Essays on monetary policy in emerging economies

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Avertissement

Mis à part l'introduction générale, les différents chapitres de cette thèse sont issus d'articles de recherche rédigés en anglais et dont la structure est autonome. Par conséquent, des termes “papier” ou “article” y font référence, et certaines informations, notamment la littérature, sont répétées d'un chapitre à l'autre.

Notice

Except the general introduction, all chapters of this thesis are self-containing research articles. Consequently, terms “paper" or “article" are frequently used. Moreover, some explanations, like corresponding literature, are repeated in different places of the thesis.

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Dedicated to my friends Rupak K. J. & Johnson Y.

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CHAPITRE 1

Présentation des travaux

Cette thèse regroupe un ensemble de quatre articles analysant la conduite de la politique monétaire dans les économies émergentes qui ont adopté un régime de ciblage d'inflation.

La première partie de ce travail est basée sur une approche positive, qui s'appuie sur l'expérience des 19 économies qui se sont dotées de ce cadre institutionnel. Nous examinons quel régime de change ces économies ont choisi, ainsi que les déterminants de leur choix. Puis, dans une démarche normative, nous analysons dans la seconde partie de cette thèse comment se définit la politique monétaire optimale en présence de chocs sur le prix des matières premières et alimentaires, et d'inégalité d'accès au crédit.

1.1 Ciblage d'inflation et régime de change : une approche positive

Le ciblage d'inflation est un cadre de politique monétaire dont la principale caractéristique est de faire reposer l'ensemble de l'ancrage nominal sur la stabilité des prix. De manière restrictive, voire caricaturale, ce régime a été décrit dans les économies développées comme un cadre dans lequel la banque centrale a un unique objectif, la stabilité des prix, qu'elle atteint à l'aide d'un unique instrument, le contrôle du taux d'intérêt court. Les économies développées qui ont choisi ce cadre institutionnel ont généralement un taux de change flottant, ce qui renforce la crédibilité de la banque centrale quand elle affirme que la stabilité des prix est son seul objectif. La première partie de cette thèse vise à établir si les économies émergentes qui ont également adopté un régime de ciblage d'inflation l'ont accompagné d'un taux de change flottant ou si à la différence des économies développées, les économies émergentes ont un système de ciblage d'inflation qui laisse place au contrôle du change.

La question de la gestion du taux change se pose pour les économies émergentes car la volatilité du taux de change nominal y représente un important défi pour les autorités monétaires. Les explications sont nombreuses et varient selon les pays. Nous retiendrons les suivantes :

- L'ampleur de la volatilité du taux de change nominal est plus importante dans les économies émergentes que dans les économies développées.
- Le "pass-through", c'est-à-dire l'impact d'une hausse des prix mondiaux sur les prix domestiques, est plus important dans les économies émergentes. (voir Mihaljek & Klau 2008 et Frankel et al. 2012).
- Un moindre développement financier réduit la possibilité de se protéger contre les variations du change et rend les entreprises plus vulnérables aux changements brusques du taux de change nominal (voir Aghion et al. 2009 et Héricourt & Poncet 2012 pour des arguments macroéconomiques et microéconomiques respectivement).
- L'Etat, les entreprises et les ménages des économies émergentes s'endettent davantage en devises étrangères que ne le font les agents des économies développées. Ce

phénomène est connu dans la littérature sous le nom de "currency mismatches". Un fort endettement en devises étrangères des agents dont les ressources sont en monnaie locale rend leur bilan très vulnérable à toute dépréciation de cette monnaie (voir Eichengreen et al. 2007 et Hausmann & Panizza 2011 à ce sujet).

- L'importante part des matières premières dans les exports de certains pays peut également jouer un rôle. Plus largement, le fait que leurs devises n'interviennent pas dans les transactions internationales augmente le risque de change.

Ces raisons expliquent pourquoi le taux de change, qu'il soit considéré comme un instrument ou un objectif, tient un rôle plus important dans la politique monétaire des économies émergentes que dans celle des économies développées. Aussi, dans le cas des pays ayant officiellement adopté un taux de change flottant, ces mêmes arguments sont mobilisés pour justifier que certaines autorités aient "peur de l'appréciation" (Levy-Yeyati et al. 2013), voir même "peur du flottement" (Calvo & Reinhart 2002) et soient réticentes à laisser la détermination du taux de change nominal au seul jeu des marchés comme elles s'y sont pourtant engagées.

