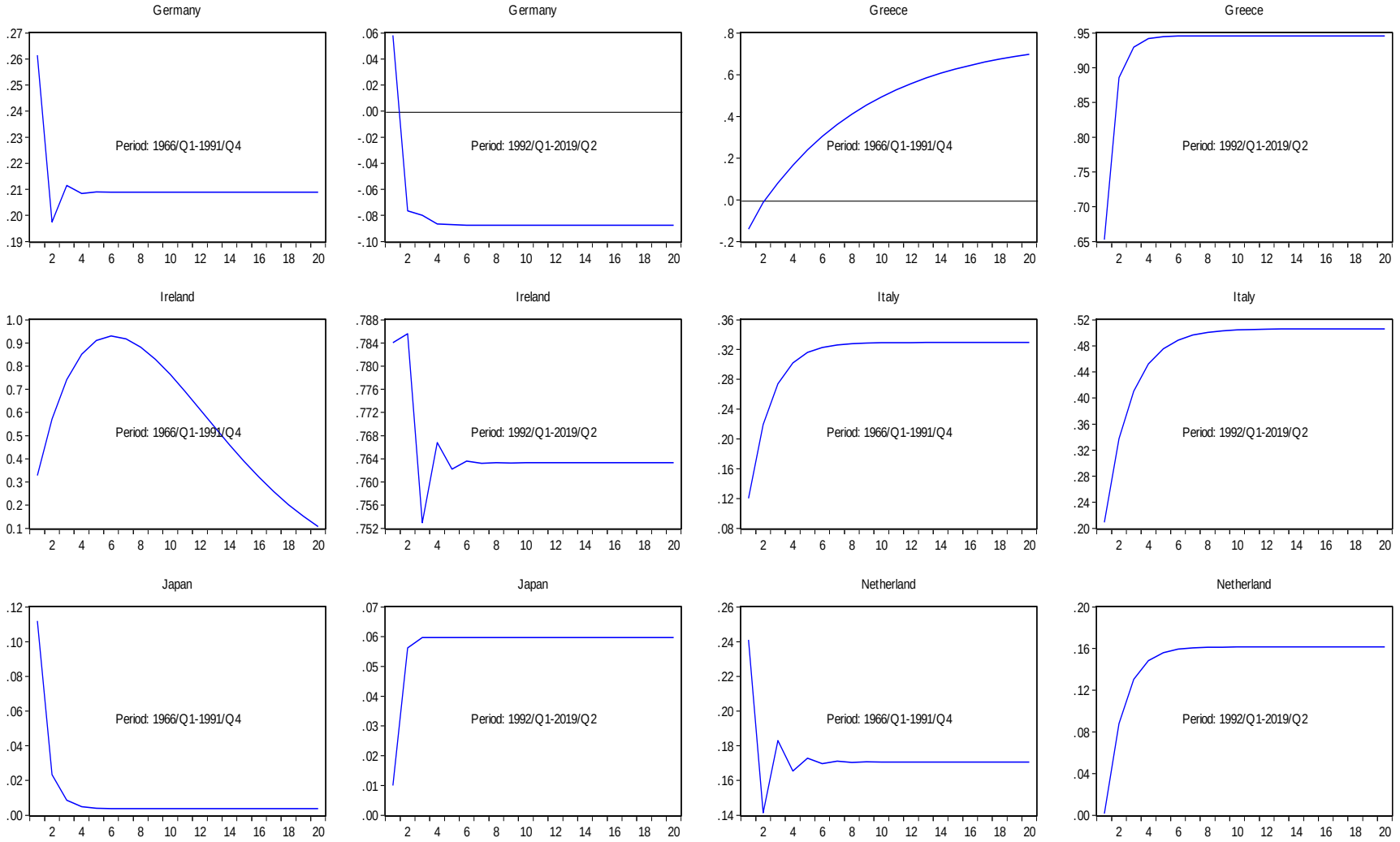


Figure 1.B.c: Sensitivity of GDP responses to expenditures impact multipliers by period of time (3rd set of countries)

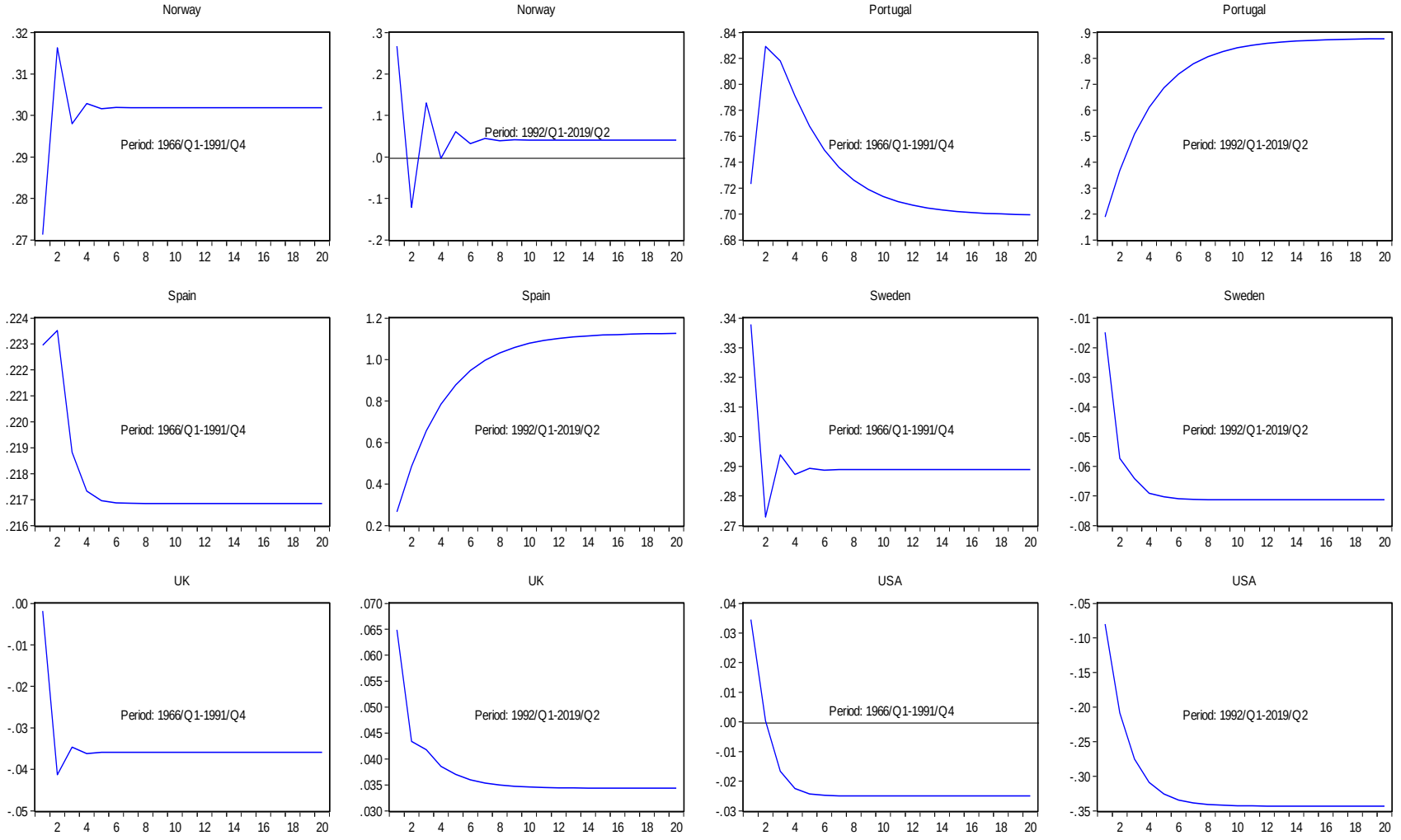
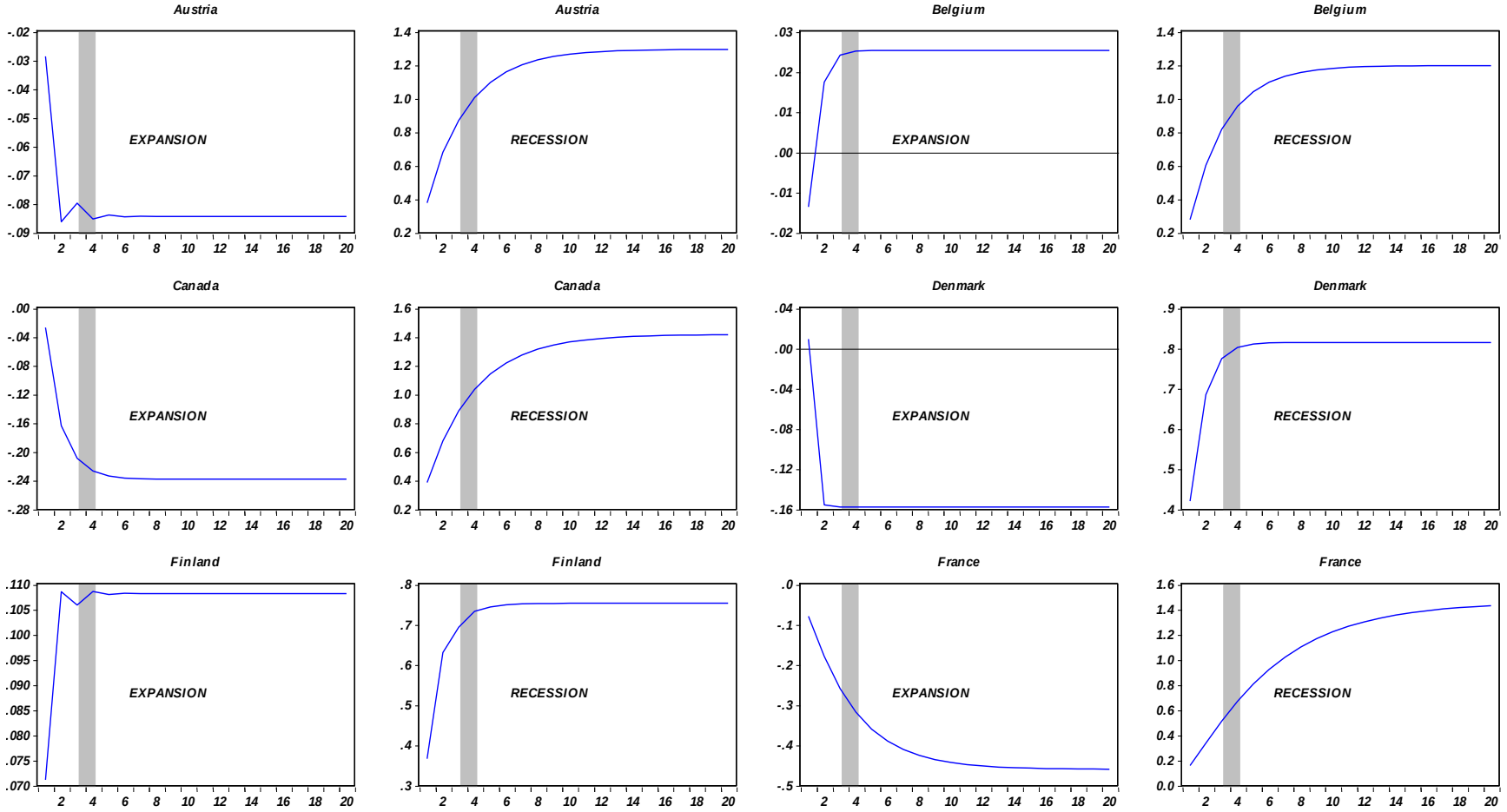
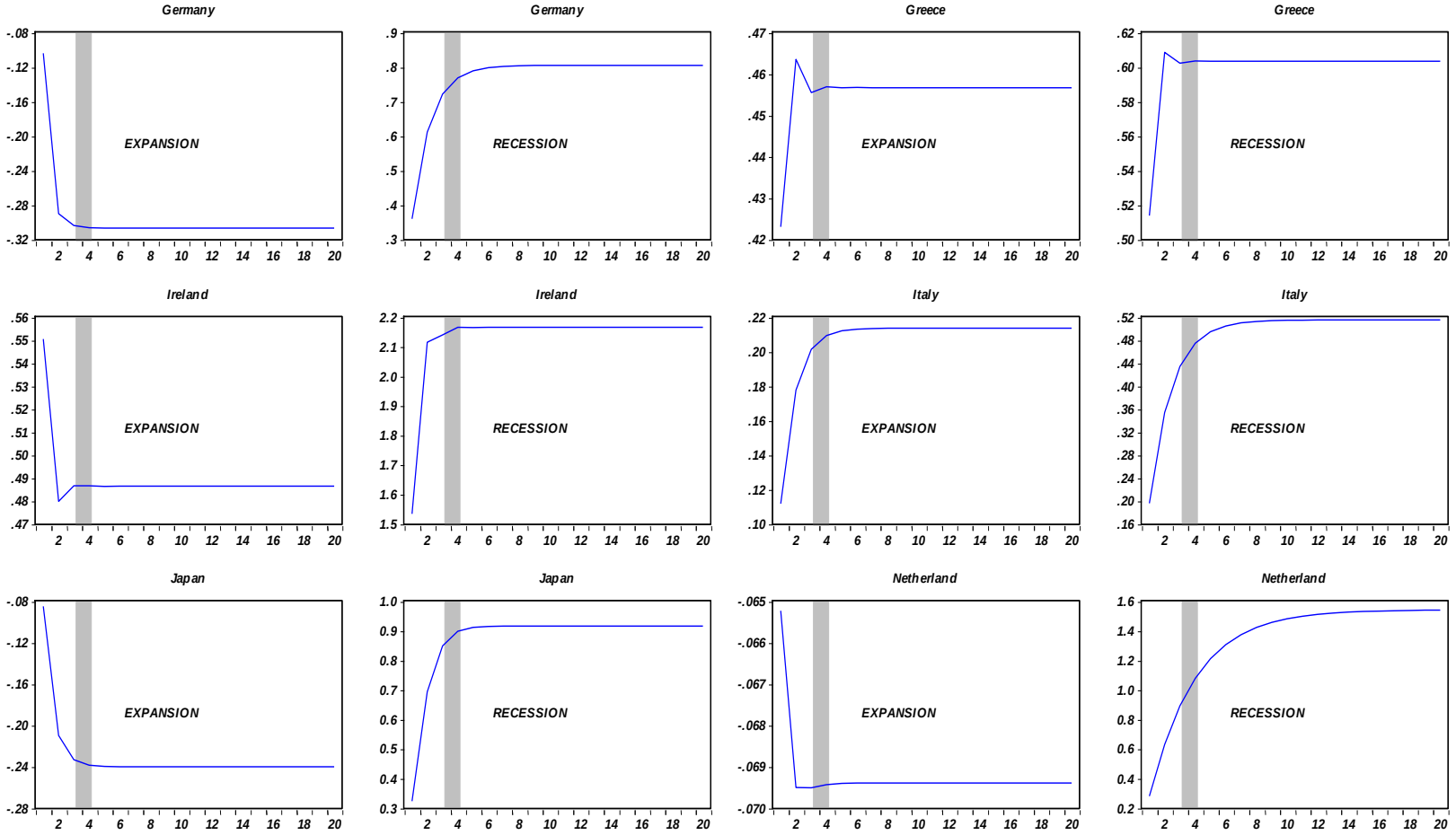


Figure 2.B.a: The effects of the business cycle (expansion verusus recession) on GDP responses to government expenditure dynamic structural shock (1st set of countries)



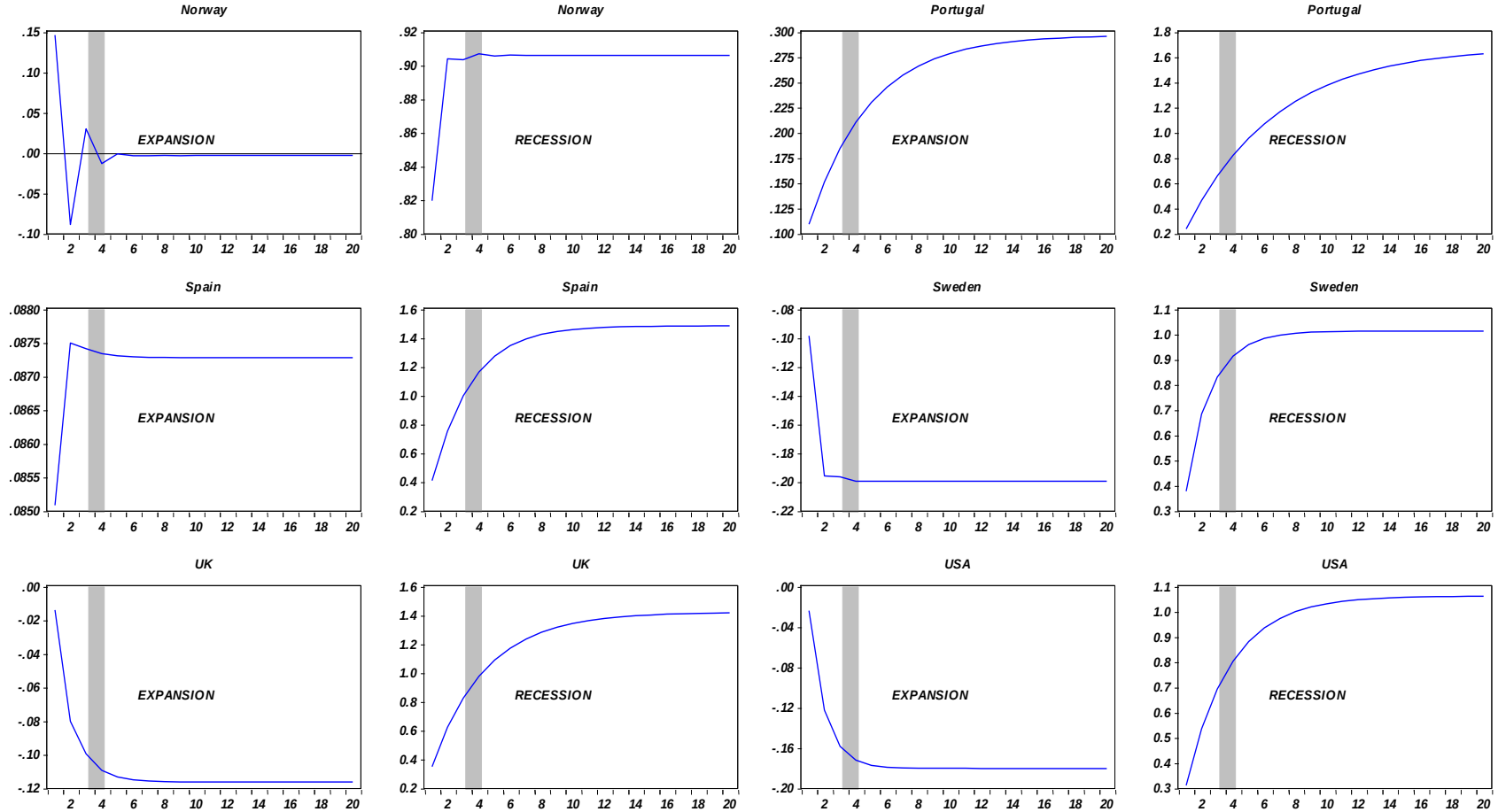
Note: Shaded area bar corresponds to the fourth quarter.

Figure 2.B.b: The effects of the business cycle (expansion verusus recession) on GDP responses to government expenditure dynamic structural shock (2nd set of countries)



Note: Shaded area bar corresponds to the fourth quarter.

Figure 2.B.c: The effects of the business cycle (expansion verusus recession) on GDP responses to government expenditure dynamic structural shock (3rd set of countries)



Note: Shaded area bar corresponds to the fourth quarter.

Figure 3.B. Expenditure multipliers effects under the business cycle versus the public debt ratio average

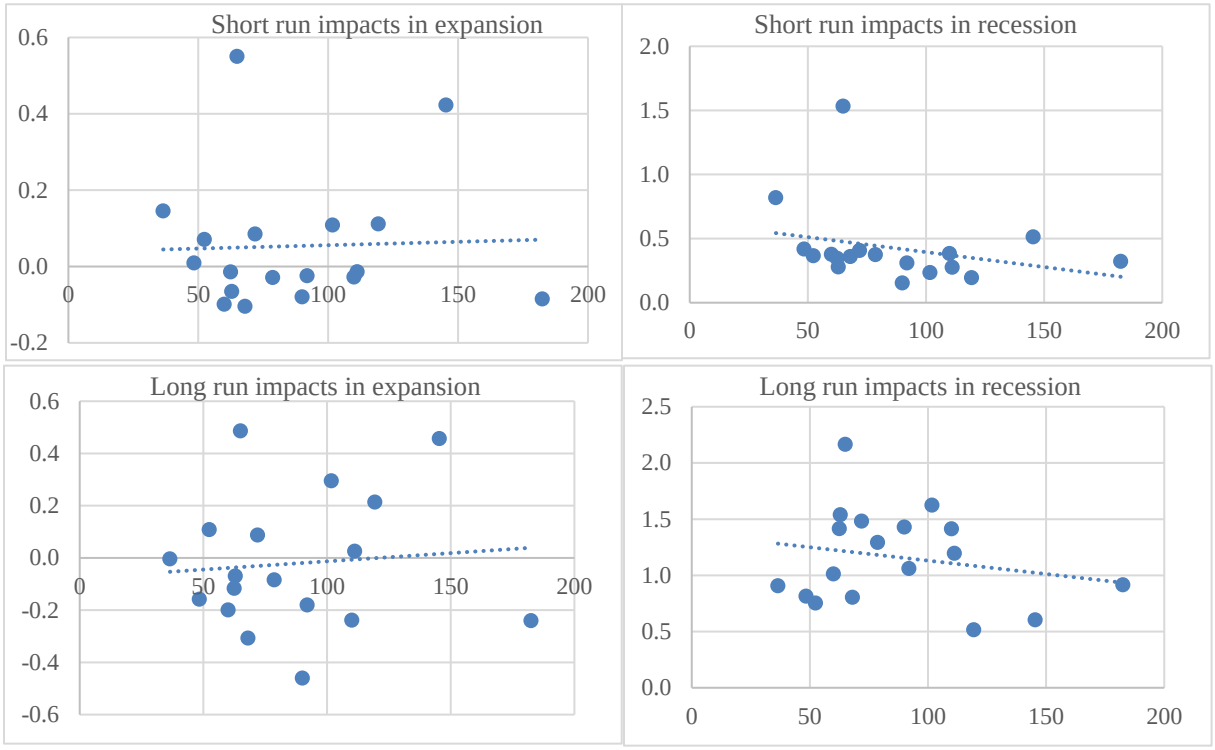


Figure 4.B. Expenditure multipliers under the debt ratio movements versus the public debt ratio average

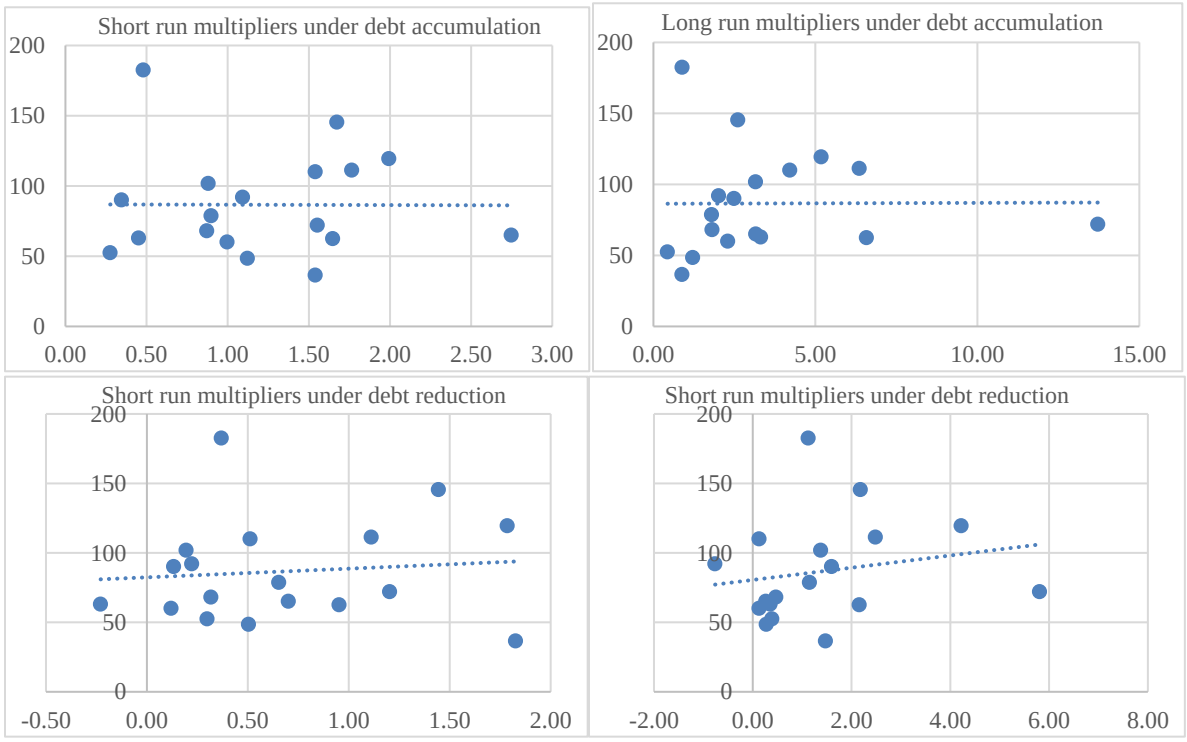
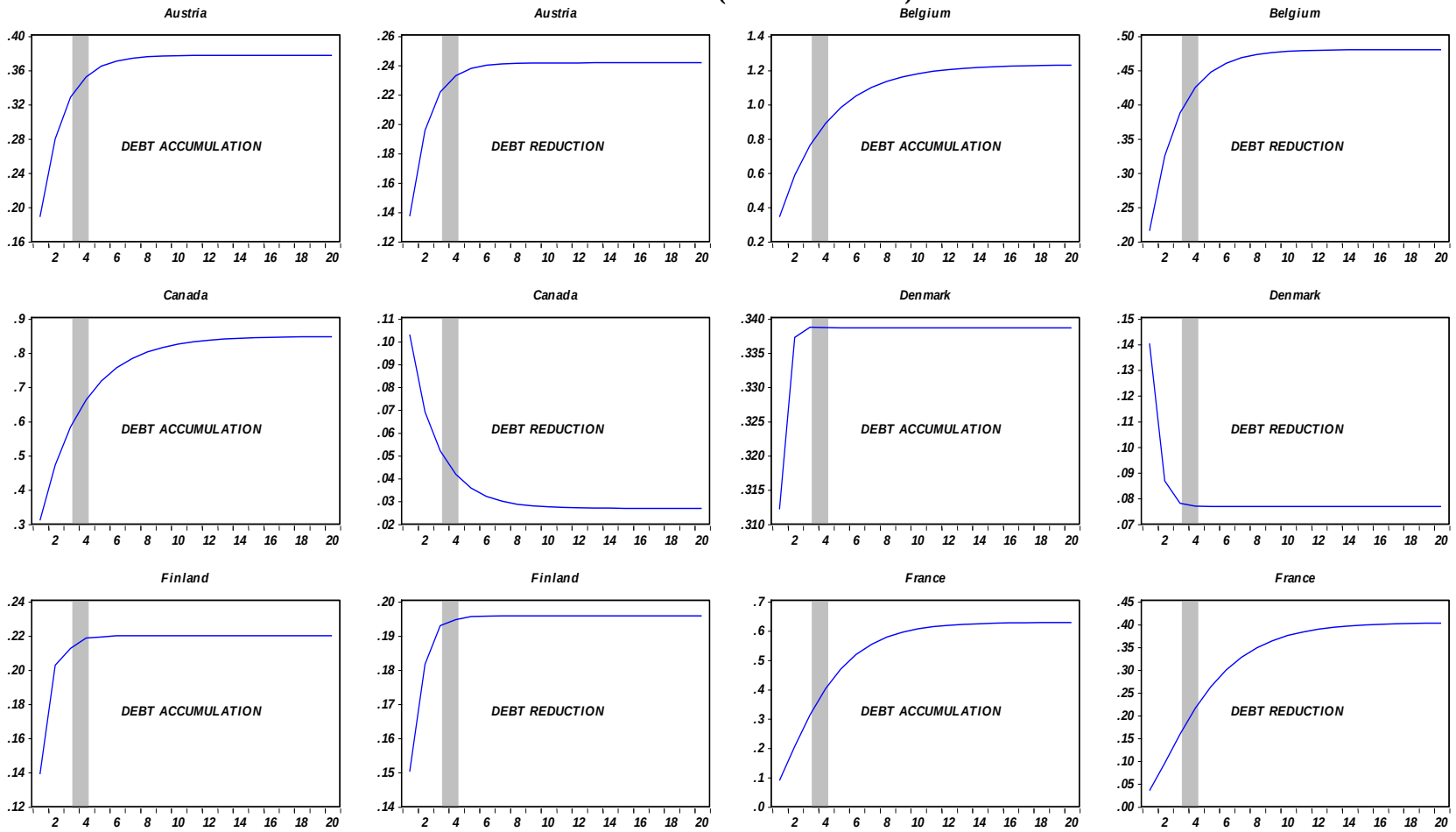
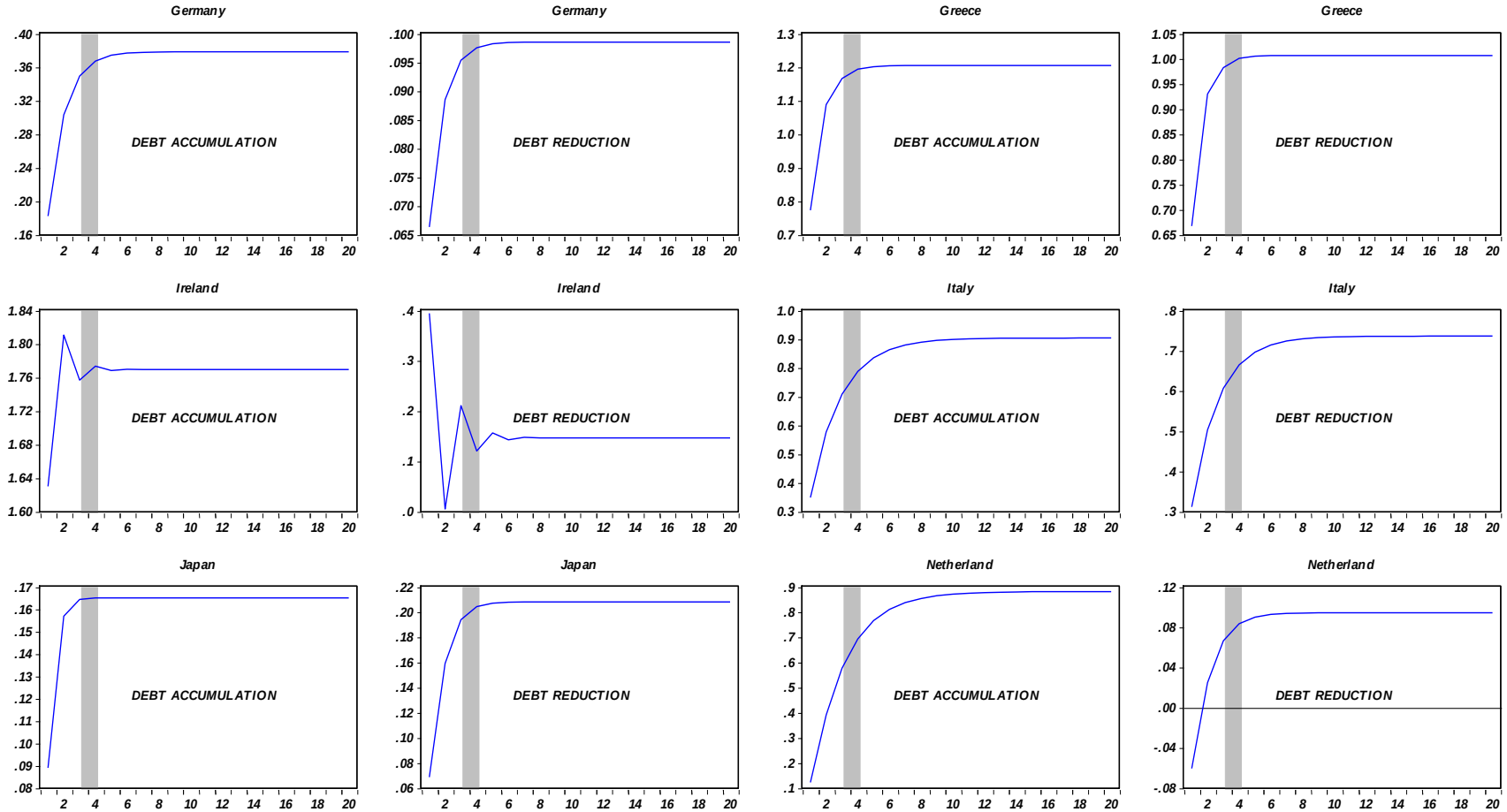


Figure 5.B.a: The effects of the debt ratio movments (accumulation versus contraction) on GDP responses to government expenditure dynamic structural shock (1st set of countries)



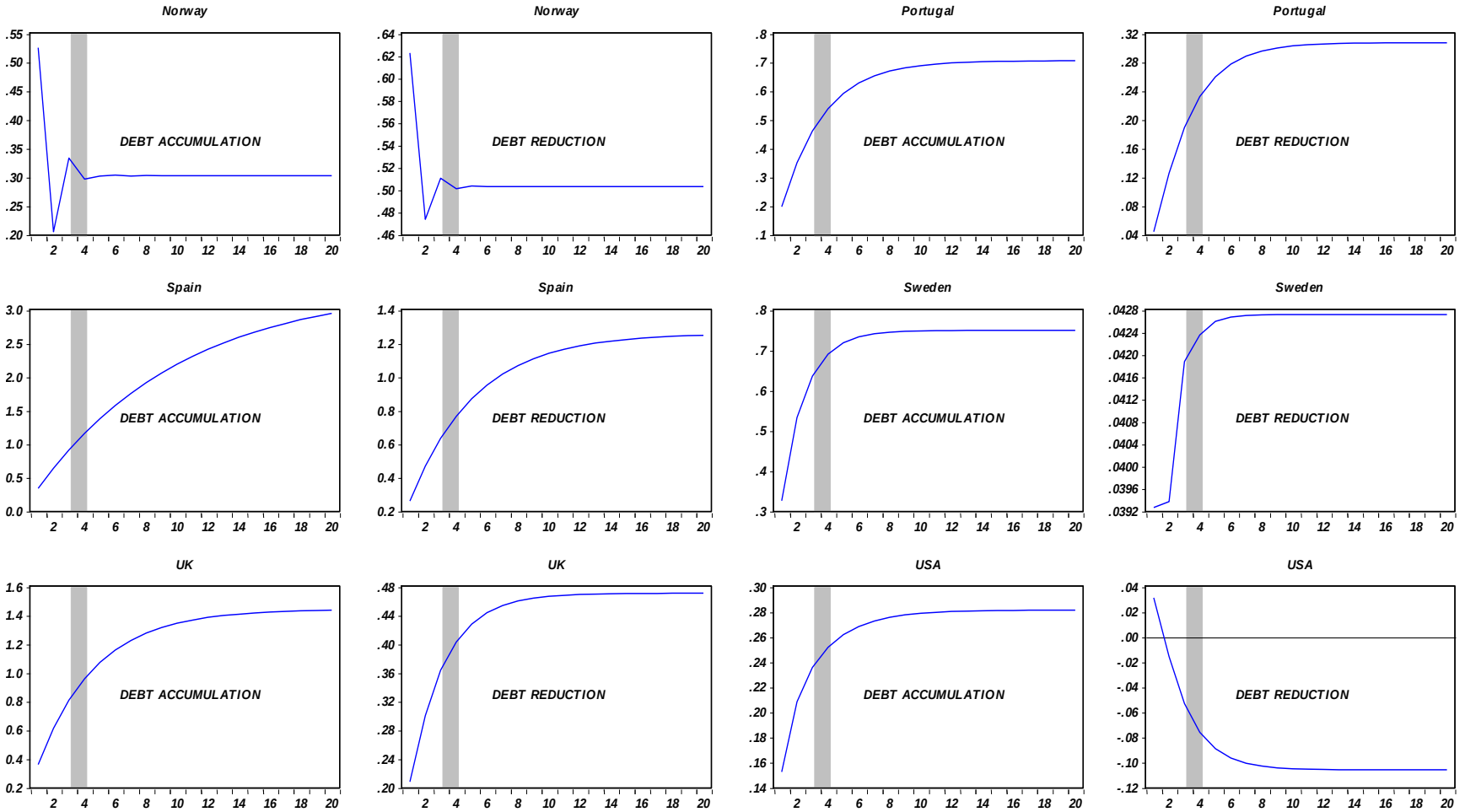
Note: Shaded area bar corresponds to the fourth quarter.

Figure 5.B.b: The effects of the debt ratio movments (accumulation versus contraction) on GDP responses to government expenditure dynamic structural shock (2nd set of countries)



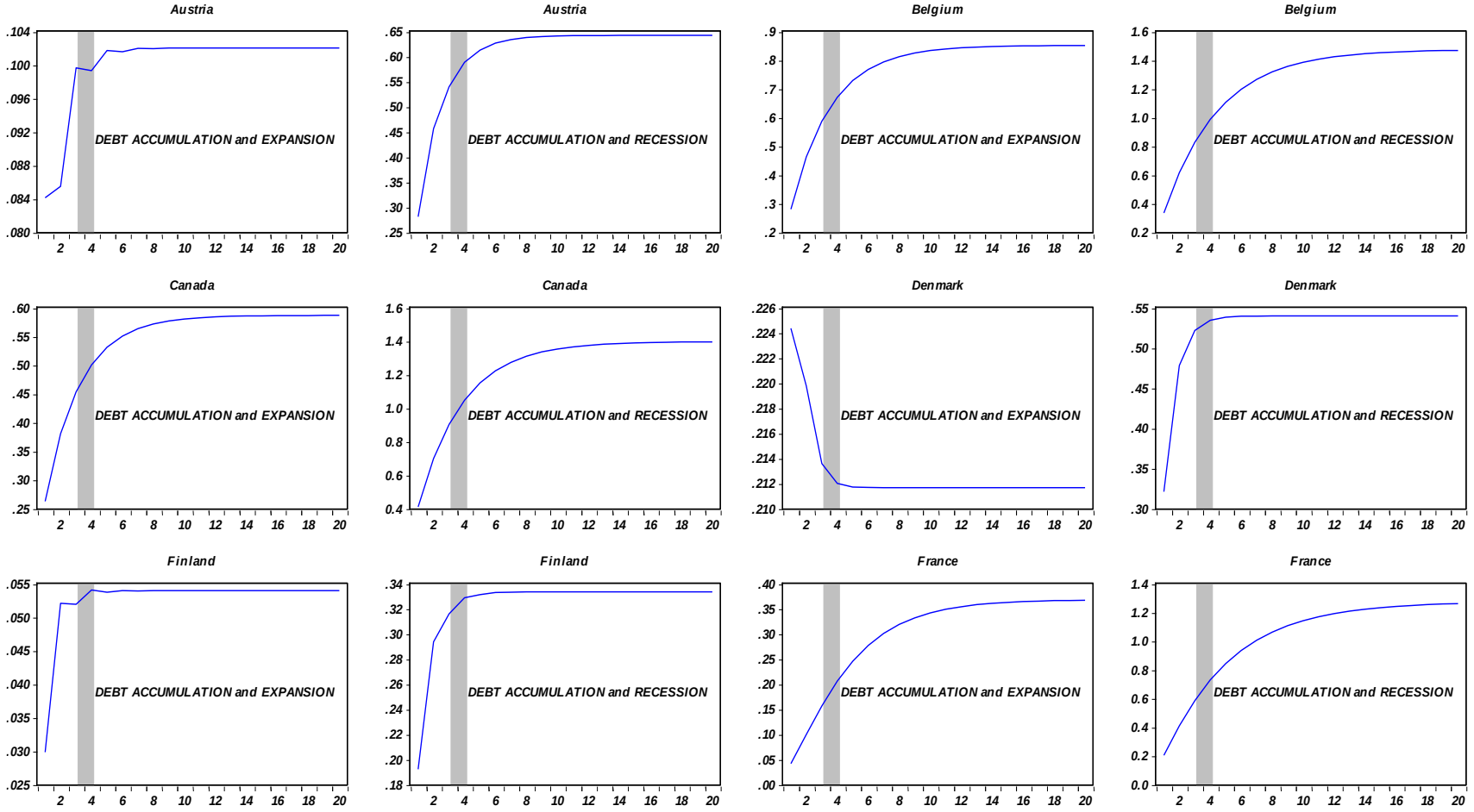
Note: Shaded area bar corresponds to the fourth quarter.

Figure 5.B.c: The effects of the debt ratio movments (accumulation versus contraction) on GDP responses to government expenditure dynamic structural shock (3rd set of countries)



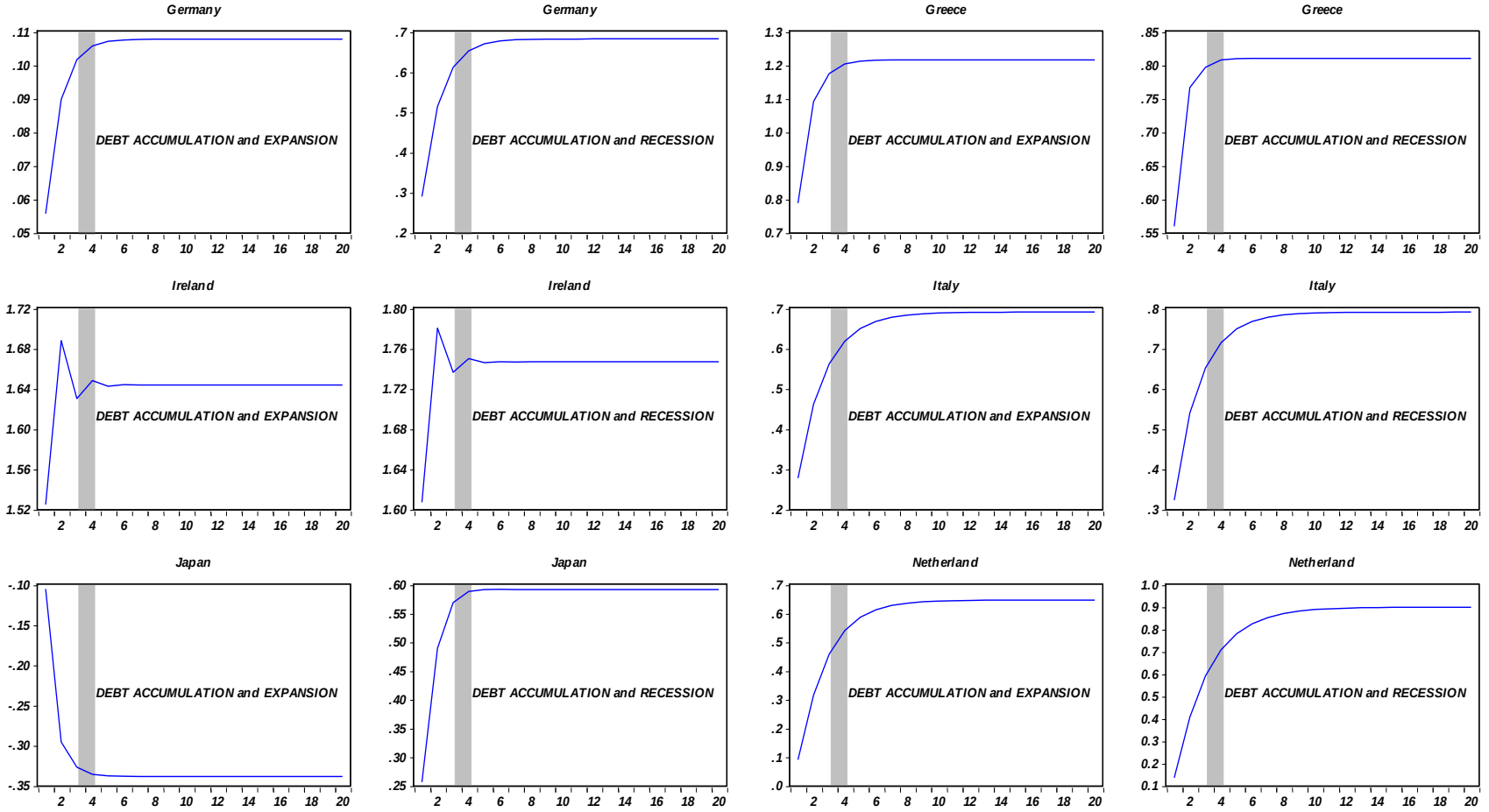
Note: Shaded area bar corresponds to the fourth quarter.

Figure 6.B.a: The effects of the debt ratio accumulation and the business cycle on GDP responses to government expenditure dynamic structural shock (1st set of countries)



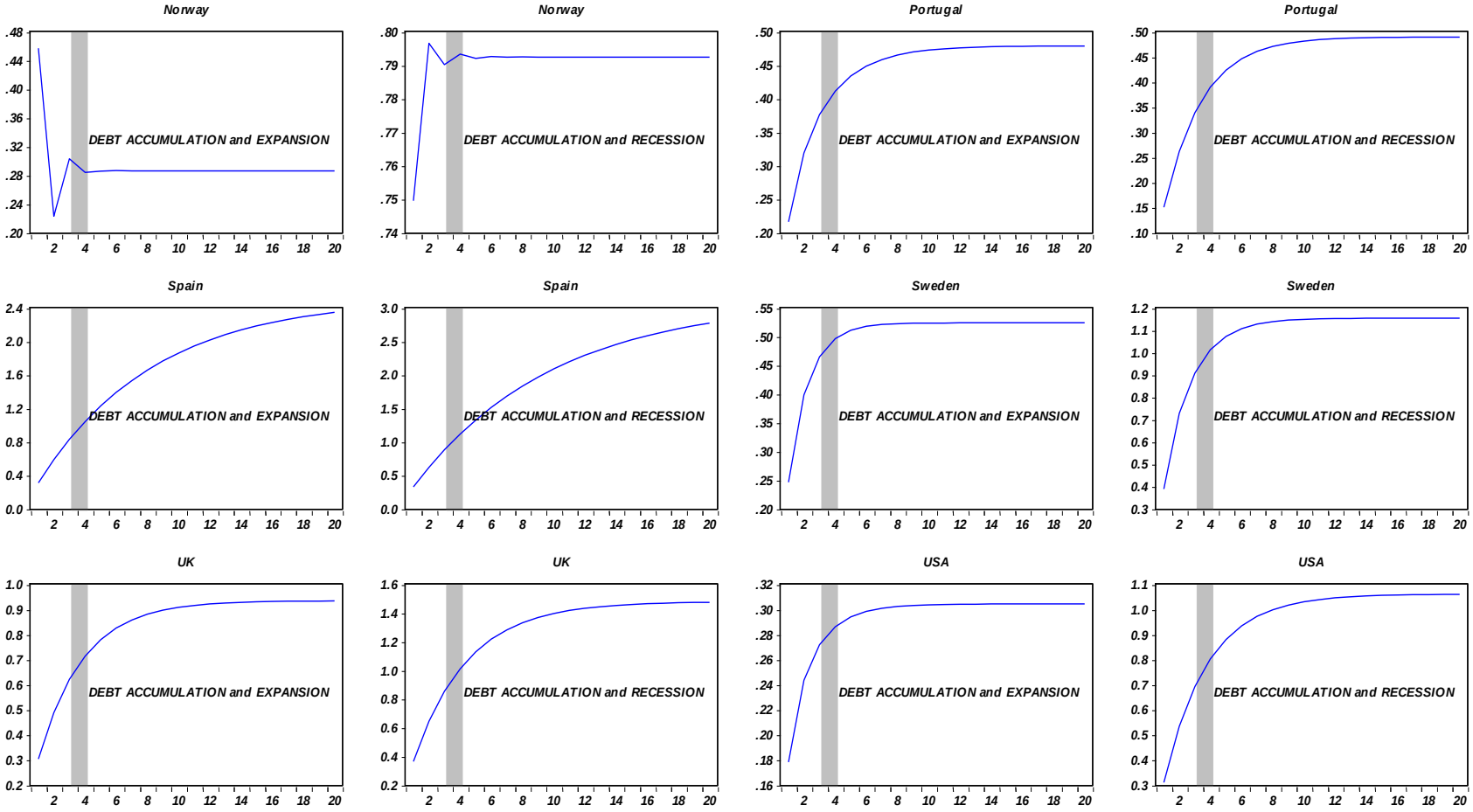
Note: Shaded area bar corresponds to the fourth quarter.

Figure 6.B.b: The effects of the debt ratio accumulation and the business cycle on GDP responses to government expenditure dynamic structural shock (2nd set of countries)



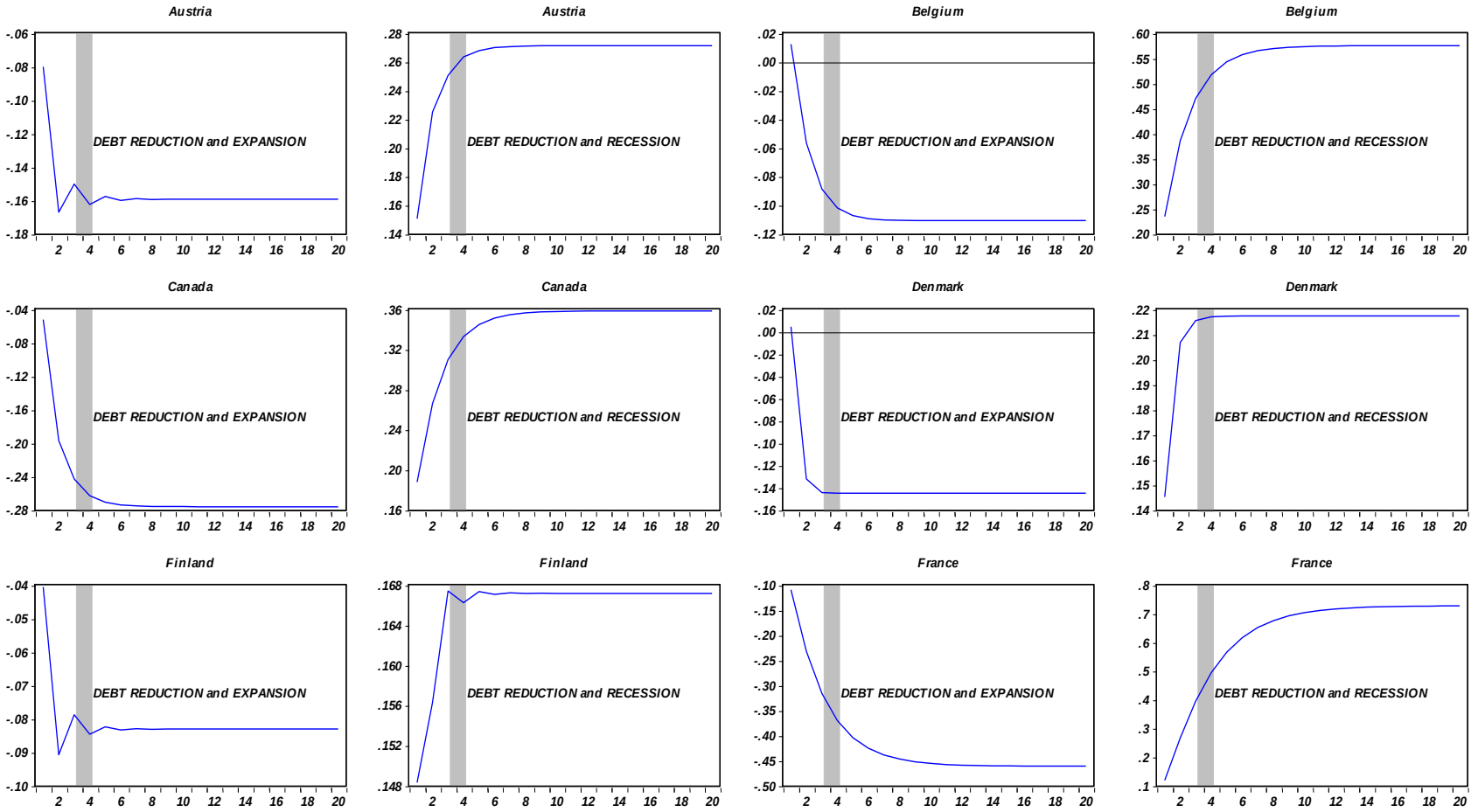
Note: Shaded area bar corresponds to the fourth quarter.

Figure 6.B.c: The effects of the debt ratio accumulation and the business cycle on GDP responses to government expenditure dynamic structural shock (3rd set of countries)



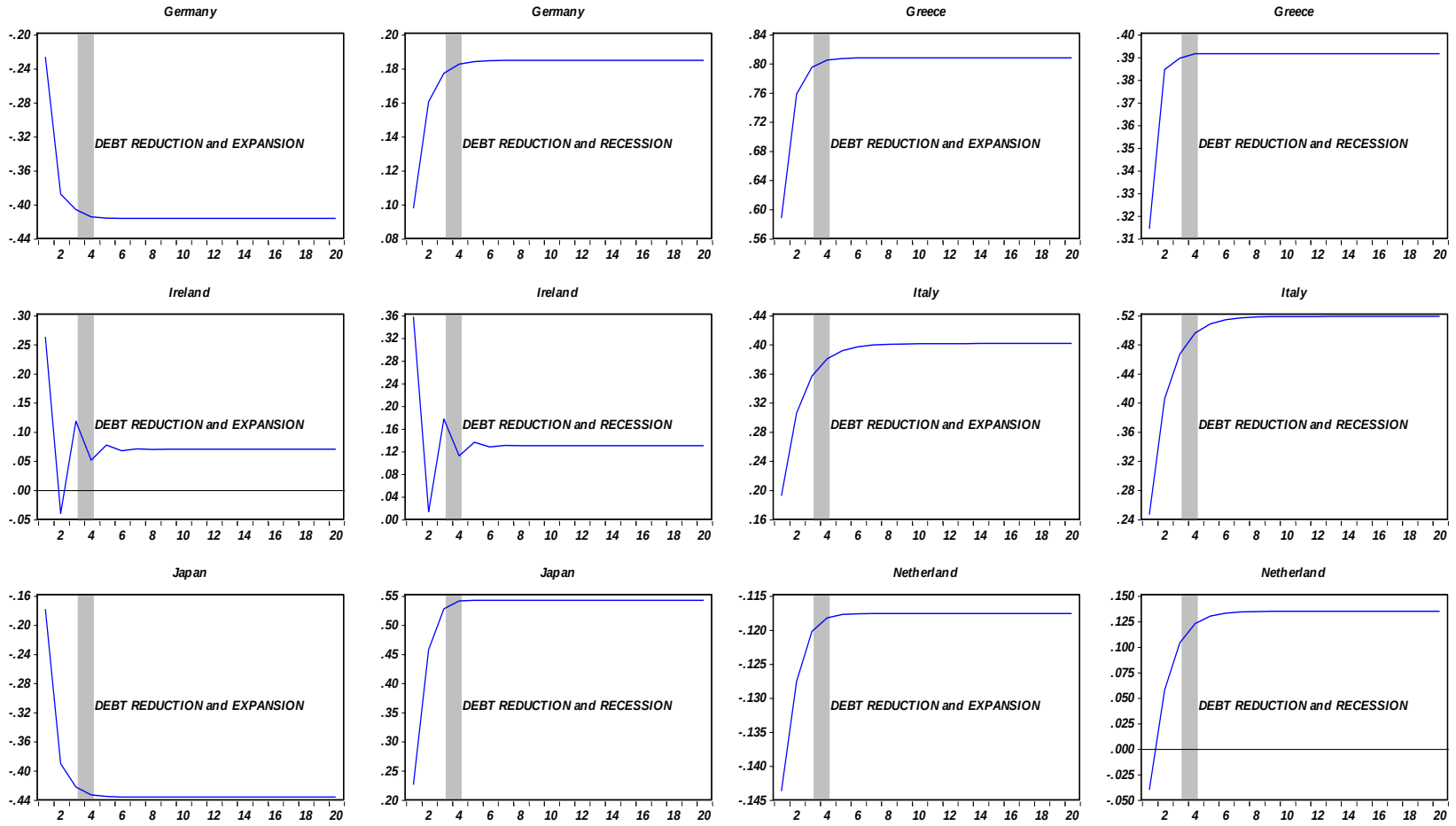
Note: Shaded area bar corresponds to the fourth quarter.

Figure 7.B.a: The effects of the debt ratio reduction and the business cycle on GDP responses to government expenditure dynamic structural shock (1st set of countries)



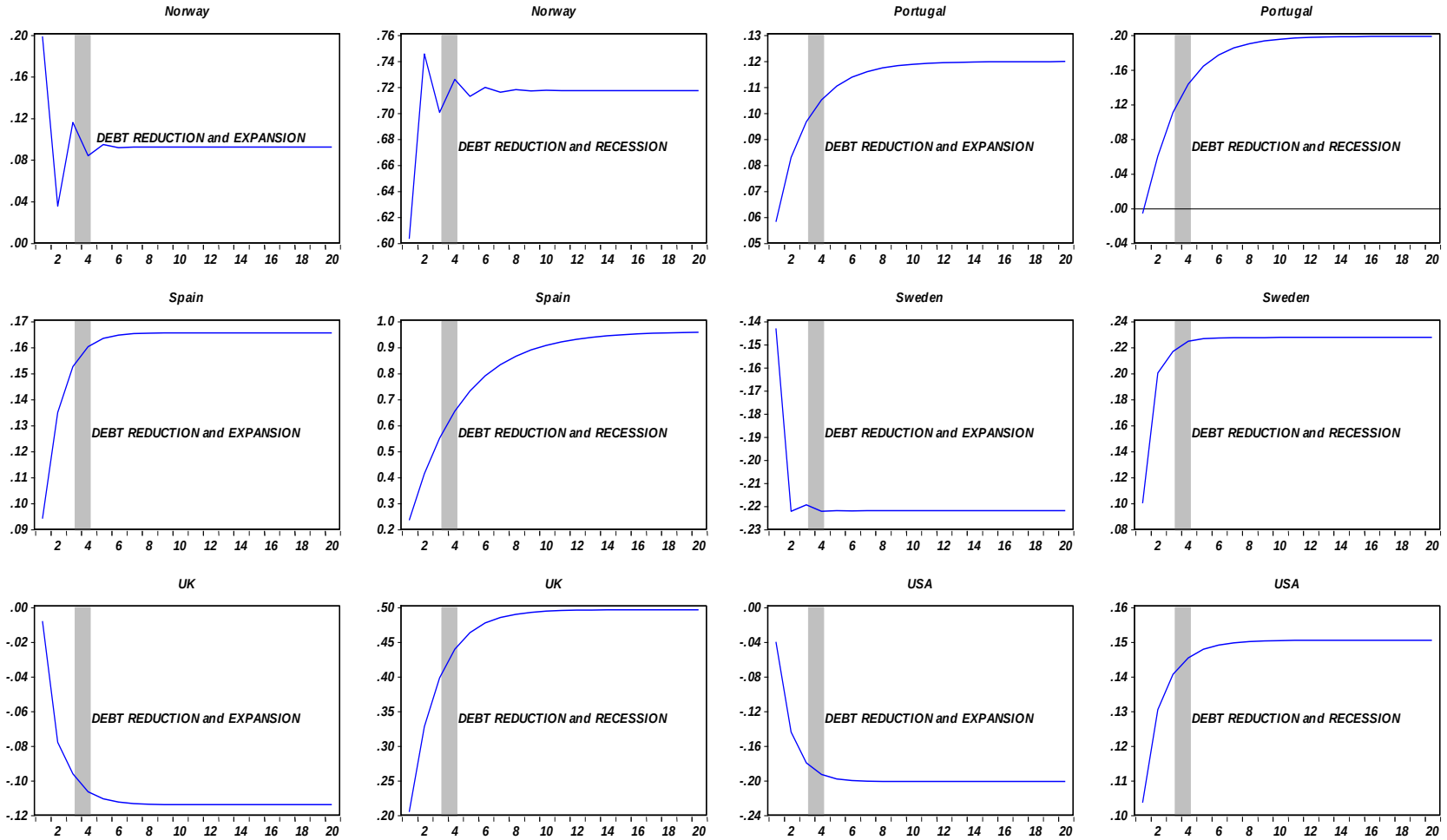
Note: Shaded area bar corresponds to the fourth quarter.

Figure 7.B.b: The effects of the debt ratio reduction and the business cycle on GDP responses to government expenditure dynamic structural shock (2nd set of countries)



Note: Shaded area bar corresponds to the fourth quarter.

Figure 7.B.c: The effects of the debt ratio reduction and the business cycle on GDP responses to government expenditure dynamic structural shock (3rd set of countries)



Note: Shaded area bar corresponds to the fourth quarter.

Figure 8.B. Eexpenditure multiplier under business cycle and public debt movements versus the public debt ratio average

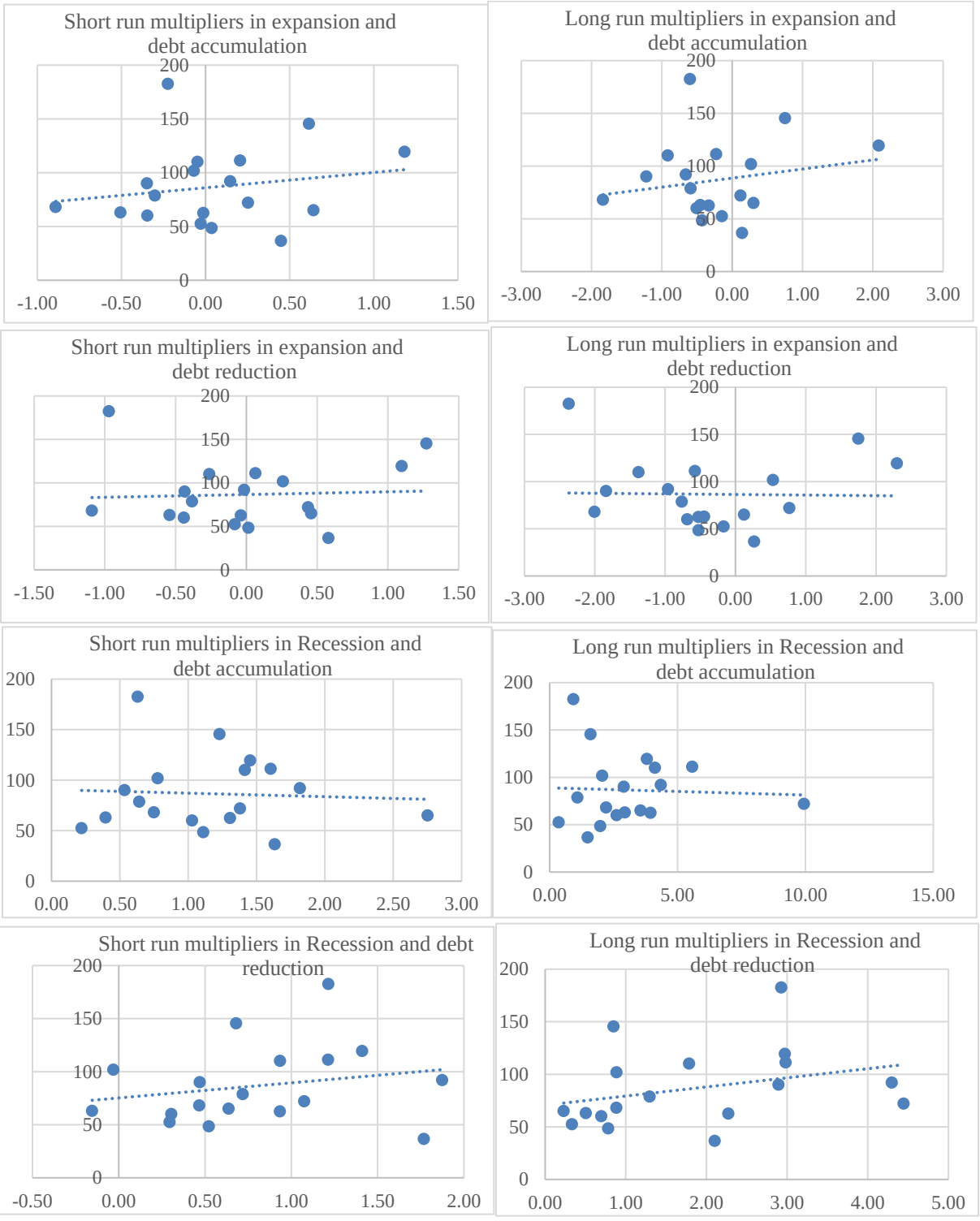
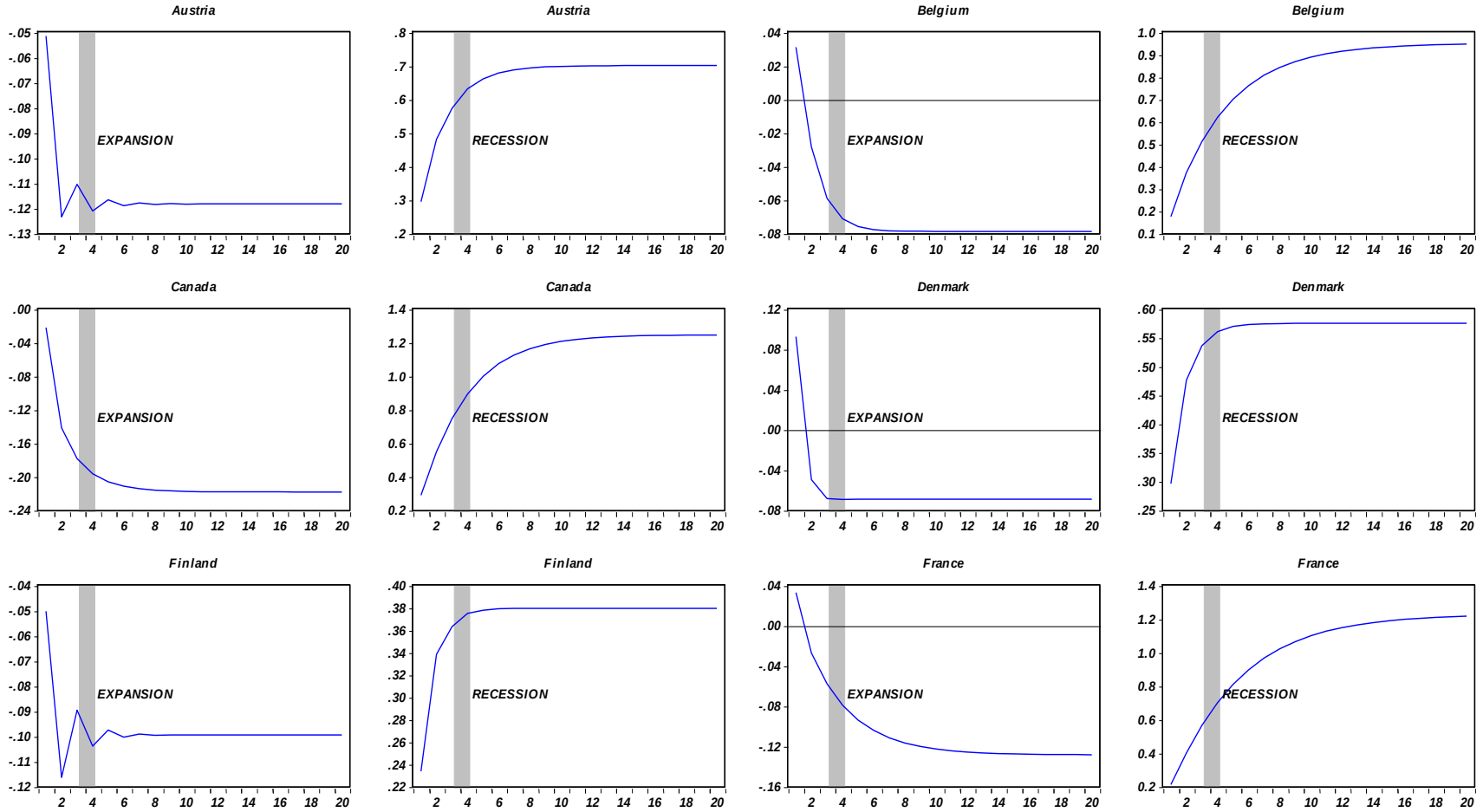
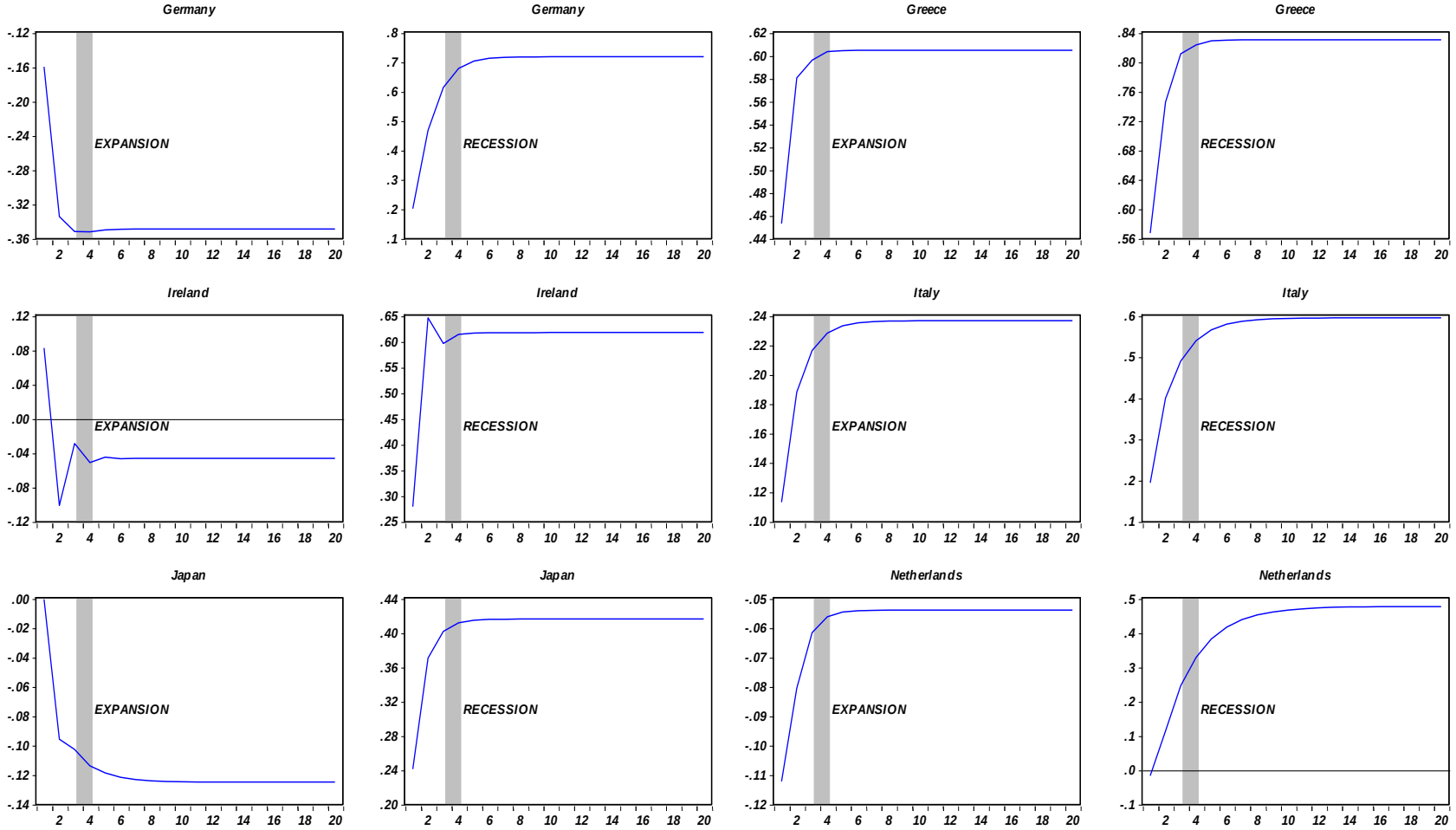


Figure 9.B.a: The endogenous effects of the public debt ratio and the business cycle on GDP responses to government expenditure dynamic structural shock from a trivarite SVAR model (1st set of countries)



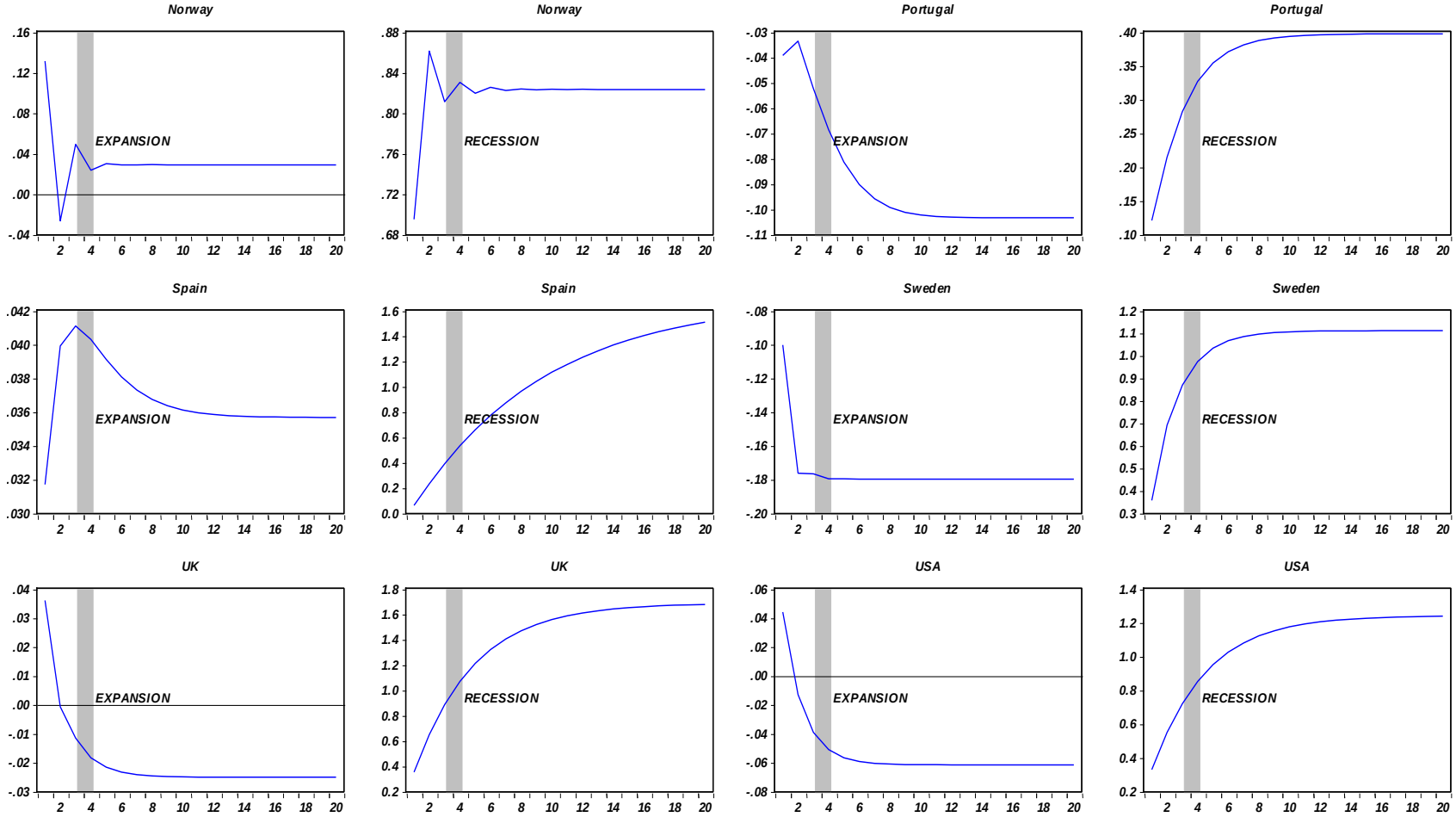
Note: Shaded area bar corresponds to the fourth quarter.

Figure 9.B.b: The endogenous effects of the public debt ratio and the business cycle on GDP responses to government expenditure dynamic structural shock from a trivarite SVAR model (2nd set of countries)



Note: Shaded area bar corresponds to the fourth quarter.

Figure 9.B.c: The endogenous effects of the public debt ratio and the business cycle on GDP responses to government expenditure dynamic structural shock from a trivarite SVAR model (3rd set of countries)



Note: Shaded area bar corresponds to the fourth quarter.

Figure 10.B The expenditure multipliers from the trivariate SVAR with endogenous debt varibale and controlled for the business cycle, scattered with the average level of the public debt ratio

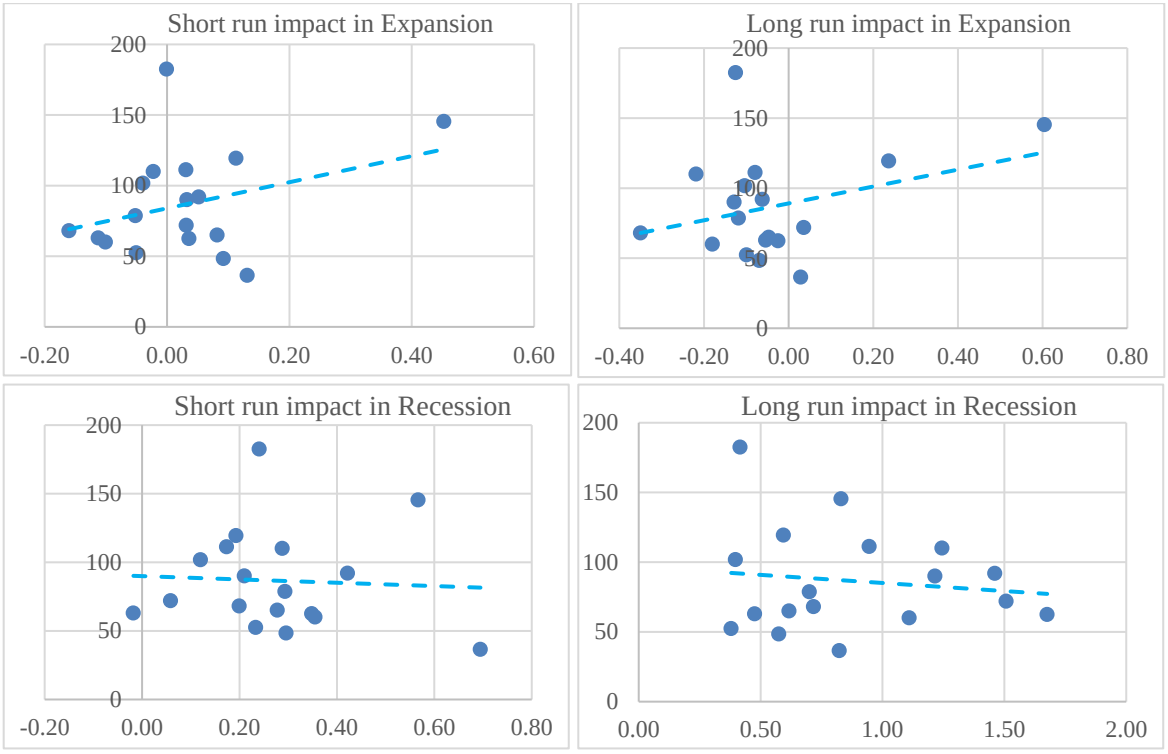


Figure 11.B.a. Impulse response functions in time of economic expansion

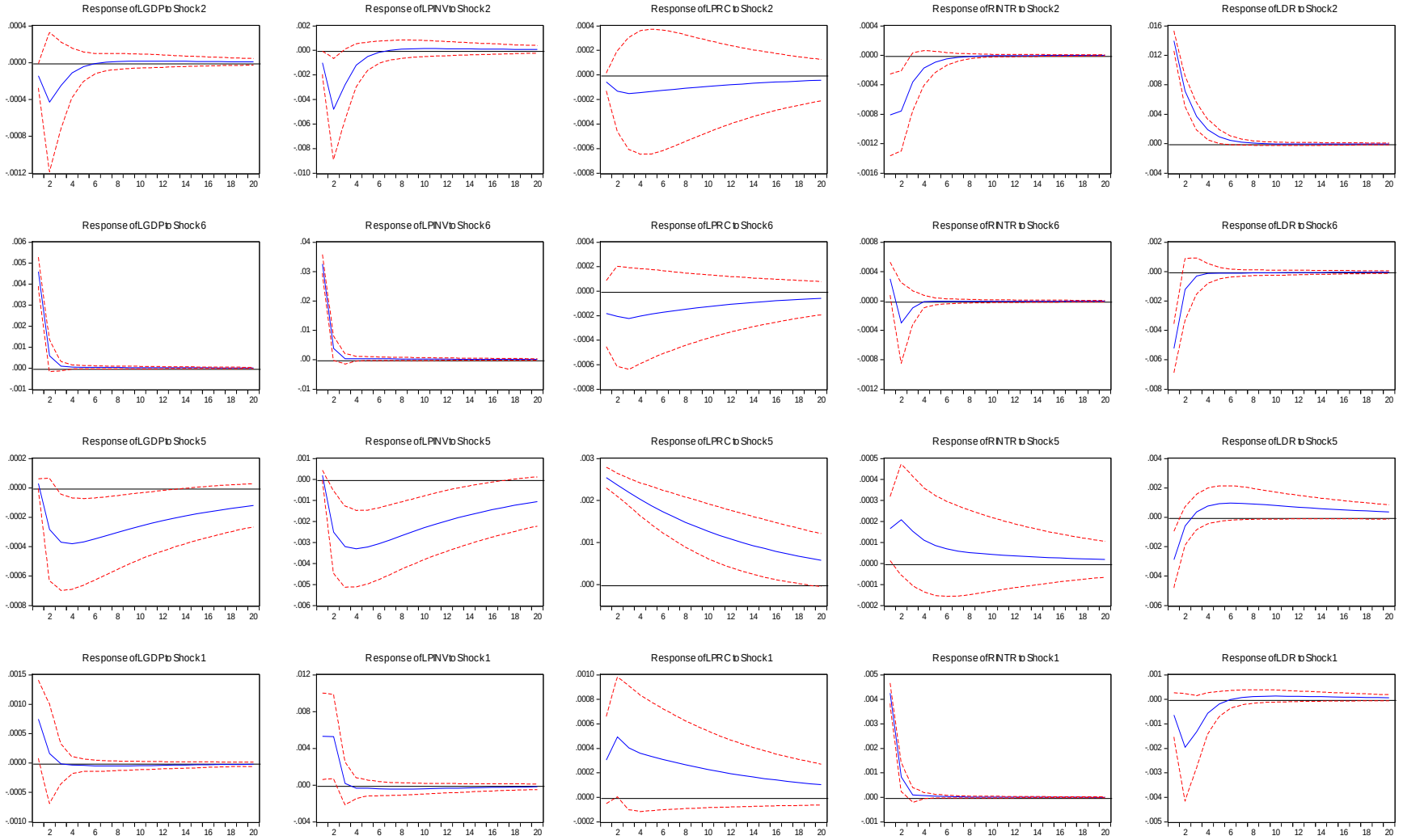


Figure 11.B.b. Impulse response functions in time of economic recession

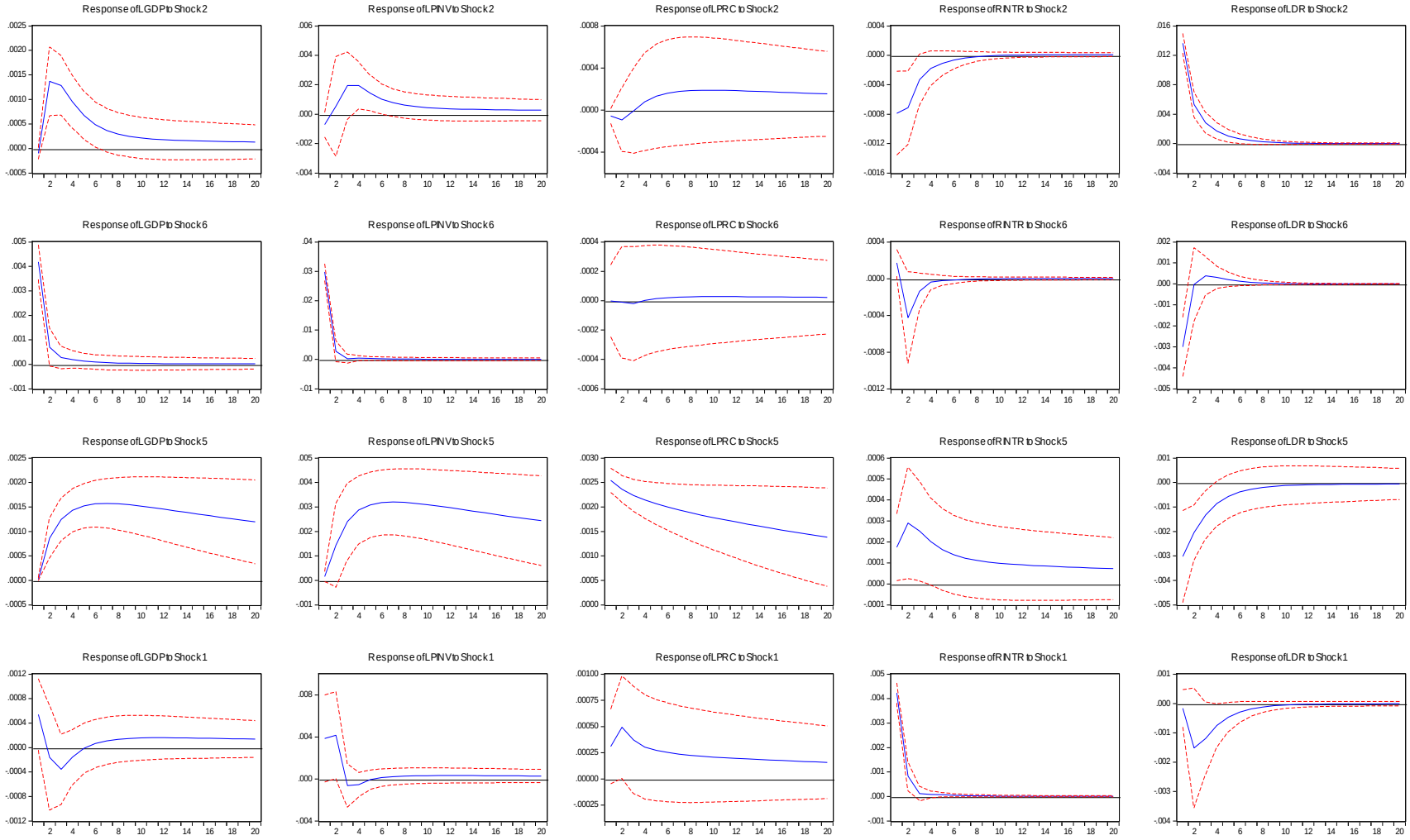


Figure 11.B.c. Impulse response functions in time of debt accumulation

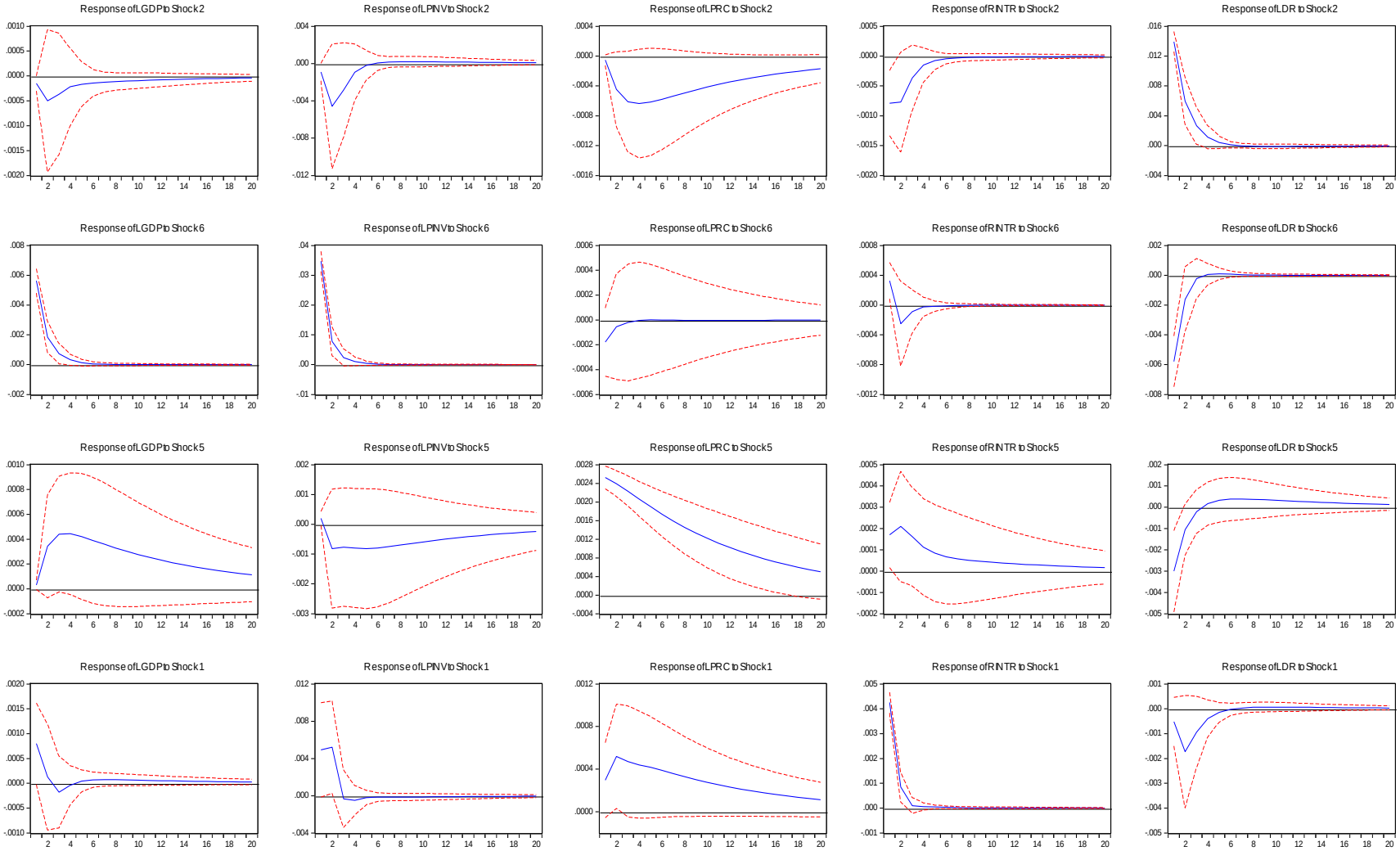


Figure 11.B.d. Impulse response functions in time of debt reduction

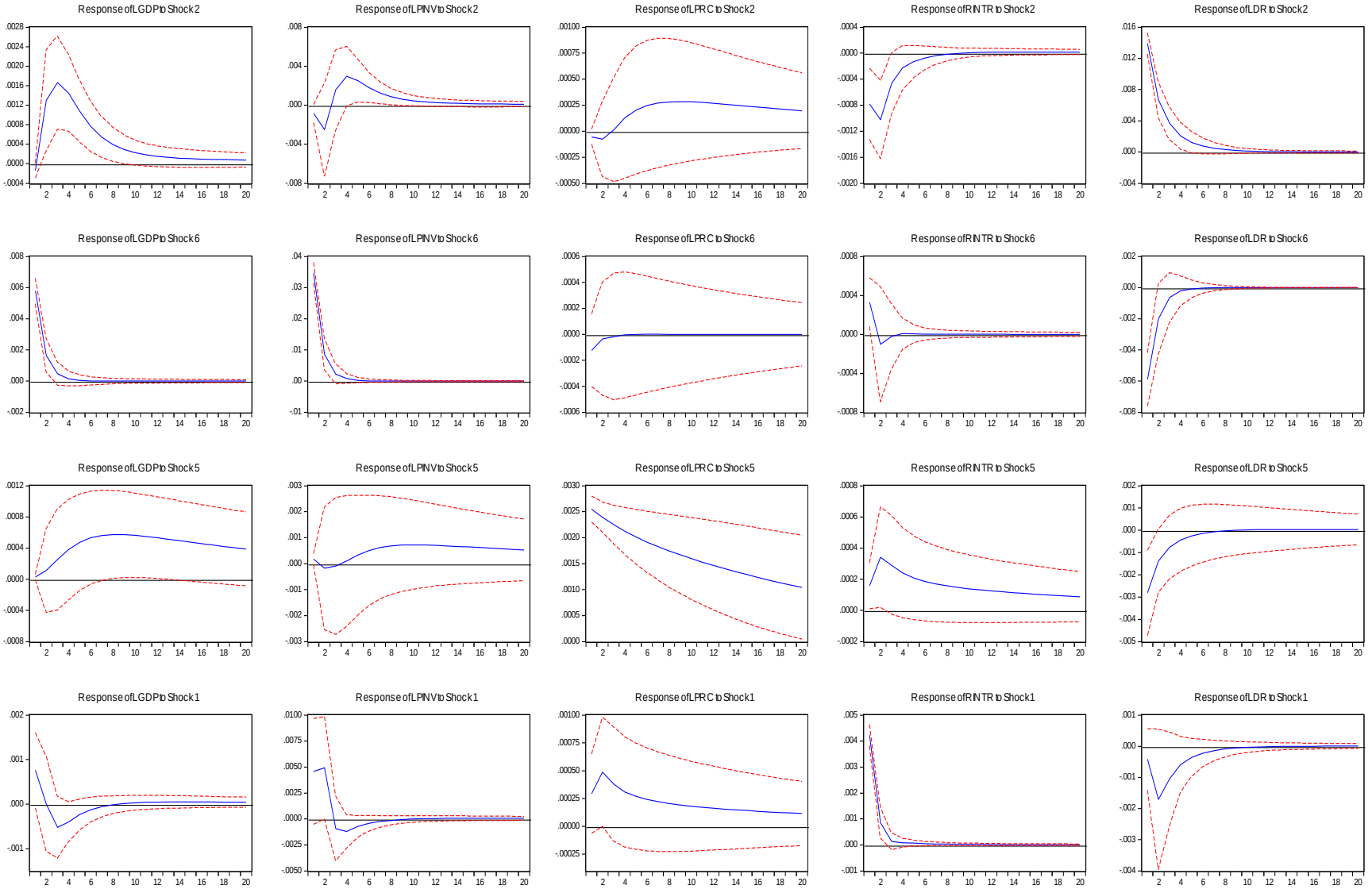


Figure 11.B.e. Impulse response functions in time of debt reduction and expansion

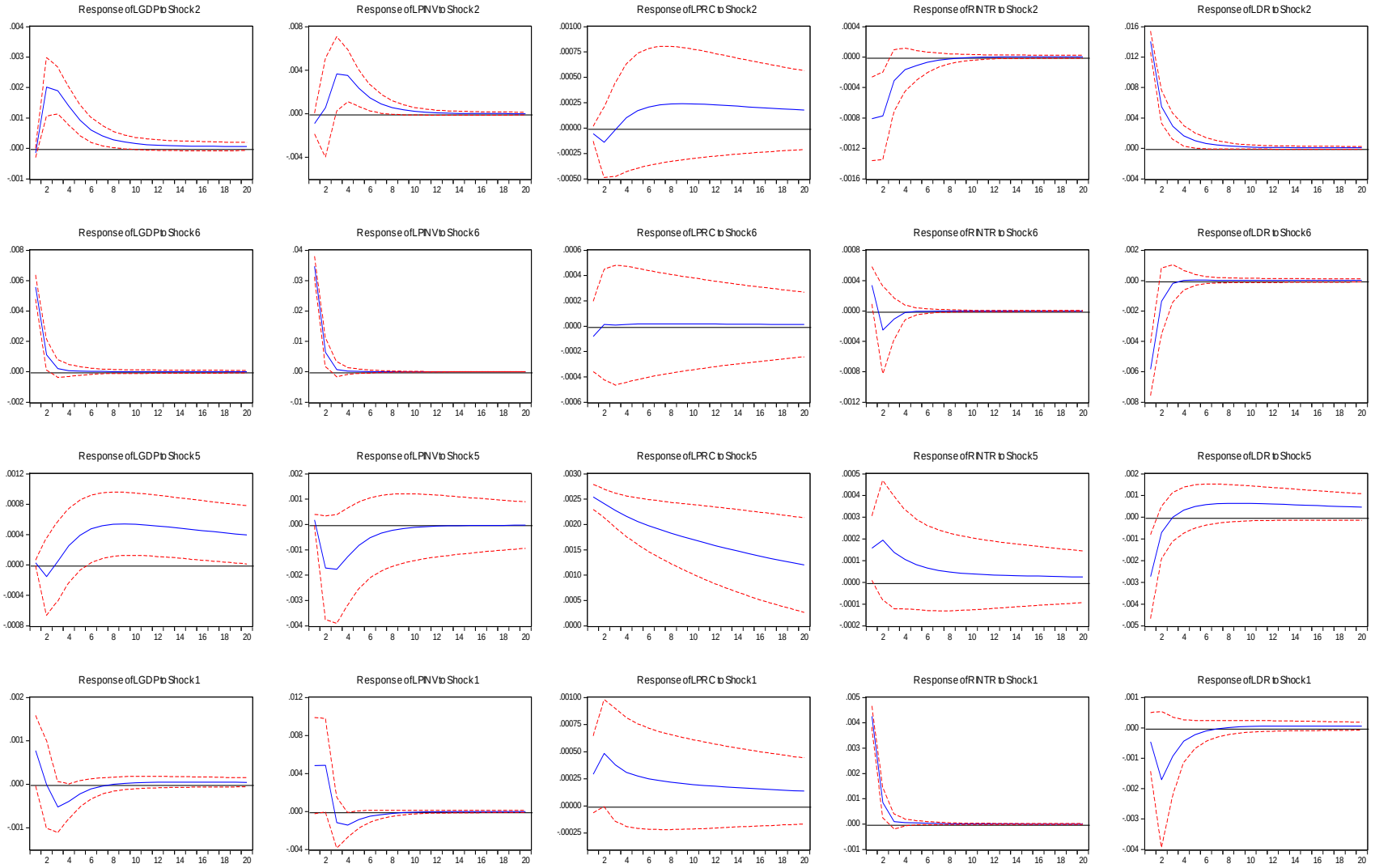


Figure 11.B.f. Impulse response functions in time of debt reduction and recession

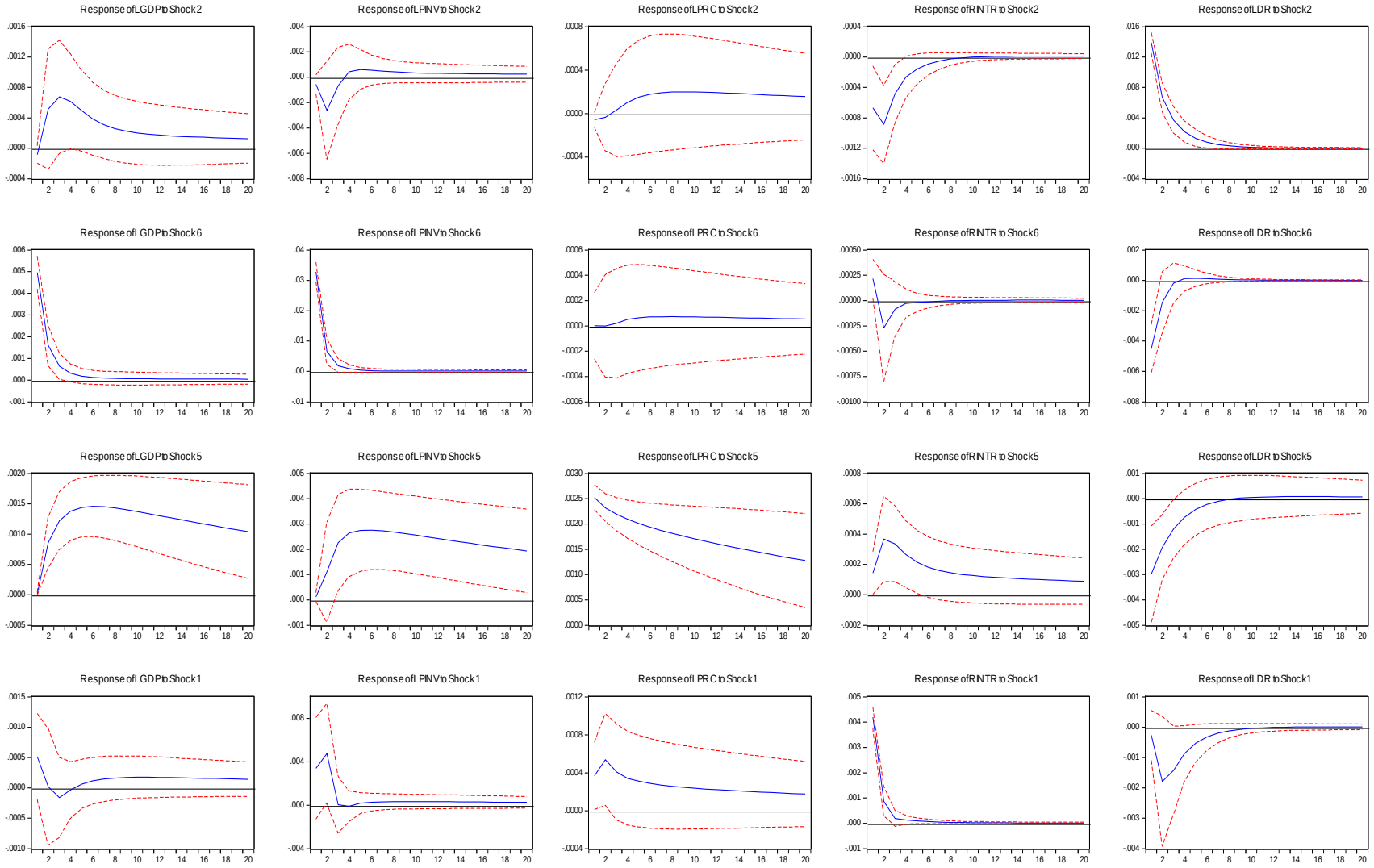


Figure 11.B.g. Impulse response functions in time of debt accumulation and expansion

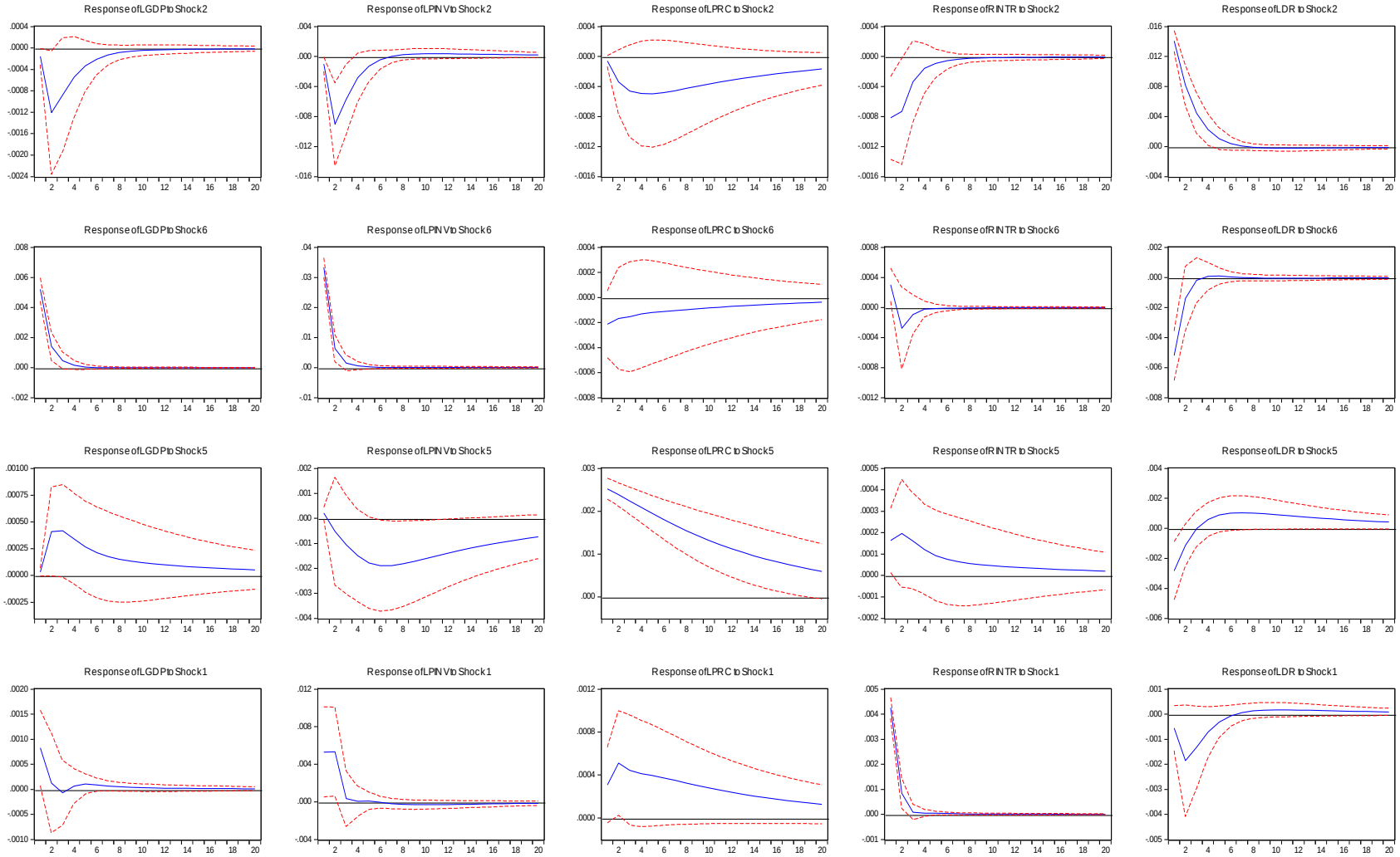
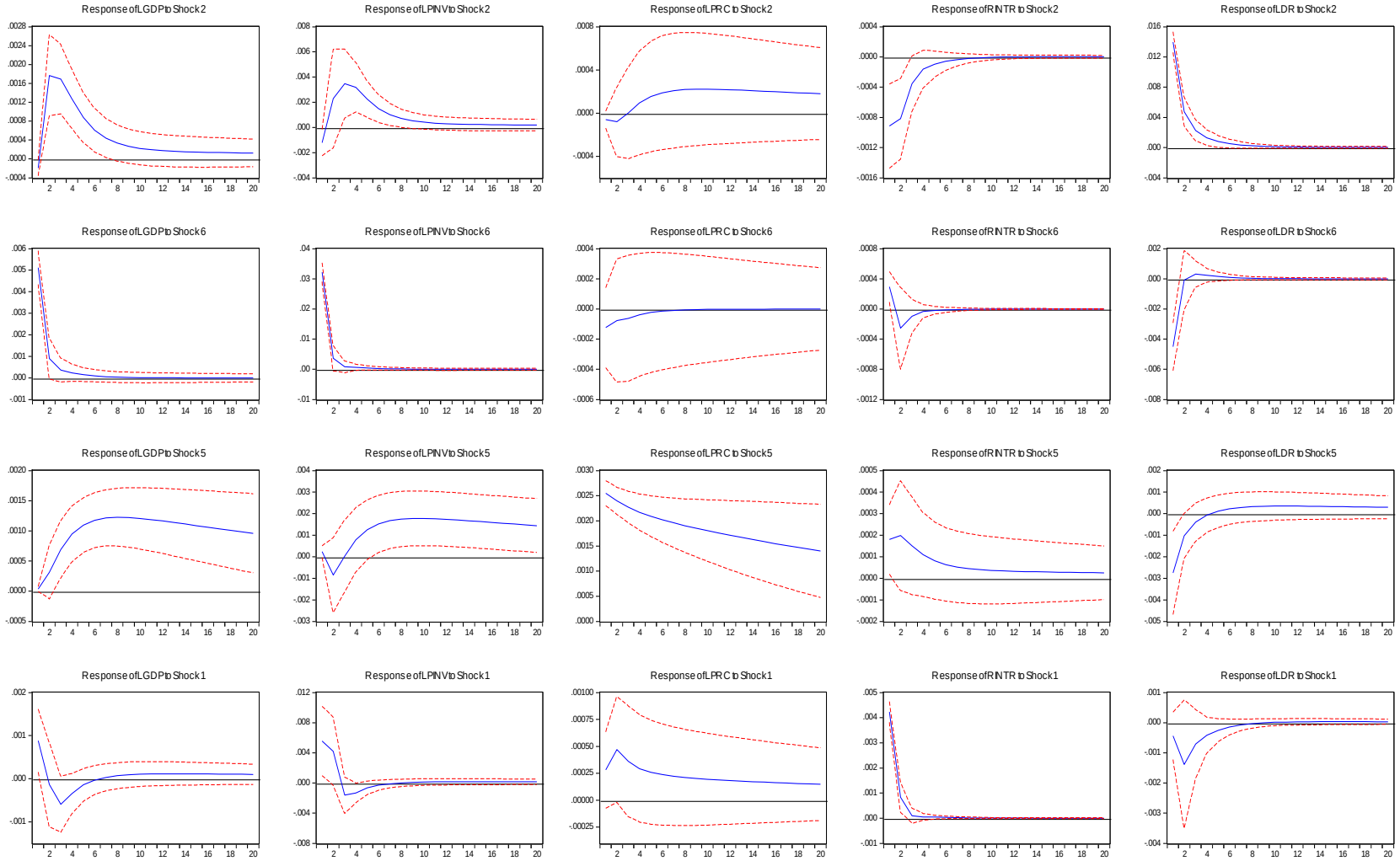