Ainsi, de nombreux auteurs ont douté qu'un régime de ciblage d'inflation avec taux de change parfaitement flottant puisse être mis en place dans les économies émergentes[1]. De fait, le taux de change tient un rôle bien plus important dans le discours officiel (si l'on se réfère par exemple aux déclarations des banquiers centraux) dans ces économies que dans les économies les plus riches. C'est pourquoi, les banques centrales des économies émergentes pourraient être amenées à adopter un régime de ciblage d'inflation "hybride"[2], c'est-à-dire une politique de ciblage d'inflation accompagnée d'une politique de contrôle du taux de change, à l'inverse des économies développées qui ont un régime de ciblage d'inflation "flexible"[3] - une politique de ciblage d'inflation accompagnée d'une politique de change flexible.

L'objectif de la première partie de cette thèse est de déterminer si les économies émergentes qui se sont tournées vers le ciblage d'inflation ont adopté un régime de ciblage flexible ou un régime de ciblage hybride. Dans le premier chapitre, une méthode de classification des régimes de change est proposée. Celle-ci permet d'établir parmi les économies émergentes qui ciblent l'inflation, celles qui ont un taux de change flottant et celles qui le contrôlent. Puis, un second chapitre met en lumière les déterminants de la politique de change.

1.1.1 Définir les régimes de change.

Le régime de change d'un pays résulte d'un choix des autorités monétaires. On pourrait donc penser qu'interroger les gouvernements sur leurs décisions suffit à connaître le régime de change de leur économie. Cependant, de nombreux travaux (à la suite de Obstfeld &

[1] voir Mishkin (2004) et Freedman & Otker (2010) en particulier.
[2] Roger et al. 2009
[3] Svensson 2010a

Rogoff 1995 et Reinhart 2000) ont montré qu'il existe un écart généralisé entre déclarations officielles et régimes effectifs. Ainsi, toute étude des régimes de change doit s'appuyer sur une classification "de facto" de ces régimes.

Tavlas et al. 2008 recensent l'existence de pas moins de 13 méthodes de classification des régimes de change. Ce grand nombre d'approches est révélateur du fait qu'il n'y a pas de définition unique des régimes de change, et que le choix de la définition dépend de l'objet étudié. Pour prendre un exemple concret, il existe des méthodes basées sur la dynamique du taux de change du marché informel[4] (tel Reinhart & Rogoff 2004) mais comme le souligne Shambaugh (2004, page 318) cette caractéristique n'est pertinente que si l'on s'intéresse au lien entre régime de change et commerce international (et non si l'on s'intéresse aux contraintes que fait peser le change sur la politique monétaire).

Dans notre cas, nous adopterons une perspective adaptée à l'étude des économies émergentes qui ciblent l'inflation. Plus précisément, nous souhaitons savoir si ces économies ont un régime flottant, ou si elles interviennent sur le marché des changes pour maîtriser les fluctuations de leur devise.

D'un point de vue théorique, cette question est portée par la volonté d'identifier si la définition restrictive du ciblage d'inflation (un objectif, un instrument) ne doit pas laisser place à une définition élargie : deux objectifs, stabilité interne et externe de la monnaie, deux instruments, taux d'intérêt et intervention sur le marché des changes.

D'un point de vue empirique, cette question est portée par deux constats. Tout d'abord, on observe depuis la crise asiatique de la fin des années 1990 un phénomène majeur d'accumulation des réserves de change dans les économies émergentes (documenté par Aizenman et al. 2010 notamment). Ceci s'explique par des arguments mercantilistes, par le besoin de se prémunir contre les "sudden-stop" (ce qui trouve une actualité toute particulière en cette fin d'été 2013) et par la volonté de se munir d'un outil d'intervention sur le marché des changes (voir Bar-Ilan & Marion 2009, Ghosh & Tsangarides 2012 et Malloy 2013). D'autre part, il est établi dans le cas des pays qui ciblent l'inflation, que le principal outil de contrôle du change est le recours à l'achat et à la vente de devises par les autorités monétaires sur le marché des changes (voir Stone et al. 2009). Ainsi la rigidité du taux de change est associée ici aux interventions sur le marché des devises. A cette définition de la rigidité du taux de change correspond une contribution majeure de la littérature des classifications des régimes de change : l'approche de Levy-Yeyati & Sturzenegger 2003. Celle-ci caractérise les régimes de change en fonction de la volatilité du taux de change nominal, de la constance de cette volatilité, et des interventions sur les régimes de change.