Figure 11.B.h. Impulse response functions in time of debt accumulation and recession



Appendix C. Data

Table 1.C: Data availability for the sample of the 18 countries

OECD quarterly national accounts: GDP and general government consumption

	Observed data start after	Estimated data range
Austria	1996Q1	1966Q1-1995Q4
Belgium	1995Q1	1966Q1-1994Q4
Canada	1966Q1	None
Denmark	1995Q1	1966Q1-1994Q4
Finland	1990Q1	1966Q1-1989Q4
France	1980Q1	1966Q1-1979Q4
Germany	1991Q1	1966Q1-1990Q4
Greece	1995Q1	1966Q1-1994Q4
Ireland	1995Q1	1966Q1-1994Q4
Italy	1996Q1	1966Q1-1995Q4
Japan	1994Q1	1966Q1-1993Q4
Netherlands	1996Q1	1966Q1-1995Q4
Norway	1978Q1	1966Q1-1977Q4
Portugal	1995Q1	1966Q1-1994Q4
Spain	1995Q1	1966Q1-1994Q4
Sweden	1993Q1	1966Q1-1992Q4
United Kingdom	1966Q1	None
United States	1966Q1	None

Table 2.C: Descriptive statistics for government consumption growth rate

1966Q1-2019Q2	AUT	BEL	CAN	DEN	FIN	FRA	GER	GRC	IRE	ITA	JAP	NED	NOR	POR	SPA	SWE	GBR	USA
Mean	-0.11	-0.07	-0.09	0.09	-0.04	-0.01	0.04	0.13	-0.38	-0.08	-0.04	-0.07	0.13	0.28	0.20	-0.07	-0.12	-0.28
Median	-0.09	-0.09	-0.13	0.08	-0.06	-0.06	0.03	-0.10	-0.15	-0.08	-0.13	-0.09	0.14	0.16	0.10	-0.21	-0.13	-0.39
Maximum	3.92	3.51	3.47	3.49	8.27	8.14	6.25	9.95	8.44	3.56	6.13	6.20	8.24	6.16	3.50	4.93	3.91	3.61
Minimum	-3.50	-3.34	-3.41	-3.6	-14.55	-6.76	-4.89	-10.2	-18.48	-5.12	-5.13	-11.08	-4.35	-3.14	-4.66	-4.93	-5.47	-4.47
Std. Dev.	1.04	0.87	1.18	1.19	2.28	0.97	1.36	2.94	2.55	1.04	1.28	1.85	1.56	1.27	1.11	1.45	1.31	1.12
Skewness	0.18	0.39	0.25	-0.1	-1.19	1.45	0.65	0.21	-1.63	-0.15	0.59	-0.82	0.19	1.33	-0.09	0.32	-0.21	0.46
Kurtosis	4.53	5.26	3.32	3.57	13.60	36.03	6.54	4.09	15.40	5.63	6.74	10.12	6.58	7.59	5.19	4.38	4.24	4.87
Jarque-Bera	21.94	50.70	3.08	3.66	1047.14	9755.39	125.99	12.01	1458.86	62.24	136.80	473.17	115.01	249.98	42.71	20.46	15.11	38.48
Probability	0.00	0.00	0.21	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1966Q1-1991Q4	AUT	BEL	CAN	DEN	FIN	FRA	GER	GRC	IRE	ITA	JAP	NED	NOR	POR	SPA	SWE	GBR	USA
Mean	-0.16	-0.02	0.07	0.22	0.20	0.03	-0.04	0.25	-0.13	-0.07	-0.32	-0.16	0.26	0.61	0.31	0.21	-0.17	-0.20
Median	-0.30	0.07	0.05	0.32	0.32	0.06	-0.07	-0.14	0.06	-0.06	-0.36	0.06	0.29	0.46	0.33	0.03	-0.09	-0.32
Maximum	2.76	2.22	3.47	3.49	8.27	8.14	5.43	9.83	2.88	2.80	6.13	5.72	8.24	6.16	3.50	4.93	3.91	3.61
Minimum	-3.50	-3.34	-3.41	-3.0	-14.55	-6.76	-4.89	-10.2	-3.36	-5.12	-5.13	-11.08	-4.22	-3.14	-4.66	-4.93	-5.47	-4.47
Std. Dev.	1.03	0.95	1.40	1.23	2.52	1.24	1.60	3.44	1.22	1.17	1.48	2.41	1.61	1.55	1.30	1.68	1.49	1.35
Skewness	0.24	-0.27	0.01	-0.3	-1.70	1.23	0.44	0.05	-0.42	-0.63	0.71	-0.95	0.66	0.95	-0.64	-0.19	-0.38	0.14
Kurtosis	3.64	3.89	2.62	3.40	14.24	27.03	4.48	3.25	3.19	5.28	6.27	6.48	8.56	5.67	4.64	3.90	3.92	3.85
Jarque-Bera	2.72	4.70	0.64	2.75	591.33	2505.17	12.74	0.31	3.16	29.03	54.47	67.45	140.38	46.10	18.64	4.06	6.13	3.44
Probability	0.26	0.10	0.73	0.25	0.00	0.00	0.00	0.86	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.05	0.18
Observations	103	103	103	103	103	103	103	103	103	103	103	103	103	103	103	103	103	103
1992Q1-2019Q2	AUT	BEL	CAN	DEN	FIN	FRA	GER	GRC	IRE	ITA	JAP	NED	NOR	POR	SPA	SWE	GBR	USA
Mean	-0.06	-0.11	-0.24	-0.0	-0.27	-0.04	0.11	0.02	-0.61	-0.10	0.23	0.00	0.00	-0.03	0.11	-0.34	-0.08	-0.35
Median	-0.08	-0.13	-0.32	-0.0	-0.34	-0.11	0.05	-0.10	-0.49	-0.08	0.19	-0.14	-0.01	-0.10	-0.03	-0.41	-0.20	-0.42
Maximum	3.92	3.51	2.60	3.36	7.58	2.30	6.25	9.95	8.44	3.56	5.17	6.20	3.62	3.48	3.48	3.65	3.21	3.16
Minimum	-3.12	-1.53	-2.93	-3.6	-10.96	-1.42	-3.11	-6.32	-18.48	-2.32	-2.10	-2.74	-4.35	-1.90	-1.79	-2.98	-3.14	-2.00
Std. Dev.	1.05	0.79	0.91	1.14	2.02	0.61	1.09	2.39	3.34	0.92	1.01	1.11	1.51	0.83	0.89	1.13	1.13	0.86
Skewness	0.13	1.38	0.34	0.02	-0.44	1.03	1.39	0.44	-1.22	0.76	1.21	2.55	-0.38	0.77	1.18	1.02	0.26	1.12
Kurtosis	5.34	7.87	4.27	3.96	12.11	5.94	11.34	5.26	9.84	5.56	7.30	15.07	3.83	5.10	5.82	5.46	3.81	5.81
Jarque-Bera	25.49	143.62	9.50	4.20	383.94	59.03	354.38	27.09	241.32	40.60	111.52	786.52	5.79	31.14	61.93	47.02	4.27	59.30
Probability	0.00	0.00	0.01	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.12	0.00

Table 3.C: Descriptive statistics for government debt to DGP ratio (in percent): different country samples (number of observations)

	AUT	BEL	CAN	DEN	FIN	FRA	GER	GRC	IRE	ITA	JAP	NED	NOR	POR	SPA	SWE	GBR	USA
Mean	78.7	111.2	110.0	48.4	52.4	90.0	68.0	145.4	65.0	119.4	182.5	62.9	36.5	101.8	72.0	60.0	62.5	92.0
Median	77.9	110.2	108.7	50.3	48.9	91.7	66.5	136.7	62.7	116.8	176.4	62.7	42.5	86.2	66.2	58.7	50.4	83.7
Maximum	94.0	136.0	133.8	62.7	70.5	113.8	82.4	191.6	129.4	138.8	240.8	78.7	57.9	146.7	106.9	77.2	92.6	138.4
Minimum	65.0	91.4	86.1	29.9	33.2	68.2	57.5	106.0	26.4	103.9	78.2	49.6	4.0	64.9	40.6	47.4	38.6	68.9
Std. Dev.	9.4	9.9	11.9	7.2	10.9	16.2	7.4	34.6	33.5	11.3	45.8	7.8	16.4	30.8	22.4	8.0	21.7	20.7
Skewness	0.1	0.6	0.2	-0.4	0.3	0.1	0.5	0.2	0.5	0.5	-0.4	0.2	-1.0	0.2	0.4	0.6	0.4	1.3
Kurtosis	1.5	3.3	2.4	2.5	1.7	1.3	2.0	1.2	1.9	1.8	2.0	1.9	2.8	1.3	1.7	2.5	1.3	3.2
Jarque-Bera	7.4	5.6	2.4	2.8	6.7	9.0	6.4	10.7	7.3	9.7	6.0	4.4	15.9	10.7	9.4	6.6	14.1	60.0
Probability	0.02	0.06	0.30	0.25	0.03	0.01	0.04	0.00	0.03	0.01	0.05	0.11	0.00	0.00	0.01	0.04	0.00	0.00
Observations	78	95	118	78	78	78	83	78	81	95	90	83	95	83	95	95	98	214

Table 4.C. Unit Root Tests Results

	GDP in level				GDP growth rate			
	ADF test statistic		PP test statistic		ADF test statistic		PP test statistic	
	t-Statistic	Prob.*	Adj. t-Stat	Prob.*	t-Statistic	Prob.*	Adj. t-Stat	Prob.*
AUSTRIA	0.2565	0.9755	0.1309	0.9674	-6.0462	0.0000	-14.6192	0.0000
BELGIUM	-0.0176	0.9551	0.0951	0.9647	-8.8412	0.0000	-8.8459	0.0000
CANADA	1.2132	0.9982	1.3062	0.9987	-9.9102	0.0000	-10.0397	0.0000
DENMARK	0.1751	0.9705	0.1018	0.9652	-13.9734	0.0000	-14.0792	0.0000
FINLAND	-0.4258	0.9011	-0.4393	0.8987	-5.4589	0.0000	-15.1845	0.0000
FRANCE	-0.9383	0.7745	-0.8584	0.7998	-10.6825	0.0000	-18.6270	0.0000
GERMANY	-0.2277	0.9315	-0.2759	0.9249	-12.9975	0.0000	-13.2900	0.0000
GREECE	-1.8730	0.3446	-1.9270	0.3194	-5.0038	0.0000	-14.8132	0.0000
IRELAND	4.3334	1.0000	3.6556	1.0000	-6.3815	0.0000	-16.4083	0.0000
ITALY	3.0219	0.9994	3.2846	0.9998	-6.8989	0.0000	-9.8068	0.0000
JAPAN	4.4270	1.0000	4.1450	1.0000	-4.8786	0.0001	-11.7076	0.0000
NETHERLAND	0.2495	0.9751	0.1247	0.9669	-16.6916	0.0000	-16.5688	0.0000
NORWAY	0.3101	0.9784	0.2740	0.9765	-17.2703	0.0000	-17.0500	0.0000
PORTUGAL	-1.3390	0.6114	-1.3711	0.5960	-5.8511	0.0000	-11.6654	0.0000
SPAIN	-0.0987	0.9469	-0.2549	0.9278	-4.1685	0.0009	-12.1406	0.0000
SWEDEN	1.2149	0.9982	1.6841	0.9996	-10.0465	0.0000	-16.4551	0.0000
UK	0.5707	0.9887	0.9282	0.9958	-8.0347	0.0000	-13.0782	0.0000
USA	1.6819	0.9996	2.0992	0.9999	-10.5931	0.0000	-10.9155	0.0000

Table 4.C. (Continued): Unit Root Tests Results

	Government spending in level				Government spending growth rate			
	ADF test statistic		PP test statistic		ADF test statistic		PP test statistic	
	t-Statistic	Prob.*	Adj. t-Stat	Prob.*	t-Statistic	Prob.*	Adj. t-Stat	Prob.*
AUSTRIA	-0.9438	0.7727	-0.8712	0.7959	-5.4560	0.0000	-18.1330	0.0000
BELGIUM	-2.3989	0.1433	-2.2107	0.2032	-9.4541	0.0000	-9.3844	0.0000
CANADA	-0.5448	0.8785	-0.5332	0.8808	-3.8224	0.0032	-16.3319	0.0000
DENMARK	-2.1121	0.2402	-2.0783	0.2537	-10.9333	0.0000	-11.8262	0.0000
FINLAND	-2.2514	0.1890	-2.0378	0.2706	-19.5700	0.0000	-18.9491	0.0000
FRANCE	-1.0675	0.7286	-1.1667	0.6889	-5.8770	0.0000	-10.0236	0.0000
GERMANY	0.5797	0.9889	0.3823	0.9818	-5.8287	0.0000	-17.4314	0.0000
GREECE	-2.0379	0.2705	-2.0599	0.2613	-4.3691	0.0004	-12.6555	0.0000
IRELAND	0.4036	0.9827	0.1888	0.9714	-4.6500	0.0001	-15.7641	0.0000
ITALY	1.7708	0.9816	2.6518	0.9982	-4.0238	0.0016	-10.9827	0.0000
JAPAN	-0.5480	0.8778	-0.5640	0.8745	-13.4690	0.0000	-13.5146	0.0000
NETHERLAND	0.6128	0.9898	0.5888	0.9892	-21.1820	0.0000	-20.5844	0.0000
NORWAY	1.0377	0.9969	0.9746	0.9963	-19.9566	0.0000	-18.9978	0.0000
PORTUGAL	-1.5195	0.5219	-1.6815	0.4392	-2.1947	0.0275	-2.5213	0.0116
SPAIN	-0.4393	0.8987	0.3556	0.9806	-2.8333	0.0554	-10.3272	0.0000
SWEDEN	6.7077	1.0000	6.1057	1.0000	-14.4874	0.0000	-14.9436	0.0000
UK	1.2851	0.9986	1.0381	0.9969	-18.0062	0.0000	-17.6151	0.0000
USA	-0.3641	0.9115	-0.7758	0.8234	-12.5167	0.0000	-13.3163	0.0000

Table 4.C. (Continued): Unit Root Tests Results

	Debt to GDP in level				Debt to GDP growth rate			
	ADF test statistic		PP test statistic		ADF test statistic		PP test statistic	
	t-Statistic	Prob.*	Adj. t-Stat	Prob.*	t-Statistic	Prob.*	Adj. t-Stat	Prob.*
AUSTRIA	-1.4969	0.5300	-1.4544	0.5513	-3.4298	0.0130	-10.0248	0.0000
BELGIUM	-2.3717	0.1527	-2.3332	0.1639	-2.1233	0.0331	-12.9174	0.0000
CANADA	-0.2620	0.5896	0.0971	0.7116	-3.9377	0.0001	-6.5118	0.0000
DENMARK	-1.8083	0.3740	-1.9389	0.3131	-8.0075	0.0000	-8.1116	0.0000
FINLAND	-0.2617	0.9248	-0.0973	0.9454	-2.5921	0.0101	-10.4421	0.0000
FRANCE	-0.5568	0.8728	-0.3347	0.9139	-3.8903	0.0034	-7.4426	0.0000
GERMANY	-0.9315	0.7735	-1.1590	0.6886	-7.3715	0.0000	-7.5112	0.0000
GREECE	-0.5351	0.8776	-0.5351	0.8776	-10.4692	0.0001	-10.4603	0.0001
IRELAND	-0.4447	0.5189	-0.2289	0.6007	-2.5790	0.0105	-6.0019	0.0000
ITALY	-0.7654	0.8237	-0.0263	0.9532	-2.4075	0.0163	-8.9413	0.0000
JAPAN	1.4708	0.9642	4.0753	1.0000	-1.9364	0.0509	-5.5025	0.0000
NETHERLAND	-0.9068	0.7812	-1.2742	0.6379	-7.5301	0.0000	-7.7581	0.0000
NORWAY	-1.9184	0.3226	-1.9162	0.3236	-9.8130	0.0000	-9.8130	0.0000
PORTUGAL	-2.0002	0.2862	-0.8953	0.7849	-1.3327	0.1676	-6.7636	0.0000
SPAIN	-1.5777	0.4898	-0.0771	0.9480	-1.8333	0.3623	-5.7902	0.0000
SWEDEN	-1.2298	0.6589	-1.2438	0.6527	-3.5245	0.0094	-9.3791	0.0000
UK	-1.2100	0.6675	-0.1698	0.9376	-2.4065	0.1427	-7.7246	0.0000
USA	-1.0519	0.7344	0.0249	0.9590	-5.6685	0.0000	-10.2270	0.0000

Table 5.C. Lag length criteria selection

AUSTRIA							BELGIUM						
Lag	LogL	LR	FPE	AIC	SC	HQ	Lag	LogL	LR	FPE	AIC	SC	HQ
0	-247.79	NA	0.236454	4.233752	4.280713	4.252819	0	-210.76	NA	0.126236	3.606154	3.653114*	3.625221
1	-224.32	45.75102	0.169989	3.903713	4.044596*	3.960916*	1	-203.43	14.28995	0.119309*	3.549690*	3.690572	3.606892*
2	-222.45	3.582547	0.176251	3.939806	4.17461	4.035143	2	-200.70	5.236902	0.121905	3.571142	3.805946	3.666479
3	-215.37	13.31614	0.167322	3.887638	4.216363	4.02111	3	-198.79	3.584916	0.126333	3.606642	3.935367	3.740114
4	-207.98	13.66067	0.158017	3.830107	4.252754	4.001714	4	-193.19	10.34576	0.122992	3.579523	4.00217	3.751131
5	-202.83	9.331025	0.155056*	3.810698*	4.327266	4.02044	5	-188.63	8.271055	0.121889	3.570021	4.086589	3.779762
CANADA							DENMARK						
0	-247.78	NA	0.236421	4.233611	4.280572	4.252678	0	-226.30	NA	0.361858*	4.659249*	4.712004*	4.680587*
1	-223.40	47.52766	0.16736	3.888124	4.029006*	3.945326*	1	-224.50	3.497872	0.378457	4.704062	4.862326	4.768076
2	-218.14	10.06771*	0.163846*	3.866825*	4.101629	3.962163	2	-218.62	11.15729*	0.364273	4.665724	4.929496	4.772414
3	-214.55	6.760736	0.165008	3.873715	4.20244	4.007187	3	-216.02	4.834917	0.374921	4.694226	5.063507	4.843592
4	-211.35	5.915857	0.167307	3.887237	4.309884	4.058844	4	-215.40	1.127446	0.401911	4.76319	5.23798	4.955233
5	-208.50	5.164119	0.170692	3.906771	4.423339	4.116513	5	-212.18	5.713769	0.408727	4.779148	5.359446	5.013866
FINLAND							FRANCE						
0	-420.09	NA	4.385257	7.154002	7.200962	7.173069	0	-101.19	NA	0.019706	1.748905	1.795865	1.767972
1	-405.51	28.4201	3.66539	6.974667	7.115549*	7.031869	1	-59.74	80.78687*	0.010446*	1.114207*	1.255089*	1.171409*
2	-398.62	13.19426*	3.490509*	6.925700*	7.160504	7.021037*	2	-56.44	6.313582	0.010572	1.126131	1.360935	1.221468
3	-395.54	5.781953	3.546396	6.941407	7.270132	7.074879	3	-52.48	7.4582	0.010581	1.126736	1.455462	1.260209
4	-392.73	5.197684	3.61958	6.961519	7.384165	7.133126	4	-49.50	5.507511	0.010768	1.144005	1.566652	1.315612
5	-388.37	7.901872	3.599509	6.955466	7.472034	7.165208	5	-46.95	4.62483	0.011042	1.168579	1.685148	1.378321
GERMANY							GREECE						
0	-296.76	NA	0.542231	5.06369	5.110651*	5.082757*	0	-497.55	NA	16.29946	8.466885	8.513846*	8.485953*
1	-290.52	12.15391*	0.522081*	5.025800*	5.166683	5.083003	1	-495.30	4.383	16.79089	8.496569	8.637451	8.553771
2	-288.89	3.120009	0.543532	5.065986	5.30079	5.161324	2	-492.66	5.051277	17.18456	8.519664	8.754467	8.615001
3	-286.62	4.279879	0.559759	5.095225	5.423951	5.228698	3	-479.44	24.87722	14.70027	8.363341	8.692066	8.496813
4	-283.72	5.345811	0.570534	5.113978	5.536625	5.285585	4	-472.77	12.31058*	14.05582	8.318197	8.740843	8.489804
5	-280.44	5.956539	0.57778	5.126106	5.642674	5.335848	5	-467.75	9.116041	13.82016*	8.300797*	8.817365	8.510539

Table 5.C. (Continued): Lag length criteria selection

IRELAND							ITALY						
Lag	LogL	LR	FPE	AIC	SC	HQ	Lag	LogL	LR	FPE	AIC	SC	HQ
0	-549.40	NA	39.25271	9.345774	9.392735*	9.364841*	0	-244.67	NA	0.224253	4.180771	4.227732	4.199838
1	-543.51	11.47876	38.01660*	9.313755*	9.454637	9.370958	1	-227.17	34.09829	0.17841	3.952061	4.092943*	4.009263
2	-542.01	2.870534	39.66607	9.356149	9.590953	9.451486	2	-220.16	13.43143	0.169542*	3.900995*	4.135799	3.996332*
3	-538.92	5.81424	40.28945	9.371565	9.70029	9.505037	3	-216.58	6.728176	0.170794	3.908178	4.236903	4.04165
4	-532.89	11.14844*	38.9361	9.337082	9.759729	9.508689	4	-213.37	5.927506	0.173155	3.921593	4.34424	4.0932
5	-530.06	5.134488	39.73469	9.356893	9.873461	9.566635	5	-210.73	4.797627	0.177264	3.944552	4.461121	4.154294
JAPAN							NETHERLAND						
0	-262.14	NA	0.301558	4.476961	4.523922*	4.496028*	0	-265.72	NA	0.320425	4.537645	4.584606	4.556713
1	-259.85	4.466312	0.310425	4.50592	4.646802	4.563122	1	-254.51	21.84813	0.283576	4.415458	4.556341*	4.472661*
2	-255.20	8.900914	0.307062	4.494947	4.729751	4.590285	2	-248.70	11.13729*	0.275007*	4.384695*	4.619499	4.480032
3	-249.00	11.67568*	0.295846*	4.457558*	4.786283	4.59103	3	-245.20	6.587284	0.277391	4.393147	4.721872	4.526619
4	-245.80	5.899851	0.300012	4.471227	4.893874	4.642834	4	-244.62	1.059464	0.29407	4.451223	4.87387	4.62283
5	-245.12	1.240386	0.317513	4.527431	5.044	4.737173	5	-242.85	3.221844	0.305514	4.488909	5.005478	4.698651
NORWAY							PORTUGAL						
0	-677.57	NA	2.596628	6.629967	6.662387	6.64308	0	-288.47	NA	0.471187	4.923252	4.970213	4.94232
1	-660.19	34.24606	2.278932*	6.499457*	6.596716*	6.538796*	1	-229.42	115.1041	0.185335	3.990144	4.131026*	4.047347
2	-658.33	3.645647	2.326857	6.520253	6.682351	6.585818	2	-221.20	15.73303	0.172572	3.91871	4.153514	4.014048
3	-653.39	9.540204	2.305721	6.511095	6.738032	6.602885	3	-214.88	11.88885	0.165949	3.8794	4.208126	4.012872*
4	-651.38	3.830484	2.351221	6.530576	6.822352	6.648592	4	-212.72	4.004849	0.171237	3.910455	4.333102	4.082062
5	-645.71	10.73068	2.313449	6.514287	6.870903	6.65853	5	-210.59	3.863845	0.176837	3.942141	4.458709	4.151883
SPAIN							SWEDEN						
0	-206.45	NA	0.241323	4.254134	4.306889	4.275472	0	-287.95	NA	0.467068	4.914474	4.961435	4.933541
1	-142.34	124.3063	0.070762	3.02728	3.185543*	3.091294	1	-274.34	26.53764	0.396839*	4.751508*	4.892391*	4.808711*
2	-135.00	13.92385	0.066113	2.959193	3.222966	3.065884	2	-272.36	3.790346	0.410701	4.785762	5.020566	4.881099
3	-128.06	12.89801*	0.062276*	2.899090*	3.268371	3.048456*	3	-269.04	6.237914	0.415566	4.797361	5.126087	4.930833
4	-125.95	3.820907	0.064769	2.937791	3.412581	3.129834	4	-263.86	9.571927*	0.407458	4.777342	5.199989	4.948949
5	-124.06	3.354557	0.067678	2.980865	3.561164	3.215584	5	-262.06	3.264871	0.423144	4.814626	5.331194	5.024368
UK							USA						
0	-272.01	NA	0.356473	4.644257	4.691218	4.663324	0	-468.51	NA	0.337747	4.590297	4.622717	4.60341
1	-241.14	60.17334	0.226067*	4.188807*	4.329689*	4.246009*	1	-455.52	25.59416	0.309396	4.502618	4.599877*	4.541957*
2	-239.14	3.82958	0.233882	4.222714	4.457517	4.318051	2	-450.61	9.577723*	0.306671*	4.493754*	4.655852	4.559318
3	-235.92	6.058877	0.237035	4.235926	4.564651	4.369398	3	-447.49	6.029241	0.309322	4.502327	4.729265	4.594118
4	-234.71	2.23206	0.248599	4.283245	4.705891	4.454852	4	-443.83	6.996665	0.310371	4.505654	4.797431	4.623671
5	-232.84	3.391929	0.257863	4.319341	4.835909	4.529083	5	-442.32	2.856712	0.318035	4.529954	4.886569	4.674196

Table 6.C. Gross External Debt Position: Foreign Currency and Domestic Currency Denominated Debt, as of September 30, 2019

US Dollars in Millions

Foreign Currency	1,418,375
Short-term	416,113
Long-term	1,002,262
Domestic Currency	17,098,332
Short-term	5,865,360
Long-term	11,232,972
Unallocated *	1,904,566
Gross External Debt Position	20,421,273

* The currency composition is unallocated for debt in Direct Investment and Trade credit and advances of the General Government.

Source: https://ticdata.treasury.gov/Publish/debtb2019q3.html

Chapter 3

Public debt effects in theory-based models with an empirical assessment of the potential public debt

Chapter 3

Public debt effects in theory-based models with an empirical assessment of the potential public debt

Abstract: Using an endogenous growth model, we simulate a parametrized endogenous potential debt that a country should target to finance its expenditure, derived from potential government spending. We run individual estimations for a sample of 20 advanced countries over the period of 1960–2015, augmenting the Cobb-Douglas production function by human capital and government expenditure stocks. The potential public debt is a time series derived from a simulated potential public expenditure. It is the debt limit curve that the economy could bear depending on its optimal production capacity and its long-term economic growth and interest rate. The results show that the public capital stock elasticities differ across countries, with an average of around 0.3. Compared to actual public debt, the targeted potential debt drops below the actual one for many countries in times of crisis, especially after the 2008 financial crisis, suggesting that countries should reduce their debt to keep potential debt above actual debt. For many countries, potential debt decreases faster in response to a rapid accumulation of actual debt, leading to an intersection between the two curves that generally materializes in times of crisis. For others, the debt situation is safer, as potential debt is higher and generally moves in parallel with actual debt. The average potential debt ratio moves from high values of 150% to 200% in Switzerland, Sweden, Denmark, Norway, the United States, Austria and The Netherlands, to low values of 50% to 80% in times of crisis, for Greece, Italy, Spain, the United Kingdom, France, Germany and Belgium. The potential public expenditure series shows a decreasing trend over time but it is still higher than the one observed in many countries in the sample. This is driven by the general decreasing trend of public capital stock productivity, especially in the Great Moderation Era (1985–2015). The policy message to increase potential public expenditure, and hence the targeted potential debt, is to enhance such productivity. This might be achievable through the choice of higher productive public capital, which implies selective public projects with higher multipliers.

JEL classification: B22, B23, C51, H54, H63.

Keywords: Potential debt, Infinitely lived agents, Endogenous growth, Government expenditure, New Keynesian models, Public capital.

1. Introduction

To assess the effects of government debt, many theoretical growth models have been designed. The first class of these models is the infinitely lived agents' models, initiated by Ramsey (1928). Later, the debate between economists about agents' lifetime horizon and the type of intergenerational operative transfer linkages between such agents led to building the concept of overlapping generations' (families/dynasties) models to account for the existence or absence of continuity between generations provided by such linkages (Samuelson, 1958; Diamond, 1965). In particular, the most debated ideas are the degree of implication of altruism between generations (such as a motive bequest) and the lifetime agents' horizon in determining the existence of government debt effects on agents' behaviour in terms of saving, capital accumulation, consumers' utility and interest rate. Important contributions to this field are those of Diamond (1965), Barro (1974), Blanchard (1985), Buiter (1988), Aiyagari (1985, 1989) and Weil (1989).[69]

In this regard, two major propositions emerged. The first, according to the neoclassical framework, is that government debt crowds out private capital by increasing interest rates (Modigliani, 1961). The second is the Ricardian equivalence for which its advocates show that debt neutrality could happen depending particularly on the existence of operative altruistic links (bequests) between generations (Barro, 1974). In this way, the debate in the economic literature emerged especially in the 1970s and 1980s, with useful contributions modelling fiscal policy insights, precisely the debt–tax swap and its effects on welfare utility and interest rates.

While the most important property characterizing the majority of neoclassical models considering government debt is that they build their reasoning on household behaviour towards public expenditure and government debt, other literature on the political economy of debt assesses the effects of public debt, studying the behaviour of governments and the influence of economic and political institutions. In this regard, two approaches are debated. The first is the normative approach, where the government is considered a social planner (a benevolent social planner), for whom the priority is to maximize the social welfare of its individuals in society (Barro, 1979; Lucas and Stokey, 1983; Aiyagari et al., 2002). The second is the positive approach, considering public debt as a state variable used by each government as a strategy to influence its successor's choices or as a way to shape private economic agents' expectations (Persson and Svensson, 1989; Alesina and Tabellini, 1990). In this regard, the most disseminated ideas are related to the effects of fiscal policy (government debt and spending policies) under governments following committed rules versus discretionary policies. In particular, the government time inconsistent[70] actions have an impact on the way economic agents form their expectations, which affects their economic decisions.

[69] See, for example, De la Croix and Michel (2010) and Weil (2008) for a large literature review.
[70] The government time inconsistency issue was raised by Kydland and Prescott (1977).

The public debt effects are also assessed theoretically and empirically in the class of endogenous growth models. The pioneering contributions in this modelling area flourished with the development of endogenous growth models, especially by Romer (1986) and Lucas (1988). These models were brought as an alternative to the neoclassical growth model of Solow (1956) and Swan (1956) (the Solow–Swan model). The principal characteristics of such models are focusing on the accumulation of knowledge and its endogenization (whether this is embodied in the form of technological progress or in the form of human capital). Since then, many sources of growth have been integrated, particularly to the production function, as inputs such as innovation, human capital, ideas and government goods, for example (Jones, 2003, 2005, 2019; Jones and Romer, 2010; Bloom et al., 2019). The latter and similar contributions assess the effects of fiscal policy (taxes, government debt and spending) generally integrating the public sector into the productive sector (Barro, 1990). However, high government spending (especially unproductive spending), jointly with assumed distortionary taxes, leads to low per-capita growth rates, according to the neoclassical growth theory, or to lower growth, according to endogenous growth theory. These results contrast with the growing empirical evidence that higher government spending and taxes (relative to the size of the economy) are not negatively correlated with the growth rate (Corsetti and Roubini, 1996).[71]

Recently, fiscal policy, and particularly government debt, was also modelled under the class of new Keynesian models,[72] despite these models still actively prioritizing monetary policy analysis (see, for example, Rupert and Šustek, 2019). These models differ from the overlapping generations models in many aspects. For example, instead of considering all taxes as a lump sum, as assumed in the overlapping generations models, recent new Keynesian models have considered fiscal policy assuming distortionary taxes. Furthermore, they join (intersect with) the literature of the political economy of debt by considering the scope of government actions and discuss government policies under commitment or discretion rules. In particular, some authors argue that optimal public debt would follow a random walk process whenever the government can achieve a time-inconsistent policy commitment (Benigno and Woodford, 2003; Schmitt-Grohe and Uribe, 2004).

This chapter is structured as follows. Section 2 reviews the existing literature, namely, the government debt effects in economic growth models, as debated in the old generation models and the endogenous growth models, as well as the very recent new Keynesian models and in the new political economy of debt (positive approach).[73] Section 3 describes the theoretical framework used to assess the effects of government debt (government expenditure) on the economy. Section 4 describes the empirical evidence. Section 5 concludes.

[71] Corsetti and Roubini (1996) interpret such facts by the imprecise distinction between productive and non-productive public spending. Many forms of public spending affect the productivity of the economy differently, either directly or indirectly. The theoretical prediction of a negative tax rate effect on growth is weakened once public spending can be qualified as productive.
[72] See, for example, Leith and von Thadden (2008), Leith and Wren-Lewis (2013) and Rossi (2014).
[73] These models are categorized, and their main results summarized, in Table A.1 of the appendix.

2. Literature review

This section is dedicated to the assessment of government debt effects in the theoretical models. Without claiming completeness, we will make an inventory of the most important contributions, modelling the effect of debt on the behaviour of economic agents and the subsequent consequences on the macroeconomic aggregates. First, we consider the government effects in the infinitely lived agents and the overlapping generations models (henceforward, ILA and OLG models). Second, a summary of the public debt effects in endogenous growth models is presented. Third, the effects of public debt are also considered and discussed in the economic literature of the new political economy of fiscal policy, also known as the positive approach of public debt and fiscal policy. We also present some studies assessing the effects of public spending and debt in the recent class of new Keynesian models, specifically in an integrated framework of fiscal and monetary policy. The fourth section concludes with two critiques of Mankiw (2000) for the ILA and OLG models and the Chari et al. (2009) critique of the new Keynesian models.

2.1. Government debt effects in the ILA and OLG models

The main ideas debated in the ILA and OLG models are mostly related to the way government bonds affect the steady state equilibrium interest rate (hence, capital accumulation) and consumption (welfare utility). In this way, two major ideas are contrasted. The proposition that public debt increases equilibrium interest rates in the steady state was confronted by the debt-neutrality idea known as Ricardian equivalence.[74] The first idea, as illustrated by Modigliani (1961), is that, in a full employment model, increasing government debt increases the conception of households' net wealth, which raises consumption and hence reduces saving, resulting in an increase in real interest rates. This reduces the output share resulting from the accumulation of capital. However, for Barro (1974), the idea that the "government debt effect on aggregate demand depends on the assumed increase of the households' net wealth" is only true in the non-full employment framework. In a full employment context, public debt effects could have no wealth effect if agents (generations) were economically connected by operative intergenerational transfers.

In this regard, two slightly different versions of the same neoclassical core model should be distinguished. The first class of model of growth assumes infinitely lived agents (ILA), (Ramsey, 1928; Cass, 1965). The second version is OLG models, which instead, have shifted the debate,

[74] Buiter (1988) defines Ricardian equivalence by stating that: "*There is debt neutrality if, given a program for public expenditure on current goods and services over time, the real equilibrium of the economy is not affected by a change in the pattern over time of lump-sum taxes. If there is debt neutrality, for instance, the substitution of borrowing today for lump-sum taxation today…does not affect the current and future behavior of private consumption and capital formation.*"

considering the intergenerational linkages between generations rather than their lifetime horizon[75] (Samuelson, 1958; Diamond, 1965). The subsequent contributions based on these models show that the debt effect is due to the degree of altruism existing between young and old generations rather than the presence of the infinitely lived agents (linkages that could result in agents with infinite lifetime horizons). This created an intense debate between the neoclassical and proponents of the Ricardian-equivalence conjecture (Barro, 1976; Feldstein, 1976).

Thereby, Diamond (1965) constructed an OLG model to study the effects of government debt (domestic and foreign) on the long-term competitive equilibrium. The economy assumes an infinitely long life and agents living for two periods, working in the first and retiring in the second. The model particularly assesses the effects of domestic and foreign debt on both utility level and the equilibrium interest rate. In this model, several key assumptions are made about national debt. First, governments have a one-period maturity avoiding the issue of the expected capital returns. Second, the debt pays the current interest rate. Third, the debt–labour ratio is held constant. Fourth, taxes are assumed as a lump sum on the youth generation.

In this model, the effects of government debt on utility and equilibrium interest rates depend on the coexistence of external and internal debt in the portfolio of government debt. Internal debt raises the interest rate and decreases the utility level in the efficient competitive equilibrium, and may increase or decrease it in the inefficient equilibrium. In particular, in the absence of external debt, domestic debt may increase utility in the case of inefficient competitive equilibrium. External debt increases the gap between the equilibrium interest rate and economic growth. Specifically, it moves the interest rate away from the golden rule solution,[76] which, in turn, reduces utility. In the case of an efficient competitive solution, external debt reduces the utility level of individuals in the long-term equilibrium. However, in the case of an inefficient solution, the external debt effect can raise or lower the utility independently of the existence of internal debt.[77] Furthermore, the debt swap (the substitution of internal debt by external debt) positively influences the interest rate and hence negatively influences utility in the efficient equilibrium, while it could reduce or increase it in the inefficient case. The author differentiates between four effects of public debt on utility: the effect of domestic debt following changes in the taxes required to finance it, the debt effect in the relative factor payments, the effect of external debt, and the debt swap effect.

Nevertheless, Barro (1974) constructed a model of overlapping generations based on Samuelson–Diamond's core model (Samuelson, 1958; Diamond, 1965) to argue that government bonds displace the interest rate, and utility in the steady-state equilibrium does not necessarily hold and depends, in particular, on the existence of operative altruistic links (bequests) between generations.

[75] According to some authors (Barro, 1974; Weil, 1989), having operative linkages in OLG models between some economic agents with defined finite time horizons leads to infinite lifetime connected generations in the OLG models.
[76] According to Phelps (1961): "*A golden age means a dynamic equilibrium in which output and capital grow exponentially at the same rate so that the capital–output ratio is stationary over time.*"
[77] The principal findings of the Diamond model, for which government deficits raise long-term interest rates, have been empirically tested in many papers, with a mixture of numerical results (Ni, 1999).

Expressly, in the absence of such linkages, the current living generation does not necessarily consider the welfare of its dependants (future generations). Therefore, shifting the tax burden to the future may change the effective lifetime budget of the current living generation. Alternatively, operative altruistic links may cancel the effect on the lifetime budget of the current living generation, as the latter is aware of the welfare of the future generation. Consequently, debt neutrality is guaranteed, as the debt-for-tax swap does not affect the resource allocations and interest rates of the current generation in this case. For Cukierman and Meltzer (1989), it is sufficient that the bequest motives do not operate for some economic agents only, to conclude under majority rule, for the non-neutrality of government debt.

Unlike Diamond's (1965) model, which considers the infinite lifetime horizon, Blanchard (1985) studies the effects of debt and accumulation of deficit in a finite lived agent's horizon.[78] This is conducted by constructing what he called an "index of fiscal policy" supposed to capture the effects of current and anticipated fiscal policy. This index has two parts, of which one shows the effect of both changes and levels of government spending on aggregate demand, while the second highlights the effects of government finance; this is reflected by the effects of both government debt and the expected sequence of accumulated deficits on aggregate demand.

The main conclusions are that a government debt increase displaces the steady-state level of foreign assets in agents' wealth in an open economy[79] and decreases the steady-state level of capital and consumption in a closed economy. Consequently, the government can choose any level of steady state of consumption (open economy) and capital (closed economy) by simply choosing its level of debt. Similarly, a decrease in current lump-sum taxes increases human wealth and consumption. The longer the taxes are differed (i.e. shifted to future generations), the larger the effect. In summary, the increase in government debt and taxes creates initial wealth effects on consumption, leading to capital decumulation, which makes capital and consumption lower in the new steady-state level.

For other authors, the way the tax cut is distributed among economic agents plays an important role in determining the effects of fiscal policy. In this way, Aiyagari (1985) used a modified version of the OLG model based on Samuelson (1958) to show that Ricardian equivalence[80] depends on the way the tax cut is distributed among agents. In particular, debt neutrality holds in an OLG framework where this distribution does not change agents' wealth allocations. The choice of the OLG model (instead of an ILA model) was attributed to the fact that this type of model allows for

[78] Blanchard (1985) imposes a constant instantaneous probability of death over agents' lifetime. This makes different agents with different ages and different levels of wealth have the same horizon and assumes the same propensity to consume. This easily enables the aggregation of the consumption function. Diamond's (1965) model adopts, however, specified population and age structures to avoid the aggregation issue.

[79] The larger the horizon of agents, the smaller the effect. Specifically, in an infinite horizon, the level of government debt has no effect on the steady-state level of foreign assets (Blanchard, 1985).

[80] Ricardian equivalence is summarized as "the debt–tax swap for financing government spending, [which] has no effect on the interest rates and consumption allocations".

a changeable real interest rate (which may be above or below the real growth rate) to different deficit policy regimes. Furthermore, the OLG models consider heterogeneous agents, which enable taxes to be distributed differently among them. On the contrary, ILA models do not allow the real interest rate to go below economic growth, while, in addition, they assume identical economic agents yielding a uniform tax distribution.

Aiyagari's results were addressed in response to Miller and Sargent (1984), for whom "a shift to a different regime with permanently higher deficits will raise the interest rate and may make it exceed the growth rate". Aiyagari (1985) shows that this statement depends on how wealth is distributed, and this does not hold when the distribution of wealth is kept unchanged. His model shows that a higher level of government spending (or similarly a cut in total taxes) can be financed by debt alone at an unchanged (and negative) interest rate and with unchanged total taxes, if the taxes are distributed in a way that maintains wealth distribution. According to the author, this implies reducing taxes for the younger generation as savers and increasing taxes on the older generation of non-savers, while keeping total taxes constant. Thus, any actual effect of higher government spending on interest rates may arise because distributional impacts are not being controlled for, and not simply because the deficit is higher. So, for Aiyagari (1985), the validity of Ricardian debt neutrality depends on the way taxes are distributed among taxpayers and not on the length of the lifetime horizon.

Taking into account the operative linkages between agents, other contributions consider instead that the effects of government bonds on economic agents' wealth are related to the way the tax bases are foreseen. In this regard, Buiter (1988) builds on the Yaari-Blanchard version[81] of the overlapping generations model to show that the real equilibrium of the economy (private consumption, capital and relative prices) is independent of the pattern of government debt and lump-sum taxation over time. For the author, the difference between the expected government tax base and the future tax base of individuals that are alive today explains the variations over time in the pattern of lump-sum taxation. The former tax base represents the resources of individuals alive today, and those yet to be born, while the latter represents the resources owned by individuals alive today only, and not the resources of individuals yet to be born. In particular, economic agents that are not linked to their future generations through intergenerational transfers do not integrate the resources of these successors' generations into their inter-temporal budget constraint. In this regard, Buiter (1988) shows that debt neutrality holds if, and only if, the population growth rate and the individual probability of death equal zero.[82] Furthermore, under the latter condition, a non-zero labour productivity rate will not destroy this debt neutrality.

[81] Private consumption behaviour is modelled following the Yaari-Blanchard approach (Yaari, 1965; Blanchard, 1985).

[82] Blanchard (1985) considers that only an uncertain lifetime condition (a positive non-zero probability of death) is sufficient to invalidate the debt-neutrality conjecture.

Contrary to the models that take into account intergenerational transfers and those considering the infinite lifetime horizon induced by such linkages as prerequisites for debt-neutrality validation,[83] Weil (1989) developed a model of "overlapping families of infinitely lived agents"[84] to show that the assumption of the "infinite lifetime horizon"[85] is not necessarily a condition that induces Ricardian debt neutrality, as well as, inversely, finite horizons not necessarily implying the violation of Ricardian neutrality. The model assumes new cohorts entering the economy over time, for which operative intergenerational linkages between some, but not all, agents, result in "*partial linkages sufficient to endow any agent alive at any date with an effectively infinite economic horizon*". For Weil (1989), newly arriving families are not linked to pre-existing dynasties through operative intergenerational transfers.[86] The infinite lifetime of the agents (dynasties) is guaranteed by the continuous arrival of families who are not linked by operative intergenerational transfers (no intergenerational altruism). The number of newly arriving families (cohorts), which measures economic disconnectedness (and heterogeneity of the population), is also the growth rate of the population. The model is viewed as an extreme version of Blanchard's (1985) version, as it focuses on the birth rate of new arrival families while setting the probability of death to zero – "*agents are born but never die*". The model of Blanchard (1985) assumes a constant population by equalling the birth to death rates. Buitter's (1988) model, however, based on Yaari (1965), assumes distinct birth and death rates.

By introducing government bonds in his model, which involves levying lump-sum taxes, Weil (1989) shows that the equilibrium interest rate hinges on the government financing decision and the rate (speed) of newly arriving cohorts (families). In particular, government bonds increase the equilibrium interest rate for a positive non-zero population growth rate. For the author, the anticipated taxes to pay the issued public debt are expected to be compensated by generations that have not yet been born. However, generations that are alive today do not consider these taxes in their consumption. This makes them better off and pushes them to spend more, "*not because they might not be alive when future taxes are levied (they will, as they live forever), but because the future tax base will include new agents to whom they are not economically connected. The real interest rate must hence rise to maintain aggregate consumption at its market-clearing level. Infinite lifetimes are therefore not inconsistent with the violation of the Ricardian debt neutrality*

[83] The relationship between altruistic intergenerational transfers, infinite time horizons and Ricardian debt neutrality has been widely debated: "*It is widely argued that operative intergenerational transfers between all generations, because they imply infinite horizons, lead to Ricardian neutrality (cf. the debate between Feldstein (1976) and Barro (1976)). It is also suggested that finite lifespans lead to the violation of the Ricardian proposition (Blanchard, 1985)*" (Weil, 1989).

[84] The assumption of "finite lifetime" adopted by OLG models is considered useless in this model by the author.

[85] The effective length of consumers' planning horizon is infinite.

[86] "*Consider, for instance, a primogeniture economy in which a parent only loves his first-born heir, enough to leave him a bequest. Assume that all parents have children, and that children do not love their parents. Each child, whether first-born or not, is, in this economy, linked through operative bequests to the never-ending chain of his first-born descendants, and is thus part of an infinitely-lived family. Children who are not first-born, however, do not belong to any pre-existing dynasty, since they were not loved by their parents: they initiate the dynasty to which they belong. The rate at which new dynasties enter the economy is a reflection, in such an environment, of the proportion of children who are not loved, or not loved enough, by their parents*" (Weil, 1989).

proposition." Furthermore, Weil (1989) constructed an example for finite horizons, for which Ricardian debt neutrality is not necessarily violated.

Besides the operative intergenerational transfers, the lifetime horizon and the way taxes and tax bases are distributed and perceived among generations, an important contribution adds the degrees of knowledge spillover across generations, as well as the substitutability between consumption and leisure, to the factors impacting equilibrium interest rates and Ricardian equivalence validation. In this way, Ni (1999) extended Diamond's OLG model, where capital is the only variable input, by allowing for capital and labour as inputs, and assuming a learning-by-doing knowledge-based growth economy in the spirit of Arrow (1962) and Lucas (1988). Diamond's (1965) model, and others like it, imply that a government deficit always reduces savings and raises interest rates. However, Ni's (1999) main model results show that the effect of government deficit on interest rates depends on the spillover of knowledge and the elasticity of labour supply. Precisely, in a neoclassical growth model with elastic labour supply and intergenerational spillover knowledge, public deficits may not necessarily raise real interest rates.[87]

The explanation for this is as follows: while a debt-for-tax swap reduces only the capital stock in the Diamond (1965) model, it reduces both the supply and demand of capital in Ni's (1999) model. Then, with consumption and leisure being good substitutes, shifting the tax burden to the future reduces current savings, capital stock and the labour supply of the near future. The overall impact on real interest rates is a result of two opposite effects of reduction in the labour supply and the accumulation of knowledge[88] from one side and capital supply from the opposite side. The reduction in future labour supply and knowledge lowers the equilibrium real interest rate, while the reduction in capital increases it (as in Diamond, 1965). The first effect may partially offset and possibly overcome the second one.

To sum up, this section was devoted to the public debt effects in the neoclassical growth models of ILA and OLG. The most debated question in these models is the links between the validity of the Ricardian argument and the lifetime horizon of individuals. Indeed, if the presence of agents with an infinite lifespan in the ILA models (based on Ramsey, 1928) validates the Ricardian equivalence theorem, the OLG (deriving their core framework from Samuelson's (1958) model and Diamond's (1965) model) assign the validity of Ricardian equivalence to the links that tie the people who die and those who will be born (Barro, 1974; Blanchard, 1985; Buiter, 1988; Weil, 1989). Beyond debt neutrality and its prerequisites, the neoclassical models show that public debt raises interest rates, in turn crowding out capital and reducing welfare and utility. However, despite important contributions in refining the analysis of government debt effects related to the bequest motives and intergenerational altruistic transfers, the effects are difficult to assess empirically

[87] Furthermore, Ni (1999) suggests, using an empirical investigation, that the dynamics of the interest rate effect are difficult to assess, and the results of empirical studies of the interest rate effect of government deficits should be carefully interpreted.

[88] Government deficits reduce the current labor supply and slow down the accumulation of knowledge.

under the ILA and OLG models. This is a result, in particular, of the difficulty gauging the degree of such bequest motives between generations.

2.2. Government debt in endogenous growth models

Models of endogenous growth theory were developed to endogenize the role of externalities and their contribution to explaining the persistence of the long-term per-capita growth rate, as an alternative to the rival neoclassical Solow–Swan model (Solow, 1956; Swan, 1956).[89] The latter considers the role of such externalities, or what is assumed to be technical progress, as exogenous. Indeed, the steady-state growth rate in the Solow–Swan model is determined entirely by exogenous elements, and macroeconomic aggregates (capital, output and consumption) grow at a constant exogenous rate of the population growth, which makes the per capita corresponding quantities constant, and hence they do not grow. Therefore, according to Barro and Sala-i-Martin (2004), the main substantive conclusions about the long term are that steady-state growth rates are independent of the saving rate or the level of technology. Specifically, a model without technological change (like the Solow–Swan model) predicts that economies will converge to a steady state with zero per-capita growth as a consequence of the diminishing returns to capital. Solow's model also appeared to be "obsolete", since the total factor productivity (TFP) measure estimated the share of growth explained by technical progress to be more than 50%, as reported by Jones and Romer (2010), or ranging between 50% and 70%, according to Hsieh and Klenow (2010). This constitutes an "empirical" argument for the emergence of endogenous growth models (Hulten, 2001; Aiyar and Feyrer, 2002; Fuentes and Morales, 2011).

With its standard framework, the Solow–Swan model was unable to explain the persistent per-capita non-zero growth rates in many developed economies, and hence was highlighted for missing the determinants of long-term growth. Thus, the crucial goal of the pioneers of the endogenous growth theory is to encompass other determinants of long-term growth. This includes broadening the concept of capital, in which the assumption of diminishing return to scale is avoided, to include other determinants as inputs in the process of production, such as human capital (Lucas, 1988; Romer, 1990), innovation, ideas and knowledge[90] (Grossman and Helpman, 1991; Jones, 1995, 2003), public goods and service flows (Barro, 1990), public capital and productive public capital (Futagami et al., 1993), public debt (Greiner, 2007).

To provide explicit contributions involving government spending and public debt in endogenous growth models, we select a benchmark of important contributions. Thus, Barro (1990) was the first

[89] In 1956 Solow and Swan published two distinct papers on the same issue, and their model is referred to as the Solow–Swan model, or often just the Solow model in reference to the more famous of the two economists.

[90] Technological progress is also viewed as a form of generating new ideas by which an economy could escape from diminishing returns to scale in the long term. Consequently, dealing with technological progress as endogenous within economic growth models, instead of exogenous, is an important strand of the endogenous growth theory. However, a technical discussion emerged on how to include ideas and some public goods in the neoclassical production function because of their non-rivalry characteristics (as for the case of ideas) and non-excludable properties (as for some public services: national defence, justice, law and order).

to introduce government services as flows in the AK modelling framework. This article triggered a series of theoretical extensions (Barro and Sala-i-Martin, 1992, 1997; Futagami et al., 1993; Turnovsky, 1997), as well as a variety of empirical contributions (Greiner, 2007, 2011, 2012, 2015, 2016; Ghosh and Mourmouras, 2004a, 2004b; Futagami et al., 2008; Maebayashi et al., 2017; Minea and Villieu, 2013; Yakita, 2008). The aim of the contributions was to establish the effect of public spending and government debt policies on productivity and long-term growth from a perspective of endogenous growth. Public spending encompasses a variety of expenditure and subsidies covering diverse sectors of health, education, research activities, research and development (R&D), public roads and infrastructure, defence and security, justice and law enforcement, and so on. Besides the direct intra-sector effects, some of this spending may also have externalities on other sectors producing knowledge, ideas and powering human capital by affecting their productivity. According to Corsetti and Roubini (1996), in addition to positive effects either on labor productivity or as rents generated proportionally by a fixed factor, as assumed in previous works (before their paper), productive public spending may also exert an external effect on the productivity of physical capital.[91] The assessment of the external effects of productive public spending is rather an empirical issue.

The Barro (1990) model highlights an explicit link between government policy and long-term economic growth in an endogenous growth model by incorporating government investment expenditure into the neoclassical production function with constant returns. The model studies a closed economy with infinite lifetime agents and inter-temporal preferences modelled by a utility function. The author justifies including government services as a separate input of the production function by the fact that private input is not a close substitute for public input. It is difficult to ensure some public activities through private firms as their charges are difficult to implement, as in the case of non-excludable services (national defence and the maintenance of law and order), or because the service is non-rival (ideas) or because external effects cause private production to be too low (as argued for basic education).

The model includes public consumption as an input in the production function, such as:

$$y = k\varphi\left(\frac{g}{k}\right) \tag{1}$$

where y, k and g are, respectively, the output per capita, the capital per capita and the government consumption of goods and services per capita. φ satisfies the conditions of positive and diminishing marginal products ($\varphi' > 0$ and $\varphi'' < 0$). Considering φ, a Cobb-Douglas production function, yields:

[91] Internet services is an example of how the same public good might affect the productivity of either final goods and/or human capital accumulation (Corsetti and Roubini, 1996).

$$\frac{y}{k} = A\left(\frac{g}{k}\right)^{\alpha} \quad (2)$$

where A is a constant net marginal product of capital and $0 < \alpha < 1$. Furthermore, the model assumes a balanced government budget (tax-financed public services) by a flat-rate income tax such as:

$$g = T = \tau y = \tau A\left(\frac{g}{k}\right)^{\alpha} \quad (3)$$

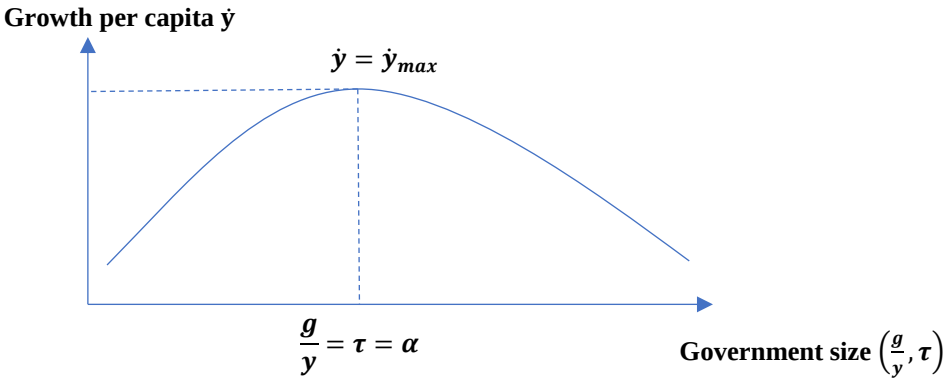
with T being the per capita amount of taxes.

Important implications under the previous assumptions result in different values of government size (g/y or τ) having different effects on the long-term growth rate. An increase in τ reduces the long-term growth rate, while an increase in g/y raises it through an increase in marginal productivity of capital ($\partial y/\partial k$). The two effects cancel each other out for the optimal government size equalizing government expenditure to output:

$$\frac{g}{y} = \tau = \alpha \quad (4)$$

Equation (4) corresponds to the maximum long-term growth rate.[92] The growth rate function of government size is an inverted U relationship (Figure 1). Hence, for a small government, the effect of raising expenditure g/y dominates the effect of raising tax rate τ, while for a large government size the negative effect of taxes on growth dominates.

Figure 1. The relationship between per-capita long-term economic growth and government size



[92] For a non-Cobb-Douglas production function, the maximum growth rate depends on the elasticity of substitution between per-capita government services and per-capita private capital. Similar conditions and results also apply for the saving rate.

As for the effects on utility, its maximization corresponds to the same conditions that maximize the economic growth rate if the elasticity of substitution of y with respect to g equals unity. Particularly in the case of the Cobb-Douglas production function and the same previous notations, government size that maximizes utility corresponds to the condition in Equation (4). If the production function is not a Cobb-Douglas form, the relative size that maximizes utility exceeds the one that maximizes growth rate if, and only if, the magnitude of substitution between g and k is superior to unity.

If Barro (1990) considers the flow of public services in the production function, Futagami et al. (1993) build on this by considering the accumulated productive public capital as an input in the production function,[93] which generates a sustained per-capita growth rate in the long term. Futagami et al. (1993) argue that public investment stimulates aggregate production indirectly via the accumulated stock instead of flows, as in Barro (1990). Furthermore, the introduction of the productive public stock allows dynamic transitional effects analysis instead of being restricted to steady-state analysis, as in Barro (1990) and others. As a result, they show that a tax rate that maximizes the economic growth rate turns out higher than the one that maximizes utility. However, despite these enhancing elements attributed to Futagami et al.'s (1993) model, the latter still considers that the government budget is balanced at any time, as assumed in Barro (1990).

Therefore, instead of assuming that government is restricted to running a balanced budget in every period, as in Barro (1990), Futagami et al. (1993), Barro and Sala-i-Martin (1992, 1997) and many other previous works, subsequent research has omitted this assumption and tried to study fiscal policies under an unbalanced government budget.[94] In this area, Corsetti and Roubini (1996) consider productive public spending to assess optimal fiscal policy (public spending, tax and financial policies) in the same framework as endogenous growth models. They relax the balanced budget assumption to unbalanced budget constraint, thus allowing for government to borrow and lend. Furthermore, they incorporate in their model a separate human capital accumulation as a second sector contrary to many previous papers restricting investigation to one-sector models where public spending can only affect the productivity of the final goods sector. This allows for studying of the properties of government policies on both the final human and non-human capital sectors. In particular, they distinguish optimal tax rates for both types of capital under different

[93] This was signalled first by Arrow and Kurz (1970), but in a non-endogenous growth framework. Assuming diminishing returns to scale in private and public capital given an amount of labor services, the per-capita growth rate depends on the exogenous rate of technological progress alone.

[94] Considering an endogenous growth model where the history of debt affects the primary surplus of the government. Greiner (2014) shows that an economy with a balanced government budget is characterized by a unique balanced growth path. Inversely, with a permanent public deficit, the balanced growth path is either non-existent or non-unique and could be either stable or unstable. Moreover, Greiner (2015) shows that a balanced government budget yields higher balanced growth and welfare and lower inflation than a situation with permanent deficits, especially (for welfare) when the government does not put a high weight on stabilizing debt. In the absence of the latter condition, welfare effects hinge on the initial conditions of public debt.

assumptions on technology and distribution, and they analyse the welfare properties of public debt and assets.

The government service flows are introduced in the production sectors, and the effects of fiscal policies and debt are studied by deriving four models depending on whether: public spending is included as input in the output sector, affecting only the productivity of physical capital (Model 1); or affecting only the productivity of human capital (Model 2); or public spending as input in the human capital sector, affecting, respectively, the same variables (Models 3 and 4).

For some useful details, especially when government service flows enter as input only in the final production goods, Corsetti and Roubini (1996) consider an aggregate social production function in the style of Cobb-Douglas, assuming constant returns to scale to its three inputs, namely, physical capital, human capital and government flows of services, as follows:

$$Y_t = A(v_t K_t)^{\alpha\epsilon}(u_t H_t)^{1-\alpha}(G_t)^{\alpha(1-\epsilon)} \tag{5}$$

where v and u are, respectively, the fraction of total physical and human capital devoted to the production of final goods, and the productivity of public spending is decreasing in the parameter $0 < \varepsilon < 1$. It follows that the optimal government size is deduced by:

$$\frac{g}{y} = \alpha(1-\varepsilon) \tag{6}$$

As $\varepsilon > 0$, the optimal government size in Corsetti and Roubini (1996) is less than the one provided by Barro (1990) in Equation (4): $\frac{g}{y} = \tau = \alpha$ superior to $\alpha(1-\varepsilon)$. According to Corsetti and Roubini (1996), the optimal government size should be properly regarded as a result of the optimal choice of spending that holds with and without distortionary taxation, while Barro (1990) and others consider the (second-best) optimal choice to be the tax rate under an instantaneously balanced budget assumption.

Despite Corsetti and Roubini (1996) assuming an unbalanced government budget, they include public spending flows as productive input, as in Barro (1990), instead of accumulated public capital, as in Futagami et al. (1993).

Recently, many works[95] have concentrated on the issue of public debt, accumulated capital stock of public spending and, generally, fiscal policy and its effects on long-term growth and welfare, in an endogenous growth framework, particularly in the presence of unbalanced budget constraint with debt dynamics. For example, Ghosh and Mourmouras (2004a) extend Futagami et al. (1993) to the case of welfare-maximizing fiscal rules, in the presence of government debt. Thus, the public

[95] A non-exhaustive list includes among these works Greiner and Semmler (1999, 2000), Ghosh and Mourmouras (2004a, 2004b), Bräuninger (2005), Greiner (2007, 2012, 2015, 2016), Futagami et al. (2008), Yakita (2008), Minea and Villieu (2013) and Maebayashi et al. (2017).

to private capital ratio is lower under a golden rule of public finance (than under other fiscal regimes), minimizing crowding-out effects. However, steady-state welfare may be lowered in a less strict budgetary rule if public consumption rises, leading to crowding-out effects. In the same context, Futagami et al. (2008) construct an endogenous growth model with productive government spending where the government finances expenditure through income tax and government debt and puts a target level of government debt relative to the size of the economy. The model distinguishes two steady states: a high-growth steady state in which an increase in government bonds reduces the growth rate; and a low-growth steady state where an increase in government bonds raises the growth rate. These results are inverted in the case of an income tax increase. For the level of welfare, it is lower in the low-growth steady state than in the high-growth steady state.

Nevertheless, Minea and Villieu (2013) assign the existence of the two steady-state growth rates to the assumption of the public debt target as a ratio to private capital. Therefore, once the target has been defined in terms of public debt-to-GDP ratio, the model leads to a unique and determined balanced growth path. Maebayashi et al. (2017) build on the models of Futagami et al. (2008) and Minea and Villieu (2013) by considering the stock of capital investment rather than flows, as in those models. Hence, they derive an optimal target debt ratio that depends on the tax rates on wage income and consumption, as well as the public investment share in total government spending. The target debt ratio set by the Stability and Growth Pact (SGP) and Maastricht Treaty, namely 60%, is judged to be higher than the optimal level. Moreover, debt reduction based on expenditure cuts alone improves welfare. In particular, fiscal consolidation based on a target level of debt-to-GDP ratio rule (i.e. the well-known 60% rule) improves welfare, and the faster the pace of debt reduction, the greater this improvement is. Furthermore, fiscal consolidation based on expenditure cuts, jointly with a tax increase, does not always improve welfare. In this case, the welfare gains (if any) are lower than those under expenditure cuts only.

In the same context of targeted ratio of public debt, other authors study the sustainability of public finance. Thus, Bräuninger (2005) uses an endogenous growth model in the form of AK production function to determine a threshold public deficit ratio. Yakita (2008) builds on Futagami et al.'s (1993) production function to determine a sustainable threshold of public finance that increases in public capital stock. Consequently, a larger public capital helps to sustain public finance. Moreover, keeping the debt finance ratio invariable, the threshold of the debt-to-public-capital ratio increases with reduced public investment in GDP ratio. Increasing public capital ratios in Bräuninger (2005) and Yakita (2008) requires higher taxes and additional bond issuance, leading to higher interest rates and crowding-out effects.

Likewise, Greiner and Semmler (1999, 2000) relax the assumption of government balanced budget and allow for capital market borrowing by the government. Thereby, they analyse the effect of a deficit-financed increase in productive government spending following some predefined budgetary regimes. Hence, fiscal policy effects are significantly determined by such budgetary

rules. Likewise, Greiner (2007) analyses an endogenous growth model with public capital and sustainable public debt.[96] The model is used to derive the necessary conditions for the existence of a sustainable balanced growth path and to analyse the growth effects of deficit-financed increases in public investment in the sustainable balanced growth path, as well as along the transition path. Additionally, in a model with elastic labour supply and a government sector in which government levies a distortionary income tax and issues bonds to finance lump-sum transfers and non-distortionary public spending, Greiner (2012) shows that the higher the debt ratio, the smaller the long-term growth rate whenever public spending is adjusted to fulfil the government inter-temporal budget constraint. However, the public debt ratio has no effect on the balanced growth rate if the adjustment is on lump-sum transfers.

Analysing the effects of public debt in an endogenous growth model with productive[97] public spending, Greiner (2015) shows that higher debt accompanies smaller long-term growth. Moreover, discretionary policy, in general, violates the inter-temporal government budget constraint along a balanced growth path. A balanced government budget gives a unique saddle-point stable growth path, while a rule-based policy can lead to two saddle-points stable balanced growth, depending on the inter-temporal elasticity of substitution of consumption and on the primary surplus policy. For Greiner (2016), an endogenous growth model with public educational spending shows that the balanced budget policy[98] and the policy with a slight deficit yield higher growth than a debt policy where public debt and GDP grow at the same rate. Furthermore, for high initial debt ratios and low inter-temporal elasticity of substitution, a strong deficit policy yields lower welfare than a balanced budget and a slight deficit policy.

In summary, if the neoclassical ILA and OLG models have been interested in the long-term effects of government fiscal policies (debt and taxation) on the saving–spending behaviour of individuals and generations, through operative linkages and transfers, the endogenous growth models have endogenized such policies to assess their effects on the steady-state growth path. Furthermore, including debt dynamics and/or public capital stock, endogenous models eventually allow for tracing of the transitional dynamics effects of fiscal and debt policies that could not be ensured by the ILA and OLG models. The extensions and development of such models triggered a prolific discussion about the composition of public expenditure (productive as input versus non-productive as utility), the non-rivalry and non-excludable goods, and the associated effects on physical and human sectors for each type of public goods. Accordingly, the differentiated effects between the types of expenditure induce different policies for the government. Despite these important

[96] Public debt sustainability is assured by assuming the ratio of the primary surplus to gross domestic income to be a positive linear function of the debt to income ratio.

[97] "*The productive public spending can be thought of as encompassing very different types of publicly provided goods and services, such as justice, enforcement of law and contracts, police services, educational services and government research activities*" (Corsetti and Roubini, 1996).

[98] Greiner (2011) compares the outcome of three budgetary rules: the balanced budget rule, a budgetary rule where debt grows in the long term but at a rate lower than the balanced growth rate, and a rule where public debt grows at the same rate as all other economic variables and where the inter-temporal budget constraint is fulfilled.

contributions, further enhancement remains, especially in considering the heterogeneity of agents' behaviour and welfare, which was also an important drawback of the ILA and OLG models (Mankiw, 2000; Maebayashi et al., 2017). Explicitly, a population could embrace a part of the agents with Ricardian behaviour, while the other part behaves following a rule of thumb.

2.3. Government debt in the new Keynesian models and the positive approach

This section presents a summary of some very recent new Keynesian models involving public debt and fiscal policy, as well as the public debt effects in the models, considering a positive approach where the political regime impacts the trajectory of public debt.

2.3.1. Government debt in the new Keynesian models

Instead of assuming that all taxes are a lump sum, especially in the assumptions about overlapping generations models, recent works have considered optimal fiscal policy, assuming distortionary taxes in the class of new Keynesian models in which social welfare is implied from a consumer utility function. The pioneering works in the new Keynesian modelling framework are principally those of Christiano et al. (2005) and Smets and Wouters (2007). Government debt effects, especially in the neoclassical models, are studied in the long term and steady-state equilibrium, especially in the ILA and OLG models and some endogenous growth models lacking transitional dynamics. However, the recent generation of the new standard Keynesian models or dynamic stochastic general equilibrium (DSGE) models have studied optimal government policies (monetary and fiscal policies) and fiscal consolidation issues considering economic fluctuations and shocks (in the short and medium term), in which public debt is set in many of these models to zero.

Nevertheless, some authors have studied the trajectory of public debt in relation to committed government actions. Particularly, optimal public debt would follow a random walk process whenever the government can achieve a time-inconsistent policy commitment (Benigno and Woodford, 2003; Schmitt-Grohe and Uribe, 2004). Specifically, the latter study the implications of price stickiness for the optimal degree of price volatility. The model considers a government issuing non-distortionary taxation and can only issue nominally risk-free debt. Specifically, under the assumption of price stickiness in this class of models, the government (social planner) chooses to rely more heavily on changes in income tax rates rather than using surprises as a shock absorber of unexpected innovations in the fiscal budget. The distortions introduced by tax changes are diminished by spreading them over time, which induces a near random walk property in tax rates and public debt.

In the context of new Keynesian models augmented by the government's budget constraint, where public spending is financed by distortionary taxes and/or debt, Leith and Wren-Lewis (2013) analyse the optimal response of government debt to shocks, focusing on the type of involved time-inconsistency policy and its implications for discretionary policies. Like the previous research,

they find that the optimal pre-commitment policy allows debt to follow a random walk path in the steady state. However, they show that, under a sticky prices framework, governments are tempted to use their monetary and fiscal policy instruments to change the steady-state level of debt in the initial period. The debt will be curved to its initial efficient steady state to encounter this temptation and therefore deter public debt from following the random walk path if following shocks. The new steady-state debt equates the original (efficient) debt level even though there is no explicit debt target in the government's objective function. Analytically, they show that the debt stabilization instrument crucially depends on the degree of nominal inertia. Furthermore, the size of the debt stock, and the welfare consequences of introducing debt, are negligible for pre-commitment policies but can be significant for discretionary policies.

Furthermore, a few studies examine the effects of high debt in fiscal consolidation actions related to the impact on the magnitude and/or sign of the fiscal multipliers. For example, Mayer et al. (2013) use a new Keynesian model to analyse whether, and how, the presence of positive levels of government debt in the steady state influences the responses of macroeconomic variables to a government spending shock. The model assumes that a fraction of the household sector is characterized by rule-of-thumb behaviour, as in Galí et al. (2007). They show that large levels of government debt in the steady state significantly influence the sign and size of short- and medium-term fiscal multipliers, which therefore depend substantially on the horizon at which the multiplier is evaluated. Furthermore, there is an interaction between the dynamics of the inflation rate and the debt level in real terms, which is absent in standard new Keynesian models in which government debt is assumed to be equal to zero in the steady state. Overall, in the presence of permanent government debt, the effect of fiscal policy on macroeconomic variables becomes difficult to predict over time.

2.3.2. The positive approach of public debt

In the previous section the ILA and OLG models were generally developed by economists in an environment where governments, being benevolent social planners, maximize the utility of their population. These models are classified under what is referred to in the economic literature as "the normative approach" (Alesina and Tabellini, 1990), the "tax smoothing" theory of the government budget (Alesina and Perotti, 1994) or "the equilibrium approach to fiscal policy" (Roubini and Sachs, 1989). The normative theory of debt and fiscal policy considers public debt as a means of smoothing consumption by distributing tax distortions over time (Barro, 1979; Turnovsky and Brock, 1980; Lucas and Stokey, 1983). The core models of this theory assume, in general, a closed economy without capital where the government is a "benevolent social planner" that maximizes the utility of a representative agent who consumes, works and saves with the same infinite (simplified) time horizon of both government and representative agent (Alesina and Perotti, 1994).

However, for advocates of the positive approach (Roubini and Sachs, 1989; Alesina and Tabellini, 1990; Grilli et al., 1991), normative theory, despite explaining the behaviour of debt in many

advanced OECD countries, has been challenged by the rapid accumulation over time of debt in almost all developed countries. Therefore, it is unable to provide a complete explanation for such a phenomenon or explain the differences in policies pursued by different countries with comparable economic conditions.

Alternatively, a positive approach has been the subject of modelling government fiscal policy, particularly debt policy, in the field of the new political economy of public debt.[99] This approach is particularly interested in the implied impacts of political process on shaping the path of government debt. The positive approach considers public debt as a state variable used by each government as a strategy to influence its successor's choices or to shape private economic agents' expectations (Persson and Svensson, 1989; Alesina and Tabellini, 1990).

In this way, Roubini and Sachs (1989) notice that, in several industrialized countries, issues of political management in coalition governments fall behind the slow rate at which fiscal deficits were reduced during the 1975–85 period. In particular, during this period weaker governments[100] had a clear preference for larger deficits. Similarly, Grilli et al. (1991) focus on the role played by public institutions in offering constraints and incentives that determine the actions of governments. Governments' ability to handle growing deficits and debt issues is influenced by the electoral practice and political process. Grilli et al. (1991), following Roubini and Sachs (1989), note that, in countries with an electoral system favouring many small political parties, governments generally have short horizons and therefore act myopically to avoid tackling the hard choices.

Persson and Svensson (1989) consider the level of public debt as the state variable that gives the current government an instrument to control a rival future government. They compare, in a two-period perfect-foresight framework, the policy of a conservative government (one that prefers less debt and deficit), which is certain to be succeeded by a liberal government (a more expansionary government), with the policy where it is certain that it will remain in power. As a result, a conservative government may borrow more if it knows it will be succeeded by a liberal government than it would once certain of remaining in power in the future. Obviously, a conservative government will collect less tax and leave more public debt than the successor would prefer. This increases the conservative government's consumption more than if it remained in government, while the liberal government (successor) with high debt and constrained resources reduces consumption more than it would if it ran alone. Thus, the time-consistent level of

[99] Alesina and Perotti (1994) provide a survey of the political economy models of budget deficit organized into six groups: 1- models based upon opportunistic policy-makers and naïve voters with "fiscal illusion"; 2- models of intergenerational redistribution; 3- models of debt as a strategic variable, linking the current government with the next one; 4- models of distributional conflicts within social groups and/or political parties in coalition governments; 5- models of geographically dispersed interests; and 6- models emphasizing the effects of budgetary institutions. In our case, we are especially interested in the third group, particularly the contributions of Persson and Svensson (1989) and Alesina and Tabellini (1990).

[100] Weaker government is characterized by a short average tenure and by the presence of many political parties in the ruling coalition.

government consumption is somewhere between the two outcomes that the two governments would prefer if ruling on their own.

Meanwhile, the Persson and Svensson (1989) approach, known as a principal-agent problem, with the conservative government being the principal and the liberal successor government being the agent, simplifies the reality by assuming that the ruling government knows with certainty that it will be succeeded by a more liberal government. They also assume the homogeneity of governments' preferences towards all public goods but different preferences for different levels of the same public good. In this regard, Alesina and Tabellini (1990) constitute an advancement in introducing uncertainty about the nature and spending behaviour of successive governments. They also consider different preferences for different items of public expenditure, while Persson and Svensson (1989) focus on different levels of the same public good.

Therefore, to properly understand the debt build-up and deficits in several industrialized economies, Alesina and Tabellini (1990) adopt a positive theory by removing the assumption that fiscal policy is set by a benevolent social planner who maximizes the welfare of a representative consumer. Specifically, their findings suggest that differences in political institutions, leading to different debt policies in different countries, or in the same country at different points in time, help to explain the debt trajectories over time and across countries. Their model[101] is derived from Lucas and Stokey (1983). In particular, Alesina and Tabellini (1990) show that debt accumulation and deficit are accentuated by the alternation of elected governments.

Explicitly, they compare the outcome of debt accumulation and deficit in a situation where governments alternate versus an outcome resulting from a social planning[102] government supposedly elected forever. Specifically, a disagreement between different governments on the composition of spending between public goods results in a deficit bias and hence an accumulation of debt higher than would be the case in the situation of a social planner. As explained by Alesina and Tabellini (1990): "*The level of debt left to the last period is larger in a democracy than with a social planner; namely the social planner would choose to balance the budget in both periods, while either one of the two parties choose to run a budget deficit in the first period leaving a positive amount of debt to be repaid in the last period. In this sense, the electoral uncertainty creates a sub-optimal deficit bias. This bias is stronger for the party with the smaller probability of reappointment.*"

[101] The model assumes mainly a constant population of identical individuals with the same time horizon, acting as consumers, workers and voters. Individuals differ only by their preferences for public goods, supplied by the government and financed by means of distortionary taxes on labor. The government is elected democratically and is chosen among two political parties, each maximizing the utility function of its electorate. Disagreements between the governments are viewed as differences about social welfare.

[102] "*A social planner: 1) do[es] not face elections; thus, she is reappointed with probability 1 in each period, 2) her preferences are a weighted average of the preferences of the citizens*" (Alesina and Tabellini, 1990).

Furthermore, the equilibrium level of government debt is higher with: 1/ a higher degree of polarization between alternating governments; and also 2/ with more likelihood of the current government not being re-elected. Moreover, as the ruling government is unable to curve the taxation and expenditure policies of its successors (whether the successor belongs to the same or the opposing party), the law of motion of public debt is the only way in which the fiscal policy of the ruling government can impact the policies of its successors.

Another important result is related to the probability of re-election. In such an uncertain environment, both governments have the same incentive for increasing debt, not certain of being re-elected, and they restrict the next period's public consumption by increasing borrowing for the current ruling period. This leads to a bias towards a larger deficit and higher debt for both governments, which helps to explain the accumulation of public debt in advanced democracies.

2.4. Discussion

The first section reviewing the effects of public debt through the ILA and OLG models leads to two principal results. The infinitely lived dynasties models, derived from Ramsey (1928), and adopted by Barro (1974) and others, validate the Ricardian equivalence proposition for which public debt is neutral. It is worth mentioning that the Ricardian equivalence proposition works assuming economic agents' rational expectations. Accordingly, the previous models show that economic agents (some, but not necessarily all) react to fiscal policy redistribution of the tax burden among generations through their bequest motives inducing operative transfers to smooth the pattern of consumption over time. However, because the OLG models of Diamond (1965) and others lack such bequest motives, a government debt issuance affects the wealth of generations by raising real interest rates, hence crowding out capital and reducing the steady-state utility.

Despite these important contributions for economic theory in assessing government debt and fiscal policy effects, these two types of model have been subject to criticism. Mankiw (2000) criticized the two modelling approaches, arguing against their adequacy and satisfactory role for analysing fiscal policy. Accordingly, the author is, first, sceptical regarding the assumption that "households smooth their consumption over time" that is adopted by both versions of the model. This assumption is far from perfect, according to Mankiw (2000). In particular, current income significantly impacts consumer spending, as many consumers are far from following completely rational expectations, instead adopting *rule-of-thumb*[103] behaviour (non-Ricardian behaviour) in their spending. Second, some individuals may enjoy long lifetime horizons (due to bequest motives), while others with short time horizons fail to smooth their consumption and accumulate wealth. Third, many households have net wealth near zero (a striking fact reported in the data),

[103] For example, Galí et al. (2007) use a new Keynesian model to empirically test government spending effects on consumption, involving *rule-of-thumb* agents that only have access to contemporaneous labour income for consumption, and *Ricardian agents* that can smooth consumption by accumulating capital.

and hence no savings, which makes them unable to follow inter-temporal consumption smoothing, as reported by the Barro-Ramsey or Diamond-Samuelson models.

Thus, for Mankiw (2000), a better model would allow for such heterogeneous behaviour that is apparent in the data. In this regard, Mankiw (2000) formulated an alternative theory mentioned as "savers–spenders theory of fiscal policy" to address the neoclassical shortcomings in public finance policies. This theory shows, in particular, that, even though government debt does not affect steady-state capital stock and income, it disrupts income distribution and consumption in the steady-state path and, in turn, raises inequality between spenders and savers. Specifically, a higher level of debt yields higher taxation to compensate for the interest payments on the debt. However, the taxes are on both savers and spenders, while the interest payments on debt fall on the savers' side. Therefore, a higher level of debt increases the steady-state income and consumption for savers (with already higher initial income) and lowers it for spenders (with initially a lower income), which raises inequality between the two groups.

The "savers–spenders" theory of Mankiw has influenced many empirical researchers on fiscal policy trying to consider the behaviour following the rule of thumb, especially in the new Keynesian models. However, this type of modelling has also not been immune to criticism. In this way, Chari et al. (2009) show that this class of model is not yet useful for public policy analysis. Chari et al. (2009) base their critiques on the model of Smets and Wouters (2007), which constitutes a fundamental reference for many recent contributions and policy-makers using the new Keynesian analysis framework. Accordingly, the Smets and Wouters (2007) state-of-the-art model adds many free parameters to these models, yielding to shocks that are dubiously structural, as well as many features that are not consistent with the microeconomic evidence.

The drawbacks of the new Keynesian modelling framework were recognized especially after the 2008 financial crisis and are frequently cited in several publications. In this way conferences with different slogans (rethinking macroeconomics, rebuilding macroeconomic theory, etc.) have gathered economists from around the world in an attempt to discover why these models failed to warn about the disaster of the financial crisis. In this way, an important project (the Rebuilding Macroeconomic Theory Project) asked a number of leading economists to describe how the benchmark new Keynesian model might be designed after the financial crisis. Approximately fifteen important articles and contributions (Blanchard, 2018; Carlin and Soskice, 2018; Ghironi, 2018; Haldane and Turrel, 2018; Hendry and Muellbauer, 2018; Krugman, 2018; Linde, 2018; Mckibbin and Stoeckel, 2018; Reis, 2018; Stiglitz, 2018; Vines and Wills, 2018; Wren-Lewis, 2018; Wright, 2018) by these economists on this question were published in the *Oxford Review of Economic Policy* (2018, vol. 34 (1–2)). The authors disagreed that the new Keynesian models benchmark of Smets and Wouters (2007) should not constitute the starting point for the newly designed model. Nevertheless, they agree that the core model should consider four elements, as described in Vines and Wills (2018). The core model should, in particular: i) incorporate financial frictions rather than assuming that financial intermediation is costless; ii) relax the requirement of

rational expectations; iii) introduce heterogenous agents; and iv) underpin the model with more appropriate micro-foundations.

3. The theoretical framework

3.1. The choice of an endogenous growth model

We showed in Section 2 that the ILA models, derived from Ramsey (1928), and adopted by Barro (1974) and others, validate the Ricardian equivalence proposition for which public debt is neutral. The latter proposition holds in an environment of perfect information assuming economic agents' rational expectations. Therefore, such models show that economic agents (some, but not necessarily all) react to fiscal policy redistribution of the tax burden among generations through their bequest motives inducing operative transfers to smooth the pattern of consumption over time. However, because the OLG models of Diamond (1965) and others lack such bequest motives, a government debt issuance affects the wealth of generations by raising real interest rates, in turn crowding out capital and reducing steady-state utility.

Despite their important contributions to the economic theory assessing government debt and fiscal policy effects, the ILA and OLG models have been subject to criticism, to some extent diminishing their contribution. Mankiw (2000) criticized the two modelling approaches, arguing against their adequacy and satisfactory role in analysing fiscal policy for several reasons:

- **First**, according to Mankiw (2000), the assumption that "households smooth their consumption over time" adopted by both versions of the model does not seem convincing. Specifically, many consumers are far from following completely rational expectations and instead adopt the *rule-of-thumb* behaviour (non-Ricardian behaviour) in their spending; hence, current income significantly impacts consumer spending. For example, Galí et al. (2007) use a new Keynesian model to empirically test the government spending effects on consumption, involving *rule-of-thumb* agents that only have access to contemporaneous labour income for consumption, and *Ricardian agents* that can smooth consumption by accumulating capital.

- **Second**, some individuals may enjoy long lifetime horizons (due to bequest motives), while others with short time horizons fail to smooth their consumption and accumulate wealth.

- **Third**, many households have net wealth near zero (a striking fact reported in the data), and hence no savings, which makes them unable to follow inter-temporal consumption-smoothing, as reported by the Barro-Ramsey or Diamond-Samuelson models.

For Mankiw (2000), a better model would allow for such heterogeneous behaviour as is apparent in the data. He therefore formulated an alternative theory mentioned as "savers–spenders theory of fiscal policy" to address the neoclassical shortcomings in the public finance policies. This theory shows that, even though government debt does not affect the steady-state capital stock and income, it disrupts income distribution and consumption in the steady-state path and, in turn, raises inequality between spenders and savers.

The "savers–spenders" theory of Mankiw has influenced many empirical researchers on fiscal policy trying to consider the behaviour of following the rule of thumb, especially in the new Keynesian models. However, the new Keynesian type of modelling has also not been immune to criticism. In this way, Chari et al. (2009) show that this class of model is not yet useful for public policy analysis. Chari et al. (2009) base their critiques on the model of Smets and Wouters (2007), which constitutes the fundamental reference for many recent contributions and policy-makers using the new Keynesian analysis framework. Accordingly, the Smets and Wouters (2007) state-of-the-art model adds many free parameters to these models, yielding to shocks that are dubiously structural, as well as many features that are not consistent with the microeconomic evidence.

Based on the previous critiques, the endogenous growth modelling framework seems to be a suitable candidate for our approach. The endogenous growth models via their productive sector (generally the Cobb-Douglas production function) are extremely flexible in encompassing many other factors to explain the per-capita long-term growth rate. Therefore, fiscal policy variables (productive government expenditure or accumulated government capital) are easily integrated to the production function to assess the effects of such variables in the steady-state (long-term) path and transitional dynamics.

3.2. Justification of government capital stock and government expenditure flows in the production function

Many studies have considered the issue of productive government spending, debt and fiscal policies, and their effects on long-term economic growth and social welfare in the context of endogenous growth models. We follow this line of research for several reasons and try to avoid many important issues. We mainly follow the approach of Barro (1990) and Barro and Sala-i-Martin (2003), but instead consider the public accumulated capital in the production sector rather than the flow of goods and services provided by the public sector. We also consider human capital, as in Corsetti and Roubini (1996), which could be an interesting measurable input. Our approach differs from Barro (1990) and Corsetti and Roubini (1996), as the latter use productive government flows in the production function, while our study uses accumulated public capital, as in Futagami et al. (1993) and Maebayashi et al. (2017).

In fact, we judge that models (either theoretical or empirical) using government expenditure flows instead of public capital stock lack some logic and compatibility with the framework of the Cobb-Douglas production function, especially when we consider the government as the production

sector, which leads to considering productive government expenditure. This results in missing an important contribution of the earlier accumulated stock of public expenditure. As the model of production function, and others considered in the endogenous growth framework, are non-dynamic (no lag or inertia of the endogenous variable is present in the explanatory variable), considering the stock of capital ensures the dynamic effects of public expenditure. This means, economically, that the earlier flow contributions in the output are considered. However, considering only current flows in the production function implies that one considers the earlier accumulated flows (which builds the public stock) fully consumed or as if depreciated with a 100% depreciation rate.

Similar earlier critiques have been addressed to the Scully (1996, 1999, 2003) model calculating growth-maximizing of the government size. The Scully model formulae follow a form similar to the Cobb-Douglas framework, linking the current output to the first lagged government flows of expenditure and the first lag of output. Furthermore, assuming that the government budget is balanced and, with the government budget constraint equalizing government expenditure flows to the taxes represented as a share of the output, this leads to the following model: $Y_{it} = \beta_0(\tau Y_{it-1})^{\beta_1}[(1 - \tau)Y_{it-1}]^{\beta_2}$, with Y as output, τ as the lump sum tax rate, and t as the time period. This model is used to derive an optimal government size (equivalent to optimal taxation rate, as the balanced budget constrained is assumed) represented by the taxation rate as $\tau = \frac{\beta_2}{\beta_1+\beta_2}$. The Scully model form is highlighted as having many drawbacks and producing spurious regressions by many authors (Chapple, 1997; Easton, 1999; Kennedy, 2000 and Hill, 2008). Kennedy's (2000) critique is related to the unfounded relationship of this particular production function, which he says as if the public capital were totally used up every year. Moreover, Hill (2008) shows that this model should use the lagged tax rate in the previous equation instead of a current tax rate. When correcting this error, the growth-maximizing size of the state varies between 9% and 29% for the United States data, while Scully (1996) reports a government size of 19% for the same country.

Beyond that, despite many studies enriching the production function with other variables without paying attention to the nature of these variables, the introduction of stocks rather than flows is more reasonable and in conformity with the logic standard form of the neoclassical production function, which has microeconomic foundations.

Furthermore, this issue is emphasized further when we go through the details of the data of such flows. Indeed, a large part of aggregate government expenditure flows, introduced in the production function, are generally public employees' wages and salaries, direct transfers and subsidies to families and other public and private institutions. Except for some transfers to the latter (which are generally small compared to the total) that could help in the production process of these institutions, wages and salaries and transfers to families and price subsidies go directly to the households' income and constitute an input to their behavioral consumption function (or utility

function). Thus, it is logically more suitable to consider it in relation to the latter instead of including it in the production function.[104]

An interesting issue that is difficult to measure, and which was mainly invoked by what is known as the positive approach of public debt in the domain of the political economy, is the crucial role of institutions in economic growth that uses debt and/or deficit as an instrument variable to curve future governments' (opposing) decisions and economic agents (Alesina and Tabellini, 1990). Considering institutions as a sort of game theory between succeeding governments, or between governments and their citizens in a normative modelling approach, is difficult. However, we could also take the role of institutions as endogenous rather than exogenous. One way is to augment the production function by a parameter of the government constraint representing the quality of the institutions. However, the role of institutions could also be considered by encompassing a formula or a parameter describing the inherent discretionary policies of the government, as in Maebayashi et al. (2017).

In the following section, we present the model.

3.3. The model

3.3.1. The productive sector

We use the production function to describe the relationship between accumulated public capital and real GDP. The production function can take different specifications, such as the constant elasticity of substitution (CES) or a trans-log production function, which under some specific restrictions can be reduced to the Cobb-Douglas production function. The latter is a special case of the former; in other words, the former are more flexible forms. The CES, for example, does not require the assumptions of perfect competition and profit maximization.[105]

We consider the Cobb-Douglas production function, which is well grounded in economic theory and mainly used in practice, to be easy to estimate, and it has good empirical properties (Razzak and Bentour, 2013). The equation[106] is as follows:

$$Y_t = A.{K_{pt}}^{\alpha} K_{gt}^{\beta} \tag{7}$$

[104] Government consumption posts and public investments are defined by the system of national accounts (SNA, 1993 and SNA, 2008) and the classification of expenditure by functions of the government, are categorized by the OECD classification (COFOG).

[105] "*Kmenta (1967) shows that estimating these flexible forms is not really difficult, except that they require [a] large number of observations because there have more parameters to estimate than in the Cobb-Douglas. Furthermore, an omitted variable problem may also be present. The omitted variable problem results in biased and inconsistent OLS parameter estimates*" (Razzak and Bentour, 2013).

[106] The time in all our equations is labelled by the subscripted lowercase letter "t*"* and could be omitted in case no confusion arises.

where Y_t, K_{pt} and K_{gt} are, respectively, the per capita of output, and the per capita of private and public capital. A is a constant designating technical progress, and α and β are shares in the national income of, respectively, private and public capital stock (also corresponding to elasticities). Private and public capital are evolving according to the following inventory equations:

$$K_{p,t} = \left(1 - \delta_{p,t-1}\right)K_{p,t-1} + I_{p,t} \tag{8}$$

$$K_{g,t} = \left(1 - \delta_{g,t-1}\right)K_{g,t-1} + G_t \tag{9}$$

where $I_{p,t}$ and G_t are, respectively, the private and public flows of investments and $\delta_{p,t-1}$ and $\delta_{g,t-1}$ are, respectively, the depreciation rate of private and public capital. To simplify, we assume the same constant depreciation rate for the private and public sectors ($\delta_{p,t-1} = \delta_{g,t-1} = \delta$)

Defining r_g as the productivity of public capital, the first-order condition derivation yields for public capital:

$$r_{g,t} = \frac{\partial Y}{\partial K_g} = \frac{\Delta Y}{\Delta K_g} = \beta \frac{Y}{K_g} \tag{10}$$

For a production function with constant returns to scale, $\beta = 1 - \alpha$, we have: $r_g = (1 - \alpha)\frac{Y}{K_g}$.

Equation (10) is equal to unity in the optimal steady state path ($r_g = 1$), which directly yields a constant optimal government size, as in Barro (1990) and Corsetti and Roubini (1996), when considering the flows of government services and not public capital. In our case, we prefer to study the economies considering that not all are in the steady state. This leads to a government expenditure size that depends on the return to public capital and its elasticity, which may differ between countries as a result of the differences in public governance and public expenditure productivities.

From Equation (9) we have:

$$\frac{\Delta K_{g,t}}{\Delta Y_t} = \frac{-\delta K_{g,t-1}}{\Delta Y_t} + \frac{G_t}{\Delta Y_t} = \left[\frac{-\delta K_{g,t-1}}{Y_{t-1}}\right]\frac{Y_{t-1}}{\Delta Y_t} + \frac{G_t}{Y_t}\frac{Y_t}{\Delta Y_t} \tag{11}$$

From Equation (10) we have the term $\frac{\Delta K_{g,t}}{\Delta Y_t} = \frac{1}{r_{g,t}}$ and $\left[\frac{-\delta K_{g,t-1}}{Y_{t-1}}\right] = \frac{-\delta\beta}{r_{g,t-1}}$. Putting $\gamma = \frac{\Delta Y_t}{Y_{t-1}}$ (which yields, $\frac{1+\gamma}{\gamma} = \frac{\Delta Y_t}{Y_t}$) as the nominal economic growth rate, and $\frac{G_t}{Y_t} = g_t = \tilde{g}_t$ the "potential"[107] government productive expenditure share to GDP, we obtain:

[107] We used the name "potential", as it is derived from a first-order condition.

$$\frac{1}{r_{g,t}} = \frac{-\delta\beta}{\gamma}\frac{1}{r_{g,t-1}} + \frac{1+\gamma}{\gamma}\tilde{g}_t \quad (12)$$

Or equivalently:

$$\tilde{g}_t = \left[\frac{\gamma}{1+\gamma}\right]\frac{1}{r_{g,t}} + \left[\frac{\delta\beta}{1+\gamma}\right]\frac{1}{r_{g,t-1}} \quad (13)$$

Neglecting the depreciation rate yields:

$$\tilde{g}_t = \left[\frac{\gamma}{1+\gamma}\right]\frac{1}{r_{g,t}} \quad (14)$$

Equation (14) implies that the potential productive government investment depends on the economic growth rate, as increasing the function of growth as the derivation according to the growth rate is positive, and inversely on public capital expenditure productivity. Hence, the higher the growth rate (higher potential of GDP also), the higher the potential public investment. Furthermore, the higher the productivity (the return $r_{g,t}$) of public capital, the lower the potential public investment.

However, once the depreciation rate has been accounted for, the effect of economic growth on the size of the government depends on the current and past productivity of public capital, as well as the elasticity and the depreciation rate parameters. The derivation of the productive share on the growth rate from Equation (13) yields: $\frac{\partial g}{\partial \gamma} = \frac{1}{r_{g,t}}\frac{1}{(1+\gamma)^2}\left[1 - \frac{\delta\beta\, r_{g,t}}{r_{g,t-1}}\right]$, and the algebraic sign of this quantity depends on the sign of the term $\left[1 - \frac{\delta\beta\, r_{g,t}}{r_{g,t-1}}\right]$.

Furthermore, the optimal government expenditure is an endogenous parameter here and not a constant one, as raised by Barro (1990) or Corsetti and Roubini (1996) (named the size of the government for these authors). The assumption made by these authors is that the marginal product of public capital is equal to one in the optimum, leading to a "constant government size". This is also due to their consideration of government flows instead of public capital, which ensures this relationship.

Proposition: In an endogenous growth framework with the Cobb-Douglas production function encompassing public capital instead of government flows, the potential productive government investment size is an endogenous parameter of economic growth and public capital productivity.

3.3.2. The human capital sector

There is a thorough body of literature on technology diffusion where human capital is an essential element. The theoretical approaches are grounded in Nelson and Phelps (1966), Grossman and Helpman (1991) and Barro and Sala-i-Martin (1997), while the empirical literature widely cites, as examples, the works of Benhabib and Spiegel (1994) and Borensztein et al. (1998). Human capital can either be an additional factor of production (Mankiw et al., 1992) or a factor influencing technical progress in the production function (Razzak and Bentour, 2013). Either way, it will appear as an additional repressor. Therefore, we consider having a measure of the stock of human capital as an additional regressor in the production function. The production function takes the form of Corsetti and Roubini (1996), except that here we consider the stock of public capital instead of flows of government services:

$$Y = A.{K_{pt}}^{\alpha\varepsilon}{H_t}^{1-\alpha}K_{gt}^{\alpha(1-\varepsilon)} \tag{15}$$

where H_t is human capital and the other variables are as previously defined.

3.3.3. The quality of public institutions

North (1990) defines institutions as "*the rules of the game in a society or, more formally, [they] are the humanly devised constraints that shape human interaction*". This characteristic of *devised human constraints* emphasizes the role of the endogenized character of institutions compared to external/exogenous factors outside human control (geography, for example). Their effects (*shape human interactions*) are mainly to shape the behaviour of humankind, thus directly impacting economic agents' incentives to invest and consumer choices. Following this effect on the incentives of economic agents, which affects the economic output of their actions, many authors have raised and emphasized the role of institutions in long-term economic growth and economic development (Barro, 1996; Acemoglu et al., 2001; Rodrik et al., 2004; Acemoglu and Robinson, 2010). Such a role is embedded (and hence endogenous) in different forms of dynamic interaction between economic, organizational, political and social factors (Aoki, 2007). The fiscal policy sector, in general, and the public debt/deficit management issues, in particular, are very important domains of public policy that are heavily determined and impacted by the institutional framework of the country.

The institutional framework plays its role in two dimensions. The first is related to the quantitative effects of government fiscal variables, which is summarized as the dimension size via the amount of expenditure and investments allocated by the government. The second is related to the qualitative aspects of government actions, which could be summarized by the quality of institutions encompassing the effects of many areas of government reform, programmes and actions (economic freedom, justice, rule of law, order and security, enforcing contracts, protecting investors, property rights, etc.). The dimension size, proxied by the stock or flows of government

expenditure, has been embedded in models of endogenous theory, as described in Section 2.2 (Barro, 1990; Futagami et al., 1993, 2008; Corsetti and Roubini, 1996). However, the second aspect of the institutions relates to their quality in its broad sense and is not easy to observe, although this plays a crucial role in shaping the effects of the institutional framework on fiscal policy input (government expenditure, government debt, deficits, etc.) and also output variables (economic growth, society welfare, income distribution, etc.).

Modelling the quality of public institutions is a challenging and complex task for economists. So, while the economic models and the endogenous growth theory struggle to clearly include the institutions' role in the production process, the task is hardly emphasized, as the political side of the institutions plays an important role that is difficult to consider. The political character of the institutions implies removing the frontiers between the two disciplines: economic science and political science. Nevertheless, some economists have attempted to include empirically the role of institutions considering the data produced on governance indicators from international institutions, such as economic and political freedom of the heritage foundation, worldwide governance indicators of the World Bank, country risk profile of the international risk country group (IRCG), business indicators of the World Bank, and so on, with fuzzy results.[108] Instead, some economists have calibrated the role of institutions to some reduced parameters.

In our case, we also limit modelling the role of institutions by considering the effect of the institutions in the production process, represented by a parameter $\theta \geq 1$ representing the quality of institutions. For $\theta = 1$, the quality of institutions has no effect on the production function, which turns out to be the same as in the previous section. The production function then becomes:

$$Y_t = A.{K_{pt}}^{\alpha\theta\varepsilon}{H_t}^{\alpha(\theta-1)}K_{gt}^{\alpha(1-\theta\varepsilon)}L_t^{(1-\alpha\theta)} \tag{16}$$

with L_t as the quantity of labour and the other variables as previously defined.

We notice that this production function exhibits constant returns to scale[109] in all its inputs as: $(\alpha\theta\varepsilon + \alpha(\theta-1) + \alpha(1-\theta\varepsilon) + (1-\alpha\theta) = 1)$. For $\theta = 1$ and $\varepsilon = 0$, the production function is a function of only public capital and labour.

[108] As a result of the non-convincing measures and fuzzy results of considering such measures representing the qualitative dimension of the institutions, we limit our next empirical application (Section 4) to the dimension size represented by the public capital stock, for which we add human capital, as discussed in Section 3.3.4. The quality of human capital is also questioned, as the measures considered are mainly based on the educational attainments represented generally by the average years of schooling for adults. In order to compare countries based on this measure, the main assumption is that: one year acquired in a society is the same across all other societies, neglecting by this the differences between educational systems between countries. Nevertheless, we consider that those differences are reduced, as the sample of countries enjoys a nearly equivalent level of development.

[109] The condition of constant returns to scale is crucial for an endogenous growth model.

Normalizing by the labour quantity L and labelling using lowercase, Equation (21) yields:

$$y_t = A.{k_{pt}}^{\alpha\varepsilon\theta}{h_t}^{\alpha(\theta-1)}k_{gt}^{\alpha(1-\varepsilon\theta)} \quad (17)$$

The lowercase variables describe the per capita of the respective higher-case quantities, as defined previously. While the original production exhibits constant returns to scale, the normalized production function's returns to scale depend on the quantity $\alpha\theta$ as the sum of the corresponding elasticities:

- $\alpha\theta = 1$: constant returns to scale. The higher the quality of institutions, the lower the input share α needed for producing
- $\alpha\theta > 1$: increasing return to scale
- $\alpha\theta < 1$: decreasing return to scale

We define ρ_x as the rate of return of the input x to the output y as the marginal rate of that input, so as: $\rho_x = \frac{\partial y}{\partial x}$. Accordingly, for public capital we have:

$$\rho_{k_g} = \frac{\partial y}{\partial k_g} = \frac{\partial Y}{\partial K_g} = \alpha(1-\varepsilon\theta)\frac{Y}{K_g} \quad (18)$$

Similarly:

$$\rho_h = \alpha(\theta-1)\frac{Y}{H} \quad (19)$$

And:

$$\rho_{k_p} = \alpha\varepsilon\theta\frac{Y}{k_p} \quad (20)$$

From the inventory public capital accumulation, the equation assuming the inventory stock is calculated in the beginning of the period and not in the last part of the period:[110]

$$K_{g,t} = \left(1-\delta_{g,t-1}\right)K_{g,t-1} + G_t \quad (21)$$

where $\delta_{g,t-1}$ is the depreciation rate of public capital accumulation $K_{g,t-1}$.

[110] The other alternative equation is to assume that the inventory stock is assessed at the end of the period (31 December instead of 1 January), and thus the equation changes slightly to: $K_{g,t+1} = \left(1-\delta_{g,t}\right)K_{g,t} + G_{t+1}$.

Dividing the equation of public capital by the first lagged output and assuming as negligible the public capital depreciation rate, we obtain:

$$\frac{\Delta K_{g,t}}{Y_t} = -\frac{\delta_{g,t-1}}{Y_t} + \frac{G_t}{Y_t} \cong \frac{G_t}{Y_t} = g \tag{22}$$

where g is government expenditure, representing the dimension size of the institutions (the state/government size). From Equation (23), we have $K_{g,t} = \frac{\alpha(1-\varepsilon\theta)}{\rho_{k_g}} Y_t$, which yields:

$$\Delta K_{g,t} = \frac{\alpha(1-\varepsilon\theta)}{\rho_{k_g}} \Delta Y_t \tag{23}$$

Considering (28), Equation (27) is now written as $\frac{\Delta K_{g,t}}{Y_t} = \frac{\alpha(1-\varepsilon\theta)}{\rho_{k_g}} . \frac{\Delta Y_t}{Y_t} = \frac{G}{Y} = g$.

As $\frac{\Delta Y_t}{Y_t} = \frac{\Delta Y_t}{Y_{t-1}} \frac{Y_{t-1}}{Y_t} = \frac{\gamma}{1+\gamma}$, where γ is the growth rate of the economy, the dimension size yields:

$$g = \frac{\alpha(1-\varepsilon\theta)}{\rho_{k_g}} \left(\frac{\gamma}{1+\gamma}\right) \tag{24}$$

The dimension size of the state is an endogenous function of quantitative quantities related to the growth of the economy and the productivity of public capital, and to a qualitative variable representing the efficiency of human capital and the quality of government institutions. In detail:

- The dimension size of the government is a function of the economic growth rate via the term $\frac{\gamma}{1+\gamma}$: the impact of the latter depends on the sign of quantity $\frac{\alpha(1-\varepsilon\theta)}{\rho_{k_g}}$. In particular, the size is a growing function of the economic growth rate if $\varepsilon\theta < 1$ and the efficiency of the public capital is positive (the derivative is positive in this case).

- The dimension size is inversely dependent on the efficiency of public capital: the higher the productivity of public expenditure, the lower the size of the government. Alternatively, lower efficiency of public capital leads to a higher government size.

- The dimension size of the government is negatively related to the human capital efficiency and the quality of institutions. A high efficiency of human capital, as well as good quality of institutions, should lead to a small size of government.