Dans ce premier chapitre, nous reprenons cette méthode, nous en désignons les principales limites et nous proposons des solutions pour l'appliquer aux économies émergentes qui ciblent l'inflation.

Notre démarche est la suivante : nous considérons que l'ensemble des données caractérisant les économies en change flottant doit être produit par un processus donné, qui diffère

[4] Marché informel, également appelé marché noir ou marché parallèle.

du processus à l'origine des observations des économies en change fixe. Nous construisons une base de données qui regroupe les observations des pays développés qui ciblent l'inflation et dont nous avons la certitude qu'ils sont en change flottant, les données de pays en change fixe et enfin les observations des économies émergentes qui ciblent l'inflation. Puis nous identifions quels sont les processus en présence. Notre approche est fondée sur des méthodes d'économétrie non-paramétrique. Nous supposons que la fonction de distribution d'un processus générateur d'observations est une Gaussienne, et nous identifions à travers l'estimation d'un modèle de mélange le nombre vraisemblable de distributions. Enfin nous calculons la probabilité pour chaque observation d'appartenir à chaque distribution.

Ainsi, nous pouvons calculer pour chaque économie émergente qui cible l'inflation, la probabilité que ses caractéristiques s'apparentent aux économies développées qui ciblent l'inflation avec un taux de change flottant, ou aux caractéristiques des économies ayant un régime rigide. Une troisième catégorie est également identifiée : un régime intermédiaire de flottement contrôlé.

Nos résultats pour l'ensemble des économies émergentes qui ciblent l'inflation indiquent que dans 52% des cas, ces pays semblent avoir un régime de change flottant semblable à celui des pays développés qui ciblent l'inflation ; 28 % des pays ont un régime dit intermédiaire, c'est-à-dire un régime dans lequel la valeur du taux de change est fixé par le jeu des marchés, jeu généralement libre, bien que les autorités monétaires se permettent d'y intervenir à leur discrétion. Enfin, dans 20 % des cas l'importance des interventions est telle que les économies ciblant l'inflation ont un régime semblable à celui des économies en change fixe.

Finalement, nous observons que la définition restrictive du ciblage d'inflation, le ciblage flexible, semble correspondre à 10 économies, alors que la définition élargie, le ciblage hybride, mêlant objectif d'inflation et objectif de change, semble dominer dans 9 pays.

1.1.2 Expliquer les régimes de change.

Le second chapitre de cette partie consacrée à la politique de change s'inscrit dans la continuité du chapitre précédent. Ayant établi quel est le régime de change de chaque économie émergente qui cible l'inflation, et comment celui-ci évolue au cours du temps, nous nous demandons ce qui peut être à l'origine du choix par les autorités monétaires d'avoir une politique de change flottant, ou au contraire d'intervenir sur le marché des changes pour influencer la valeur de leur devise. Nous envisageons deux grandes familles de déterminants du régime de change : les explications générales, valables pour tous types de pays, et les explications propres aux pays qui ciblent l'inflation.

Plus précisément, nous considérons le premier ensemble d'explications comme variables de contrôle, et nous utilisons le second ensemble afin de tester la complémentarité entre politique de change et politique de ciblage d'inflation. Nous souhaitons déterminer si la politique de change vient soutenir la politique de ciblage d'inflation, ou si, au contraire, les deux politiques sont dissociées.