Alternative equations for the dimension size:

$$\rho_{k_g} = \frac{\partial y}{\partial k_g} = \frac{\partial Y}{\partial K_g} = \frac{\Delta Y}{\Delta K_g} = \alpha(1-\varepsilon\theta)\frac{Y}{K_g} \tag{25}$$

$\rho_{k_g} = \alpha(1-\varepsilon\theta)\frac{Y}{K_g}$ and $g = \frac{\alpha(1-\varepsilon\theta)}{\rho_{k_g}}\left(\frac{\gamma}{1+\gamma}\right)$ yields:

$$g = \left(\frac{\gamma}{1+\gamma}\right)\frac{K_g}{Y} \tag{26}$$

Or:

$$g = \frac{\alpha(1-\varepsilon\theta)}{\frac{\Delta Y}{\Delta K_g}}\left(\frac{\gamma}{1+\gamma}\right) = \alpha(1-\varepsilon\theta)\left(\frac{\gamma}{1+\gamma}\right)\frac{\Delta K_g}{\Delta Y} \tag{27}$$

3.3.4. The government sector

The budget constraint is defined as:

$$B_t = (1+i_t)B_{t-1} + GI_t + SG_t - T_t \tag{28}$$

where B_t is government bonds, i_t is the nominal interest rate, and, GI_t, SG_t and T_t are, respectively, government flows of expenditure on productive capital, social and security government spending, and tax revenue. The quantity $GI_t + SG_t - T_t$ is the primary balance (primary surplus or deficit, depending on its sign). Some authors (Obstfeld, 1997; Haslag and Young, 1998; Terra, 2015)[111] add a term of seigniorage revenue, which we assume to be non-existent or negligible[112] in our case. We assume that state dependency on seigniorage revenue is likely to happen when the government fails to fulfil its financing needs for expenditure through conventional taxes or bond sales. Furthermore, the option of seigniorage (*fiat money*) may lead to hyperinflation, which may be self-defeating. These conditions are of less importance in advanced economies (which are the focus of the case study of this chapter).

Dividing both sides of this equation by the nominal output production p_tY_t with p_t the price deflator of real output Y_t, and manipulating the left-hand-side equation term (LHS) to raise the real growth rate and inflation terms yields:

$$b_t = \frac{1+i_t}{1+\gamma_t}b_{t-1} + gi + sg_t - \tau_t \tag{29}$$

where b_t, gi_t, sg_t and τ_t are the ratios to the output of public debt, government productive investment, government social and security spending and tax revenue, respectively, while γ_t is the

[111] "*Seigniorage is government revenue resultant from the emission and maintenance of the stock of currency in circulation"* (Terra, 2015). "*The government resources constraint establishes that the change in government debt should be equal to the interest payment on the existing debt added to the resources necessary to supply public goods, minus the seigniorage revenue*" (Terra, 2015).

[112] Generally, money-creation revenue accounts for less than 2% of GDP (Haslag and Young, 1998).

current nominal economic growth. This equation describes the law of motion in an inter-temporal balanced government budget.

3.3.5. The productive potential government capital and potential government debt

In this section, we link the results of the productive sector (Section 3.3.1) to the government sector (Section 3.3.2). Equation (14) leads to an endogenous potential government investment (which will be simulated in the first step).

Equations (14) and (17) could be jointly used to derive a potential endogenous (limit) of public debt in relation to economic and monetary conditions (economic growth, public capital productivity, interest rate). For example, Maebayashi et al. (2017) consider that the government could have a targeted potential level of debt in the long term ($b_{t-1} = b_t = \tilde{b}_t$). We assume that this potential debt limit will be designated only to financing the potential government investment needs ($-\tilde{g}_t$), while we can assume that social and security spending are financed by tax revenue; this means that $sg_t - \tau_t = 0$ and $gi_t = -\tilde{g}_t$ (gi_t is negative, as it is a financing need to be filled by the new issuance of debt; otherwise, there is a positive primary surplus and accumulating new debt is not necessary). Considering this case, Equation (17) yields:

$$\tilde{b}_t = \frac{(1+\gamma_t)}{(\gamma_t - i_t)}(-\tilde{g}_t) = \frac{(1+\gamma_t)}{(i_t - \gamma_t)}\tilde{g}_t \tag{30}$$

Replacing $\tilde{g}_t$, as described in (14), leads to:

$$\tilde{b}_t = \frac{(1+\gamma_t)}{(i_t - \gamma_t)}\left(\left[\frac{\gamma_t}{1+\gamma_t}\right]\frac{1}{r_{g,t}} + \left[\frac{\delta\beta}{1+\gamma_t}\right]\frac{1}{r_{g,t-1}}\right) \tag{31}$$

Equation (30) (or 31) delivers an endogenous potential (optimal/maximal/limit) debt that a country could target in the long term based on its economic fundamentals related to its potential productive expenditure, economic growth rate and interest rate. As we are considering the long term, the interest rate considered is the long-term interest rate. Note that the denominator is the difference between interest rates and economic growth. The higher this denominator, which means a higher interest rate than economic growth (unfavourable economic conditions), the lower the potential debt that a country could issue. This denominator constitutes an inertia bringing down potential debt in bad economic conditions, where interest rate spreads are higher. Inversely, the higher the growth rate, the higher the potential debt (the derivation of the potential debt to growth rate is strictly positive).

4. Empirical evidence

Considering all the previous elements and discussions, this section augments the productive sector by two additional endogenized inputs representing the government and human capital sectors. The public sector is included through its dimension size of only productive investments (gross capital formation flows and stocks).

The set of countries studied is composed of 20 advanced countries (the same sample as considered in the first chapter), most of which are parts of the European Union, of which 12 adhere to the European Monetary Union, while the rest of the countries generally adopt a floating exchange rate system. These countries are, respectively: Australia, Austria, Belgium, Canada, Denmark, France, Germany, Greece, Ireland, Italy, Japan, The Netherlands, Norway, New Zealand, Portugal, Spain, Sweden, Switzerland, the United Kingdom and the United States of America.

Data for the accumulated private and public capital stocks is drawn from the IMF database,[113] for which the data is made available for 170 countries. The data range covers the period 1965–2015, and the database was last updated in January 2017. Either public or private stocks are constructed according to the inventory method following the equation:

$$K_{x,it+1} = (1 - \delta_{x,it})\, K_{x,it} + (1 - \delta_{x,it}/2)\, I_{x,it} \tag{32}$$

where $K_{x,it}$ is the stock of capital ($x = \{public;\ private\}$), $\delta_{x,it}$ is the corresponding depreciation rate and $I_{x,it}$ is the investment flows (gross capital formation for the sector *x*).

To construct the time series of the stocks using the perpetual inventory stock equation (32), assumptions made about the initial values of stock and data on investment flows are described fully in the IMF (2015).[114] Tables A.2 and A.3 in Appendix A give a summary of the data coverage, sources, description of the variables and the corresponding descriptive statistics.

Other variables such as labour and population are drawn from World Development Indicators of the World Bank database,[115] while the human capital is from the Barro and Lee website, displaying educational attainment and average years of schooling for a large set of countries and a wide range of time periods.[116] The human capital data is produced by an interval of five years from 1950 to 2010 (i.e. 1950; 1955; 1960; …; 2005 and 2010), which we extrapolated by simply moving averages to fill the gaps between the extremities of the five-year intervals. The whole methodology

[113] Accessible database on excel file is through the hyperlink in the PDF document "*Investment and Capital Stock Dataset*": https://www.imf.org/external/np/fad/publicinvestment/pdf/csupdate_jan17.pdf.
[114] http://www.imf.org/external/np/fad/publicinvestment/data/info122216.pdf.
[115] https://databank.worldbank.org/home.aspx
[116] http://www.barrolee.com/

and the sources used to produce such data are fully explained in Barro (1993) and revised in Barro (2013).

4.1. Estimation of the Cobb-Douglas production function

The Cobb-Douglas production function encompassing human capital is modified and log-linearized to take the form of the following specification:

$$lnY_t = \alpha . lnK_{g,t} + \beta . lnK_{p,t} + (1-\beta).\ln(h_t . L_t) + C + \epsilon_t \quad (33)$$

where Y_t is the output, $K_{g,t}$ represents the stock of public capital and $K_{p,t}$ the private capital stock, and L_t is the labour, adjusted for human capital by average years of schooling h_t. The private capital stock and the labour variables ensure constant returns to scale. *C* is a constant term and ϵ_t is the error terms assumed to behave independently and identically distributed.

We produce estimations of the previous specification using public capital stock in Table 1, over two periods of data history: the period 1960–2015; and the sub-period 1960–2007, which excludes the economic financial crisis and its subsequent impacts. Table 1 shows the estimated elasticities for all the variables of Equation (33), along with their statistical significance. Overall, the estimations have a high significant coefficient for all countries, with high adjusted R-squared going beyond 95% for all countries and a high Fisher (F-test) global significance.[117]

The country results show that 15 out of 20 countries have significant public capital stock elastities for the two periods, with one negative significant elasticty for Greece in the first period and three negative elasticities for Austria, Greece and Japan in the second period. Over the two periods, Australia, Denmark and New Zealand have non-significant public capital elasticties. The average of accepted postive elasticties is around 0.32 and 0.36 for the two periods, respectively, and this average drops, when taking into account negative accepted elastitcities to 0.30 and 0.25, respectively, over the two periods. Higher elastictities (over 0.5) are recorded for the two periods, respectively, by Ireland (1.04 and 1.14), followed by Germany (0.59 and 0.51) and Sweden (0.57 and 0.51). Menawhile, many countries have elasticities ranging between 0.15 (the United States) and 0.25 (Canada and Belgium, for example), except France, which showed a lower accepted eslasticy value of around 0.07. Figure 2 summarizes the significant elasticities for government

[117] The Durbin-Watson statistics are also low for all estimations, which indicates the presumption of a cointegration relationship in the data. However, in designing the rest of the simulations for the public debt potential, our model is intended to consider only the long-term effects (classical effects), while the short-term effects (Keynesian effects) are examined in Chapter 2, which links the effects of the public deficit financed by government bonds to fiscal policy effects via the multiplier effect (the Keynesian multiplier). Therefore, cointegration and error correction model formulations are not considered here, where we limit ourselves to long-term estimations. Besides, considering such formulations will completely modify the form of the Cobb-Douglas production function, which is theory grounded rather than ad hoc compilations, and complicate obtaining the overall elasticity effects.

capital stocks, for which we assume an average of 0.30 as elasticity for the few non-significant elasticities (Australia, Austria, Denmark and New Zealand).

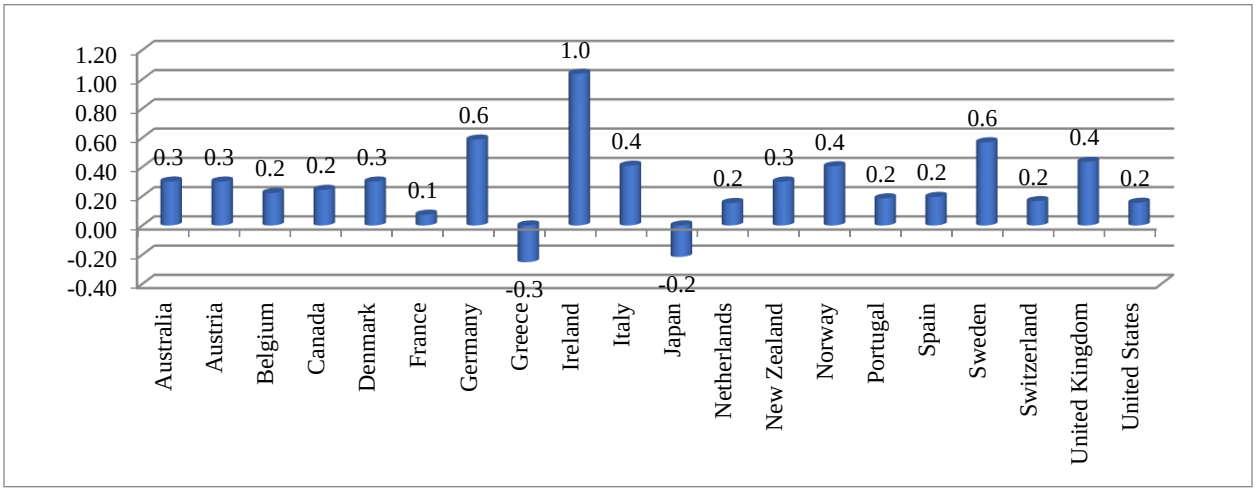
Table 1. Specification estimation results using government investment stocks

Specification: $lnY_t = \alpha.lnK_{g,t} + \beta.lnK_{p,t} + (1-\beta).\ln(h_t.L_t) + C + \epsilon_t$

		Sample 1960-2015			Sample 1960-2007		
		Public capital K_g	*Private capital* K_p	*Intercept*	*Public capital* K_g	*Private capital* K_p	*Intercept*
		α	β	C	α	β	C
Australia	Coefficient	0.045	0.884***	-1.944*	0.007	1.090***	0.757
	Probability	0.167	0.000	0.085	0.821	0.000	0.530
Austria	Coefficient	0.207	1.239***	0.763	-0.184**	1.966***	11.002***
	Probability	0.128	0.000	0.848	0.028	0.000	0.000
Belgium	Coefficient	0.222***	0.995***	-2.097*	0.208***	0.963***	-2.415**
	Probability	0.000	0.000	0.093	0.000	0.000	0.033
Canada	Coefficient	0.243***	0.171	-11.808***	0.338***	-0.020	-14.650***
	Probability	0.000	0.113	0.000	0.000	0.860	0.000
Switzerland	Coefficient	0.166***	0.396***	-8.458***	0.145***	0.485**	-7.366***
	Probability	0.000	0.000	0.000	0.003	0.022	0.005
Denmark	Coefficient	-0.012	0.413***	-7.263***	-0.029	0.478***	-6.413***
	Probability	0.732	0.000	0.000	0.400	0.000	0.000
France	Coefficient	0.073***	0.621***	-5.514***	0.065***	0.646***	-5.173***
	Probability	0.000	0.000	0.000	0.000	0.000	0.000
United Kingdom	Coefficient	0.435***	0.390***	-10.758***	0.077	0.728***	-4.330*
	Probability	0.000	0.000	0.000	0.562	0.000	0.082
Germany	Coefficient	0.587***	0.351***	-12.470***	0.515***	0.498***	-10.256***
	Probability	0.000	0.000	0.000	0.000	0.000	0.000
Greece	Coefficient	-0.251***	2.186***	15.217***	-0.207***	2.157***	14.679***
	Probability	0.000	0.000	0.000	0.000	0.000	0.000
Ireland	Coefficient	1.038***	-1.394***	-32.801***	1.144***	-1.627***	-35.925***
	Probability	0.000	0.005	0.000	0.000	0.002	0.000
Italy	Coefficient	0.408***	1.224***	-1.167	0.428***	1.135***	-2.299***
	Probability	0.000	0.000	0.104	0.000	0.000	0.007
Japan	Coefficient	-0.215	1.075***	2.146	-0.269*	1.138***	3.336
	Probability	0.135	0.000	0.562	0.076	0.000	0.387
Netherlands	Coefficient	0.153***	1.861***	8.420**	0.107**	1.842***	8.466**
	Probability	0.003	0.000	0.012	0.040	0.000	0.015
Norway	Coefficient	0.405***	0.243***	-11.014***	0.448***	0.143***	-12.318***
	Probability	0.000	0.000	0.000	0.000	0.001	0.000
New Zealand	Coefficient	-0.009	1.552***	6.691***	-0.043	1.865***	10.733***
	Probability	0.814	0.000	0.001	0.349	0.000	0.001
Portugal	Coefficient	0.185***	0.637***	-5.795***	0.241***	0.757***	-4.674***
	Probability	0.000	0.000	0.000	0.000	0.000	0.000
Spain	Coefficient	0.195***	-0.500	-19.316***	0.185***	-0.075	-14.301***
	Probability	0.000	0.158	0.000	0.000	0.849	0.005
Sweden	Coefficient	0.568***	-0.625***	-22.670***	0.508***	-0.637***	-22.500***
	Probability	0.000	0.008	0.000	0.000	0.001	0.000
United States	Coefficient	0.155*	0.735***	-4.866*	0.083	0.863***	-2.691
	Probability	0.085	0.000	0.061	0.464	0.000	0.391

Notes: Coefficient and probability are, respectively, the estimated elasticities of the Cobb-Douglas production function (since the equation is log-linearized) and their corresponding p-values. *, ** and *** means significance at 10%, 5% and 1%, respectively.

Figure 2. Government capital stock elasticities



Source: Author's own calculations

For estimations of Equation (33), using government capital flows instead of government capital stock, Table 2 shows that 16 out of 20 countries have significant government investment elastities for the period 1960–2015, with one negative elasticty recorded for Greece, and 17 countries for the period of 1960–2007, with two negative significant elasticties shown for Greece and Germany in this period. The average of accepted positive elasticities is around 0.24 and 0.26 for the two respective periods, while it is reduced to around 0.21 and 0.19 over the two periods, respectively, when accounting for negative accepted elasticties (Greece for the two periods, and Germany for the period 1960–2007).

By country, higher elasticities of between 0.30 and 0.50 are recorded for Sweden, Norway, Ireland, The Netherlands and Italy. Belgium and New Zealand's elasticities are, respectively, negative and non-significant and positive non-accepted for the two periods of estimations. The values of positive elasticities range between:

- Relatively low values of around 5% to 15% recorded for four countries, namely, Australia, Austria, Canada, Denmark, France, Germany and Japan;
- Medium values of around 15% to 25% obtained for countries such as Switzerland, the United Kingdom, Portugal, Spain and the United States;
- Relatively high values of public capital elasticities shown for Ireland, Italy, The Netherlands, Norway and Sweden.

Some countries tend to crowd out private capital with public capital where the elasticity of private capital is either low positive or negative accepted, as with Spain, or positive and rejected, as with Ireland (1965–2007).

Table 2. Specification estimation results using government investment flows

		Specification: $lnY_t = \alpha.lnI_{g,t} + \beta.lnK_{p,t} + (1-\beta).\ln(h_t.L_t) + C + \epsilon_t$					
		1960-2015			1960-2007		
		I_g	K_p	*Intercept*	I_g	K_p	*Intercept*
		α	β	C	α	β	C
Australia	Coefficient	0.115***	0.667***	-4.604***	0.119***	0.778***	-3.258**
	Probability	0.002	0.000	0.001	0.001	0.000	0.011
Austria	Coefficient	0.143**	1.543***	4.953***	0.004	1.575***	5.615***
	Probability	0.013	0.000	0.000	0.918	0.000	0.000
Belgium	Coefficient	-0.009	1.978***	10.167***	-0.030	1.931***	9.671***
	Probability	0.894	0.000	0.003	0.639	0.000	0.005
Canada	Coefficient	0.120***	0.500***	-6.801***	0.210***	0.340***	-8.999***
	Probability	0.000	0.000	0.000	0.000	0.000	0.000
Switzerland	Coefficient	0.236***	0.396***	-8.165***	0.181***	0.567***	-6.149***
	Probability	0.000	0.000	0.000	0.003	0.003	0.005
Denmark	Coefficient	0.019	0.421***	-7.279***	0.044**	0.528***	-6.080***
	Probability	0.233	0.000	0.000	0.012	0.000	0.000
France	Coefficient	0.106***	0.634***	-5.300***	0.099***	0.656***	-5.017***
	Probability	0.000	0.000	0.000	0.000	0.000	0.000
Great Britain	Coefficient	0.183***	0.805***	-3.567***	0.102***	0.810***	-3.215***
	Probability	0.000	0.000	0.000	0.010	0.000	0.000
Germany	Coefficient	0.142	0.853***	-3.005	-0.273**	1.401***	5.042**
	Probability	0.366	0.000	0.210	0.048	0.000	0.025
Greece	Coefficient	-0.109***	1.776***	9.299***	-0.130***	2.018***	12.317***
	Probability	0.004	0.000	0.000	0.000	0.000	0.000
Ireland	Coefficient	0.302***	0.591***	-5.965**	0.419***	0.196	-10.743***
	Probability	0.000	0.004	0.015	0.000	0.387	0.000
Italy	Coefficient	0.472***	0.943***	-3.415***	0.479***	1.246***	-0.047
	Probability	0.000	0.000	0.008	0.000	0.000	0.965
Japan	Coefficient	0.077**	0.684***	-4.721***	0.211***	0.513***	-7.527***
	Probability	0.049	0.000	0.000	0.000	0.000	0.000
Netherlands	Coefficient	0.321***	1.082***	-0.668	0.292***	1.136***	0.045
	Probability	0.000	0.000	0.791	0.000	0.000	0.985
Norway	Coefficient	0.398***	0.213***	-10.281***	0.467***	0.044	-12.289***
	Probability	0.000	0.006	0.000	0.000	0.516	0.000
New Zealand	Coefficient	0.042	1.363***	4.256*	0.028	1.562***	6.754*
	Probability	0.335	0.000	0.074	0.552	0.000	0.052
Portugal	Coefficient	0.180***	0.624***	-5.421***	0.212***	0.744***	-4.128***
	Probability	0.000	0.000	0.000	0.000	0.000	0.001
Spain	Coefficient	0.163***	-0.239	-15.649***	0.159***	-0.027	-13.159***
	Probability	0.000	0.384	0.000	0.001	0.948	0.010
Sweden	Coefficient	0.520***	0.337	-9.695***	0.427***	0.383	-8.944***
	Probability	0.000	0.158	0.001	0.000	0.110	0.003
United States	Coefficient	0.193***	0.624***	-5.974***	0.209***	0.602***	-6.340***
	Probability	0.000	0.000	0.000	0.000	0.000	0.000

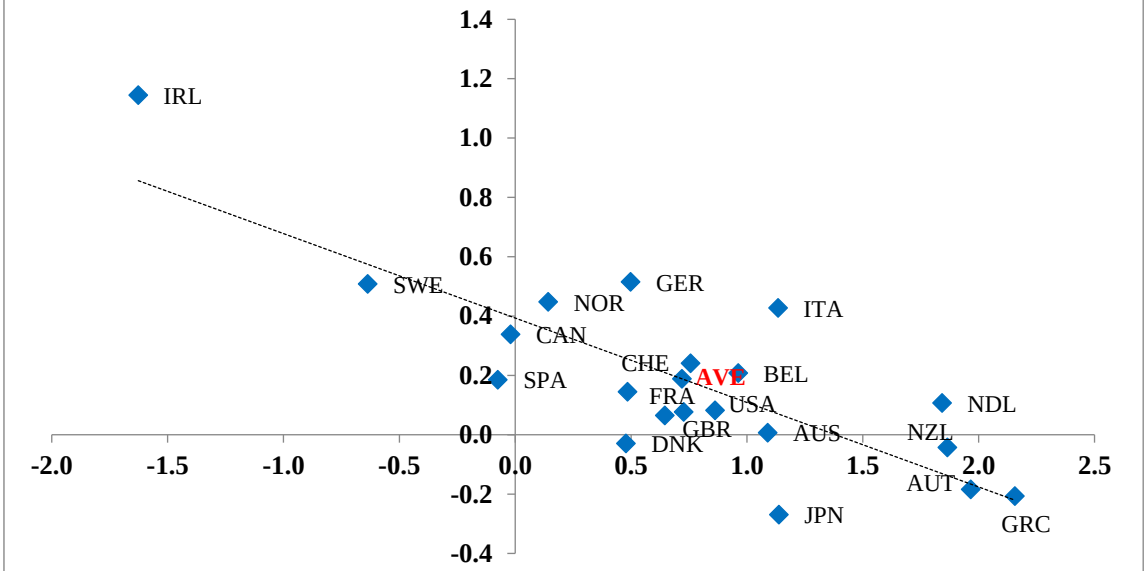
Notes: Coefficient and probability are, respectively, the estimated elasticities of Cobb-Douglas production function (since the equation is log-linearized) and their corresponding p-values. *, ** and *** means significance at 10%, 5% and 1%, respectively.

The overall average of accepted elasticities over the two periods is around 20%. This value is somewhat below the average value, which we estimated using panel data for the whole sample of the same countries. The estimated value for the panel group is around 25% and corresponds exactly to what is found by Barro's (1993) panel estimations for government investment flows. Focusing on the United States' data, the elasticity is around 0.19 and 0.21 over the two periods and is very robust to data sample variations in our estimations.

A conducted robustness check generally shows that the elasticity of public capital flows for the United States varies between 17% and 0.23% following sample time variations. Furthermore, Hill (2008) shows that the growth-maximizing size of the state varies between 9% and 29% for the United States (large interval), while Scully (1996), with a different specification to ours, reports a government size of 19% for the same country. For the countries for which government investment flow elasticities are rejected over the two periods of estimation, we can consider the average of all elasticities (0.20) as a calibrated elasticity for all these countries in the subsequent calculations. We can also adopt calibrated parameters based on similarities between countries. For the case of Japan, however, an estimation over earlier samples gives highly accepted positive but decreasing elasticities over time. Belgium also has a sensitive elasticity to sample changes. The elasticity becomes accepted starting from 1980, where we find a positive accepted elasticity of 7.6% over 1980–2015.

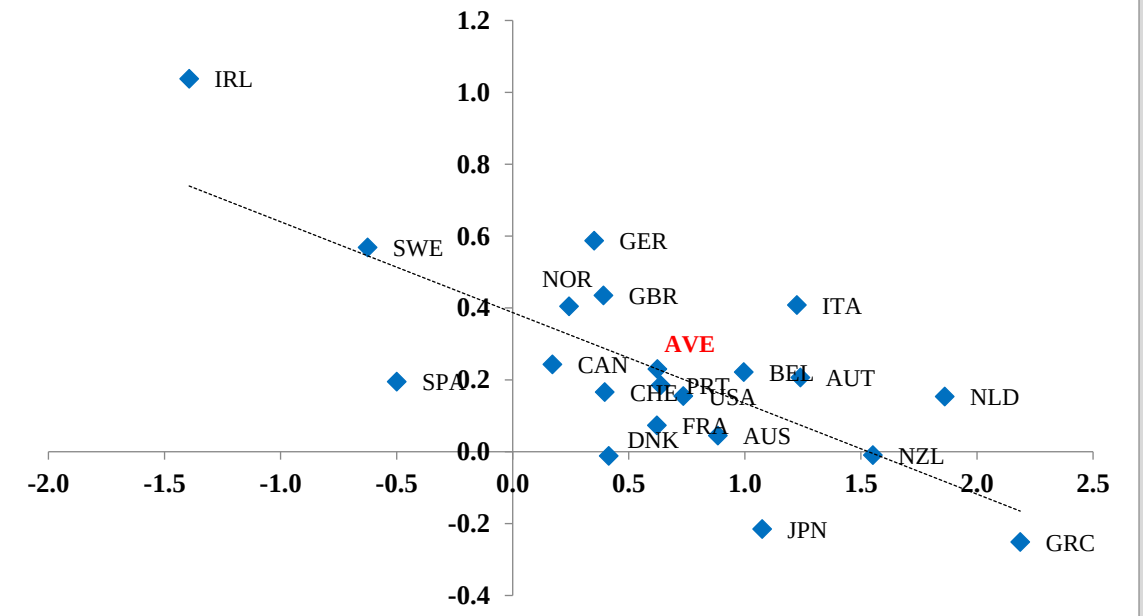
Inspecting the elasticities of public and private capital, we notice that higher government capital elastictities (and also higher government flow elasticities) are accompanied by lower or negative private capital (flow) elasticities or rejected private capital elasticties. This is particularly the case for countries such as Ireland, Norway, Spain and Sweden. This might be attributed to the crowding-out effect of private investment by government investment. Drawing scatter plots for private and public capital elasticities for the two periods clearly shows this tendancy. Figures 3 and 4 present a negative relatiship between public and private capital elasticties for the periods 1960–2015 and 1960–2007, respectively, with Ireland and Greece representing two opposite extreme points in these figures (the red-coloured dot in the two figures indicates the simple average of elasticties of the sample). The same trend is shown when considering investment flows instead of stocks (Figures B.1 and B.2 in the appendix).

Figure 3 : Scatter plot elastictities of Public Investment stocks versus Private capital stocks (*Kp, Ig*): Sample 1960-2007



Trendline equation: y = -0.2846x + 0.3933
R^2 = 0.65; Sample 1960-2007

Figure 4 : Scatter plot elastictities of Public Investment Stocks versus Private capital stocks (*Kp, Ig*): Sample 1960-2015



Trendline Equation: y = -0.2527x + 0.3873
R^2 = 0.53; Sample 1960-2015

4.2. Simulations of targeted/potential public debt ratios

Based on the results of Table 1 for capital stock elasticities, we note that there are no big differences between elasticities for the two periods (1960–2007 and 1960–2015). Therefore, to save space, we pursue our calculations considering the results of elasticities over the whole period of 1960–2015. To conduct simulations and calculus, we decided to produce two simulated exercises. The first one is based on the estimated elasticity of each country, and the second is based on the average of all countries' elasticities (equal to 0.3).

However, for the countries for which elasticities are not accepted across the simulated period, we decided to consider only the average of elasticities as the benchmark for their elasticities. These countries are Australia, Austria, Denmark and New Zealand. Greece, over both periods, and Japan, over the period 1960–2007, although they have negative accepted elasticities, are analysed assuming these are the true elasticities. Hence, the simulation is done considering their negative elasticities[118] and the average of the elasticities (0.30). For the rest of the countries, we simulate the rest of our calculations considering the countries' elasticities and the average of countries' elasticities (0.3).

Simulation steps

- First, we use the previous government capital values' elasticities (Table 1), estimated for the period 1965–2015, to generate the "return" of the government productive investment using the formulae $r_{g,t} = \frac{\partial Y}{\partial K_g} = \alpha \frac{Y}{K_g}$ (equation (10)).

- Second, we generate the public potential investment based on Equation (13) $\left(\tilde{g}_t = \left[\frac{\gamma_t}{1+\gamma_t}\right]\frac{1}{r_{g,t}} + \left[\frac{\delta\beta}{1+\gamma_t}\right]\frac{1}{r_{g,t-1}}\right)$.

- To avoid high fluctuations generated by data, we use the Hodrick-Prescott filter[119] to smooth the generated potential public investment, before introducing it in the next step.

[118] Having negative elasticities does not mean that this should lead to negative simulated investment. These two countries have positive simulated investment (see Table 2 for elasticities and Figure B.3 for simulated public investment flows).

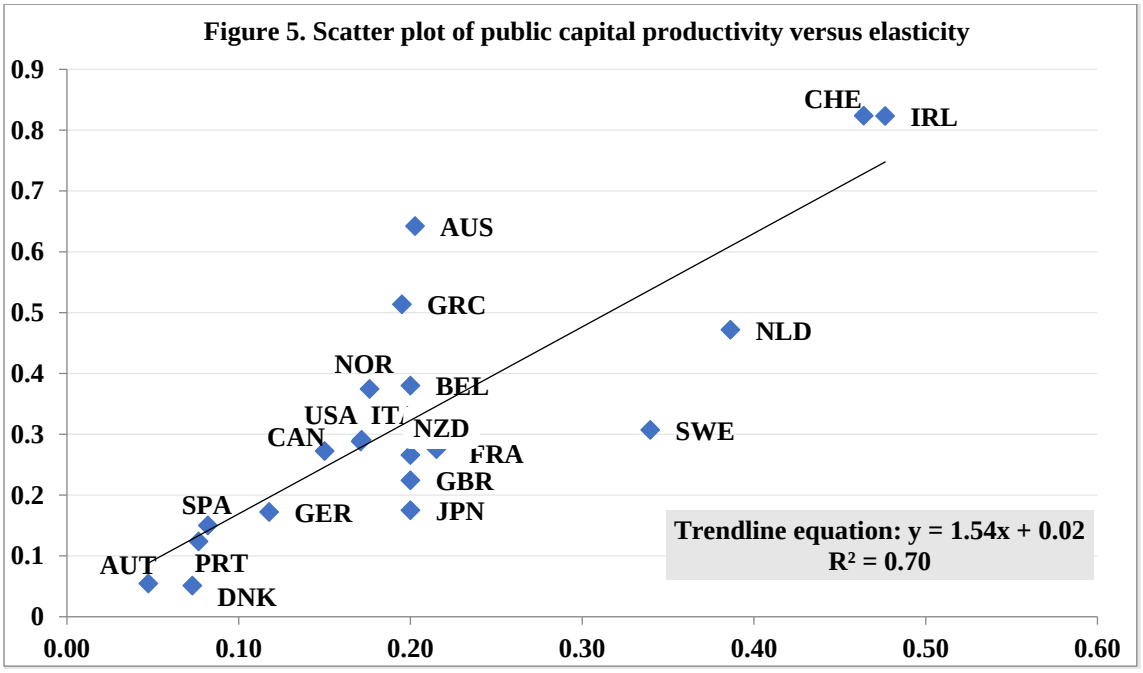
[119] To obtain a smooth estimate of the long-term trend component of a series, the Hodrick-Prescott filter (HP filter hereafter) is a widely used smoothing method among researchers. The method first appeared in a working paper in the early 1980s, was applied to analyse the post-war US business cycles and published later in 1997 (Hodrick and Prescott, 1997). A time series Y_t could be decomposed to its long-term trend G_t (a sum of growth component) and cyclical component C_t: $Y_t = G_t + C_t$. The HP filter algorithm works to smooth the original series by estimating its trend component, while the cyclical component results as the difference between the original series and its trend. The trend component is the one that minimizes $\sum_1^T (C_t)^2 + \lambda \sum_1^T [(G_t - G_{t-1}) - (G_{t-1} - G_{t-2})]^2$, where T is the number of observations and λ is a positive parameter of smoothing that depends on the frequency of the time series. The higher the data frequencies, the larger the value of λ, and the larger λ, the higher the penalty of changes in the trend's growth rate (represented by the second term of the previous equation) and the smoother the trend component. In practice, λ is set empirically to be 1,600 for quarterly data, as suggested by Hodrick and Prescott (1997), while for annual data, λ is set to 100 in many applications, which we also consider in ours.

Focusing on the long-term tendency and avoiding fluctuations seems to be in line with our focus on the long-term analysis.

- Third, we simulate the potential public debt using Equation (30) $\left(\tilde{b}_t = \frac{(1+\gamma_t)}{(i_t-\gamma_t)}\tilde{g}_t\right)$.

First, generating public capital returns/productivity shows, on average, big differences between countries due, mainly, to differences in elasticities. The public capital productivity averages are widely different across countries, ranging from low values of 5% to 15% in Austria, Denmark, Portugal and Spain, and very high values of 80% recorded in countries with high values of elasticities, namely, Ireland and Switzerland (Figure 5).

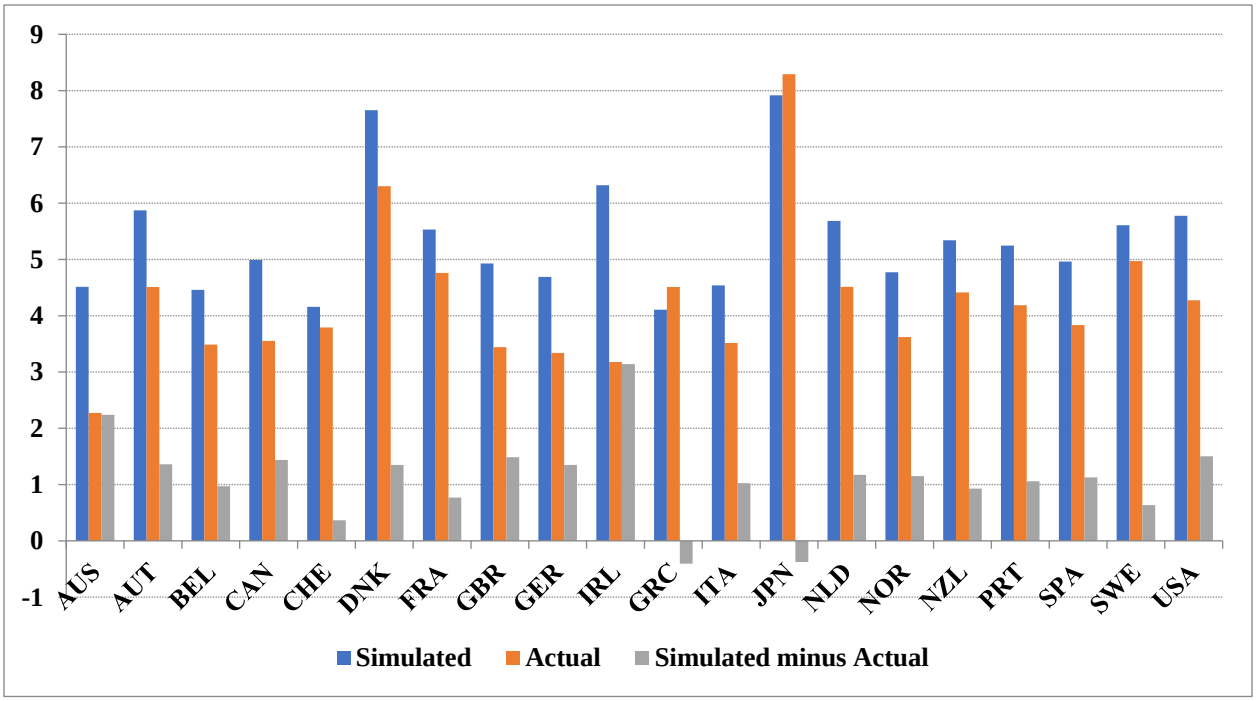
Figure 5. Scatter plot of public capital productivity versus elasticity



Second, we simulate the potential government investment based on the public capital marginal productivity (derived from the marginal product of capital, Equation (13)). For comparison, we produce the descriptive statistics for both observed and simulated government productive investment (gross capital formation) and draw the averages in Figure 6. This shows that, overall, the simulated variable overcomes the actual one in all countries by about one to three percentage points, except for Japan and Greece, where the actual one is, on average, slightly above the simulated one (by 0.4 percentage points). In particular, the simulated debt ratio is double the actual one in Australia and Ireland. Figures B.3 and B.4 in Appendix B show the tendency for all countries towards actual and simulated potential government investment, respectively.[120] In all countries, government investments (actual and simulated) tend to decrease over time (Figure B.5).

[120] For all figures and tables when it applies, we point to variables in the form of "Y_XXX", where Y is the variable presented (simulated) and XXX is the three-character country code. Table A.4 (in the appendix) presents these codes.

Figure 6. Actual and simulated productive public investment flows (gross capital formation) as % of GDP



Third, we simulate the results for the debt limit that a country could target, considering the previously simulated potential government investment and the conditions of economic and monetary performance, reflected by the average long-term interest rates and economic growth, respectively. Data on long-term interest rates is extracted from the OECD database.[121] We call this simulated debt "potential debt". We use the term "potential", as this is related to "potential" government investment (potential, as it is derived from the first condition of maximizing output, that is, marginal productivity of capital). It is, in fact, the optimal (maximal) public debt that a country can issue to finance its potential government productive investment and is directly related to public capital productivity (efficiency). This potential public debt is like a mirror (an opposite picture) of the actual debt. This is due to the differential between interest rates and economic growth that appears in the denominator of the potential debt with an opposite sign of the actual accumulated debt formula. This constitutes an inertia lowering potential debt when interest rates are higher than economic growth, which pushes down potential debt under actual debt, attracting the attention of policy-makers to the danger of the debt situation. The danger of public debt could be measured by the distance between simulated and actual debt. The higher this distance, the safer the debt is.

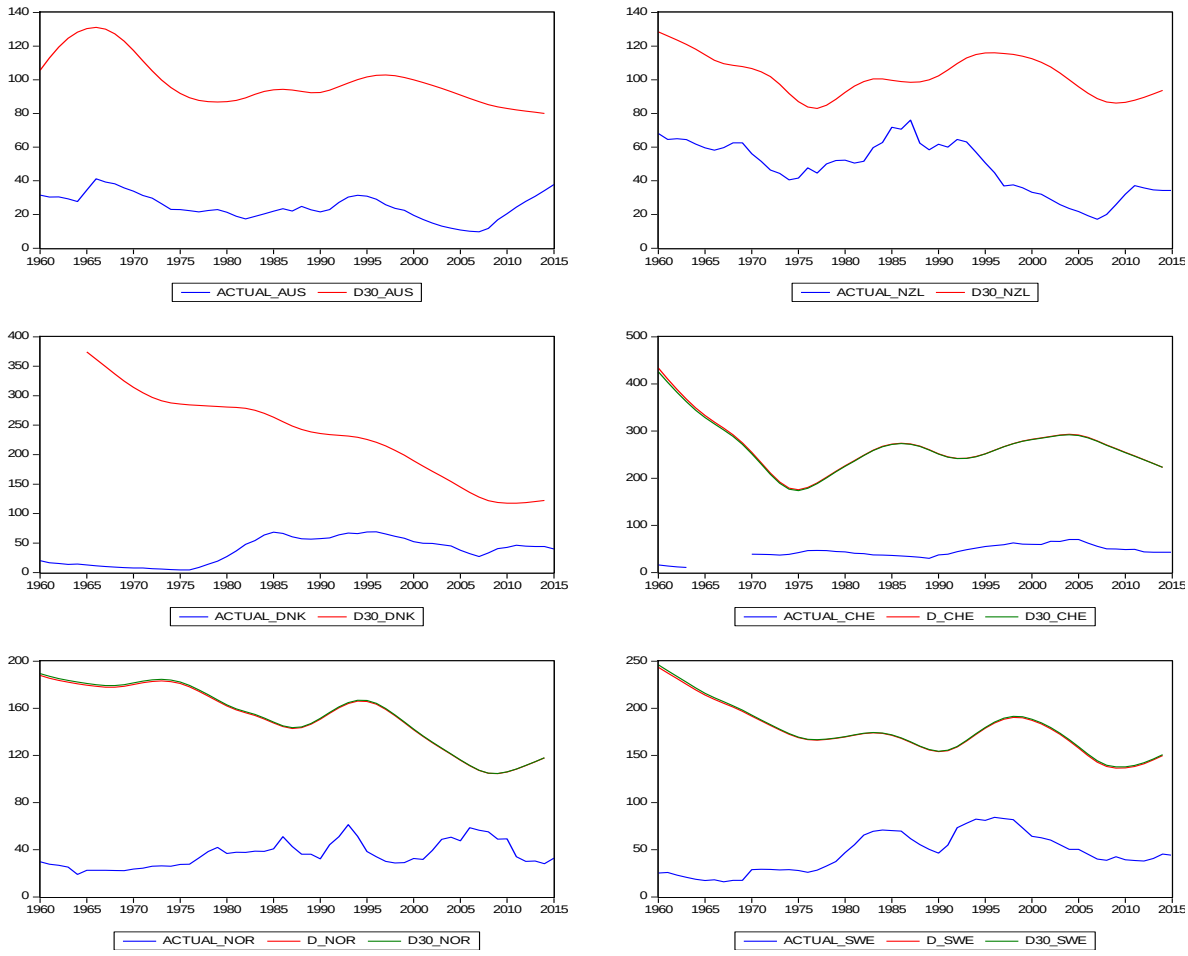
First, we consider the simulation using the growth and long-term interest rate differential average over the period 1960–2015. We produce a set of figures that show the tendencies of simulated

[121] https://stats.oecd.org/

public debt for each country. Figures 7, 8, 9 and 10 produce such simulated debt results, along with actual public debt, over the period 1960–2015 for the 20 sample countries.

The first set of graphs (Figure 7) presents six countries where the debt is not threatening, as we could still target potential debt that is higher than actual debt over history. These countries are Australia, New Zealand, Denmark, Switzerland, Norway and Sweden. The average potential debt to GDP is approximately 96.9% for Australia, and 100.5% for New Zealand, with lower values of around 80% for both countries. The remaining countries have higher potential average of public debt based on their performances, which are around 230% in Denmark, 250% in Switzerland, 150% in Norway and 170% in Sweden, respectively.

Figure 7. Simulated potential paths of public debt versus the actual path based on potential simulated government investment and economic and monetary performances for Australia, New Zealand, Denmark, Norway, Sweden and Switzerland*



*: countries having only two curves are those for which elasticities aren't significant, and thus we limit the exercise of simulated public debt to their elasticities as the average of all significant elasticities (0.3).

Figure 8 shows a group of four non-euro area countries with floating exchange rates and larger-sized economies, namely, the United States, Japan, the United Kingdom and Canada. The sustainable path of the first three countries is undermined during the financial crisis. Actual public debt remains with a long history under targeted public debt until around the period of crisis (2008–10), although the two paths (simulated and observed) converge over time, showing that these countries accumulate public debt over time during the prosperity periods of the 1960s and the Great Moderation Era of the 1990s. For Japan, the formula shows negative explosive potential debt based on the average long-term interest rate and growth rate over the whole period. However, for this country, the long-term interest rate is observed over 1989–2015 only. A robustness check for countries is conducted based on their performances over certain specific periods and not the whole period. However, simulation is always produced over the whole period to visualize the track of simulated debt over the entire period.

For the other countries, the United States and Canada, although potential debt has a tendency to decrease over time to converge towards actual increasing debt, it still does not constitute a threat to public finance sustainability. However, the United Kingdom presents a different picture compared to the United States and Canada. Simulated debt is exceeded by actual debt in the year 2008 and stays under actual debt for the period 2008–15, despite an upward shift. The average potential debt ratios to target to finance potential expenditure is around 195.5% for the United States, 100.2% for the United Kingdom and 145.5% for Canada.

Figure 8. Simulated potential paths of public debt versus the actual path based on potential simulated government investment and economic and monetary performances for the United States, Japan, the United Kingdom and Canada

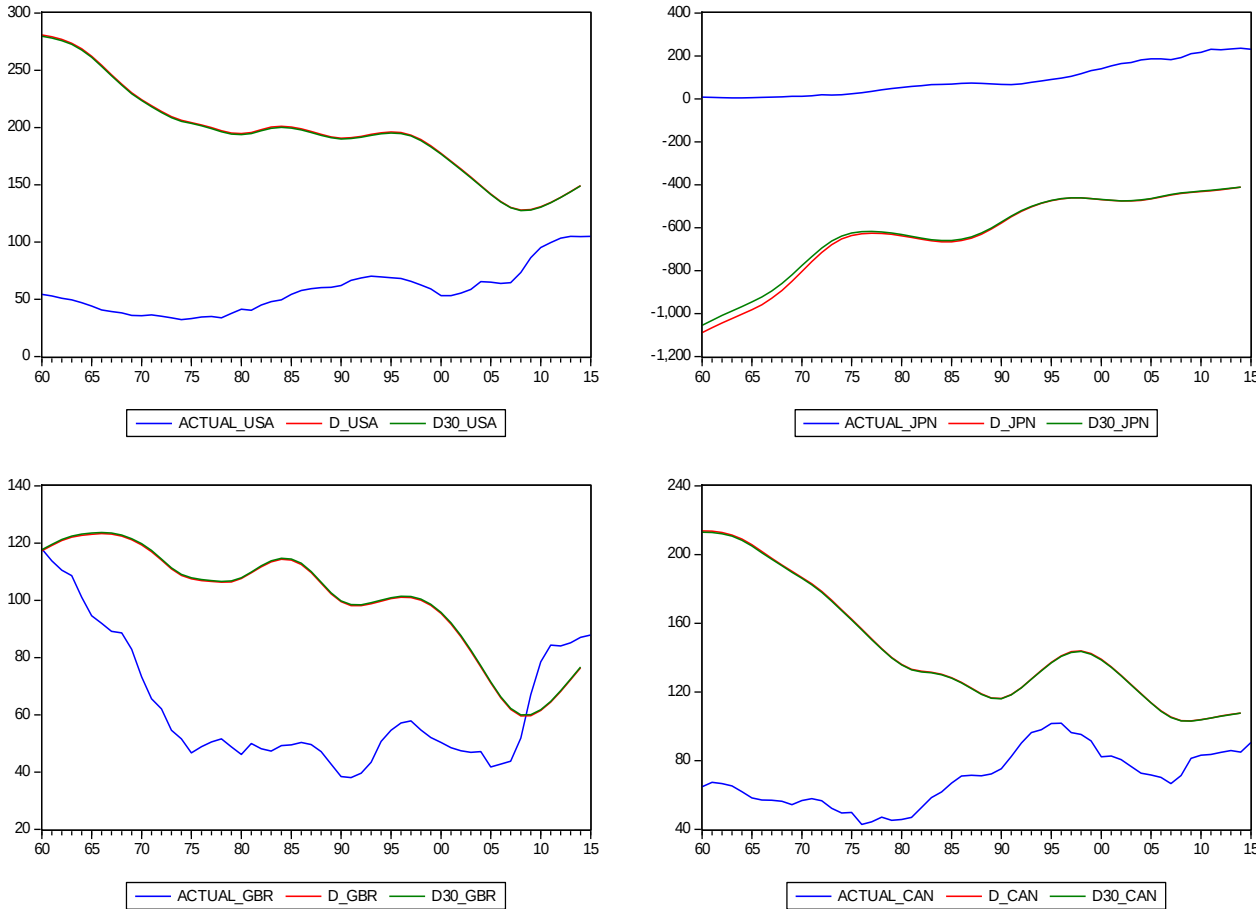
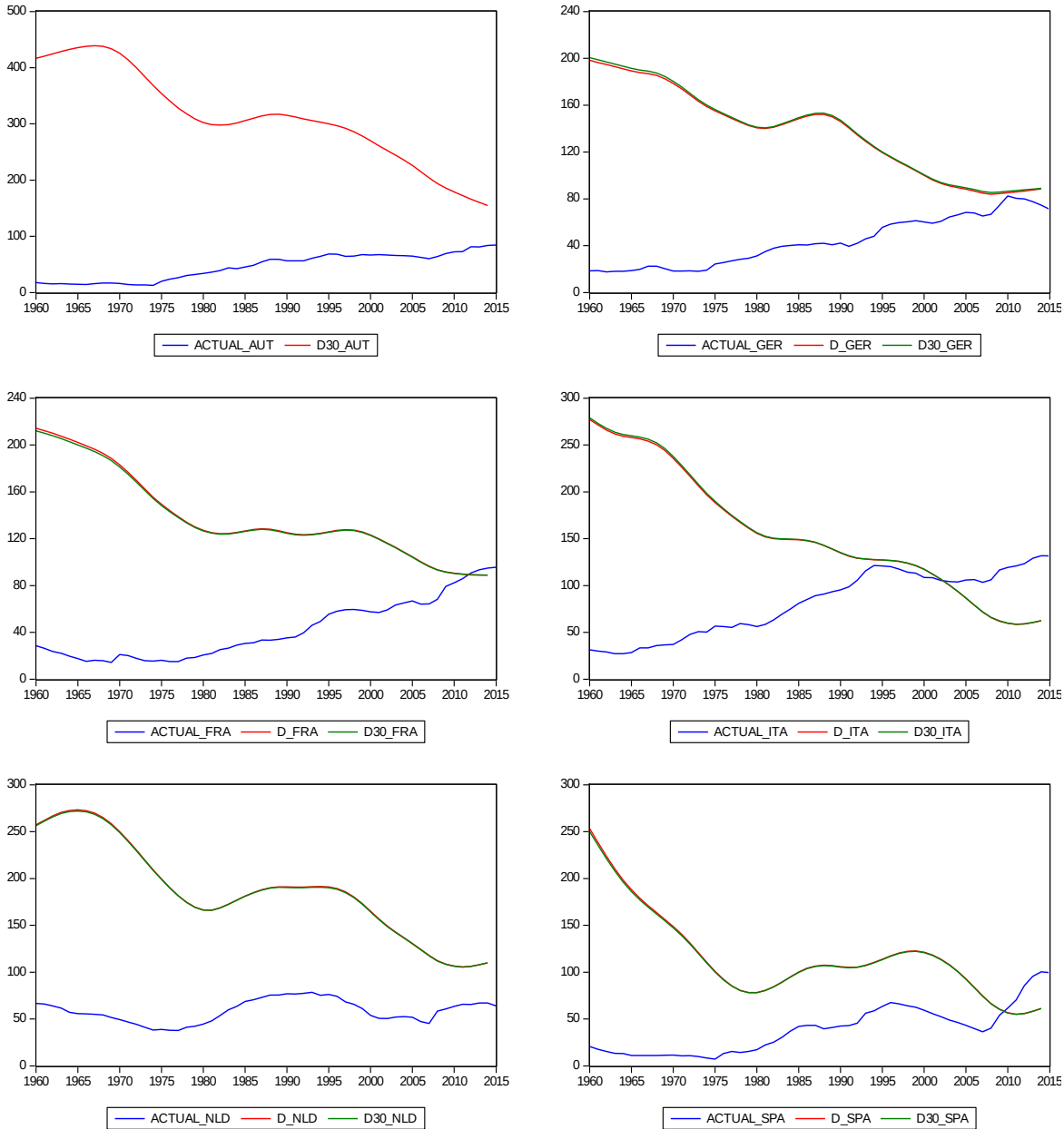


Figure 9 presents the results for a set of euro area countries, namely, Austria, Germany, France, Italy, The Netherlands and Spain.[122] For Austria and The Netherlands, potential debt remains higher than actual debt over the whole period. However, for Italy, Spain and, to some extent, France, potential debt falls below actual debt in 2002 for Italy (with potential equalling actual around 100%), in 2012 for France (with equality in 91%) and in 2010 for Spain (with equality in around 60%). Germany also has a negative trend of potential debt approaching actual debt in around 2010 (at nearly 90%) without crossing it. Potential debt stays below actual debt at around 55% in Spain, 58% in Italy and 88% in France. Therefore, these could be the safer limits of debt (not altering growth) for these countries, and they could keep their public debt under control at lower ratios than these values. In conclusion, for this set of countries, the potential debt to target

[122] As a reminder, note that Austria's estimated elasticity is not statistically significant, and the graph shows the simulated debt for Austria based on the average of elasticities equalling 0.3.

in bad times is around 60% to 90%, based on an average of their economic and monetary performances. However, in normal economic conditions, potential debt could reach more than double these values.

Figure 9. Simulated potential paths of public debt versus the actual path based on potential simulated government investment and economic and monetary performances for Austria, Germany, France, Italy, The Netherlands and Spain*



*: Countries with only two curves are those for which elasticities are not significant, and thus we limit the exercise of simulated public debt to their elasticities as the average of all significant elasticities (0.3)

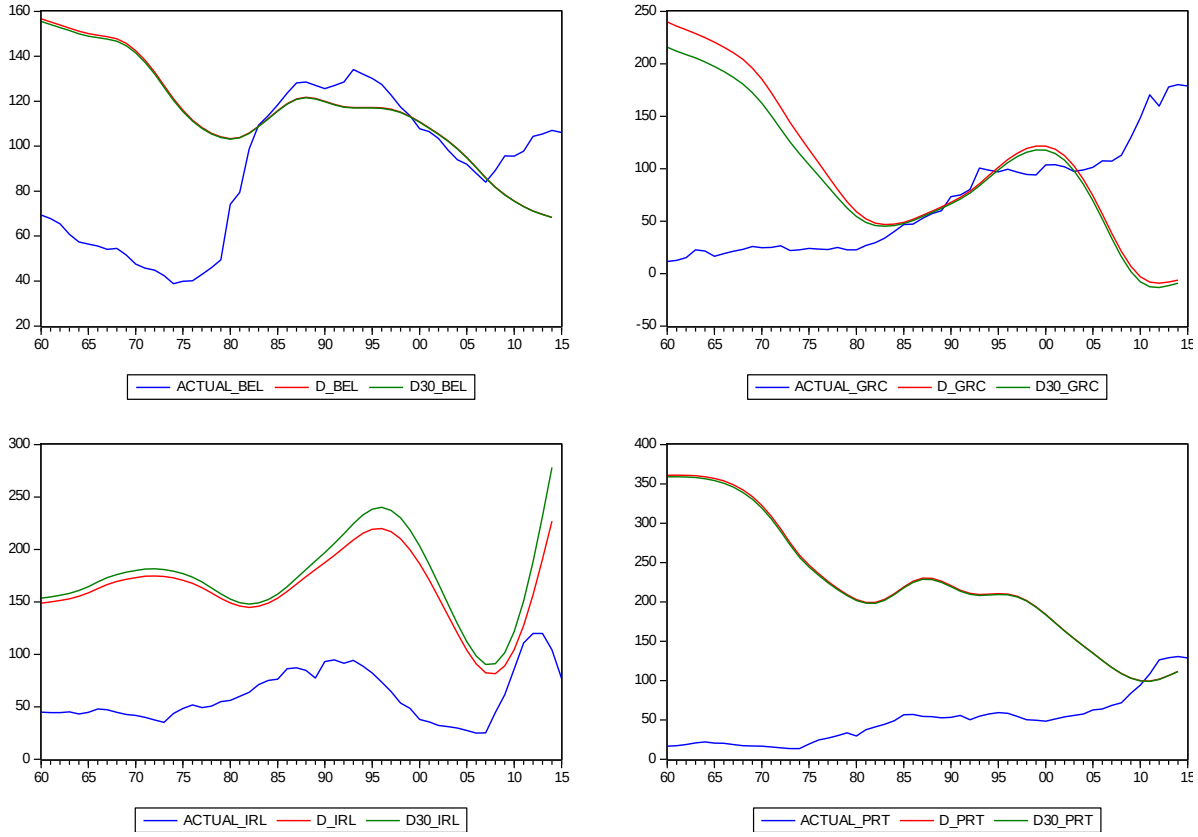
The last group of countries (Figure 10) focuses on the rest of the eurozone countries, namely, Greece, Portugal, Ireland and Belgium. Except for Portugal, which has the same tendency for potential debt as Spain and Italy (Spain and Italy are described in Figure 9), the three other countries have different stories of their own. Belgium's potential debt goes below its actual debt in the early years of the 1980s and follows the same tendency as actual debt until 2008, where it drops and the two curves disconnect and evolve oppositely. Potential debt continues to decrease until it reaches a lower value of 68% at the end of the period.

For Greece, potential debt crosses actual debt in 1985 at a lower rate of public debt around 47% and remains with the trend of actual debt for a decade, where potential debt once again surpasses actual debt in 1995 and stays until 2002, where it drops again below actual debt (as in Italy). Potential debt continues to decrease under actual debt until the end of the period and even becomes negative starting in 2010, reaching around -10% in 2011–15. The negative number should be interpreted in the sense that Greece in this period should not hold any public debt based on its economic performance at this time.

Nevertheless, some results create serious questions about the validity of the data of interest rates, inflation, growth, and so on, used to simulate the formulae for those countries and their sensitivity to the actual data.[123] For Ireland, there are two periods where debt is unsustainable (targeted debt is below actual debt), in 1983–93 and 2008–14. However, Belgium shows an apparently unsustainable path from the 1980s.

[123] Data distribution is relatively heterogenous between countries, where some variables are normally distributed for some countries and others are not, as shown by Jarque-Berra, Skewness and Kurtosis for this data in Table A.3 (Appendix A).

Figure 10. Simulated potential paths of public debt versus the actual path based on potential simulated government investment and economic and monetary performances for Belgium, Greece, Ireland and Portugal



4.3. Robustness check

4.3.1. The impact of data shortness

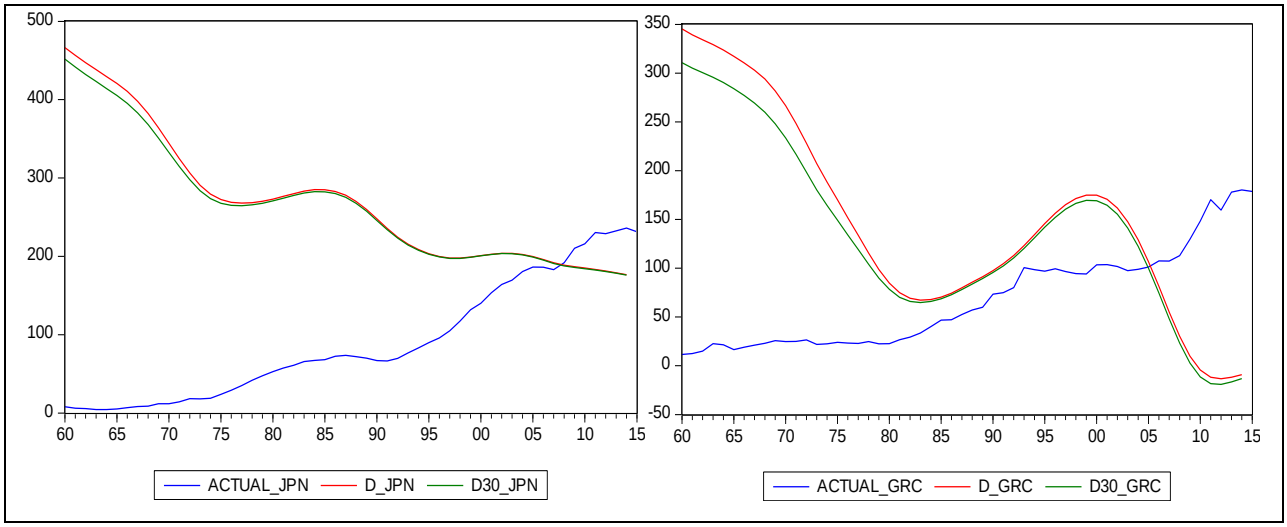
The data on long-term interest rates from the OECD database is unfortunately short samples for some countries such as Japan, where the data time series starts in 1989, and for Greece in 1998.[124] Therefore, for robustness check and to avoid the problem of data shortness, we produce estimations for potential debt, calibrating the differential of growth and interest rate in the denominator of Equation (30) by the data of the United States (but we leave the growth rate in the numerator unchangeable and proper to the country itself). This is also a test for our formula against some irregular observations in the data. In fact, countries such as Japan, Greece and Ireland are

[124] For this purpose we checked many other international sources reporting data on interest rates for government bonds, securities and treasury bills, such as the International Financial Statistics (IFS) of the IMF, the Bank for International Settlements (BIS) and the Federal Reserve Bank of Saint Louis (https://fred.stlouisfed.org/tags/series?t=interest+rate%3Blong-term). These sources report data on long-term interest rates for different periods, depending on the country, which is the same data as reported by the OECD database.

interesting cases to study, with higher accuracy and deep investigation of the data, and even specifications to be re-estimated. Along the same lines, Barta (2018) analyses and compares the cases of Belgium, Canada, Denmark, Greece, Ireland, Italy and Japan, since the 1970s, to identify factors that differentiate countries accumulating threatening debt from those that keep their debt under control. He notes that practices in fiscal policy management make a difference rather than the political bias impact of debt accumulation, as proposed by some authors in reference to the positive approach of public debt (Persson and Svensson, 1989; Alesina and Tabellini, 1990).

Figure 11 shows the results for Greece and Japan for this exercise. According to the new simulated debt for Japan, this becomes positive and high with a downward tendency until crossing the increasing accumulated debt in 2008 at the ratio of 192%. The results produced for Greece are also improved compared to its own data on interest rates, as previously explained. The intersection between actual and potential debt is materialized in 2005 at an average ratio of debt equivalent to 100%. Indeed, an IMF note on fiscal space calculating the debt limit based on the fiscal reaction function, and the interest rate growth differential, shows that the public debt dynamics are not on a sustainable path to converge to a finite steady-state ratio for the following countries: Greece, Italy, Japan and Portugal (Ostry et al., 2010).

Figure 11. Simulated potential public debt for Greece and Japan using the US long-term interest rate and economic growth differential



An exercise of simulation is also conducted for all the other countries calibrating the gap (long-term interest rate – growth) by the United States one, but although the tendency changes slightly for many countries, the years of intersections between actual and simulated debt are delayed for some countries, such as Belgium, until the year of the financial crisis (the intersection using its

own data is around 1982). For the United Kingdom, potential debt stays higher even in times of crisis when calibrating with the United States' interest rates, and for many other countries the average of the simulated debt increases substantially, especially for Australia, Austria, New Zealand, Belgium, France, Italy, Spain, Greece and The Netherlands. However, for some countries, such as Denmark, Sweden, Norway and The Netherlands, the average is almost stable between the two exercises, while it decreases substantially for Switzerland. The results for all the sample countries are stacked in Figure B.6 in Appendix B.

4.3.2. The impact of elasticity

To gauge the effects of elasticity changes, we assess the effects of three values – the estimated one from the model, then the one calibrated to 0.15 and 0.30 values – on potential government investment and debt (Table 3). First, we see that the impact of variation of elasticities is higher for small countries than sizeable countries. Doubling the value of elasticity (for example, from 0.15 to 0.30) leads to a decrease in simulated public debt, on average, by around three points of GDP for small countries such as Greece and Ireland. This impact is, however, contained, on average, at around 1 to 2 points of GDP for sizeable countries (the United States, Japan, Germany, France, the United Kingdom).

Table 3. The effects of elasticity changes on the potential public debt limit

	D		D15		D30		D15-D30		D-D30	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Australia	99.3	96.2	98.3	95.2	96.9	93.9	1.3	1.4	2.3	2.4
Austria	300.7	303.0	301.1	303.3	300.2	302.6	0.9	0.7	0.6	0.4
Belgium	111.4	114.3	111.7	114.5	111.0	114.0	0.7	0.4	0.4	0.2
Canada	138.9	132.3	139.4	132.8	138.5	132.0	0.9	0.9	0.3	0.3
Denmark	233.3	237.7	233.0	237.5	232.7	237.2	0.3	0.2	0.6	0.4
France	131.1	125.8	130.9	125.7	130.4	125.4	0.4	0.3	0.7	0.4
Germany	130.9	140.6	132.6	141.8	132.0	141.4	0.6	0.4	-1.1	-0.8
Greece	90.1	82.9	84.5	80.7	82.6	79.8	1.9	0.9	7.6	3.1
Ireland	163.5	167.3	177.9	176.2	175.1	174.8	2.8	1.4	-11.6	-7.5
Italy	143.3	136.8	145.0	137.5	144.0	137.1	1.0	0.4	-0.7	-0.3
Japan	-591.1	-592.7	-585.1	-589.2	-582.8	-587.8	-2.3	-1.4	-8.2	-5.0
Netherlands	178.9	181.5	178.9	181.5	178.3	181.1	0.6	0.4	0.6	0.4
New Zealand	101.7	100.8	101.0	100.4	100.4	100.0	0.6	0.4	1.3	0.8
Norway	150.5	154.8	152.4	156.8	151.3	155.6	1.2	1.2	-0.8	-0.8
Portugal	209.8	209.8	210.2	210.1	208.5	208.8	1.8	1.3	1.4	1.0
Spain	105.1	105.7	105.4	105.8	104.6	105.2	0.8	0.6	0.6	0.4
Sweden	170.3	170.5	171.7	171.2	171.2	171.0	0.5	0.2	-0.9	-0.4
Switzerland	254.7	259.6	254.8	259.6	253.4	258.9	1.4	0.8	1.3	0.7
United Kingdom	98.1	101.6	98.9	102.4	98.5	102.0	0.4	0.4	-0.4	-0.4
United States	187.4	194.9	187.5	194.9	186.7	194.0	0.8	0.9	0.7	0.9

4.3.3. The impact of the differential "long-term interest rate – economic growth rate"

Since the elasticity impact is not highly determinant on the results, as previously shown, we keep constant the elasticity of public capital at the average of 0.30[125] for all countries and simulate the impacts of the gap between interest rate and growth. In fact, as shown in the previous paragraph, the elasticity impact is very low on the results compared to what we will show for the differential in interest rates and economic growth. Furthermore, we focus on some countries where long-term interest rate data is available over the whole history. We choose, for example, sizeable countries, namely, the United States of America, France, the United Kingdom and Canada (Japan and Germany were excluded for reasons of data shortness on interest rates). We simulate results considering the whole period, and the two sub-periods 1960–84, as well as in the so-called Great Moderation Era,[126] 1985–2015, to see the effects of the gap between interest rates and growth (the denominator in Equations 30 or 31). Descriptive statistics of long-term interest rates and economic growth for these countries are displayed in Table 4. We note that the difference between long-term interest rates and economic growth is higher in the period 1960–84 than in the period 1985–2015.

Table 4. Real long-term interest rates and real economic growth differential for selected countries

	Long Term Interest Rates (% per annum)		GDP Growth rate (%)		Gap [interest rate-growth]	
Sample: 1960-2015	Mean	Median	Mean	Median	Mean	Median
France	7.3	6.7	2.9	2.4	4.5	4.3
United States	6.3	6.1	3.1	3.3	3.2	2.8
United Kingdom	7.8	7.5	2.4	2.6	5.4	4.9
Canada	7.0	6.8	3.2	3.1	3.8	3.7
Sample: 1960-1984	Mean	Median	Mean	Median	Mean	Median
France	9.4	8.6	4.2	4.5	**5.2**	4.0
United States	7.3	6.8	3.6	4.5	**3.7**	2.4
United Kingdom	9.7	8.8	2.5	2.7	**7.2**	6.1
Canada	8.3	7.6	4.2	4.0	**4.1**	3.5
Sample: 1985-2015	Mean	Median	Mean	Median	Mean	Median
France	5.6	4.9	1.8	2.0	**3.8**	2.9
United States	5.5	5.3	2.7	2.7	**2.8**	2.5
United Kingdom	6.2	5.1	2.3	2.5	**3.9**	2.5
Canada	6.0	5.5	2.4	2.6	**3.5**	2.9

[125] We should remember that this is the average of the significant estimated public capital elasticities over the sample of countries. Fixing the elasticity for all countries to a common value allows comparison of the countries' results based on the impact of the interest rate and economic growth gaps alone.

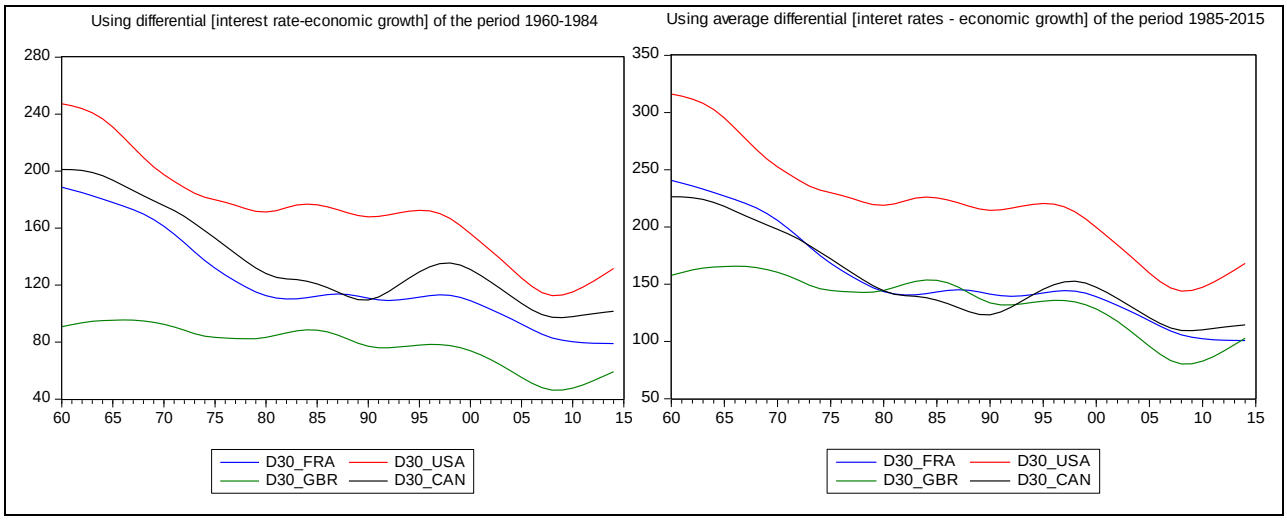
[126] The Great Moderation Era is first described by Stock and Watson (2003) analysing, over the period 1960–2002, the United States quarterly GDP volatility, shown to be highly reduced after 1985 compared to the previous period. This tendency of output and price stability is mainly attributed to the macroeconomic stabilization policies followed by independent central banks (Bernanke, 2004). Some economists argue that this period came to an end in 2007 with the 2008 financial crisis, while others argue that the GDP volatility averages are still lower than pre-1985, assuring the continuity of the Great Moderation Era (Clark, 2009).

The effects of interest rates and economic growth differences are produced in Table 5 and Figure 11. Overall, there are sizeable and substantial effects on potential debt for the four selected countries. The averages of simulated public debt, over the period 1960–84 (Scenario 1), is around 168% for the United States, 118% for France, 78% for the United Kingdom and 135% for Canada. These averages are, respectively, higher in the Great Moderation Era, 1985–2015 (Scenario 2), by around 38 points of GDP in France, 52 points in the United States, 57 points in the United Kingdom and 20 points in Canada. For the whole period, the averages of simulated debt are 137% in France, 195% in the United Sates, 100% for the United Kingdom and 145% for Canada.

Table 5. Simulated effect of differences between long-term interest rates and economic growth

Simulating potential debt over the period 1960-2015, using constant elasticity of public capital = 0.30				
	France	United States	United Kingdom	Canada
Mean	137.4	194.7	100.5	145.1
Median	126.2	194.6	106.6	134.3
Maximum	212.1	279.7	123.7	213.0
Minimum	88.8	127.4	59.9	102.9
Scenario 1: simulating potential debt using interest rates and growth of the period 1960-1984				
	France	United States	United Kingdom	Canada
Mean	122.2	172.2	77.6	137.1
Median	112.3	172.1	82.3	126.9
Maximum	188.6	247.3	95.5	201.2
Minimum	79.0	112.6	46.3	97.2
Scenario 2: simulating potential debt using interest rates and growth of the period 1985-2015				
1985-2015	France	United States	United Kingdom	Canada
Mean	156.0	220.1	134.7	154.4
Median	143.2	220.0	142.9	142.8
Maximum	240.7	316.1	165.8	226.5
Minimum	100.8	144.0	80.3	109.5
Scenario 2 - Scenario 1				
1985-2015	France	United States	United Kingdom	Canada
Mean	33.7	47.9	57.1	17.3
Median	31.0	47.9	60.5	16.0
Maximum	52.0	68.8	70.2	25.3
Minimum	21.8	31.4	34.0	12.2

Figure 12. Simulated potential debt sensitivity to the differential of interest rates and economic growth for selected countries



4.4. Discussion

Contrary to the second chapter, where we adopted a short-term approach assessing the impact of the presence of public debt on GDP via the effects on the fiscal multipliers, as well as the interaction with the business cycle and other economic variables, this chapter has adopted a long-term approach based on an endogenous growth model to assess the relationship between public debt and economic growth. Economists (classical and new classical) adopting this approach generally try to avoid the role of empirical estimations and data in their calculations (adhering to the Lucas (1976) and Sims (1972) critiques). They prefer calibration to estimation and argue as if all economies are in the steady state in the long term, which is not necessarily true. Furthermore, calibration is another way of deriving parameters that are under the control of economic theory and do not necessarily reflect the behaviour and data-generating process proper to each country. Furthermore, the results of the calibrated models are theoretical and not so easy to interpret by the policy-makers. In our case, we judge it useful that countries are not necessarily in the steady-state path and hence considered in transitional dynamics, even in the long term; we prefer to run estimations in the long term, being suitable for the approach of endogenous theory, and we stay away from calibrated elasticities. The only calibrations adopted in some variables are based on data averages.

Chapter 1 of this thesis reported detailed literature on the public debt threshold, which reported different numerical thresholds revealing sensitivity to the countries' sample (for panel regressions), to the period and the country on individual levels (for single-country regressions). The importance of the debt limits has already been taken into consideration before the recent financial crisis, first by the Europeans in the establishment of the European Monetary Union (Maastricht criterion of 60%), and by multilateral institutions in designing their loan programmes, especially the International Monetary Fund and the World Bank institutions. These Breton Woods

Institutions designed an approach called debt sustainability analysis (DSA) for low-income countries (LIC) and market access economies (i.e. emerging economies and advanced economies). This practical framework became operational and was applied especially to LIC in 2002 (IMF and the World Bank, 2005, 2013). However, since the 2008 crisis, this approach is permanently revised and has been updated to include other highly indebted countries, which is the case for advanced countries (IMF, 2013). The DSA is a kind of stress test for debt sustainability based on limits of some important financial indicators, namely, bond yield spreads, external financing requirements (as a percentage of GDP), public debt held by non-residents (share of total), public debt in foreign currency (share of total) and annual change in the share of short-term public debt at original maturity. A safer benchmark gross government debt of 60% and 70% of GDP was calculated for the groups of emerging countries and advanced countries, respectively. The 70% limit was able to reach 85% for the group of advanced countries. This threshold is less than the 90% threshold that fits all countries suggested by Reinhart and Rogoff (2010).

In this section, we compare our results with some results produced in the recent literature that have adopted modelling techniques derived from economic theory, although the approaches differ. Some papers that conclude debt limits, and then the fiscal space defined as these debt limits minus actual debt, are influential and have important policy implications (Ostry et al., 2010, 2015; Ghosh et al., 2013; Pienkowski, 2017). For many of these researchers, the debt limit is assessed around the period of the financial crisis of 2008/2009. Therefore, to compare our results with those raised by some authors, we limit this comparison to a very short period or a specific year of comparison (for example, around the 2008 financial crisis).

Returning to our earlier results, Table 6 shows the average limits over the crisis period, 2009–12, for the 20 countries in the sample. The second column shows observed average debt over the period 2009–12, the third, fifth and seventh columns show, respectively, the averages of simulated potential debt over the same period considering the economic performances proper to each country (Potential1), then simulation based on the calibration of economic growth and long-term interest rates to the Great Moderation Era (1985–2015) performances (Potential2), and the simulation calibrating long-term interest rates and economic growth to those of the United States for all countries (Potential3). The other columns, Gap1, Gap2 and Gap3, present the difference between the previous simulations (Potential1, Potential2 and Potential3) and observed debt (actual), respectively. When actual debt overcomes simulated debt, the gap is negative, and the country should curve the accumulation of debt by rapid de-leveraging.

A negative gap over the years of the financial crisis (2008–12) is recorded for Belgium, the United Kingdom and Spain, and highly negative for Japan, Greece and Italy (Gap1). Portugal, Germany and France also recorded very low but positive gaps. Considering the Great Moderation Era, Gap2 is negative for Portugal, in addition to the previous countries cited for Gap1, except the United Kingdom and Japan. The latter recorded high potential debt in contrast to high negative potential debt for Gap1. Considering the third simulation, Greece, Italy, Japan and Portugal are countries

with worrying debt, even considering the United States' benchmark for economic growth and interest rate performances. However, some countries' potential debt has significantly increased in this simulation. This is the case for Australia, New Zealand, France, the United Kingdom, Spain and, to a lesser extent, Germany. Other countries, however, have seen their potential debt decrease in this last simulation, namely, Austria and Switzerland.

Table 6. Simulated potential debt following the 2009–2012 crisis

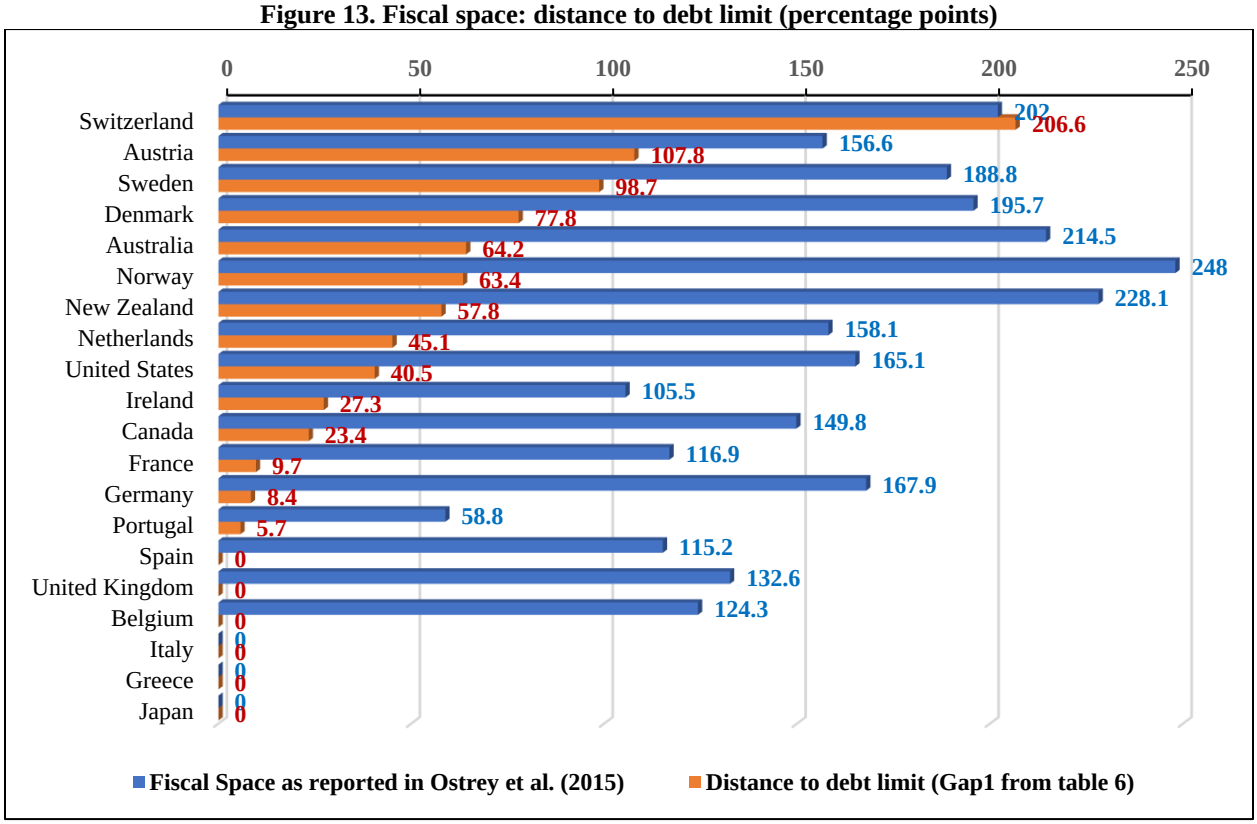
Sample: 2009-2012	Actual	Potential1	Gap1	Potential2	Gap2	Potential3	Gap3
Switzerland	48.4	255	206.6	283.8	235.4	131.8	83.4
Austria	71.9	179.8	107.8	133.2	61.3	112.1	40.2
Sweden	39.5	138.2	98.7	121.9	82.4	148.8	109.3
Denmark	41.6	119.4	77.8	100.9	59.3	126.8	85.2
Australia	20.3	84.4	64.2	95.6	75.4	126.6	106.4
Norway	43.5	107	63.4	86.1	42.6	111.7	68.2
New Zealand	30.2	87.9	57.8	91.1	60.9	153.1	123
Netherlands	62.8	107.8	45.1	126.7	64	110.8	48.1
United States	91.5	132	40.5	149.2	57.7	132	40.5
Ireland	84.5	111.8	27.3	310.1	225.6	141	56.5
Canada	80.8	104.2	23.4	110.8	30	122.5	41.7
France	81.2	90.9	9.7	103.1	21.9	124.7	43.4
Germany	76.8	85.2	8.4	102	25.2	95.8	19
Portugal	96.8	102.5	5.7	70.5	**-26.3**	86.8	**-10**
Spain	62.4	58.9	**-3.5**	59.5	**-2.9**	92.7	30.3
United Kingdom	73.2	62.7	**-10.5**	84	10.8	103.4	30.3
Belgium	96.5	76	**-20.5**	84.3	**-12.2**	98.3	1.8
Italy	117.2	60.9	**-56.3**	41.1	**-76.1**	63	**-54.2**
Greece	144.2	1.5	**-142.7**	1.1	**-143.1**	2.1	**-142**
Japan	215.5	-432.1	**-647.5**	876.5	661	185	**-30.4**

Note: Countries are filtered, according to the column Gap1, from high values to lower values.

In the same way, Ghosh et al. (2013) use the approach of Ostry et al. (2010) to calculate the debt limits for advanced countries and to produce a fiscal space defined as the difference between that debt limit and the actual debt-to-GDP ratio, based, in particular, on the interest rate and economic growth differential and considering the primary balance. They find that Greece, Italy, Japan and Portugal have no fiscal space as their debt is unsustainable. However, the other countries have enough fiscal space, especially given that the assessed debt limits range from minimum values of 152% and 154% for Canada and Germany, respectively, to high values of 246% and 263% for Ireland and Norway, respectively. For the set of countries with positive fiscal space, the latter values are around low values of 50% to 70% recorded for the United States, Ireland and Belgium, medium values from 75% to 100% recorded for the United Kingdom, France and Germany, and higher values of higher than 100%, especially in northern countries (Norway, Sweden and Denmark) and Australia and New Zealand. These results are generally in line with our results in Table (6).

The same exercise was updated by the international rating agency, Moody's, adopting the same approach as Ostry et al. (2010) and Ghosh et al. (2013), to calculate a distance to debt limit for a sample of advanced and emerging economies. The sample of countries also covers the 20 advanced countries that we studied in this chapter, in addition to other countries. The results are reproduced in Ostry et al. (2015) in a figure summarizing these distances to debt limit, which are reproduced in Figure 13. The latter indicates that Japan, Italy and Greece have zero fiscal space, which was also confirmed by our results in Table 6 (Gap1). Belgium, Spain and the United Kingdom also report negative differences between potential debt and actual debt in Table (6), concordant to some extent with Moody's results, where fiscal space is very low, except for the United Kingdom. Our results (Table 6) also show that Switzerland, Austria, Sweden, Denmark, Australia, Norway, New Zealand, The Netherlands, The United States and, to some extent, Ireland and Canada have safer potential debt higher than actual debt, while France, Germany and Portugal have average potential debt approaching actual debt. These results are also generally in line with Moody's calculations, as reported in Ostry et al. (2015), which are reproduced in Figure 13.

Figure 13. Fiscal space: distance to debt limit (percentage points)



Note: For comparison purposes, distance to debt limit, as defined in Ostry et al. (2015), is reproduced and reported for our sample jointly with the distance from actual to potential debt calculated by our method (Gap1 in Table 6). For negative Gap1 (potential tolerable debt below observed debt), we report zero instead of negative numbers.

In another IMF paper (Pienkowski, 2017), the debt limit for advanced countries is found to be 137% of GDP. This debt tolerance can be enhanced by issuing GDP-linked bonds, which can increase this limit to 238% of GDP for all advanced countries (when the bonds issuance is 100% linked to GDP). The author concludes that this linked debt to GDP clearly shows that there is no one-size-fits all, which endorses our results.

Another important point revealed in this chapter is the effects of the interest rates and economic growth differential (gap) in shaping the curve of potential public debt over time. The effects are higher on potential public debt in the Great Moderation Era (1986–2015) than in 1960–85. This is due to the gap being higher, on average, in the 1960–85 period and narrowing in the Great Moderation Era (Table 4). This latter period is characterized, on average, by lower interest rates, but also lower economic growth compared to 1960–85, which makes the differential between long-term interest rates and economic growth lower than the one in 1960–85, as revealed in Table 4. As a consequence of lower interest rates, the Great Moderation Era has played a bigger role in the accumulation of public debt that countries nowadays struggle to decrease (Cecchetti el al., 2011). A recent debate was triggered by Blanchard (2019) assuming that, on average (opposite to the case here for long-term interest rates), interest rates are lower along history than economic growth, which makes debt safer in advanced economies and means that there is nothing to be concerned about. Some economists interpreted this as an appeal for fiscal expansion and avoiding fiscal austerity. More details of this debate are presented in the Chapter 2, as well as a recent discussion about the type of interest rates by Blanchard (2019) in his analysis.

The third result is that potential government investment to GDP ratios are, on average, higher than the observed government investment ratios, and they tend to decrease over time. This may indicate that, first, countries are not reaching their potential productive investments, and, second, that the issued public debt may drift from financing productive capital to other government expenses as an enhancement of the welfare state needs and ageing population expenditure. In fact, the size of social spending in OECD countries increased from 18% in 1980 to 26% in 2014 (Alesina and Passalacqua, 2015).

Despite the importance of such results, some caveats should be considered, and future development could enhance the results of our approach. First, we assumed that potential debt is only issued to finance potential public capital derived by the model, while the finance of the other current government expenditure is supposedly filled by collecting taxes. This may have led to generating simulated higher potential public debt, which stays high, above actual debt, especially in good times for many countries. However, tax revenue is not sufficient to compensate the financing needs of total expenditure. For example, according to the OECD database website, tax revenue in France was around 45% of GDP in 2015 (above an average of 34% for OECD countries), while general expenditure stood at around 57% (social expenditure 43% plus social protection 14%). Government investment was around 3.5%. Hence, a deficit of approximately 11 points of GDP was not compensated by taxes (around 20% of additional taxes are needed to finance such needs).

If we adjust the potential debt to consider such a fact (let us reduce potential government expenditure for all countries by an extra 20% of their actual taxes),[127] the potential public debt is significantly reduced, on average, for example, to 35% over the period 1960–2015, 72% in Germany, 21% in Italy, 50% in Ireland, 38% in Spain, 62% in Canada and 115% in the USA. Without considering this fact, averages are higher and are, respectively, 131% in France and Germany, 143% in Italy, 163% in Ireland, 105% in Spain, 139% in Canada and 187% in the United States. Some other countries, such as the United Kingdom, saw potential debt significantly reduced to very low levels.

In this chapter, the adopted theoretical framework of the Cobb-Douglas production function has focused on the long-term approach to simulate the potential debt that a country could target without undermining its public finances. However, this long-term approach omits the short-term effects of fiscal policies, which are highly determinant in public debt management. The framework of endogenous growth models could be suitable for long-term analysis, while debt related to fiscal-policy short-term effects is omitted. Furthermore, we derived potential debt from potential public productive investment, neglecting the effects of other public expenditure such as social spending in education, justice, health, and so on. In fact, as stated by Corsetti and Roubini (1996), *"The productive public spending can be thought of as encompassing very different types of publicly provided goods and services, such as justice, enforcement of law and contracts, police services, educational services and government research activities"*. Social spending in education, health, justice, and others, is to enhance human capital, and to create qualified political and economic institutions, which develop the business environment. The rule of law and order, as well as security, are also crucial determinants ensuring stability for the business environment. Taking this into consideration, it is highly recommended to consider the effects of such categories of expenditure and to analyse their impacts on economic growth in both the short and long terms.

5. Conclusion

Contrary to the first chapter, which examined the purely statistical–econometric relationship between economic growth and public debt, albeit with advanced econometric tools (Hansen's regression kink method), this chapter has extended the investigation to the role of theory-based models, taking into consideration country-specific fundamentals. Therefore, the chapter first surveyed the effects of public debt on economic growth in different classes of theoretical and empirical public debt models (OLG, ILA, endogenous growth models, new Keynesian DSGE models, and the normative versus the positive approach). In the second part, an endogenous model was applied to the sample studied in the first chapter, made up of 20 developed economies.

[127] The results of this exercise for all countries are reproduced in Figure B.6 in the appendix.

In this model, we simulated a parameterized formula for a potential/limit debt that a country could target to finance its productive investments. These limits, linked to economic growth and public capital productivity, as well as the interest rate, are dynamic, country- and time-specific and tend to evolve contrary to actual accumulated public debt. Simulated public debt, in particular, drops under actual levels of debt in times of crisis, especially for many advanced countries severely affected by the crisis. This sends a clear message of policy recommendation that countries are safe from the danger of public debt as long as potential debt (simulated/targeted) stays higher than actual public debt. The results show that many countries are under the stress of public debt, especially after the financial crisis of 2008. For countries such as Ireland, this stress is short-lived, and potential debt quickly remains higher than actual debt following the redressing in economic activity a few years after the crisis. However, for many other countries, the effects are prolonged. The results also revealed that countries such as Greece, Belgium and, to some extent, Italy, had problems of accumulated debt, in the early 1980s for the two first countries, and the early 2000s for Italy.

The potential (limit) public debt is country-specific and evolves contrary to actual accumulated debt over time. Indeed, it moves in line with the public capital productivity trend, which historically tends to decline while actual public debt is rolling over. The story of the debt limit was intensely debated at the forefront of the 2008 financial crisis. The different results found in the literature supporting the debt limit existence, whether for all countries (or at least for countries of the same level of development), or case-specific countries, tend to discuss the threshold debt generally, as a one-size-fits-all for countries, whether determined endogenously or set exogenously. However, the added value of the present work is that the debt limit is an endogenous parametrized function linked to the economic returns (productivity) of public capital financed by such issued debt. Another point to note is that, although we found that the endogenous debt limit, whenever it exists, is country- and time-specific, using Hansen's (2017) regression kink method in the first chapter, this chapter added the finding that potential debt limits are determined yearly based on the country's principal macroeconomic fundamentals.

Appendix A. Tables

Table A.1. Summary and features of the models of public debt and fiscal policy

Authors	Type	Main Features	Main hypotheses	Results
Diamond (1965)	OLG	- Two periods of infinite long-life agents living for 2: working in the 1st and retiring in the 2nd. - Study the impact of domestic/foreign debt on the interest rate and utility level.	- Governments have a one period maturity. - Debt pays the current interest rate. - Taxes are lump-sum. - Debt labor ratio is kept constant.	- Domestic debt raises interest rate and lowers utility in the efficient case. - Results for the inefficient case depend on the existence of the foreign debt with domestic debt. - Foreign debt widen the gap between the interest rate and growth, lowers utility in the efficient case. - Results for utility are mixed for the inefficient case. Debt Swap has the same effects.
Barro (1974)	OLG	- The model's features are mainly based on the Samuelson-Diamond properties. - Study the effects of public debt on interest rate and utility in steady state equilibrium.	- The model's hypotheses are mainly based on the Samuelson (1958) and Diamond (1965) models' assumptions.	- Government bonds effects on the interest rate and utility does not necessarily hold and depends especially on the existence of operative altruistic links (bequest motives) between generations. - Intergenerational transfers guarantee debt-neutrality as the debt-for-tax swap does not affect the resource allocations and interest rates of the current generation.
Blanchard (1985)	ILA	- A finite lived agents' horizon. - Studies the effects of debt and deficit accumulation. - Design an "index of fiscal policy" capturing the effects of current and expected fiscal policy.	- Taxes are lump-sum. - Constant probability of death.	- Debt increase (in the steady state): changes the foreign assets in agents' wealth in an open economy, and, decreases the level of capital and consumption in a closed economy. - Taxes decrease: raises wealth and consumption. Effect is larger the longer taxes are shifted to future generations. Debt and taxes increases create an initial wealth effects on consumption, leading to capital decumulation which makes capital and consumption lower in the new steady-state level.
Aiyagari (1985)	OLG	- Use a modified version of the OLG model of Samuelsson (1958). - Assess the Ricardian equivalence validation.	- Enabling changeable interest rate to deficit policy regimes. - Taxes distributed differently across heterogeneous agents.	- Ricardian equivalence validation depends on the way taxes are distributed among agents and not on the length of the lifetime horizon. The debt-neutrality holds if the tax distribution does not change agents' wealth allocations. A higher level of spending can be financed by debt at an unchanged interest rate, if taxes' distribution maintains wealth distributions.
Buiter (1988)	OLG	- The model is based on the Yaari-Blanchard models. - Evaluates the effects of government bonds on economic agents' wealth.	- Private consumption behavior is modelled following Yaari (1965) and Blanchard (1985) approaches.	- The equilibrium is independent of the pattern of the public debt and lump-sum taxation over time. - The difference between expected government tax base and the future tax base of the current individuals explains the lump-sum taxation variations over time. Agents not linked to the future generations by bequest transfers omit their successors' resources from their budget constraint. - Debt-neutrality holds if and only if the population growth and the probability of death sums to zero. Under this condition, a non-zero labor productivity rate will not destroy this debt-neutrality.

Weil (1989)	ILA	- A model of "overlapping families of infinitely lived agents", aims to show that: 1st, the "infinite lifetime horizon" assumption do not necessarily imply debt-neutrality; 2nd, the "finite horizons" don't necessarily violate debt-neutrality.	- Assumes new cohorts over time, and new families aren't linked to the existing by transfers. - Operative transfers between some but not all agents result in partial linkages leading to infinite economic horizon. - Agents' infinite lifetime is assured by the arrival of the families who are not linked by transfers.	- The equilibrium interest rate hinges on the government financing decision (government bonds by levying lump-sum taxes in this case) and speed of new arrival cohorts/families. - Government bonds increase the equilibrium interest rate for a positive non-zero population growth rate: expected taxes to pay the issued debt are compensated by generations that are not yet born and are not considered by the current generations. The real interest rate must hence rise to maintain aggregate consumption at its market-clearing level. Infinite lifetimes are so not inconsistent with the violation of the debt-neutrality assumption. Also, finite horizons do not necessarily violate the latter.
Barro (1990)	EGT	- Aims at establishing the effect of public spending and government debt policies on utility and long-term growth in a perspective of endogenous growth theory. - The model studies a closed economy with infinite lifetime agents and intertemporal preferences modelled by a utility function.	- Adopts an AK modeling framework assuming constant returns to scale and including the flows of public services as input in the production function. - Argues that private inputs are not a close substitute for public inputs as some public activities are difficult to be insured by private firms (defense, law and order), or the service is non-rival (ideas), or as external effects cause lower private output (basic education). - Assumes timely balanced-budget.	- In case of a Cobb-Douglas production function, $\frac{y}{k} = A\left(\frac{g}{k}\right)^{\alpha}$: an increase in taxes reduces the long-term growth while an increase in expenditures raises it by raising marginal productivity of capital. - The two effects cancel for the optimal government size equalizing government expenditure to tax rate and the share of the capital $\left(\frac{g}{y} = \tau = \alpha\right)$. The growth rate function of the government size is an inverted U curve: for a government small size, raising expenditures' effect dominates raising tax rate's effect, while for a large government size, the negative effect of taxes on growth dominates. - Maximum utility corresponds to same conditions maximizing growth if the elasticity of substitution of y to g = 1. - In non-Cobb-Douglas case: maximum growth depends on the elasticity of substitution between public services and private capital and, the relative size maximizing utility exceeds the one maximizing growth rate if and only if the magnitude this elasticity substitution is superior to 1.
Futagami et al. (1993)	EGT	- Same approach as in Barro (1990). Study the effect of public capital stock (instead of government services flows) and public debt policies on utility and growth.	- Adopts an AK modeling framework. - The model includes the stock of public capital as an input in the production function. - Assumes timely balanced-budget.	- Public investment stimulates aggregate production indirectly via the accumulated stock instead of flows as does Barro (1990). The introduction of the productive public stock allows dynamic transitional effects analysis instead of being restricted to the steady state analysis as in Barro (1990). - Tax rate maximizing economic growth rate is higher than the one maximizing utility.
Corsetti and Roubini (1996)	EGT	- Multi-sector model encompassing productive public spending to assess optimal fiscal policy in the approach of endogenous growth models. - Incorporate a separate human capital accumulation as a second sector. - The production function is a Cobb-Douglas with physical capital, human capital and flows of public goods.	- Assume unbalanced budget constraint allowing government borrowing/lending. - 4 models are derived depending whether: public spending as input in the output sector, affects the productivity of capital (model 1); affects the productivity of human capital (model 2); or public spending as input in the human capital sector, affects respectively the same previous variables (models 3 and 4).	- Distinguish an optimal tax rates on both types of capital under different assumptions on technology and distribution and analyze the welfare properties of public debt and assets. - If the government spending is an input in the production function only (not in the human sector), the optimal choice of the government spending leads to a constant ratio of expenditures to output in every time independently of the tax policy. This ratio is less than the one found by Barro (1990) $\left(\frac{g}{y} = \alpha(1-\varepsilon) < \alpha \; as \; \varepsilon > 0\right)$. In model 1, the optimal tax on human capital is zero and the one on physical capital is positive. This result is inverted in model 2. In both models (1 and 2), a government optimal choice of both government spending and tax rates leads to an instantaneous balanced budget and the optimal public debt is zero.

Benigno and Woodford (2003); Schmitt-Grohe and Uribe (2004)	NKT	- New Keynesian models augmented by the government's budget constraint. - Aim at analyzing the optimal response of government debt to shocks focusing on the type of the involved time-inconsistency policy.	- New Keynesian framework based on Christiano et al. (2005) and Smets and Wouters (2007). - Assume sticky prices in the short run. - Expenditures are financed by ***non-distortionary*** taxes and or by issuing only nominal risk-free debt.	- Optimal public debt would follow a random walk path if the government can achieve a time-inconsistent policy commitment. Under the assumption of price stickiness, the government (social planner) chooses to rely more heavily on changes in income tax rates rather than using surprises as a shock absorber of unexpected innovations in the fiscal budget. - The distortions introduced by tax changes are diminished by spreading them over time which induces a near random walk property in tax rates and public debt.
Leith and Wren-Lewis (2013)	NKT	- New Keynesian models augmented by the government's budget constraint. - Aim at analyzing the optimal response of government debt to shocks involving time-inconsistency policy and its implications for discretionary policies.	- New Keynesian (DSGE) framework based on Christiano et al. (2005) and Smets and Wouters (2007). - The model assumes sticky prices in the short run. - Public spending is financed by ***distortionary taxes*** and/or by debt.	- Optimal pre-commitment policy allows debt to follow a random walk path in the steady state. - However, under sticky prices framework, government is tempted to use its policy instruments to change the steady state level debt in the initial period. Debt is curved to initial efficient steady state to encounter this temptation and thus deter the public debt to follow random walk path if following shocks; the new steady state debt equates the original (efficient) debt level despite there is no explicit debt target in the government's objective function. Debt stabilization instruments depend on the degree of nominal inertia. The size of the debt stock and welfare consequences of introducing debt are negligible for pre-commitment policies but can be significant for discretionary policies.
Mayer et al. (2013)	NKT	- New Keynesian model analyzing the responses of macroeconomic variables, in the steady state, to a government spending shock in the presence of positive levels of government debt.	- Derived assumptions of New Keynesian models. - The model assumes a fraction of the household sector to follow a rule-of-thumb behavior as in Gali et al. (2007) (non-Ricardian agents).	- Large government debt in steady state impact the sign and size of short/medium run fiscal multipliers, depending on the horizon's evaluation of these multipliers. - Presence of dynamic interactions between inflation and debt level in real terms (absent in standard New Keynesian models where debt is set to zero in the steady state). - In the case of permanent debt, the fiscal policy effect becomes difficult to predict over time.
Persson and Svensson (1989)	PAD	- A principal-agent problem, aiming at comparing the policy of a conservative government, certain of been succeeded by a liberal government, to the policy where he is certain of his reelection. The level of public debt is an instrument of the current government to control the rival future government.	- Two-period perfect-foresight framework, - Assume the ruling government is certain that he will be succeeded by a liberal government. Assume homogeneity of governments' preferences towards all public goods but different preferences for different levels of the same public good.	- A conservative government may borrow more if he knew that he will be succeeded by a liberal government than it would do once certain of remaining in power in the future; A conservative government will collect less tax and leave more public debt than what the successor would prefer. - This raises the ruler government consumption than it would be if he will stay in the government, while the successor with high debt and constrained resources reduces consumption than it would be if he runs solely. Thus, the time-consistent level of government consumption is somewhere in between the two outcomes of what each of the two governments would prefer if ruling on his own.

Alesina and Tabellini (1990)	PAD	A political/positive theory of debt aiming at understanding the debt build-up and deficits in several industrialized economies Explicitly, they compare the outcome of debt accumulation and deficit in situation where governments alternate versus an outcome resulting from a social planner government supposed elected forever.	- Assume uncertainty about the nature and spending behavior of succeeding governments. - Assume different preferences for different items of public spending and a constant population of identical individuals with the same time horizon. - Individuals differ only by their preferences for public goods, supplied by the government and financed by means of distortionary taxes on labor. -Government is elected among two parties maximizing each the electorate utility function.	- Differences in political institutions, leading to different debt policies, help explain debt paths over time and across countries. Debt accumulation and deficit are emphasized by the alternation of the elected governments. Disagreement of different governments on the structure of the spending results in a deficit bias and an accumulation of debt higher than it would be in case of a social planner. - The debt left to the last period is larger in a democracy than with a social planner. - The electoral uncertainty creates a sub-optimal deficit bias. This bias is stronger for the party with the smaller probability of reappointment". The equilibrium level of government debt is higher; 1/ the higher the degree of polarization between alternating governments and 2/ the more likely the current government will not be reelected. Moreover, as the ruling government is unable to curve the taxation and expenditure policies of its successors, the law of motion of the public debt is the only way by which the fiscal policy of the ruling government can impact the policies of its successors.
Greiner (2007; 2012; 2015; 2016)	EGT	- 2007: Endogenous growth model with public capital and sustainable debt. - 2012: Endogenous growth with elastic labor supply and a government sector. - 2015: Endogenous growth model with productive public spending. - 2016: An endogenous growth model with public educational spending	- 2007: Assume the ratio of the primary surplus to gross domestic income to be a positive linear function of the debt ratio. - 2012: Government levies distortionary income tax and issues bonds to finance lump-sum transfers and non-distortionary public spending. - 2015: Rational identical households with perfect foresight maximizing their utility. - 2016: Same assumptions as in Greiner (2015).	- 2007: The model is used to derive necessary conditions for the existence of a sustainable balanced growth path and analyze growth effects of deficit financed increases in public investment. - 2012: The long-run growth rate is smaller the higher the debt ratio whenever public spending is adjusted to fulfill the government inter-temporal budget constraint. - 2015: Higher debt goes along with smaller long-run growth. Moreover, discretionary policy violates the intertemporal government budget constraint along a balanced path. - 2016: Balanced budget policy and a slight deficit policy yield higher growth than a policy where debt and GDP grow at the same rate. For high debt and low elasticity of substitution, a high deficit policy yields lower welfare than a balanced budget and a slight deficit policy.
Maebayashi et al. (2017)	EGT	- Consider a stock of capital investment in endogenous framework. - Examine how reducing public debts in the economy with large public debts affects transition of the economy and welfare.	- Builds on Futagami et al. (2008) assumptions but instead consider public capital not flows as input. - Assume the depreciation rate of public capital is zero.	- Derive an optimal target debt ratio that depends on the tax rates on wage income and consumption, and the ratio of public investment to total spending. Fiscal consolidation based on a debt ratio target rule improves welfare and this improvement is more the fastest the pace of debt reduction is. - Fiscal consolidation based on expenditure cuts jointly with a tax increase does not always improve welfare. In this case, the welfare gains (if any) are lower than those under expenditure cuts only.
Mankiw (2000)	SST	- A critic of ILA and OLG models and alternative theory mentioned as "Savers-Spenders Theory of fiscal policy" to address the neoclassical shortcomings considering that "households smooth their consumption over time" is inaccurate as many consumers are far from following complete rational expectations.	- Assume the role-of-thumb behavior (non-Ricardian) in the consumers spending. - Some individuals may enjoy long lifetime horizons (due to bequest motives) while others having short time horizons fail to smooth their consumption and accumulate wealth.	- Even if debt does not affect the steady state capital stock and income, it disrupts the income distribution and consumption leading to raise inequality between spenders and savers. A higher level of debt yields higher taxation to compensate for the interest payments on the debt. But taxes are on both savers and spenders while interest payments on debt fall on the savers side. Thus, a higher level of debt increases the steady sate income and consumption for savers and lowers it for the spenders which raise inequality between the two groups. - Many agents have no saving (data fact), so unable to smooth intertemporal consumption as reported by the ILA or OLG models. A better model would allow for such heterogeneous behaviors.
Chari et al. (2009)	CNK	- A critic to the New Keynesian models based on the study of Smets and Wooters (2007) core model.	- Critics based on the examination of Smets and Wooters (2007) properties and assumptions.	- New Keynesian models are not yet useful for public policy analysis. These models include many free parameters yielding to shocks that are dubiously structural as well as many features that are not consistent with microeconomic evidence.