Nos résultats, basés sur une approche en économétrie de panel, indiquent que les principaux déterminants du régime de change sont à trouver dans la structure financière de l'économie. En particulier, le niveau d'endettement de l'économie en fonds d'origine étrangère, et le niveau de développement du secteur financier sont les deux principales variables qui, au sein des économies émergentes qui ciblent l'inflation, expliquent le choix du régime de change. Les théories sous-jacentes à ces variables justifient les interventions sur le marché des changes dans le but de limiter la volatilité du taux de change, en particulier dans le cas où la monnaie domestique se déprécie, (1) afin de limiter les effets de valorisation de la dette (ou du montant des remboursements) des agents endettés en devises étrangères, (2) dans un contexte ou le faible développement des marchés financiers ne permet pas de disposer de techniques sophistiquées pour maîtriser ces effets.

Concernant l'interaction ou la complémentarité entre politique monétaire et politique de change, nos résultats semblent indiquer une dissociation des deux pratiques. Ce résultat s'articule autour de deux éléments. Tout d'abord, la politique de change ne semble pas être perçue comme un soutien de la politique monétaire. Ainsi, l'hypothèse selon laquelle les banques centrales ayant des difficultés à mettre en place une stratégie de ciblage d'inflation crédible, se tourneraient vers le contrôle du taux de change comme substitut à l'ancrage nominal et comme canal de contrôle des anticipations d'inflation ne semble pas validée. Deuxièmement, nos résultats indiquent que les pratiques de contrôle du taux de change diminuent fortement dans la période qui précède l'adoption du régime de ciblage d'inflation, et qu'elles se maintiennent par la suite à un niveau réduit. Cela semble confirmer l'hypothèse selon laquelle l'adoption d'un régime de change flottant est une condition préalable à l'adoption du ciblage d'inflation ; le rythme des interventions devenant marginal par la suite.

1.2 Ciblage d'inflation et conduite de la politique monétaire : une approche normative

La seconde partie de cette thèse a une visée normative : nous cherchons à définir quelle politique monétaire est optimale. Notre démarche est théorique, elle s'appuie sur des modéles d'équilibre général dynamique et stochastique (DSGE).

1.2.1 Prix alimentaires.

Nous nous intéressons tout d'abord à la prise en compte par les autorités monétaires des chocs frappant le prix des biens alimentaires et des matières premières. Notre propos n'est pas d'accorder une place centrale à la politique monétaire dans la gestion des crises alimentaires. Loin de nous cette idée : en aucun cas la politique monétaire ne peut se substituer aux politiques visant à assurer la sécurité alimentaire des populations, telles les stratégies de stockage ou de prix subventionnés. Cependant, nous affirmons que dans les économies en développement dans lesquelles la consommation alimentaire représente en moyenne 50% des dépenses des ménages, les autorités monétaires ne peuvent pas aborder la gestion de l'inflation des prix alimentaires de la même manière que dans les économies développées, où ces dépenses ne représentent que 20% des budgets. Ce chapitre vise donc à mettre en lumière l'importance de ces différences dans les mécanismes de transmission des chocs mondiaux vers l'économie domestique, et en tire les conséquences quant à la conduite de la politique monétaire.

Les prix des biens alimentaires ont connu deux envolées en 2007 puis en 2011, dans le sillage d'une hausse générale du prix des matières premières. L'indice du prix des biens alimentaires calculé par la FAO a ainsi augmenté de plus de 50% entre janvier 2006 et juin 2008, puis a connu à nouveau une hausse similaire entre décembre 2008 et décembre 2010. Ces variations spectaculaires se sont transmises à l'inflation domestique, en particulier dans les pays en développement et émergents, mettant à l'épreuve les stratégies de ciblage d'inflation que ces pays avaient largement adoptées au cours de la décennie précédente.

Trois types de taux d'inflation peuvent être utilisés dans la mise en œuvre de la politique monétaire : l'inflation sous-jacente, c'est-à-dire l'inflation des biens à prix "rigides" (ceux pour lesquels il existe des rigidités nominales et qui donc connaissent les plus faibles variations) ; l'inflation hors biens alimentaires ; ou l'inflation totale (l'indice de l'ensemble des prix à la consommation).

La littérature théorique, à partir de Aoki (2001) (voir également Kollmann 2002 et Gali & Monacelli 2005), apporte des arguments en faveur d'un ciblage de l'inflation sous-jacente en cas de choc sur les prix relatifs. Les arguments qui soutiennent le ciblage de l'inflation sous-jacente sont de deux ordres : tout d'abord en ciblant l'inflation sous-jacente la politique monétaire est efficace car elle réduit les frictions monétaires ; enfin, en évitant de cibler l'inflation totale qui contient des prix très volatils, tel l'énergie et les biens alimentaires frais, la banque centrale évite de cibler une information bruitée, et se concentre sur les signaux réels contenant l'information sur le risque inflationniste.

Dans la pratique, la notion d'inflation sous-jacente n'est pas aisée à cerner, et définir un indice de prix qui corresponde à la notion théorique d'inflation sous-jacente se révèle une gageure. Pour pallier cette difficulté, les autorités monétaires ont souvent associé inflation sous-jacente et inflation hors prix des biens alimentaires et de l'énergie. Cibler un tel indice des prix hors alimentaire signifie que la banque centrale ne s'intéresse pas à l'évolution des prix alimentaires pour la conduite de sa politique.

Cependant assimiler l'inflation sous-jacente à l'inflation hors alimentation et énergie pourrait être moins pertinent pour les pays en développement et émergents que pour les économies développées dans la mesure où les biens alimentaires forment une part beaucoup plus importante de la consommation des ménages.

Pour évaluer la règle de politique monétaire la plus à même de stabiliser l'économie, nous construisons un modèle d'équilibre général stochastique (DSGE) représentant une petite économie ouverte. Les biens alimentaires sont, pour une part, des biens échangeables dont le prix domestique reflète le prix sur les marchés internationaux et, d'autre part, des biens purement domestiques non échangés au niveau international (il s'agit par exemple de biens trop rapidement périssables ou qui ne correspondent pas aux standards internationaux) et dont le prix est fixé par les producteurs nationaux. Ce cadre nous permet d'évaluer l'effet sur l'économie domestique de chocs intervenus sur le prix alimentaire mondial. Pour cela, nous calibrons les paramètres du modèle en fonctions des données de la FAO, et suite à l'estimation d'un modèle VAR nous reproduisons la structure des chocs frappant ces économies.

Dans ce cadre, conformément à la littérature, il s'avère optimal de cibler l'inflation sous-jacente. Toutefois, nous montrons que si l'inflation hors alimentation est une bonne approximation de l'inflation sous-jacente dans les pays riches, ce n'est pas le cas dans les pays en développement et émergents. Dans ces économies les biens alimentaires représentent une part significative des échanges. Or une grande partie de ces biens étant purement domestiques, la politique monétaire a un impact sur la fixation de leurs prix, ouvrant la possibilité de réaliser des gains d'efficacité dans la dynamique des prix par la réduction des frictions monétaires.

Nous montrons ainsi que plus un pays est pauvre, plus la part des biens alimentaires purement domestiques dans la consommation est grande, rendant indispensable la prise en compte de l'évolution des prix de l'alimentation par la banque centrale. A l'inverse, plus un pays est riche, plus ses habitants consomment des biens alimentaires dont le prix est fixé au niveau mondial, ce qui justifie l'utilisation de l'inflation sous-jacente comme indice des pressions inflationnistes.

Finalement, les économies émergentes étant des économies connaissant une évolution rapide, ce que nous décrivons peut-être perçu comme une séquence de la politique monétaire optimale. Ainsi, au fur et à mesure qu'une économie émergente connaît une croissance forte et rapide, sa population s'enrichit et réoriente son alimentation. A une consommation de biens alimentaires purement domestiques, elle substitue des biens alimentaires de qualité internationale, dont les caractéristiques sont similaires à celle des biens alimentaires consommés ailleurs dans le monde. Le marché pertinent de ces biens étant le marché mondial, leur prix est déterminé au niveau mondial. Aussi, il n'est plus fonction de la seule conjoncture domestique, et ce faisant il échappe à l'influence de la banque centrale nationale. Cette dernière, qui ne pouvait ignorer les prix alimentaires dans sa politique monétaire quand ceux-ci dépendait des conditions domestiques, doit donc au fur et à mesure que l'économie se développe et que les préférences des agents évoluent, réduire progressivement la place accordée à l'alimentaire dans sa politique, pouvant, à terme, aller jusqu'à les ignorer.