Table A.2. description of variables and data sources

The IMF dataset on investment and capital stock, July 2017.	
Public Investment	General government investment (gross fixed capital formation), in billions of constant 2011 international dollars.
Public Capital	Government capital stock (constructed based on government investment flows), in billions of constant 2011 international dollars.
Private Investment	Private investment (gross fixed capital formation), in billions of constant 2011 international dollars.
Private Capital	Private capital stock (constructed based on private investment flows), in billions of constant 2011 international dollars.
GDP	Gross domestic product, in billions of constant 2011 international dollars.
Background material on data construction	The accompanying 2017 Update of the Manual "*Estimating Public, Private, and PPP Capital Stocks*" (http://www.imf.org/external/np/fad/publicinvestment/data/info122216.pdf) and (http://www.imf.org/external/pp/longres.aspx?id=4959) describes in great detail the series' definitions, the investment series' data sources, as well as the methodology in constructing the stock series. The methodology follows the standard perpetual inventory equation and largely builds on Gupta et al. (2014) *"Efficiency-Adjusted Public Capital and Growth"* and Kamps (2006) "*New Estimates of Government Net Capital Stocks for 22 OECD Countries, 1960–2001"*.
Information sources	Information on public and private investment and GDP comes from three main sources: the OECD Analytical Database (August 2016 version) for OECD countries, and a combination of the National Accounts of the Penn World Tables (PWT, version 9.0) and the IMF World Economic Outlook (WEO, April 2016) for non-OECD countries. Information on country income groupings used in depreciation rates' assumptions is from the World Bank World Development Indicators.
Additional notes	Note that all data series (public investment and capital stock, private investment and capital stock, GDP, etc.) are expressed in billions of constant 2011 international dollars (purchasing power parity adjusted), using the corresponding component-specific deflators from OECD, PWT, and WB databases mentioned above.
Source of the above part of this Table	"IMF Investment and Capital Stock Dataset, 2017", drawn from http://www.imf.org/external/pp/longres.aspx?id=4959.
Other data from other sources	
Interest rates	We consider long term interest rates from OECD database statistics
Inflation	GDP deflator percent change, GDP deflators are from OECD database statistics
Tax revenues	Tax revenues as percent of GDP are from
Government expenditures	General government expenditures as percent of GDP are from OECD database website
Social expenditure	Social spending as percent of GDP are from OECD database website
Labor	We consider a working age population [15, 64] as a proxy for labor data from the World Development Indicators database of the World Bank.
Human capital	Measured by average years of schooling of population [15, 64] from Barro-Lee dataset (www.barrolee.com)

Table A.3. Descriptive statistics

Public investment (Public Gross Capital Formation) as percent of GDP																				
Sample: 1960 2015	AUS	AUT	BEL	CAN	CHE	DNK	FRA	GBR	GER	GRC	IRL	ITA	JPN	NLD	NOR	NZL	PRT	SPA	SWE	USA
Mean	2.3	4.7	3.4	3.6	3.7	6.3	4.8	3.6	3.5	3.2	4.5	3.6	8.3	4.7	3.6	4.5	4.3	3.9	5.0	4.5
Median	2.2	4.4	2.9	3.5	3.7	4.6	4.5	3.2	3.1	2.8	4.6	3.5	8.8	4.1	3.5	4.6	4.4	3.9	4.7	4.2
Maximum	3.5	6.9	6.4	4.9	4.6	14.0	6.6	6.6	6.1	5.5	6.7	5.0	11.9	8.0	4.8	6.7	6.1	5.7	7.6	7.1
Minimum	1.7	2.5	2.4	2.8	2.2	3.3	3.7	1.6	1.9	1.9	2.1	2.5	4.2	3.3	2.6	2.4	2.4	2.5	3.9	3.4
Std. Dev.	0.4	1.5	1.1	0.6	0.5	3.4	0.7	1.4	1.4	1.1	1.2	0.6	2.3	1.4	0.5	0.9	0.9	0.7	1.1	1.0
Skewness	1.0	0.1	1.3	0.4	-0.6	0.9	0.9	0.7	0.4	0.8	-0.1	0.5	-0.5	1.0	0.4	-0.5	-0.3	0.3	1.0	1.4
Kurtosis	3.7	1.5	3.4	1.9	3.7	2.2	2.9	2.1	1.7	2.3	2.0	2.8	2.2	2.6	3.1	3.0	2.5	3.2	3.0	3.8
Jarque-Bera	10.7	5.5	15.6	4.5	4.0	8.7	7.6	5.9	5.8	6.6	2.5	2.8	3.7	10.3	1.6	2.1	1.3	1.1	8.7	19.9
Probability	0.0	0.1	0.0	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.3	0.3	0.2	0.0	0.5	0.4	0.5	0.6	0.0	0.0
Private investment (Private Gross Capital Formation) as percent of GDP																				
	AUS	AUT	BEL	CAN	CHE	DNK	FRA	GBR	GER	GRC	IRL	ITA	JPN	NLD	NOR	NZL	PRT	SPA	SWE	USA
Mean	14.9	22.2	23.7	16.3	21.9	16.8	18.9	16.4	17.8	13.2	25.1	22.5	17.9	18.1	19.3	11.7	21.0	20.1	17.5	14.3
Median	14.3	22.4	23.9	16.0	22.0	17.1	18.9	16.4	17.4	13.4	24.5	21.7	18.0	18.0	19.6	11.3	21.0	19.5	17.5	13.8
Maximum	22.2	24.3	30.0	20.8	24.2	23.9	21.9	21.4	21.5	19.0	34.2	31.0	22.9	22.1	27.0	15.2	27.6	28.4	21.0	17.9
Minimum	11.1	19.1	16.2	12.7	17.2	10.7	16.9	13.1	16.0	6.7	16.5	17.3	12.4	15.3	12.8	8.8	14.9	14.9	13.3	11.1
Std. Dev.	3.0	1.5	3.1	2.1	1.6	3.5	1.2	1.9	1.5	2.6	3.9	3.4	2.3	1.6	3.5	1.8	3.0	3.5	1.7	1.9
Skewness	0.9	-0.4	-0.5	0.5	-0.9	0.2	0.4	0.4	0.9	-0.4	0.3	0.9	0.1	0.4	0.0	0.4	0.0	0.8	-0.3	0.4
Kurtosis	2.7	2.0	3.3	2.4	3.7	1.9	2.8	2.9	2.7	3.1	2.7	3.0	3.0	2.7	2.3	2.2	2.8	3.0	2.8	2.1
Jarque-Bera	7.5	3.8	2.4	2.9	9.0	3.0	1.3	1.7	6.9	1.5	0.9	7.8	0.0	1.5	1.2	3.2	0.2	5.2	1.0	3.5
Probability	0.0	0.2	0.3	0.2	0.0	0.2	0.5	0.4	0.0	0.5	0.6	0.0	1.0	0.5	0.6	0.2	0.9	0.1	0.6	0.2
Government capital stock in billions of 2011 constant US Dollars (ppp)																				
KG	AUS	AUT	BEL	CAN	CHE	DNK	FRA	GBR	GER	GRC	IRL	ITA	JPN	NLD	NOR	NZL	PRT	SPA	SWE	USA
Mean	163	188	157	464	174	221	1237	980	1490	100	54	904	3622	376	94	62	118	525	221	6752
Median	147	209	192	435	178	228	1233	1025	1671	80	50	907	3779	382	85	66	102	460	232	6229
Maximum	364	237	235	870	275	261	1921	1254	1777	216	124	1386	5991	553	198	105	219	1056	314	10889
Minimum	54	88	44	184	49	132	463	536	726	29	13	376	716	178	26	28	40	168	91	3276
Std. Dev.	82	48	66	189	74	34	459	182	333	61	34	319	1904	103	51	20	59	281	66	2257
Skewness	0.76	-0.77	-0.55	0.46	-0.25	-1.17	-0.12	-1.04	-1.11	0.74	0.81	-0.05	-0.19	-0.16	0.39	0.16	0.42	0.53	-0.51	0.37
Kurtosis	2.82	2.11	1.68	2.31	1.73	3.50	1.75	3.23	2.76	2.18	2.57	1.75	1.52	2.34	1.95	2.42	1.76	2.02	2.12	1.96
Jarque-Bera	5.41	7.38	6.96	3.08	4.32	13.4	3.76	10.17	11.68	6.69	6.56	3.67	5.45	1.26	3.97	1.02	5.20	4.86	4.24	3.85
Probability	0.07	0.02	0.03	0.21	0.12	0.00	0.15	0.01	0.00	0.04	0.04	0.16	0.07	0.53	0.14	0.60	0.07	0.09	0.12	0.15

Table A.3. (continued): Descriptive statistics

Private capital stock in billions of 2011 constant US Dollars (ppp)																				
KP	AUS	AUT	BEL	CAN	CHE	DNK	FRA	GBR	GER	GRC	IRL	ITA	JPN	NLD	NOR	NZL	PRT	SPA	SWE	USA
Mean	710	534	721	1326	709	282	3036	2597	4560	294	205	3639	5034	895	353	103	380	1781	487	12793
Median	636	533	687	1315	731	266	3227	2718	4670	293	180	3879	5163	905	395	98	364	1608	502	12126
Maximum	1575	748	992	2420	909	469	4331	3670	5742	491	433	4686	7997	1275	515	168	585	3298	669	22156
Minimum	234	243	359	434	374	115	1144	1113	2402	118	54	1839	941	383	155	48	161	649	254	4427
Std. Dev.	375	164	189	596	158	114	1027	844	1046	113	122	868	2622	276	105	34	136	849	115	5845
Skewness	0.70	-0.21	-0.19	0.16	-0.57	0.26	-0.45	-0.33	-0.52	0.12	0.69	-0.64	-0.26	-0.29	-0.46	0.36	0.04	0.47	-0.36	0.28
Kurtosis	2.51	1.74	2.01	1.88	2.17	1.73	1.91	1.63	2.02	1.81	2.27	2.11	1.50	1.94	2.00	2.14	1.71	1.94	2.18	1.77
Jarque-Bera	5.16	4.15	2.63	3.16	4.64	4.36	4.64	5.41	4.76	3.46	5.63	5.73	5.87	3.42	4.30	2.94	3.89	4.72	2.77	4.24
Probability	0.08	0.13	0.27	0.21	0.10	0.11	0.10	0.07	0.09	0.18	0.06	0.06	0.05	0.18	0.12	0.23	0.14	0.09	0.25	0.12
GDP in billions of 2011 constant US Dollars (ppp)																				
	AUS	AUT	BEL	CAN	CHE	DNK	FRA	GBR	GER	GRC	IRL	ITA	JPN	NLD	NOR	NZL	PRT	SPA	SWE	USA
Mean	519	233	290	850	292	174	1588	1514	2339	212	100	1495	2945	481	188	86	179	908	261	9258
Median	461	218	278	831	283	169	1565	1459	2260	207	66	1595	3186	437	179	76	174	839	252	8579
Maximum	1074	381	465	1538	454	246	2503	2538	3618	365	286	2192	4568	789	335	157	289	1590	446	16940
Minimum	165	85	111	275	139	87	540	696	973	57	23	501	575	177	60	38	49	241	112	3212
Std. Dev.	269	93	108	380	86	50	608	570	803	83	74	532	1331	195	88	34	80	412	94	4272
Skewness	0.54	0.10	0.06	0.25	0.22	-0.02	-0.07	0.30	-0.07	-0.06	0.78	-0.41	-0.36	0.18	0.19	0.59	-0.08	0.21	0.36	0.31
Kurtosis	2.08	1.77	1.83	1.86	2.11	1.65	1.79	1.75	1.72	2.29	2.20	1.83	1.67	1.73	1.67	2.11	1.60	1.81	2.02	1.72
Jarque-Bera	4.72	3.61	3.25	3.61	2.32	3.88	3.47	4.52	3.84	1.20	7.17	4.76	5.33	4.07	4.48	5.09	4.62	3.68	3.43	4.70
Probability	0.09	0.16	0.20	0.16	0.31	0.14	0.18	0.10	0.15	0.55	0.03	0.09	0.07	0.13	0.11	0.08	0.10	0.16	0.18	0.10
Working age population (15-65) in millions																				
	AUS	AUT	BEL	CAN	CHE	DNK	FRA	GBR	GER	GRC	IRL	ITA	JPN	NLD	NOR	NZL	PRT	SPA	SWE	USA
Mean	10.88	5.12	6.56	17.95	4.51	3.39	36.96	37.33	52.68	6.55	2.26	37.08	79.11	9.70	2.74	2.20	6.33	25.47	5.52	162.00
Median	10.91	5.17	6.67	18.25	4.50	3.44	38.24	37.28	53.51	6.61	2.12	38.35	81.06	10.15	2.71	2.15	6.51	25.45	5.43	161.00
Maximum	15.79	5.79	7.31	24.32	5.57	3.64	42.13	41.87	55.88	7.42	3.11	39.04	87.13	11.15	3.41	3.00	7.07	31.76	6.18	212.00
Minimum	6.29	4.59	5.90	10.49	3.50	2.94	29.09	34.11	48.84	5.47	1.64	32.85	59.31	7.01	2.26	1.39	5.34	19.62	4.93	109.00
Std. Dev.	2.78	0.41	0.41	4.19	0.55	0.21	3.96	2.31	2.61	0.73	0.50	2.05	7.59	1.32	0.32	0.48	0.61	3.90	0.35	31.69
Skewness	0.05	0.00	0.03	-0.21	0.15	-0.52	-0.39	0.57	-0.30	-0.17	0.46	-0.69	-0.91	-0.59	0.47	0.06	-0.35	0.13	0.44	0.00
Kurtosis	1.88	1.52	2.15	1.90	2.07	2.06	1.91	2.19	1.46	1.38	1.88	1.87	2.85	1.95	2.31	1.84	1.59	1.78	2.20	1.82
Jarque-Bera	2.95	5.14	1.69	3.25	2.23	4.56	4.21	4.52	6.35	6.42	4.95	7.38	7.74	5.85	3.14	3.18	5.82	3.63	3.34	3.23
Probability	0.23	0.08	0.43	0.20	0.33	0.10	0.12	0.10	0.04	0.04	0.08	0.02	0.02	0.05	0.21	0.20	0.05	0.16	0.19	0.20

Table A.4. Countries sample and their corresponding alpha-3 codes used in all Tables and figures whenever it applies

Country	Country code
Australia	AUS
Austria	AUT
Belgium	BEL
Canada	CAN
Switzerland	CHE
Denmark	DNK
France	FRA
Germany	GER
Greece	GRC
Ireland	IRL
Italy	ITA
Japan	JPN
Netherlands	NLD
New Zealand	NZL
Norway	NOR
Portugal	PRT
Spain	SPA
Sweden	SWE
United Kingdom	GBR
United States	USA

Appendix B. Figures

Figure B.1. Scatter plot elastictities of public investment fLows versus private capital stocks (*Kp, Ig*): Sample 1960-2007

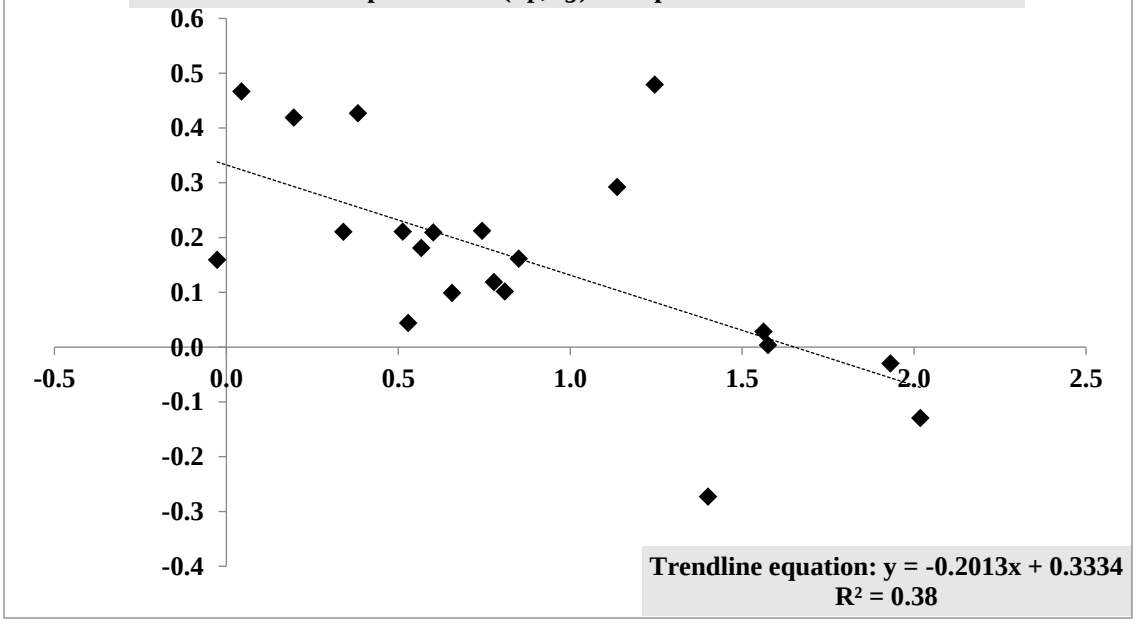


Figure B.2. Scatter plot elastictities of public investment flows versus private capital stocks (*Kp, Ig*): Sample 1960-2015

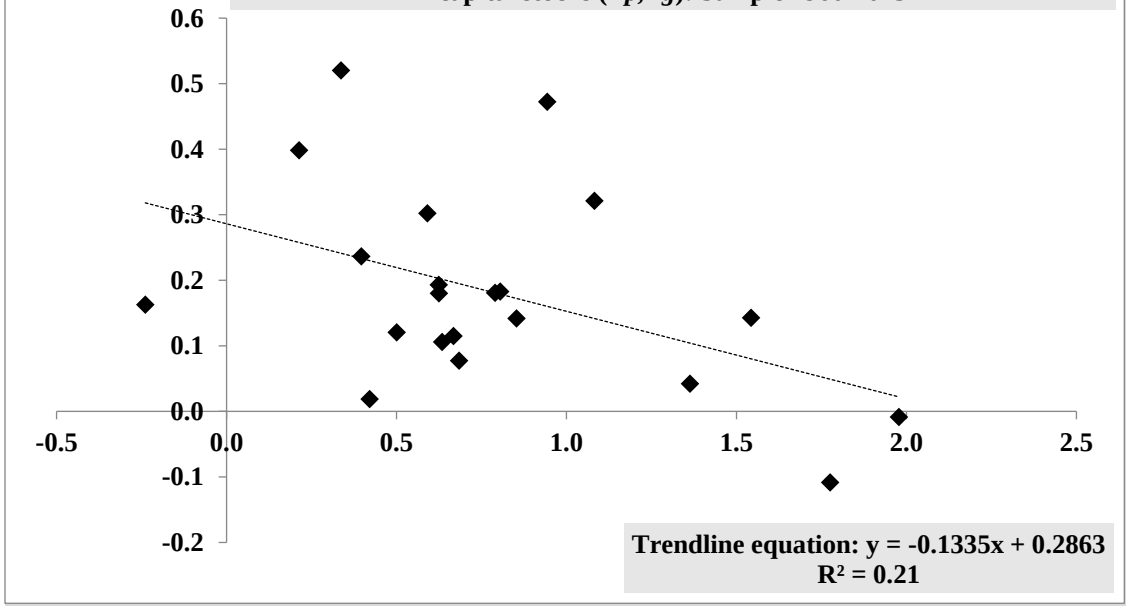


Figure B.3. Simulated public investment flows as percent of GDP

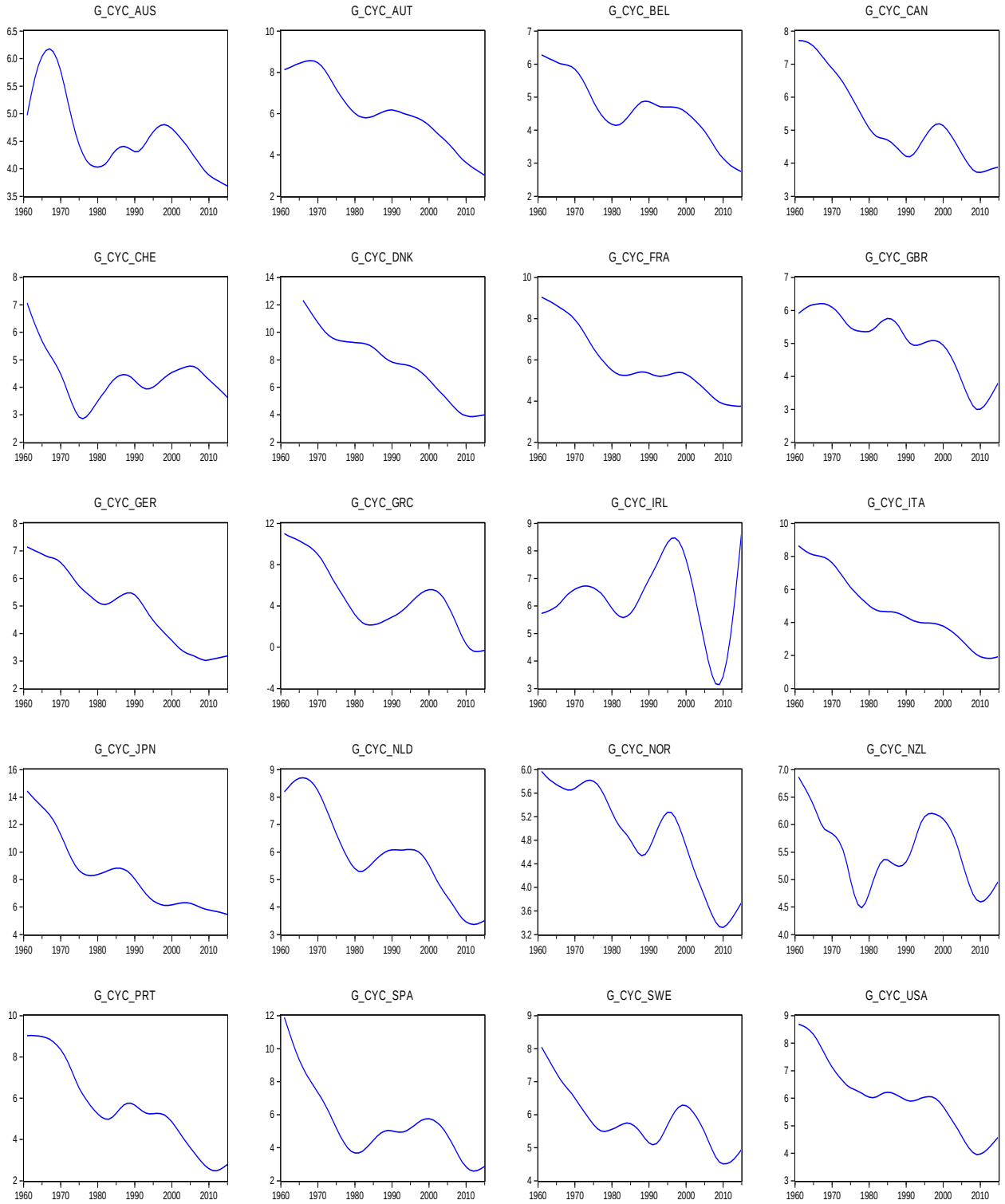


Figure B.4. Actual public investment flows as percent of GDP

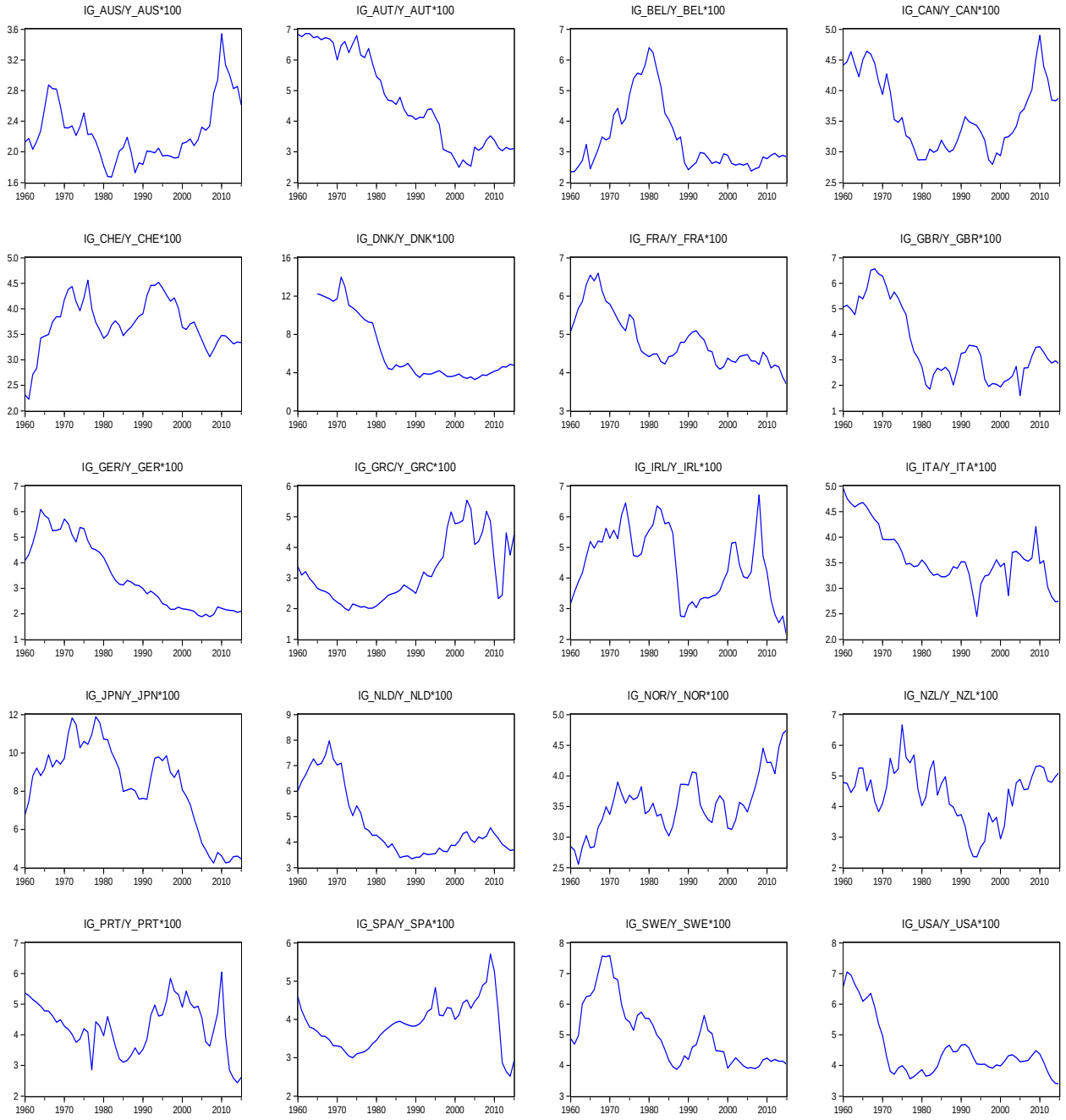


Figure B.5. Simulated and actual public investment flows as percent of GDP

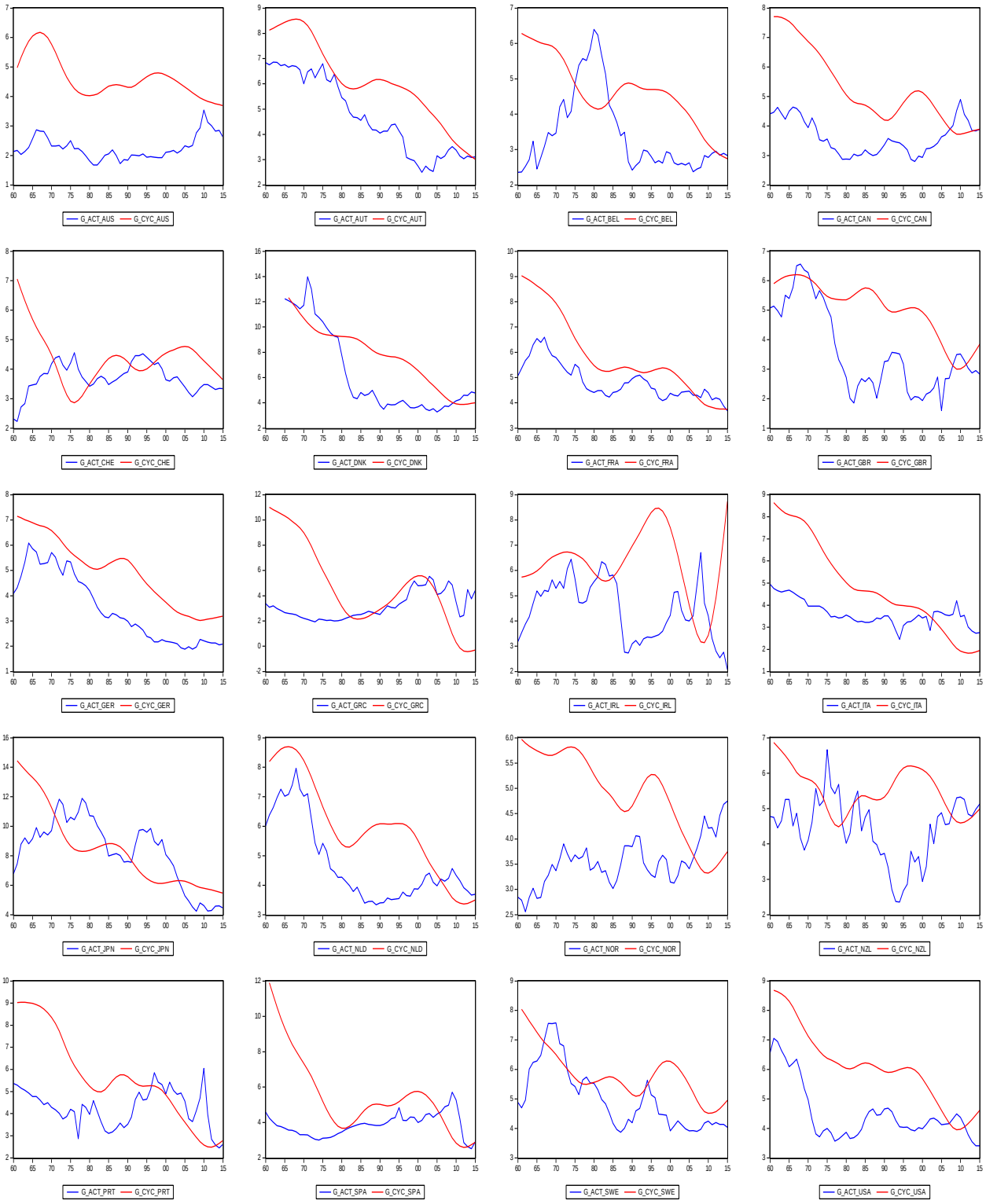


Figure B.6. simulated potential public debt calibrating differential interest rate and economic growth to the ones of the United States

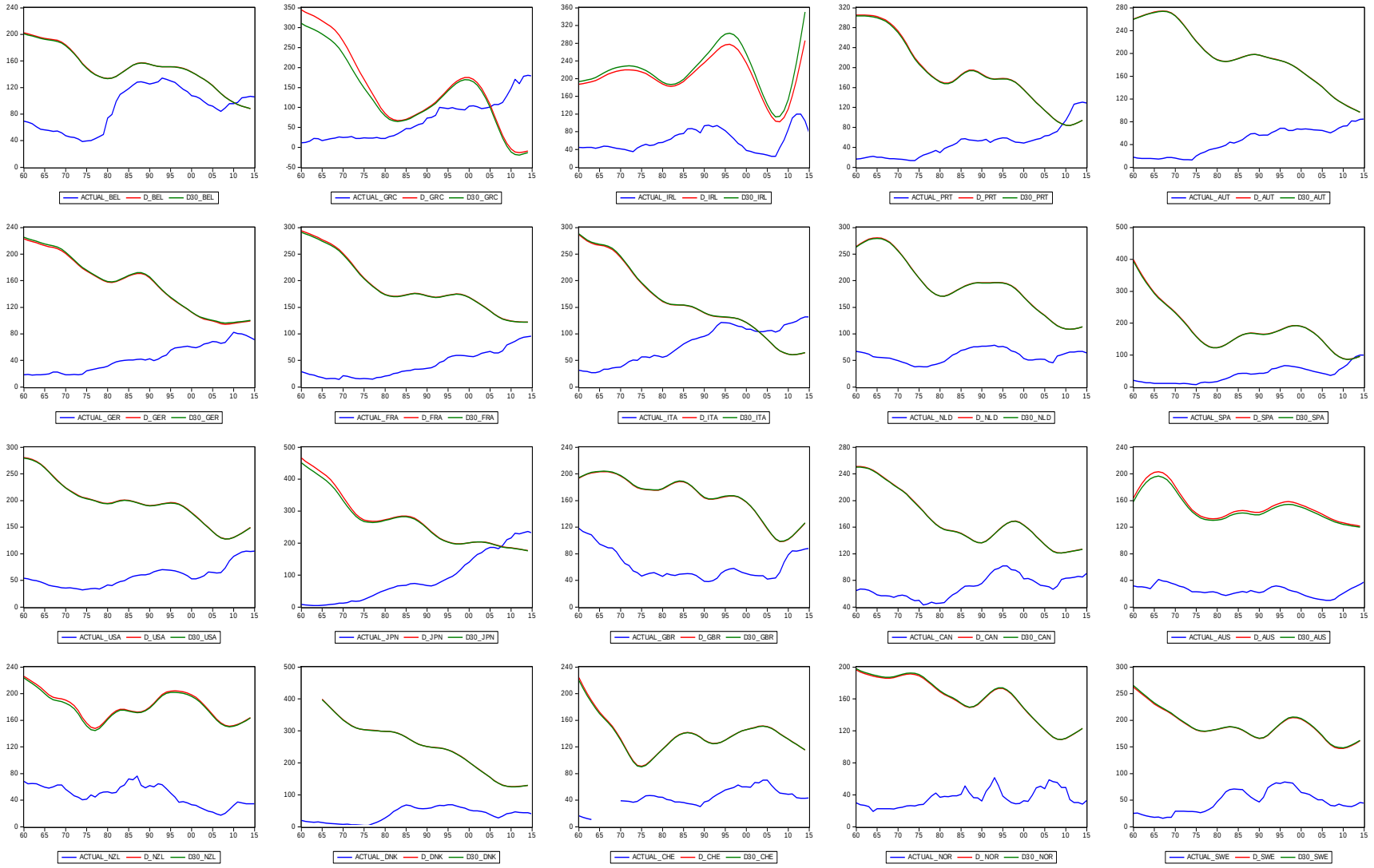
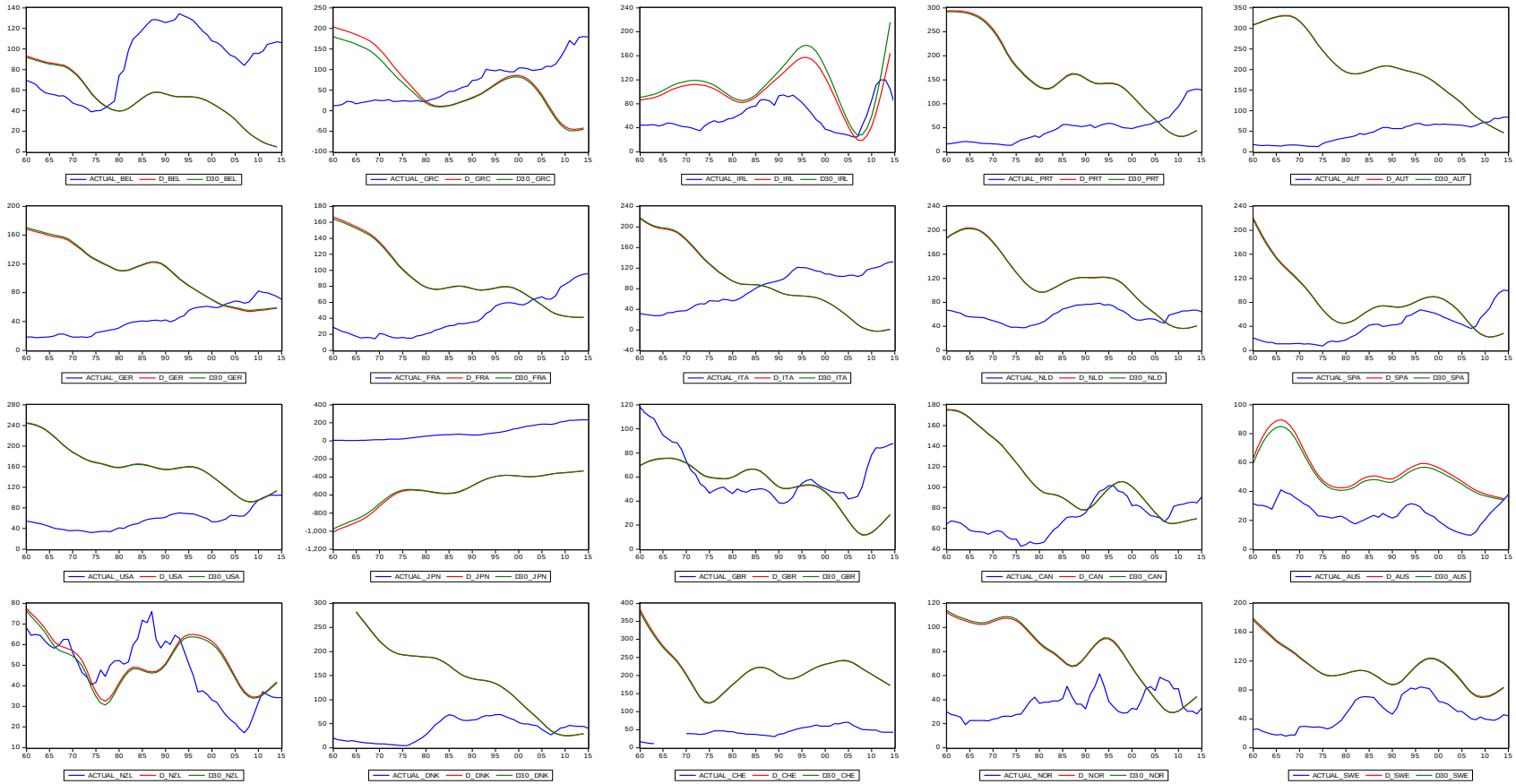


Figure B.7. Actual and simulated potential public debt corresponding to financing the potential public capital and an extra 20% of actual tax revenues



General Conclusion

The aim of this thesis was to examine the relationship between public debt and economic growth, particularly the impact of the former on the latter. Although this issue was mainly debated in the post-war era, leading to a variety of theoretical models involving the long-term effects of public debt, as well as the short-term effects, the debate about this subject was revived for the advanced countries following the 2008 crisis. This thesis re-examined, first, the validity of Reinhart and Rogoff's (2010) conjecture of a common debt threshold, which stated that debt to GDP ratios above 90% reduce economic growth for a sample of advanced countries, thus creating a controversial debate among economists and policy-makers. Second, it assessed the short-term and, third, long-term effects of public debt on economic growth.

At this level, the methodology used the most recent advanced econometrics methods, focusing on the relationship between the two variables, based purely on the data-generating process and comparing it to a large body of empirical literature on this issue that flourished after the 2008 crisis (Chapter 1). Then, the relationship was analysed considering the economic channels through which public debt acts on economic growth, first, in the short term (Chapter 2) and, second, in the long term (Chapter 3). In the short term, as public debt is generated to finance government expenditure (including government investments), the public debt and economic growth linkages were examined by adopting a fiscal policy assessment framework invoking the expenditure multipliers. In the long term, public debt and economic growth are linked by adopting a theoretical framework of endogenous growth models.

The principal conclusions of our thesis lead us to reject the common debt ratio that applies to all countries for a sample of 20 advanced countries. It shows, specifically, that the relationship between public debt and economic growth is rather time- and country-specific. Furthermore, in a short-term framework, public debt accumulation and contraction have different impacts on economic growth through expenditure multipliers. The latter are also revealed in our thesis to be sensitive to other factors related to the business cycle (expansion, recession), the public debt ratio development (accumulation, contraction) and the coexistence of cross-cutting of these factors. In the long term, public debt is linked, in the context of the endogenous growth framework, to the macroeconomic fundamentals and public expenditure's productivity.

Specifically, Chapter 1 made important contributions to the empirical debate about a common public debt threshold that applies to all countries. Without claiming exhaustivity, this chapter summarized a large survey covering the main body of important empirical literature econometrically studying the relationship between public debt and economic growth, following the controversial paper of Reinhart and Rogoff (2010). Furthermore, the empirical contribution of Chapter 1 focused particularly on analysing a sample of 20 advanced economies, including 10 euro countries, considering a long period of analysis that goes back to 1880. In the first step, we ran a variety of panel regressions for an economic growth function as a quadratic polynomial of the

public debt ratio following Checherita and Rother (2010). In the second step Chapter 1 addressed the debt–growth link with a novel and innovative approach for individual countries using the Hansen (2017) "regression kink" method. This method has the power to detect endogenously the turning point between explained and explanatory variables compared to models fixing the exogenous threshold.

For the panel regressions, we used appropriate methods of estimations and tests to deal with several econometric issues such as endogeneity, sample bias, heterogeneity, non-linearity and reverse causality. Panel estimations were conducted varying the country sample, as well as considering sub-periods of time, by break points following world events occurring in the international system. All these analyses show that the debt–growth nexus changes widely over time and by sample countries. Furthermore, the revealed relationship is altered by data and cross-country heterogeneity. The heterogeneity decreases when omitting sizeable countries from the sample and is less manifested in the sample of 10 euro countries.

Applied to the debt and growth relationship by country, the regression kink method sorted out a variety of different curves depending on the country. Therefore, some countries could grow with high debt to GDP ratios, others could see their growth shrink from low debt ratios, while growth in others was insensitive to public debt. The study also reveals the instability of the relationship over time. Every country exhibits a different relationship by period, especially when the transition is between periods known for specific changes in the international monetary system.

All of the results in Chapter 1, whether panel regressions or Hansen (2017) regression kink, stand in contrast to the existence of a common threshold and its 90% value, as claimed by Reinhart and Rogoff (2010). It not only argues against the 90% threshold value but also clearly rejects any common threshold. The threshold, whenever it exists, is country-specific rather than following a common rule to fit all. Consequently, as the public debt and economic growth relationship is country-specific (one size does not fit all), the main recommendation of Chapter 1 is for more investigation using models based on theory to study the effects of public debt on economic growth considering the economic properties and fundamentals.

Chapter 2 was dedicated, in particular, to examining the relationship between public debt and economic growth in the short term, through Keynesian multipliers. Specifically, we studied the impact of public debt accumulation on the size of the expenditure multipliers, as well as the effects of the business cycle. We adopted, in this chapter, the structural vector autoregressive (SVAR) methodology, running a panoply of bi-variates and tri-variate SVAR models on quarterly data for a sample of 18 OECD countries with different exchange rate regimes, monetary policies and degrees of openness. Besides, we estimated an SVAR with six fiscal and monetary variables for the United States to highlight the channels by which public debt affects economic growth. In all the above-mentioned SVAR models, we controlled for business cycle and public debt movement effects to deduce spending multipliers for these cases.

The results show that, controlling for business cycle effects, the expenditure multipliers are much higher in times of recession than times of expansion. Moreover, our results do not support the general tendency of spending multipliers being weak, and even negative, as revealed by some researchers, in recent decades compared to the 1960s, 1970s and 1980s. The previous results are in line with what was observed in the recent literature regarding fiscal multipliers, in advanced economies, namely, being large in times of recession and weak, or even negative, in times of expansion. Furthermore, controlling exogenously for public debt movements, independent of the business cycle, it was revealed that spending multipliers are larger in periods of debt accumulation than in debt contraction periods. Also, jointly controlling exogenously for debt movements and the business cycle reveals that multipliers are higher under debt accumulation in cases of expansion and recession. However, introducing endogenously the public debt to GDP variable in an SVAR leads to higher multipliers in recessions than expansions.

Furthermore, the main results of the United States model show that government expenditure has positive but short-lived effects on economic growth. Furthermore, the public debt crowds out private investment, leading to a lowering growth rate in times of expansion, while in times of recession the public debt effects on growth are positive. This crowding-out effect may play *pass-through* to the expenditure multipliers and could explain, *ceteris paribus*, the weak size of spending multipliers, while in times of recession the crowing-in effect leads to higher multipliers.

In the panoply of SVAR models considered in Chapter 2, it was noted that recession periods generally have a persistent effect on variables for which convergence to the long-term path following the shock is achieved more slowly compared to expansion time. The policy implication of this is that fiscal stimulus effects could take time to materialize in depressed economies, while the effects could be short-lived in times of expansion, which should be considered by policy-makers in their spending decisions.

As the public debt and growth relationship also involves long-term effects, Chapter 3 extends the investigation of the public debt effects in relation to the role of theory-based models of public debt on long-term economic growth, considering country-specific fundamentals. Therefore, an endogenous growth model was adopted for the same sample studied in Chapter 1, constituted by 20 developed countries. Specifically, a Cobb-Douglas production function was augmented by the stock of public capital and linked to a public debt equation through the productivity of public capital. Therefore, theoretical formulae and empirical simulations were derived based on this framework. For the theoretical results, we concluded that, in an endogenous growth framework, with the Cobb-Douglas production function encompassing public capital instead of government flows, the potential productive government investment is an endogenous parameter of economic growth and public capital productivity.

Furthermore, we simulated a parameterized formula for a potential/limit debt that a country could target to finance its productive investments. This potential, linked to economic growth and public

capital productivity, as well as the interest rate, is dynamic, country- and time-specific and has a tendency to evolve in contrast to the actual accumulated public debt. This, in particular, responds to the main recommendation made in Chapter 1, that the public debt threshold is time- and country-specific, which should be studied considering a country's economic fundamentals. It also responds to the caveats of the research highlighted in Chapter 1, which set and tested, in particular, the exogenous values of thresholds.

Moreover, the results of Chapter 3 show that the simulated public debt drops under the actual levels of debt in times of crisis for many advanced countries that are severely affected by the crisis. This has a clear message regarding policy recommendation that countries are safer from threats of public debt as long as the potential debt (simulated/targeted) stays higher than the actual public debt. The results show that many countries are under stress of public debt, especially after the financial crisis of 2008. For some countries, such as Ireland, this stress is short-lived, and the potential debt quickly remains higher than the actual one following economic recovery. However, for many other countries, the effects are prolonged. The potential debt also revealed that some countries (Greece, Belgium and Italy) had debt issues in periods before the 2008 crisis.

The added value of Chapter 3 is that the debt limit is an endogenous parametrized function linked to the economic returns (productivity) of public capital financed by such issued debt. The potential public expenditure series shows a decreasing trend over time, albeit still higher than the observed one in many countries of the sample. This is driven by the general decreasing trend of public capital stock productivity, especially in the great moderation era (1986–2007). The policy message to increase potential public expenditure, and hence the targeted potential debt, is to enhance such productivity. To rephrase Krugman's (1994) statement about the importance of productivity in the long term, "*productivity isn't everything, but in the long run it is almost everything*". Productivity enhancement could be achievable through the choice of higher productive public capital, which implies selective public capital projects with higher output multipliers.

Across the three chapters, the thesis counters any common debt ratio threshold that applies to all countries. The subject of growth and public debt remains one of the most debated subjects in fiscal policy after the 2008 financial crisis. This importance will continue, and we expect more research about it in the medium and long term in relation to many current events. Indeed, the current sanitary crisis of 2020, qualified by many politicians as a time of war because of the harsh measures of emergencies and confining and locking down populations, leads to hibernation of almost all economic sectors for months. Consequently, all the experts and national and international forecasting institutions are at least unanimous about the inevitable recessions, if not prolonged depressions, in the world and in almost all economies of advanced, emergent and developing countries. All government financial measures (monetary and fiscal), which are likely to deepen the deficits and increase public debt levels, once combined with a shrinkage in GDP, lead to soaring ratios of public debt. In this way, some economists expect public debt ratios to jump for many countries by 20 to 40 percentage points of GDP. Historical examples, according to Kose et al.

(2020), show similar differences in accumulated debt to GDP ratios, comparing before and after the crises, where, for example, it reached approximately 31% and 35%, respectively, for Indonesia and Thailand in the 1997 financial crisis, and around 27% and 38%, respectively, for Latvia and Ireland in the 2008 financial crisis. The recovery and economic growth levels, which are highly uncertain, are conditioned by the prolonged measures, depending on the evolution of the Covid-19 pandemic and the development of a vaccine.

In the current trend, fiscal policy, which was subordinated to monetary policy in the Great Moderation (1986–2007) has, since the 2008 crisis, become active and is leading the scene. The Covid-19 crisis will lead to greater involvement of fiscal policy; in particular, the conventional monetary policy has already reached its limit in using the conventional framework, particularly in many advanced economies, where nominal interest rates are reaching, or near to reaching, the zero lower bound. Although some views postulate that the trend of low interest rates is in favour of reduced public debt costs, which seems to point to a sustainable public debt path around higher levels, the threat of reverting the interest rates path in response to expected inflation in the future in an environment of low economic growth would plunge many highly-indebted countries into other waves of unsustainable and sovereign debt crisis.

Therefore, research on fiscal policy, and particularly the public debt overhang issues and economic growth, is likely to remain hotly debated for a long time to come. Many questions are, hence, worth raising regarding public debt and economic growth in the post-Covid-19 economic crisis. These include studying many conflictual objectives of fiscal policy aimed at saving jobs, as well as rescuing firms from bankruptcy, and raising growth, hence, countries' revenues in the short term, while dealing with the subsequent effects of raising public debt, particularly in the medium to long term. Moreover, the nature of the current economic crisis is likely to raise many issues in economic policies. An example revealed by the 2008 crisis is that fiscal multipliers are sensitive to the business cycle and many other determinants related to countries' economic fundamentals. The current crisis is qualified as a dual shock of demand and supply shocks, which may have an important impact on the global macroeconomic framework, and particularly on the fiscal policy framework. Therefore, modelling public debt and fiscal policy effects may fall outside the regular traditional framework. At the country level, many challenges and coordination issues may seem to be highly solicited, and their effects should be assessed, especially across the eurozone.

References

Abbas A., Basdevant O., Eble S., Everaert G., Gottschalk J., Hasanov F., Park J., Sancak C., Velloso R. and Villafuerte M. 2010. "Strategies for Fiscal Consolidation in the Post-Crisis World", IMF Fiscal Affairs Department, International Monetary Fund.

Abbas S. A., Belhocine N., ElGanainy A. and Horton M. 2010, "A Historical Public Debt Database", IMF working paper 10-245, International Monetary Fund.

Acemoglu D. and Robinson J. A. 2010. "The Role of Institutions in Growth and Development", Review of Economics and Institutions, vol. 1(2), pp. 1-33.

Acemoglu D., Johnson S. and Robinson J. A. 2001. "The Colonial Origins of Comparative Development: An Empirical Investigation", American Economic Review, vol. 91(5), pp. 1369-1401.

Afonso A. and Leal S. 2018. "Fiscal Multipliers in the Eurozone: A SVAR analysis", REM working paper 047.

Ahiakpor J. C. W. 2013. "the Modern Ricardian Equivalence Theorem: Drawing the Wrong Conclusions from David Ricardo's Analysis", Journal of the History of Economic Thought, vol. 35(1), pp. 77-92.

Aiyagari S. R. 1985. "Deficits, interest rates, and the tax distribution", Quarterly Review, Federal Reserve Bank of Minneapolis, vol. 9(1), pp. 5-14.

Aiyagari S. R. 1989. "Equilibrium existence in an overlapping generations model with altruistic preferences", Journal of Economic Theory, vol. 47(1), pp. 130-152.

Aiyagari S. R., Marcet A., Sargent, T. and Seppala J. 2002. "Optimal Taxation without State-Contingent Debt", Journal of Political Economy, vol. 110(6), pp. 1220-1254.

Aiyar S. and Feyrer J. 2002. "A Contribution to the Empirics of Total Factor Productivity", Dartmouth College working paper.

Aizenman J. and Pasricha G. K. 2011. "Net Fiscal Stimulus During the Great Recession", NBER working paper 16779, National Bureau of Economic Research.

Alesina A. and Passalacqua A. 2015. "The Political Economy of Government Debt", NBER working paper 21821, National Bureau of Economic Research.

Alesina A. and Perotti R. 1994. "The Political Economy of Budget Deficits", NBER working paper 4637, National Bureau of Economic Research.

Alesina A. and Tabellini G. 1990. "A positive theory of fiscal deficits and government debt", Review of Economic Studies, vol. 57(3), pp. 403-414.

Alesina A., Favero C. and Giavazzi F. 2015. "The output effect of fiscal consolidation plans", Journal of International Economics, vol. 96, pp. 19-42.

Alichi A., Shibata I. and Tanyeri K. 2019. "Fiscal Policy Multipliers in Small States", IMF working paper 19/72, International Monetary Fund.

Ando M. 2017. "How much should we trust regression-kink-design estimates?", Empirical Economics, vol. 53, pp. 1287-1322.

Aoki M. 2007. "Endogenizing institutions and institutional changes", Journal of Institutional Economics, vol. 3(1), pp. 1-31.

Arin K. P., Koray F. and Spagnolo N. 2015. "Fiscal multipliers in good times and bad times", Journal of Macroeconomics, vol. 44, pp. 303-311.

Arrow K. J. 1962. "The Economic Implications of Learning by Doing", Review of Economic Studies, vol. 29, pp. 155-173.

Arrow K. J. and Kurz M. A. 1970. "Public Investment, the Rate of Return, and Optimal Fiscal Policy", Baltimore, Johns Hopkins University Press.

Aschauer D. 2000. "Do states optimize? Public capital and economic growth", The Annals of Regional Science, vol. 34(3), pp. 343-363.