1.2.2 Contraintes d'accès au crédit.

La quatrième et dernière partie de cette thèse est dédiée aux contraintes d'accès au crédit et aux effets redistributifs de la politique monétaire.

Notre point de départ est tout à fait standard dans la littérature économique, qu'elle soit d'inspiration keynésienne ou classique : nous nous demandons d'où provient l'efficacité de la politique monétaire ? En quoi la politique monétaire peut-elle avoir un impact sur le fonctionnement de l'économie ?

Dans les modèles d'équilibre général à dynamique stochastique nouveaux-keynésiens (issus du courant de la synthèse néo-classique et keynésien) la politique monétaire a un impact sur l'économie en fonction de l'allocation des facteurs qu'elle permet. C'est à partir de cette allocation factorielle que l'on jauge et compare l'optimalité des politiques monétaires.

Cette allocation factorielle peut être statique (ou intra-temporelle) à travers l'impact de la politique monétaire sur la dispersion des prix, ou dynamique (inter-temporelle) par son impact sur le lissage de la consommation au cours du temps.

L'efficacité de la politique monétaire dû à la dispersion des prix vient de l'existence de "rigidités nominales". Ce terme désigne l'impossibilité pour les entrepreneurs de modifier leur prix chaque jour comme ils le souhaiteraient, par exemple pour répercuter l'évolution de leurs coûts. Les raisons théoriques derrière ce phénomène observé empiriquement sont nombreuses : coût d'étiquette, incertitude pour le consommateur, etc. Dans les modèles macro-économiques, toutes ces explications sont en général mises de côté et remplacées par un mécanisme simple qui impose que seule une fraction des entreprises est autorisée à modifier ses prix au cours d'une période donnée. Il s'agit des prix rigides "à la Calvo" dont la dynamique est assimilée à l'inflation sous-jacente. Comme nous l'avons souligné dans le chapitre précédent, la politique "optimale" des banques centrales consiste à limiter l'inflation de ces prix. En effet, dans les secteurs à prix rigides les entreprises n'appliquent pas automatiquement le prix qu'elles souhaiteraient afficher. Cet écart entre prix effectifs et prix souhaités produit une perte de bien-être. Or, plus l'inflation est forte, plus l'écart entre prix effectifs et prix souhaités est grand. Voilà pourquoi l'inflation est indésirable dans ce type de modèle et pourquoi en contrôlant l'inflation les autorités monétaires conduisent l'économie vers sa situation dite optimale.

L'efficacité de la politique monétaire dû au lissage de la consommation vient de l'arbitrage réalisé par les agents entre consommation présente et future. Si l'on suppose que les agents ont accès au crédit et à l'épargne, alors leur choix de consommation présent dépend des choix passés (par exemple par l'épargne mobilisée) et engage le futur (par exemple par l'endettement qu'il faudra rembourser). La politique monétaire exerce une influence sur ces choix en déterminant le taux d'intérêt qui prévaut dans l'économie. L'efficacité de la politique monétaire va ainsi dépendre de sa capacité à modifier les termes de l'arbitrage entre consommation et épargne (réalisé par les agents) en fonction de la conjoncture ou de tout événement frappant l'économie domestique. Ainsi, en ayant une politique contra-cyclique[5], consistant à augmenter les taux d'intérêt en période de hausse d'activité ou de revenu (et inversement en cas de choc négatif), les autorités monétaires peuvent lisser au cour du temps l'effet d'un choc sur l'économie. Ce lissage de l'activité est perçu comme optimal en cela qu'il réduit la volatilité du cycle économique, l'écart entre périodes fastes et récession.

Ces deux effets de la politique monétaire, l'allocation intra et inter-temporelle, sont à

[5] Les politiques contra-cycliques incluent les règles de taux d'intérêt de type "Règle de Taylor", voir Taylor (1993) ou Woodford (2003).

l'origine de la majorité des développements obtenus dans les modèles nouveau-keynésiens. Ainsi le chapitre précédent de cette thèse peut se lire comme une application multisectorielle du problème de dispersion des prix.

Dans le présent chapitre, nous souhaitons revenir sur le second effet de la politique monétaire : la gestion des incitations inter-temporelles.