Athey S. and Imbens G. W. 2017. "The State of Applied Econometrics: Causality and Policy Evaluation", The Journal of Economic Perspectives, vol. 31(2), pp. 3-32.

Auerbach A. J. and Gorodnichenko Y. 2012. "Measuring the Output Responses to Fiscal Policy", American Economic Journal: Economic Policy, vol. 4, pp. 1-27.

Auerbach A. J. and Gorodnichenko Y. 2013. "Fiscal Multipliers in Recession and Expansion" in Fiscal Policy after the Financial Crisis, Alberto Alesina and Francesco Giavazzi, eds., University of Chicago Press.

Auerbach A. J. and Gorodnichenko Y. 2017. "Fiscal Stimulus and Fiscal Sustainability", NBER working paper 23789, National Bureau of Economic Research.

Auerbach A. J., Gorodnichenko Y. and Murphy D. 2019. "Local Fiscal Multipliers and Fiscal Spillovers in the United States", IMF Economic Review, vol. 68, pp. 195-229.

Aussilloux V., Gouardo C. and Lenglart F. 2018. "Baisser le poids des dépenses publiques : les leçons de l'expérience des pays européens", Note d'analyse 74, France Stratégie.

Bachmann R. and Sims E. R. 2012. "Confidence and the transmission of government spending shocks", Journal of Monetary Economics, vol. 59, pp. 235-249.

Baglan D. and Yoldas E. 2013. "Government debt and macroeconomic activity: a predictive analysis for advanced economies", Finance and Economics Discussion Series, 05, Federal Reserve Board.

Baldacci E., Gupta S. and Mulas-Granados C. 2009. "How effective is fiscal policy response in systemic banking crises?", IMF working paper 09/160, International Monetary Fund.

Barnichon R. and Matthes C. 2017. "Understanding the Size of the Government Spending Multiplier: It's in the Sign", Federal Reserve Bank of Richmond, Working Paper No. 17-15.

Barrell R., Holland D. and Hurst I. 2012. "Fiscal Consolidation: Part 2. Fiscal Multipliers and Fiscal Consolidations," OECD Economics Department Working Paper No. 933, OECD, Paris.

Barro R. J. 1974. "Are Government Bonds Net Wealth?", Journal of Political Economy, vol. 82(6), pp. 1095-1117.

Barro R. J. 1976. "Perceived wealth in bonds and social security and the Ricardian equivalence theorem: Reply to Feldstein and Buchanan", Journal of Political Economy, vol. 84(2), pp. 343-350.

Barro R. J. 1979. "On the determination of the public debt", Journal of Political Economy, vol. 87(5), pp. 940-971.

Barro R. J. 1990. "Government spending in a simple model of endogeneous growth", Journal of Political Economy, vol. 98(S5), pp. 103-125.

Barro R. J. 1996. "Democracy and Growth", Journal of Economic Growth, vol. 1(1), pp. 1-27.

Barro R. J. and Lee J. W. 1993. "International comparisons of educational attainment", Journal of Monetary Economics, vol. 32(3), pp. 363-394.

Barro R. J. and Lee J. W. 2013. "A new data set of educational attainment in the world, 1950–2010", Journal of Development Economics, vol. 104, pp. 184-198.

Barro R. J. and Redlick C. J. 2011. "Macroeconomic Effects from Government Purchases and Taxes", Quarterly Journal of Economics, vol. 126(1), pp. 51-102.

Barro R. J. and Sala-i-Martin X. 1992. “Convergence”, Journal of Political Economy, vol. 100(2), pp. 223-251.

Barro R. J. and Sala-i-Martin X. 1997. “Technological Diffusion, Convergence, and Growth”, Journal of Economic Growth, vol. 2(1), pp. 1-26

Barro R. J. and Sala-i-Martin X. 2003. Economic Growth, 2nd edition, MIT Press.

Barta Z. 2018. “In the Red: The Politics of Public Debt Accumulation in Developed Countries”, Ann Arbor: University of Michigan Press.

Batini N., Callegari G. and Melina G. 2012. “Successful Austerity in the United States, Europe and Japan”, IMF working paper 12/190, International Monetary Fund.

Batini N., Eyraud L., Forni L. and Weber A. 2014. “Fiscal Multipliers: Size, Determinants, and Use in Macroeconomic Projections”, Technical Notes and Manuals 14/04.

Baum A. and Koester G.B. 2011. “The Impact of Fiscal Policy on Economic Activity over the Business Cycle: Evidence from a Threshold VAR Analysis”, Bundesbank Discussion Paper, 03/2011.

Baum A., Poplawski-Ribeiro M. and Weber A. 2012. “Fiscal Multipliers and the State of the Economy”, IMF working paper 12/286, International Monetary Fund.

Baum A., Checherita-Westphal C. and Rother P. 2013. “Debt and growth: New evidence for the euro area”, Journal of International Money and Finance, vol. 32(1), pp. 809-821.

Benhabib J. and Spiegel M. 1994. “The roles of human capital in economic development: evidence from aggregate cross-country data”, Journal of Monetary Economics, vol. 34, pp. 143-173.

Benigno P. and Woodford M. 2003. “Optimal Monetary and Fiscal Policy: A Linear Quadratic Approach”, NBER working paper 9905, National Bureau of Economic Research.

Bentour E. M. 2018. “On the public debt and growth threshold: one size does not necessarily fit all”, Cahier de recherche du Creg, n° 2018.01, Université Grenoble Alpes.

Bentour E. M. 2020. “Government Expenditure Multipliers Under Oil Price Swings”, AMF working paper series, Arab Monetary Fund.

Bentour E. M. and Razzak W. A. 2013. “Do developing countries benefit from foreign direct investments? An analysis of some Arab and Asian countries”, Review of Middle East Economics and Finance, vol. 9(3), pp. 357-388.

Bernanke B. 1986. “Alternative Explanations of the Money–Income Correlation”, Carnegie Rochester Conference Series on Public Policy, vol. 25, pp. 49–99.

Bernanke B. 2004. “The Great Moderation”, Remarks before the Meetings of the Eastern Economic Association, Washington, D.C., February 20.

Berti K., De Castro F. and Salto M. 2013. “Effects of fiscal consolidation envisaged in the 2013 Stability and Convergence Programmes on public debt dynamics in EU Member States”, Economic Papers 504.

Bi H., Shen W. and Yang S. S. 2016. “Debt-dependent effects of fiscal expansions”, European Economic Review, vol. 88, pp. 142-157.

Blanchard O. 1985. “Debt, Deficits, and Finite Horizons”, Journal of Political Economy, vol. 93(2), pp. 223-247.

Blanchard O. 2006. “Comments on Alan Blinder’s ‘The Case Against the Case Against Discretionary Policy’”, in the Macroeconomics of Fiscal Policy, ed. Richard W. Kopcke, Geoffrey M.B. Tootell, and Robert K. Triest, pp. 63-67. Cambridge, MA: The MIT Press.

Blanchard O. 2018. “On the future of macroeconomic models”, Oxford Review of Economic Policy, vol. 34(1-2), Spring-Summer, pp. 43-54.

Blanchard O. 2019. “Public Debt and Low Interest Rates”, American Economic Review, vol. 109(4), pp. 1197-1229.

Blanchard O. and Perotti R. 2002. “An Empirical Characterization of the Dynamic Effects of Changes in Government Spending and Taxes on Output”, Quarterly Journal of Economics, vol. 117(4), pp. 1329-1368.

Blanchard O. and Quah D. 1989. “The Dynamic Effects of Aggregate Demand and Supply Disturbances”, American Economic Review, vol. 79, pp. 655-673.

Bloom N., Jones C. I., Van Reenen J. and Webb M. 2019. “Are Ideas Getting Harder to Find?”, NBER working paper 23782, National Bureau of Economic Research.

Blot C., Cochard M., Creel J., Ducoudré B., Schweisguth D. and Timbeau X. 2014a. “Fiscal Consolidation in Times of Crisis: is the Sonner Really the Better?”, Revue de l’OFCE, vol. 132, pp. 159-192.

Blot C., Cochard M., Creel J., Ducoudré B., Schweisguth D. and Timbeau X. 2014b. “Fiscal Consolidation, Public Debt and Output Dynamics in the Euro Area: lessons from a simple model with time-varying fiscal multipliers”, Revue d’Économie Politique, vol. 124, pp. 953-989.

Borensztein E., De Gregorio J. and Lee J-W. 1998. "How does foreign direct investment affect economic growth?", Journal of International Economics, vol. 45(1), pp. 115-135.

Boussard J., De Castro F. and Salto M. 2012. "Fiscal Multipliers and Public Debt Dynamics in Consolidations", European Commission Economic Papers 460, European Commission.

Bräuninger M. 2005. "The Budget Deficit, Public Debt, and Endogenous Growth", The Journal of Public Economic Theory, vol. 7(5), pp. 827-840.

Breusch T. S. and Pagan A. R. 1980. "The Lagrange Multiplier Test and its Application to Model Specifications in Econometrics", Review of Economic Studies, vol. 47(1), pp. 239-253.

Broner F., Clancy D., Martin A. and Erce A. 2019. "Fiscal Multipliers and Foreign Holdings of Public Debt", ECB working paper 2255, European Central Bank.

Buchanan J. 1976. "Barro on the Ricardian Equivalence Theorem", Journal of Political Economy, vol. 84(2), pp. 337-42.

Buiter W. H. 1988. "Death, Birth, Productivity Growth and Debt Neutrality", The Economic Journal, vol. 98(391), pp. 279-93.

Caggiano G., Nodari G. and Castelnuovo E. 2015. "Estimating Fiscal Multipliers: News from a Non-linear World", The Economic Journal, vol. 125(584), pp. 746-776.

Caner M., Grennes T. and Koehler-Geib F. 2010. "Finding the tipping point when sovereign debt turns bad", World Bank Policy Research working paper 5391, World Bank.

Canova F. and De Nicolò G. 2002. "Monetary Disturbances Matter for Business Fluctuations in the G-7", Journal of Monetary Economics, vol. 49(6), pp. 1131-1159.

Canzoneri M., Collard F., Dellas H. and Diba B., 2015. "Fiscal multipliers in recessions", The Economic Journal, vol. 126, pp. 75-108.

Card D., Lee D. S., Pei Z. and Weber A. 2012. "Nonlinear Policy Rules and the Identification and Estimation of Causal Effects in a Generalized Regression Kink Design", NBER working paper 18564, National Bureau of Economic Research.

Card D., Lee D. S., Pei Z. and Weber A. 2017. "Regression Kink Design: Theory and Practice", in Matias D. Cattaneo, Juan Carlos Escanciano (ed.), Regression Discontinuity Designs (Advances in Econometrics, volume 38), Emerald Publishing Limited, pp. 341-382.

Carlin W. and Soskice D. 2018. "Stagnant productivity and low unemployment: stuck in a Keynesian equilibrium", Oxford Review of Economic Policy, vol. 34(1-2), pp. 169-194.

Casalis A., 2017. “Non-linear effects of the financial cycle on fiscal multipliers”, nonpublished, University of York.

Cass D. 1965. “Optimum Growth in an Aggregate Model of Capital Accumulation”, Review of Economic Studies, vol. 32(3), pp. 233-240.

Cecchetti S. G., Mohanty M. S. and Zampolli F. 2011. “The real effects of debt”, BIS working paper 352, Bank for International Settlements.

Chapple S. 1997. “One for the X-files: A critical assessment of Professor Scully’s ‘Taxation and economic growth in New Zealand’”, Report to the Periodic Report Group, New Zealand Institute of Economic Research, Wellington, November.

Chari V. V., McGrattan E. R. and Kehoe P. J. 2009. “The New Keynesian Models: Not Yet Useful for Policy Analysis”, American Economic Journal: Macroeconomics, vol. 1(1), pp. 242-266.

Chatelain J-B. and Ralf K. 2012. “The Failure of financial macroeconomics and what to do about it”, The Manchester School, vol. 80, pp. 21-53.

Checherita C. and Rother P. 2010. “The impact of high and growing government debt on economic growth: an empirical investigation for the Euro area”, ECB working paper 1237, European Central Bank.

Chen F. 2007. “Sensitivity of Goodness of Fit Indexes to Lack of Measurement Invariance”, Structural Equation Modeling: A Multidisciplinary Journal, vol. 14(3), pp. 464-504.

Chen C., So M. and Liu F. 2011. “A review of threshold time series models in finance”, Statistics and Its Interface, vol. 4, pp. 167-181.

Cherif R. and Hasanov F. 2017. “Public debt dynamics: the effects of austerity, inflation, and growth shocks”, Empirical Economics, vol. 54(1), pp. 1087-1105.

Chinn M. 2013. “Fiscal Multipliers”, The New Palgrave Dictionary of Economics, Steven N. Durlauf and Lawrence E. Blume, eds. Palgrave Macmillan.

Christiano L. J., Eichenbaum M. and Evans C. L. 2005. “Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy”, Journal of Political Economy, vol. 113(1), pp. 1-45.

Christiano L., Eichenbaum M. and Rebelo S. 2011. “When Is the Government Spending Multiplier Large?”, Journal of Political Economy, vol. 119(1), pp. 78-121.

Christiano L. J., Eichenbaum M. S. and Trabandt M. 2018. “On DSGE Models”, Journal of Economic Perspectives, vol. 32(3), pp. 113-140.

Chudik A., Mohaddes K., Pesaran M. H. and Raissi M. 2017. "Is there a debt-threshold effect on output growth?", Review of Economics and Statistics, vol. 99(1), pp. 135-150.

Clark T. 2009. "Is the Great Moderation Over? An Empirical Investigation", Economic Review, Federal Reserve Bank of Kansas City, pp. 5-42.

Coenen G., Erceg C. J., Freedman C., Furceri D., Kumhof M., Lalonde R., Laxton D., Lindé J., Mourougane A., Muir D., Mursula S., de Resende C., Roberts J., Roeger W, Snudden S, Trabandt M. and Veld J. 2012. "Effects of Fiscal Stimulus in Structural Models", American Economic Journal: Macroeconomics, vol. 4(1), pp. 22-68.

Cogan J. F. and Taylor J. B. 2012. "What the Government Purchases Multiplier Actually Multiplied in the 2009 Stimulus Package", in Government Policies and the Delayed Economic Recovery, Lee Ohanian, John B. Taylor, Ian Wright (eds.) Hoover Press, Stanford, pp. 85-114.

Cogan J. F., Cwik T., Taylor J. B. and Wieland V. 2010. "New Keynesian versus old Keynesian government spending multipliers", Journal of Economic Dynamics and Control, vol. 34(10), pp. 281-295.

Cogan J. F., Taylor J. B., Wielend V. and Wolters M. 2013. "Fiscal Consolidation Strategy", Journal of Economic Dynamics and Control, vol. 37(2), pp. 404-421.

Cole H. and Ohanian L. 2004. "New Deal Policies and the Persistence of the Great Depression: A General Equilibrium Analysis", Journal of Political Economy, vol. 112(4), pp. 779–816.

Colletaz G. and Hurlin, C. 2006, "Threshold effects of the public capital productivity: An international panel smooth transition approach", working paper 2006-01, Laboratoire d'économie d'Orleans.

Combes J. L., Minea A., Mustea L. and Sow N. M. 2014. "The Euro and the Crisis: Evidence on Recent Fiscal Multipliers", Revue d'Économie Politique, vol. 124(6), pp. 1013-1038.

Cooley T. and LeRoy S. 1985. "A-theoretical macroeconomics: A critique", Journal of Monetary Economics. vol. 16, pp. 283-308.

Correia I., Farhi E., Nicolini J.P. and Teles P. 2012. "Unconventional Fiscal Policy at the Zero Bound".

Corsetti G. and Roubini N. 1996. "Optimal Government Spending and Taxation in Endogenous Growth Models", NBER working paper 5851, National Bureau of Economic Research.

Corsetti G., Meier A. and Müller G. J. 2012. "What Determines Government Spending Multipliers?", IMF Working Paper 12/150, International Monetary Fund.

Corsetti G., Kuester K., Meier A. and Müller G. J. 2013. "Sovereign risk, fiscal policy, and macroeconomic stability", Economic Journal, vol. 123, pp. 99-132.

Cukierman A. and Meltzer A. H. 1989. "A Political Theory of Government Debt and Deficits in a Neo-Ricardian Framework", American Economic Review, vol. 79(4), pp. 713-32.

Curdia V. and Woodford M. 2016. "Credit Frictions and Optimal Monetary Policy", Journal of Monetary Economics, vol. 84, pp. 30-65.

De la Croix D. and Michel P. 2010. A Theory of Economic Growth: Dynamics and Policy in Overlapping Generations, Cambridge University Press.

DeLong J. B. and Summers L. 2012. "Fiscal Policy in a Depressed Economy", Brookings Papers on Economic Activity, vol. 43(1), pp. 233-297.

Denton F. T. 1971. "Adjustment of Monthly or Quarterly Series to Annual Totals: An Approach Based on Quadratic Minimization", Journal of the American Statistical Association, vol. 66, pp. 99–102.

Desai M. 1981. "Testing Monetarism", Frances Pinter (Publishers) Ltd., London.

Di Sanzo S. and Bella M. 2015, "Public debt and growth in the Euro area: evidence from parametric and nonparametric Granger causality", The B.E. Journal of Macroeconomics, vol. 15(2), pp. 631-648.

Diamond P. A. 1965. "National Debt in a Neoclassical Growth Model", American Economic Review, vol. 55(5), pp. 1126-1150.

Easton B. 1999. "The whimpering of the state. Policy after MMP", Auckland, University of Auckland Press.

Eberhardt M. and Presbitero A. F. 2015. "Public debt and growth: Heterogeneity and non-linearity", Journal of International Economics, vol. 97(1), pp. 45-58.

Egert B. 2015. "The 90% public debt threshold: the rise and fall of a stylized fact", Applied Economics, vol. 47(34-35), pp. 3756-3770.

Eggertsson G. B. 2011. "What fiscal policy is effective at zero interest rates?", NBER Macroeconomics Annual, vol. 25, pp. 59-112.

Eggertsson G. B. and Woodford M. 2003. "The Zero Bound on Interest Rates and Optimal Monetary Policy", Brookings Papers on Economic Activity, vol. 1, pp. 139-211.

Egron B. 2018. “Réduction du ratio de dette publique : quels instruments pour quels effets ?”, working paper 2018-1, EconomiX.

Elmendorf D. and Mankiw N. 1999. “Government Debt”, in Taylor, J. and Woodford, M. (eds.), Handbook of Macroeconomics, 1C, pp. 1615-1669, North-Holland.

Erceg C. J. and Lindé J. 2012. “Fiscal Consolidation in an Open Economy”, American Economic Review, vol. 102(3), pp. 186-191.

Estevão M. and Samake I. 2013. “The Economic Effects of Fiscal Consolidation with Debt Feedback”, IMF working paper 13/136, International Monetary Fund.

European Commission. 2012. “Report on Public finances in European Monetary Union -2012”, European Economy Number 4/2012 (the report could be accessed online from the link: https://ec.europa.eu/economy_finance/publications/european_economy/2012/pdf/ee-2012-4.pdf).

European Commission. 2013. “Study on the impacts of fiscal devaluation”, Taxation papers n. 36.

Eyraud L. and Weber A. 2013. “The Challenge of Debt Reduction during Fiscal Consolidation”, IMF working paper 13/67, International Monetary Fund.

Farhi E. and Werning I. 2017. “Fiscal Multipliers: Liquidity Traps and Currency Unions”, in Handbook of Macroeconomics 2, pp. 2417-2492.

Farhi E., Gopinath G. and Itskhoki O. 2013. “Fiscal Devaluations”.

Faust J. 1998. “The Robustness of Identified VAR Conclusions about Money”, Carnegie Rochester Conference Series on Public Policy, vol. 49(1), pp. 207-244.

Fazzari S., Morley J. and Panovska I. 2015. “State dependent effects of fiscal policy”, Studies in Nonlinear Dynamics and Econometrics, vol. 19, pp. 285-315.

Feldstein M. S. 1974. “Perceived Wealth in Bonds and Social Security: A Comment”, Journal of Political Economy, vol. 84(2), pp. 331-36.

Ferguson T. and Johnson R. 2011. “A world upside down? Deficit fantasies in the great recession”, International Journal of Political Economy, vol. 40(1), pp. 3-47.

Feyrer J. and Sacerdote B. 2013. “How Much Would US Style Fiscal Integration Buffer European Unemployment and Income Shocks? (A Comparative Empirical Analysis)”, American Economic Review, vol. 103(3), pp. 125-128.

Forni M. and Gambetti L. 2010. “Fiscal Foresight and the Effects of Government Spending”, CEPR Discussion Paper 7840.

Fotiou A. 2019. “Non-linearities and fiscal policy”, European University Institute Working Papers, MWP (2019/11), pp. 1-55.

Fox K. A. 1956. “Econometric Models of the United States”, Journal of Political Economy, vol. 64(2), pp. 128-142.

Freedman C., Kumhof M., Laxton D., Muir D. and Mursula S. 2010. “Global effects of fiscal stimulus during the crisis”, Journal of Monetary Economics, vol. 57, pp. 506-526.

Fuentes R. J. and Morales M. 2011. “On the measurement of Total Factor Productivity: A Latent Variable Approach”, Macroeconomic Dynamics, vol. 15, pp. 145-159.

Futagami K., Iwaisako T. and Ohdoi R. 2008. “Debt policy rule, productive government spending, and multiple growth paths”, Macroeconomic Dynamics, vol. 12, pp. 445-462.

Futagami K., Morita Y. and Shibata A. 1993. “Dynamic analysis of an endogenous growth model with public capital”, Scandinavian Journal of Economics, vol. 95, pp. 607-625.

Galí J. 1992. “How Well Does The IS-LM Model Fit Postwar U. S. Data?”, Quarterly Journal of Economics, vol. 107(2), pp. 709-738.

Galí J. 2018. “The State of New Keynesian Economics: A Partial Assessment”, Journal of Economic Perspectives, vol. 32(3), pp. 87-112.

Galí J., López-Salido J. D. and Vallés J. 2007. “Understanding the effects of Government Spending on Consumption”, European Economic Association Journal, vol. 5(1), pp. 227-270.

Ghironi F. 2018. “Macro needs micro”, Oxford Review of Economic Policy, vol. 34(1-2), pp. 195-218.

Ghosh A., Kim J., Mendoza E., Ostry J. and Qureshi M. 2013. “Fiscal Fatigue, Fiscal Space, and Debt Sustainability in Advanced Economies”, The Economic Journal, vol. 123(566), pp. F4-F30.

Ghosh S. and Mourmouras I. A. 2004a. “Endogenous growth, welfare and budgetary regimes”, Journal of Macroeconomics, vol. 26, pp. 623-635.

Ghosh S. and Mourmouras I. A. 2004b. “Debt, growth and budgetary regimes”, Bulletin of Economic Research, vol. 56, pp. 241 250.

Glocker C., Sestieri G. and Towbin P. 2019. “Time-varying fiscal spending multipliers in the UK”, working paper 643, Banque de France.

Gomez-Puig M. and Sosvilla-Rivero S. 2015. "On the bi-directional causal relationship between public debt and economic growth in EMU countries", IREA working paper 2015-12, Research Institute of Applied Economics.

Gomez-Puig M. and Sosvilla-Rivero S. 2017. "Heterogeneity in the debt-growth nexus: Evidence from EMU countries", IREA working paper 2017-06, Research Institute of Applied Economics.

Gonzales-Garcia J., Lemus A. and Mrkaic M. 2013. "Fiscal Multipliers in the ECCU", IMF working paper 13/117, International Monetary Fund.

Gonzalez A., Teräsvirta T. and van Dijk D. 2005. "Panel smooth transition regression models", SEE/EFI working paper series in Economics and Finance, No. 604.

Gordon R. J. and Krenn R. 2010. "The End of the Great Depression 1939-41: Policy Contributions and Fiscal Multipliers", NBER working paper 16380, National Bureau of Economic Research.

Gorodnichenko Y., Mendoza E. and Tesar L. 2012. "The Finnish Great Depression: From Russia with Love", American Economic Review, vol. 102(4), pp. 1619-44.

Gossé J.-B. and Guillaumin C. 2013. "L'apport de la représentation VAR de Christopher A. Sims à la science économique", L'Actualité économique, Revue d'analyse économique, vol. 89(4), pp. 305-319.

Greiner A. 2007. "An endogenous growth model with public capital and sustainable government debt", Japanese Economic Review, vol. 58(3), pp. 345-361.

Greiner A. 2011. "Economic Growth, Public Debt and Welfare: Comparing Three Budgetary Rules", German Economic Review, vol. 12(2), pp. 205-222.

Greiner A. 2012. "Public debt in a basic endogenous growth model", Economic Modelling, vol. 29(4), pp. 1344-1348.

Greiner A. 2014. "Fiscal and Monetary Policy in a Basic Endogenous Growth Model", Computational Economics, vol. 45(2), pp. 285-301.

Greiner A. 2015. "Public Debt, Productive Public Spending and Endogenous Growth", Japanese Economic Review, vol. 66(4), pp. 520-535.

Greiner A. 2016. "Human capital formation and public debt: growth and welfare effects of three different deficit policies", Journal of Economic Policy Reform, vol. 19(4), pp. 369-385.

Greiner A. and Semmler W. 1999. "An endogenous growth model with public capital and government borrowing", Annals of Operations Research, vol. 88, pp. 65-79.

Greiner A. and Semmler W. 2000. "Endogenous growth, government debt and budgetary regimes", Journal of Macroeconomics, vol. 22(3), pp. 363-384.

Grilli V., Masciandaro D., Tabellini G., Malinvaud E. and Pagano M. 1991. "Political and Monetary Institutions and Public Financial Policies in the Industrial Countries", Economic Policy, vol. 6(13), pp. 341-392.

Grossman G. M. and Helpman E. 1991. "Quality Ladders in the Theory of Growth", The Review of Economic Studies, vol. 58(1), pp. 43-61.

Haldane A. G. and Turrell A. E. 2018. "An interdisciplinary model for macroeconomics", Oxford Review of Economic Policy, vol. 34(1-2), pp. 219-251.

Hall R. 2009. "By how much does GDP rise if the Government buys more output?", Brookings Papers on Economic Activity, vol. 2, pp. 183-231.

Hansen B. E. 2017. "Regression Kink with an Unknown Threshold", Journal of Business and Economic Statistics, vol. 35(2), pp. 228-240.

Hansen A. H. 1959. "The Public Debt Reconsidered: A Review Article", Review of Economics and Statistics, vol. 41(4), pp. 377-78.

Hansen B. E. 1999. "Threshold effects in non-dynamic panels: estimation, testing, and inference", Journal of Econometrics, vol. 93(2), pp. 334-368.

Hansen B. E. 2000. "Sample splitting and threshold estimation", Econometrica, vol. 68, 575-603.

Haslag J. H. and Young E. R. 1998. "Money creation, reserve requirements, and seigniorage", Review of Economic Dynamics, vol. 1(3), pp. 677-698.

Hegeland H. 1954. "The Multiplier Theory", Lund Social Science 9, p. 261.

Henderson D. J., Parmeter C. F. and Su L. 2015. "Nonparametric Threshold Regression: Estimation and Inference", mimeo.

Hendry D. F. and Muellbauer J. N. 2018. "The future of macroeconomics: macro theory and models at the Bank of England", Oxford Review of Economic Policy, vol. 34(1-2), pp. 287-328.

Herndon T., Ash M. and Pollin R. 2013. "Does high public debt consistently stifle economic growth? A critique of Reinhart and Rogoff", PERI working paper 322.

Hill R. 2008. "Optimal taxation and economic growth: a comment", Public Choice, vol. 134, pp. 419-427.

Hodrick R. J. and Prescott E. C. 1997. "Postwar U.S. Business Cycles: An Empirical Investigation", Journal of Money, Credit and Banking, vol. 29(1), pp. 1-16.

Hoover K. D., Johansen S. and Juselius K. 2008. "Allowing the Data to Speak Freely: The Macroeconometrics of the Cointegrated Vector Autoregression", American Economic Review, vol. 98(2), pp. 251-255.

Horvath M. 2009. "The effects of government spending shocks on consumption under optimal stabilization", European Economic Review, vol. 53(7), pp. 815-829.

Hsieh C. T. and Klenow P. J. 2010. "Development Accounting", American Economic Journal: Macroeconomics, vol. 2(1), pp. 207-223.

Huidrom R., Kose M. A., Lim J. J. and Ohnsorge F. L. 2016. "Do Fiscal Multipliers Depend on Fiscal Positions?", Policy Research working paper 7724. World Bank Group.

Hulten C. 2001. "Total Factor Productivity: A Short Biography", in New Developments in Productivity Analysis, Charles R. Hulten, Edwin R. Dean, and Michael J. Harper, eds., Studies in Income and Wealth, vol. 63, The University of Chicago Press for the National Bureau of Economic Research, Chicago, pp. 1-47.

ILO. 2011. "A review of global fiscal stimulus", European Commission-International Institute for Labour Studies (EC-IILS) Joint Discussion Paper Series No. 5.

Ilzetzki E., Mendoza E. G. and Végh C. A. 2013. "How big (small?) are fiscal multipliers?", Journal of Monetary Economics, vol. 60(2), pp. 239-254.

IMF. 2009. Group of Twenty, Meeting of the Deputies, January 31–February 1, London, U.K., Note by the Staff of the IMF. https://www.imf.org/external/np/g20/pdf/020509.pdf.

IMF. 2013. "Staff Guidance Note for Public Debt Sustainability Analysis in Market-Access Countries", International Monetary Fund.

IMF. 2015. "Making Public Investment more Efficient", Policy Report, June, Washington DC.

IMF and The World Bank. 2005. "Operational Framework for Debt-Sustainability Assessments in Low-Income Countries—Further Considerations".

IMF and The World Bank. 2013. "Staff Guidance Note on the Application of the Joint Bank-Fund Debt Sustainability Framework for Low Income Countries".

Jones C. I. 1995. "R&D-Based Models of Economic Growth", Journal of Political Economy, vol. 103(4), pp. 759-784.

Jones C. I. 2003. "Population and Ideas: A Theory of Endogenous Growth", in P. Aghion, R. Frydman, J. Stiglitz, and M. Woodford, eds., Knowledge, Information, and Expectations in Modern Macroeconomics: In Honor of Edmund S. Phelps, Princeton University Press.

Jones C. I. 2005. "Growth and Ideas", in P. Aghion and Durlauf S., eds, Handbook of Economic Growth, edition 1, vol. 1, chapter 16, pp. 1063-1111.

Jones C. I. 2019. "Paul Romer: Ideas, Nonrivalry, and Endogenous Growth", Scandinavian Journal of Economics, vol. 121(3), pp. 859-883.

Jones C. I. and Romer P. M. 2010. "The New Kaldor Facts: Ideas, Institutions, Population, and Human Capital", American Economic Journal: Macroeconomics, vol. 2(1), pp. 224-245.

Kennedy P. E. 2000. "On measuring the growth-maximizing tax rate", Pacific Economic Review, vol. 5(1), pp. 89-91.

Keynes J. M. 1936. The General Theory of Employment, Interest and Money, Palgrave Macmillan.

Kilponen J., Pisani M., Schmidt S., Corbo V., Hledik T., Hollmayr J., Hurtado S., Júlio P., Kulikov D., Lemoine M., Lozej M., Lundvall H., Maria J. R., Micallef B., Papageorgiou D., Rysanek J., Sideris D., Thomas C. and De Walque G. 2015. "Comparing fiscal multipliers across models and countries in Europe", ECB working paper 1760, European Central Bank.

Kirchner M., Cimadomo J. and Hauptmeier S. 2010. "Transmission of Government Spending Shocks in The Euro Area: Time Variation and Driving Forces", ECB working paper 1219, European Central Bank.

Klein L. R. and Goldberger A. 1955. An Econometric Model of the United States, 1929-1952, Amsterdam: North-Holland.

Klein L.R. 1950. "Economic Fluctuations in the United States, 1921–1941", New-York: John Wiley.

Kmenta J. 1967. "On Estimation of the CES Production Function", International Economic Review, vol. 8, pp. 180-189.

Kose M. A., Nagle P., Ohnsorge F. and Sugawara N. 2020. "Global Waves of Debt: Causes and Consequences", Advanced Edition. World Bank.

Kourtellos A., Stengos T. and Tan C. M. 2013. "The effect of public debt on growth in multiple regimes", Journal of Macroeconomics, vol. 38(Part A), pp. 35-43.

Krugman P. 1994. The Age of Diminished Expectations: U.S. Economic Policy in the 1990s, MIT Press.

Krugman P. 2018. “Good enough for government work? Macroeconomics since the crisis”, Oxford Review of Economic Policy, vol. 34(1-2), pp. 156-168.

Krugman P. 2019. Melting Snowballs and the Winter of Debt. The New York Times, Jan. 9, https://www.nytimes.com/2019/01/09/opinion/melting-snowballs-and-the-winter-of-debt.html.

Kumar M. and Woo J. 2010. “Public Debt and Growth”, IMF working paper 10-74, International Monetary Fund.

Kydland F. and Prescott E. 1982. “Time to Build and Aggregate Fluctuations”, Econometrica, vol. 50(6), pp. 1345-1370.

Kydland F. E. and Prescott E. C. 1977. “Rules Rather than Discretion: The Inconsistency of Optimal Plans”, Journal of Political Economy, vol. 85(3), pp. 473-492.

Lee S., Park H., Seo M. H. and Shin Y. 2017. “Testing for a Debt-threshold Effect on Output Growth”, Accepted version in Fiscal Studies.

Leeper E. M., Richter A. W. and Walker T. B. 2012. “Quantitative Effects of Fiscal Foresight”, American Economic Journal: Economic Policy, vol. 4(2), pp. 115-144.

Leeper E. M., Walker T. B. and Yang S-C. S. 2013. “Fiscal Foresight and Information Flows”, Econometrica, vol. 81(3), pp. 1115-1145.

Leith C. and von Thadden L. 2008. “Monetary and fiscal policy interactions in a New Keynesian model with capital accumulation and non-Ricardian consumers”, Journal of Economic Theory, vol. 140(1), pp. 279-313.

Leith C. and Wren-Lewis S. 2013. “Fiscal sustainability in a new Keynesian model”, Journal of Money, Credit and Banking, vol. 45(8), pp. 1477-1516.

Lin T. 2014. “High dimensional threshold quantile regression with an application to debt overhang and economic growth”, Job market paper, University of Wisconsin.

Lindé J. 2018. “DSGE models: still useful in policy analysis?”, Oxford Review of Economic Policy, vol. 34(1-2), pp. 269-286.

Lindé J. and Trabandt M. 2013. Fiscal Multipliers in a Nonlinear World.

Liu Z., Wang P. and Zha T. 2011. “Land-Price Dynamics and Macroeconomic Fluctuations”, Federal Reserve Bank of San Francisco, working paper 2011-16.

Lucas R. E. 1976. “Econometric policy evaluation: A critique”, Carnegie Rochester Conference Series on Public Policy, vol. 1(1), pp 19-46.

Lucas R. E. 1988. "On the Mechanics of Economic Development", Journal of Monetary Economics, vol. 22, pp. 3-42.

Lucas R. E. and Stokey N. L. 1983. "Optimal Fiscal and Monetary Policy in an Economy Without Capital", Journal of Monetary Economics, vol. 12, pp. 55-93.

Maebayashi N., Hori T. and Futagami K. 2017. "Dynamic analysis of reductions in public debt in an endogenous growth model with public capital", Macroeconomic Dynamics, vol. 21, pp. 1454-1483.

Mankiw N. G. 2000. "The Savers-Spenders Theory of Fiscal Policy", American Economic Review, vol. 90(2), pp. 120-125.

Marchionne F. and Parekh S. 2015. "Growth, debt and inequality", Economic Issues, vol. 20(2), pp. 67-94.

Mayer E., Rüth S. and Scharler J. 2013. "Government debt, inflation dynamics and the transmission of fiscal policy shocks", Economic Modelling, vol. 33, pp. 762-771.

Mazza J. 2019. "Is public debt a cheap lunch?", Jan, 21, 2019. https://www.bruegel.org/2019/01/is-public-debt-a-cheap-lunch/.

Mbaye S., Badia M. and Chae K. 2018. "Global Debt Database: Methodology and Sources", IMF working paper 18/111, International Monetary Fund.

McKibbin W. J. and Stoeckel A. 2018. "Modelling a complex world: improving macro-models", Oxford Review of Economic Policy, vol. 34(1-2), pp. 329-347.

Mertens K. and Ravn M. O. 2010. "Measuring the Impact of Fiscal Policy in the Face of Anticipation: A Structural VAR Approach", The Economic Journal, vol. 120(544), pp. 393-413.

Mian A. and Sufi A. 2012. "The Effects of Fiscal Stimulus: Evidence from the 2009 'Cash for Clunkers' Program", Quarterly Journal of Economics, vol. 127(3), pp. 1107-1142.

Miller P. J. and Sargent T. J. 1984. "A reply to Darby", Federal Reserve Bank of Minneapolis Quarterly Review, vol. 8(Spring), pp. 21-26.

Mincer J. 1974. "The Human Capital Earnings Function", NBER Chapters, in: Schooling, Experience, and Earnings, pages 83-96, National Bureau of Economic Research.

Minea, A. and Parent, A. 2012, "Is High Public Debt Always Harmful to Economic Growth? Reinhart and Rogoff and Some Complex Nonlinearities", CERDI working paper 2012-18.

Minea A. and Villieu P. 2013. "Debt policy rule, productive government spending, and multiple growth paths: A note", Macroeconomic Dynamics, vol. 17, pp. 947-954.

Modigliani F. 1961. "Long Run Implications of Alternative Fiscal Policies and the Burden of the National Debt", Economic Journal, vol. 71(284), pp. 730-755.

Molnár M. 2012. "Fiscal consolidation: What factors determine the success of consolidation efforts?", OECD Journal: Economic Studies, vol. 2012/1.

Mustea L. 2015. "How large are fiscal multipliers in the US?", Procedia Economics and Finance, vol. 20, pp. 423-427.

Nakamura E. and Steinsson J. 2014. "Fiscal Stimulus in a Monetary Union: Evidence from US Regions", American Economic Review, vol. 104(3), pp. 753-92.

Nelson R. and Phelps E. 1966. "Investment in Humans, Technological Diffusion, and Economic Growth", American Economic Review, vol. 56(1/2), pp. 69-75.

Ni S. 1999. "National Debt, Savings, and Real Interest Rates in a Neoclassical Model with Endogenous Labour Supply and Knowledge-Based Growth", The Canadian Journal of Economics, vol. 32(5), pp. 1227-1244.

Nickel C. and Tudyka A. 2014. "Fiscal stimulus in times of high debt: reconsidering multipliers and twin deficits", Journal of Money, Credit and Banking, vol. 46(7), pp. 1313-1344.

Nielsen H. S., Torben S. and Taber C. R. 2010. "Estimating the Effect of Student Aid on College Enrollment: Evidence from a Government Grant Policy Reform", American Economic Journal: Economic Policy, vol. 2(2), pp. 185-215.

North D. C. 1990. Institutional Change, and Economic Performance, Cambridge University Press.

Obstfeld M. 1997. "Dynamic Seigniorage Theory", Macroeconomic Dynamics, vol. 1(3), pp. 588-614.

Obstfeld M. and Taylor A. M. 2002. "Globalization and Capital Markets", NBER working paper 8846, National Bureau of Economic Research.

O'Driscoll G. P. 1977. "The Ricardian Nonequivalence Theorem", Journal of Political Economy, vol. 85(1), pp. 207-210.

OECD. 2009. "Policy Responses to the Economic Crisis: Investing in Innovation for Long-Term Growth".

OECD. 2011. “Fiscal consolidation: targets, plans and measures”, OECD Journal on Budgeting, vol. 11/2.

OECD. 2012. “Fiscal Consolidation: How Much is Needed to Reduce Debt to a Prudent Level?”, OECD Economics Department Policy Notes, No. 11, April.

Ostry J. D., Ghosh A. R., Kim J. I. and Qureshi M.S. 2010. “Fiscal Space”, IMF Staff Position Note 10/11, International Monetary Fund.

Ostry J. D., Ghosh A.R. and Espinoza R. 2015. “When Should Public Debt Be Reduced?”, IMF Staff Discussion Note SDN/15/10, International Monetary Fund.

Ouliaris S., Pagan A. and Restrepo J. 2018. “Quantitative Macroeconomic Modeling with Structural Vector Autoregressions – An EViews Implementation”, unpublished e-book available online at: https://www.eviews.com/StructVAR/structvar.pdf.

Owyang M. T., Ramey V. A. and Zubairy S. 2013. “Are Government Spending Multipliers Greater during Periods of Slack? Evidence from Twentieth-Century Historical Data”, American Economic Review, vol. 103(3), pp. 129-134.

Pan H. and Wang C. 2013. “Co-movement of Government Debt and Economic Growth in the Euro-area: A Bayesian Dynamic Factor Model Analysis”, International Economic Journal, vol. 27(4), pp. 625-643.

Panizza U. and Presbitero A. F. 2012. “Public Debt and Economic Growth Is There a Causal Effect?”, Money and Finance Research Group (MoFiR) working paper 65.

Panizza U. 2015. “Public debt and long-term economic growth: the research and policy agenda”, Lecture delivered at the 43rd Economics Conference of the Oesterreichische National Bank, Vienna.

Parker J. A., 2011. “On Measuring the Effects of Fiscal Policy in Recessions”, Journal of Economic Literature, vol. 49(3), pp. 703-718.

Parraga Rodriguez S. 2018. “The dynamic effects of public expenditure shocks in the United States”, Journal of Macroeconomics, vol. 56, pp. 340-360.

Perdichizzi S. 2017. “Estimating Fiscal multipliers in the Eurozone: A Nonlinear Panel Data Approach”, working paper 58, Università Cattolica del Sacro Cuore, Dipartimento di Economia e Finanza (DISCE), Milano.

Perotti R. 2005. “Estimating the Effects of Fiscal Policy in OECD Countries”, CEPR Discussion Paper 4842.

Perotti R. 2011. “The Effects of Tax Shocks on Output: Not So Large, But Not Small Either”, NBER working paper 16786, National Bureau of Economic Research.

Persson T. and Svensson L. E. O. 1989. “Why a Stubborn Conservative would Run a Deficit: Policy with Time-Inconsistent Preferences”, Quarterly Journal of Economics, vol. 104(2), pp. 325-345.

Pesaran H. M., Ullah A. and Yamagata T. 2008. “A bias-adjusted LM test of error cross-section independence”, Econometrics Journal, vol. 11(1), pp. 105-127.

Pesaran M. H. 2004. “General diagnostic tests for cross section dependence in panels”, CESifo working paper 1233.

Pesaran M. H. 2006. “Estimation and Inference in Large Heterogeneous Panels with a Multifactor Error Structure”, Econometrica, vol. 74(4), pp. 967-1012.

Pescatori A., Sandri D. and Simon J. 2014. “Debt and growth: Is there a magic threshold?”, IMF working paper 14/34, International Monetary Fund.

Phelps E. S. 1961. “The Golden Rule of Accumulation: A Fable for Growthmen”, American Economic Review, vol. 51, pp. 638-643.

Phelps E. S. 2018. “The Fantasy of Fiscal Stimulus”, Wall Street Journal, Oct 19.

Philippon T. 2019. “The True Cost of Public Debt”, https://www.stern.nyu.edu/experience-stern/faculty-research/true-cost-public-debt

Pienkowski A. 2017. “Debt Limits and the Structure of Public Debt”, IMF working paper 17/117, International Monetary Fund.

Poghosyan T. 2017. “How Do Public Debt Cycles Interact with Financial Cycles?”, Empirical Economics, vol. 54(71), pp. 425-460.

Priftis R. and Zimic S. 2018. “Sources of borrowing and fiscal multipliers”, Bank of Canada Staff working paper 2018-32.

Quesnay F. 1758. Tableau Economique. 3d ed. Reprint, Edited by M. Kuczynski and R. Meek. London: Macmillan, 1972.

Ramey V. 2011. “Identifying Government Spending Shocks: It’s All in the Timing”, Quarterly Journal of Economics, vol. 126(1), pp. 1-50.

Ramey V. 2016. “Macroeconomic Shocks and their Propagation”, chapter 2 in Handbook of Macroeconomics (Pages 71-162). Edited by John B. Taylor and Harald Uhlig, Volume 2.

Ramey V. 2018. “Ten years after the Financial Crisis: What have we learned from the renaissance of fiscal research?”, Journal of Economic Perspectives. Forthcoming.

Ramey V. A. and Zubairy S. 2018. “Government Spending Multipliers in Good Times and in Bad: Evidence from US Historical Data”, Journal of Political Economy. vol. 126(2), pp. 850-901.

Ramsey F. P. 1928. “A Mathematical Theory of Saving”, The Economic Journal, vol. 38(152), pp. 543-559.

Reinhart C. M. and Rogoff K. S. 2009. This Time Is Different: Eight Centuries of Financial Folly, Princeton University Press.

Reinhart C. M. and Rogoff K. S. 2010. “Growth in a time of debt”, American Economic Review, vol. 100(2), pp. 573-578.

Reinhart C. M., Reinhart V. R. and Rogoff K. S. 2012. “Public debt overhangs: Advanced economy episodes since 1800”, Journal of Economic Perspectives, vol. 26(3), pp. 69-86.

Reis R. 2018. “Is something really wrong with macroeconomics?”, Oxford Review of Economic Policy, vol. 34(1-2), pp. 132-155.

Riera-Crichton D., Vegh C. A. and Vuletin G. 2014. “Fiscal Multipliers in Recessions and Expansions: Does It Matter Whether Government Spending Is Increasing or Decreasing?”, Policy Research working paper 6993, World Bank.

Rodrik D., Subramanian A. and Trebbi F. 2004. “Institutions Rule: The Primacy of Institutions over Geography and Integration in Economic Development”, Journal of Economic Growth, vol. 9(2), p.131-165.

Rodrik D. 2011. The Globalization Paradox: Democracy and the Future of the World Economy, W. W. Norton.

Romer C. and Bernstein J. 2009. “The Job Impact of the American Recovery and Reinvestment Plan”, January 8, 2009.

Romer C. D. and Romer D. H. 2010. “The Macroeconomic Effects of Tax Changes: Estimates Based on a New Measure of Fiscal Shocks”, American Economic Review, vol. 100(3), pp. 763-801.

Romer D. 2011. “What Have We Learned about Fiscal Policy from the Crisis?”, IMF Conference on Macro and Growth Policies in the Wake of the Crisis, March.

Romer P.M. 1986. “Increasing Returns and Long-Run Growth”, Journal of Political Economy, vol. 94(5), pp. 1002-1037.

Romer P.M. 1990. “Human capital and growth: Theory and evidence”, Carnegie-Rochester Conference Series on Public Policy, Elsevier, vol. 32(1), pages 251-286.

Rossi R. 2014. “Designing monetary and fiscal policy rules in a new Keynesian model with rule-if-thumb consumers”, Macroeconomic Dynamics, vol. 18(2), pp. 395-417.

Roubini N. and Sachs J. D. 1989. “Political and economic determinants of budget deficits in the industrial democracies”, European Economic Review, vol. 33(5), pp. 903-938.

Rupert P. and Šustek R. 2019. “On the mechanics of New-Keynesian models”, Journal of Monetary Economics, vol. 102, pp. 53-69.

Samuelson P. 1958. “An Exact Consumption-Loan Model of Interest with or without the Social Contrivance of Money”, Journal of Political Economy, vol. 66(6), pp. 467-482.

Schmitt-Grohe S. and Uribe M. 2004. “Optimal Monetary and Fiscal Policy under Sticky Prices”, Journal of Economic Theory, vol. 114, pp. 198-230.

Scully G. W. 1996. “Taxation and economic growth in New Zealand”, Pacific Economic Review, vol. 1(2), pp. 169-177.

Scully G. W. 1999. “Unfinished reform: taxation and economic growth in New Zealand”, Journal of Private Enterprise, vol. 14(2), pp. 92-114.

Scully G. W. 2003. “Optimal taxation, economic growth, and income inequality”, Public Choice, vol. 115, pp. 299-312.

Shapiro M. and Watson M. 1988. “Sources of Business Cycles Fluctuations”, in NBER Macroeconomics Annual 1988, vol. 3.

Sharpe T. P. 2013. “Institutional arrangements and public debt threshold limits”, International Review of Applied Economics, vol. 27(6), pp. 707-728.

Sims C. 1972. “Money, Income, and Causality”, American Economic Review, vol. 62(4), pp. 540-552.

Sims C. 1980. “Macroeconomics and Reality”, Econometrica, vol. 48(1), pp. 1-48.

Sims C. 1986. “Are Forecasting Models Usable for Policy Analysis?”, Federal Reserve Bank of Minneapolis, Quarterly Review (Winter), pp. 2-16.

Smets F. and Wouters R. 2007. “Shocks and Frictions in U.S. Business Cycles: A Bayesian DSGE Approach”, American Economic Review. vol. 97(3), pp. 506-606.

Solow R. 1956. “A Contribution to the Theory of Economic Growth”, Quarterly Journal of Economics, vol. 70, pp. 65-94.

Spilimbergo A., Symansky S. and Schindler M. 2009. “Fiscal Multipliers”, IMF Staff Position Note, SPN/09/11, International Monetary Fund.

Stiglitz J. 2018. “The Myth of Secular Stagnation”, Project Syndicate, August 28.

Stiglitz J. 2018. “Where modern macroeconomics went wrong”, Oxford Review of Economic Policy, vol. 34(1-2), pp. 70-106.

Stock J. H. and Watson M. W. 2003. “Forecasting Output and Inflation: The Role of Asset Prices”, Journal of Economic Literature, vol. 41(3), pp. 788-829.

Swan T. W. 1956. “Economic growth and capital accumulation”, Economic Record, vol. 32(2), pp. 334-361.

Syssoyeva-Masson I. and De Sousa Andrade J. 2017. “The effect of public debt on growth in multiple regimes in the presence of long-memory and non-stationary debt series”, CeBER working paper 7.

Tagkalakis A. 2008. “The effects of fiscal policy on consumption in recessions and expansions”, Journal of Public Economics, vol. 92(5-6), pp. 1486-1508.

Taylor J. B. 2011. “An Empirical Analysis of the Revival of Fiscal Activism in the 2000s”, Journal of Economic Literature, vol. 49(3), pp. 686-702.

Taylor J. B. 2018. “Fiscal Stimulus Programs During the Great Recession”, Economics Working Paper 18117. Hoover Institution, Stanford.

Terra C. 2015. “Principles of International Finance and Open Economy Macroeconomics: Theories, Applications and Policies”, Academic Press, 1st edition.

Thistlethwaite D. and Campbell D. 1960. “Regression-Discontinuity Analysis: An alternative to the ex post facto experiment”, Journal of Educational Psychology, vol. 51(6), pp. 309-317.

Tinbergen J. 1939. “Statistical Testing of Business-Cycle Theories. II. Business Cycles in the United States of America 1919-1932”, Geneva: League of Nations.

Turnovsky S. J. 1997. “Fiscal policy in a growing economy with public capital”, Macroeconomic Dynamics, vol. 1, pp. 615-639.

Turnovsky S. J. and Brock W. A. 1980. “Time consistency and optimal government policies in perfect foresight equilibrium”, Journal of Public Economics, vol. 13(2), pp. 183-212.

Uhlig H. 2005. “What Are the Effects of Monetary Policy on Output? Results from an Agnostic Identication Procedure”, Journal of Monetary Economics, vol. 52(2), pp. 381-419.

Vines D. and Wills S. 2018. “The rebuilding macroeconomic theory project: an analytical assessment”, Oxford Review of Economic Policy, vol. 34(1-2), pp. 1-42.

Vines D. and Wills S. 2018. “The financial system and the natural real interest rate: towards a ‘new benchmark theory model’”, Oxford Review of Economic Policy, vol. 34(1-2), pp. 252-268.

Weil P. 1989. “Overlapping families of infinitely-lived agents”, Journal of Public Economics, vol. 38(2), pp. 183-198.

Weil P. 2008. “Overlapping Generations: The First Jubilee”, Journal of Economic Perspectives, vol. 22(4), pp.115-134.

Wieland V., Cwik T., Muller G. J., Schmidt S. and Wolters M. 2012. “A new comparative approach to macroeconomic modeling and policy analysis”, Journal of Economic Behavior and Organization, vol. 83(3), pp. 523-541.

Wold, H. 1954. “A Study in the Analysis of Stationary Time Series”, Second revised edition, Almqvist and Wiksell Book Co., Uppsala.

Woo J., Kinda T. and Poplawski-Ribeiro M. 2013. “Economic Recovery from Recessions: The Role of Fiscal Policy, and Structural Reforms”, IMF working paper, International Monetary Fund.

Woodford M. 2003. Interest and Prices: Foundations of a Theory of Monetary Policy, Princeton University Press.

Woodford, M. 2011. “Simple Analytics of the Government Expenditure Multiplier”, American Economic Journal: Macroeconomics, vol. 3(1), pp. 1-35.

World of Work Report. 2010. From one crisis to the next? International Institute for Labour Studies, ILO (republished under Willey Online Library, July 3, 2012).

Wren-Lewis S. 2018. “Ending the microfoundations hegemony”, Oxford Review of Economic Policy, vol. 34(1-2), pp. 55-69.

Wright R. 2018. “On the future of macroeconomics: a New Monetarist perspective”, Oxford Review of Economic Policy, vol. 34(1-2), pp. 107-131.

Yaari M. 1965. “Uncertain lifetime, life insurance, and the theory of the consumer”, Review of Economic Studies, vol. 32, pp. 137-150.

Yakita A. 2008. “Sustainability of public debt, public capital formation, and endogenous growth in an overlapping generations setting”, Journal of Public Economics, vol. 92, pp. 897-914.

Zhang Y., Zhou Q. and Jiang L. 2017. “Panel kink regression with an unknown threshold”, Economics Letters, vol. 157(2017), pp. 116-121.