Dans la continuité des chapitres précédents, nous nous demandons si ces modélisations, pensées pour les économies développées, sont valables pour les économies émergentes. En particulier, la gestion des incitations inter-temporelles repose sur l'existence d'un arbitrage entre consommation et épargne. Celui-ci est possible uniquement à condition que les agents aient accès aux services financiers d'épargne et de crédit. Cette hypothèse parait fondée dans les économies développées : la part d'adultes ayant un compte ouvert dans une institution financière est de 97% en France et 88% aux Etats-Unis. Cependant, dans les économies émergentes, seul un adulte sur deux a un compte dans une institution financière, et ce chiffre tombe à un sur quatre dans les économies à faibles revenus[6]. Similairement, seule une petite entreprise sur trois a accès au crédit dans les pays aux revenus intermédiaires, contre plus de deux tiers dans les économies développées.

Afin d'évaluer la manière dont ces caractéristiques des économies émergentes modifient les canaux de transmission de la politique monétaire, nous modélisons une petite économie ouverte, dans laquelle seule une partie de la population a accès au crédit.

Ces ménages contraints financièrement, ne pouvant épargner ou emprunter, consomment au cours de chaque période l'ensemble de leur revenu. Nous montrons que la politique monétaire influence leurs choix par ses effets sur leur revenu réel. En effet, par sa politique de taux d'intérêt la banque centrale peut contrôler la dynamique des prix (à travers les mécanismes que nous avons décrits précédemment et qui impliquent qu'au moins une partie de la population ne soit pas contrainte financièrement). Ainsi, en choisissant de répondre à un choc par sa politique de taux, la banque centrale influence le niveau des prix dans l'ensemble de l'économie, et en cela le revenu réel (ou encore le pouvoir d'achat) des agents contraints financièrement. Or, ces agents consommant à chaque période l'ensemble de leurs revenus, c'est plus généralement leur bien-être qui est ainsi modifié.

Afin d'illustrer concrètement comment la présence d'agents contraints financièrement transforme l'analyse de la politique monétaire, nous incorporons cette contrainte dans le cadre d'analyse des prix alimentaires construit au chapitre précédent. Ainsi, nous modélisons une économie habitée par deux populations : des agriculteurs (travaillant à la production de biens agricoles) et des ouvriers d'usines (travaillant à la production de biens manufacturés). Chaque secteur a son propre salaire, et dans chacune de ces populations une partie des ménages n'a pas accès au crédit. Nous calibrons notre modèle à partir des données d'accès au crédit de la Banque Mondiale et nous reproduisons la structure des chocs vus dans le chapitre précédent.

Nous montrons comment la réponse optimale de la politique monétaire se pose en des

[6] Ces chiffres prennent en compte toutes les institutions financières, y compris les coopératives, les institutions de micro-finance ou les postes offrant ces services. Voir : Demirgüç-Kunt & Klapper 2012)

termes nouveaux. En effet, en choisissant de répondre ou non à la hausse des prix alimentaires, les autorités monétaires vont influencer le niveau général des prix (les canaux de transmission sont détaillés dans l'article) et ainsi avoir un impact sur le bien-être des agents contraints financièrement dont la consommation s'identifie au revenu réel. Cependant, les salaires des agriculteurs et des ouvriers ne sont pas les mêmes. Aussi, en ajustant le niveau des prix aux variations de salaires, les autorités monétaires influencent le bien-être d'une population au détriment d'une autre. Suite à un choc sur les prix alimentaires, la question de la politique monétaire n'est plus *comment* stabiliser l'économie domestique, mais sur *qui* reporter le coût de la volatilité générée par le choc.

Parmi les effets envisageables qui différencient les deux populations contraintes financièrement, nous montrons par exemple que les agriculteurs souhaiteraient que la banque centrale augmente son taux d'intérêt afin de limiter la hausse des prix, notamment en laissant la monnaie s'apprécier, tandis que les ouvriers préféreraient que la banque centrale n'intervienne pas, notamment pour éviter que l'appréciation de la monnaie ne réduise la valeur de leurs exports et augmente la volatilité de leurs salaires réels.

Notre résultat selon lequel la politique monétaire optimale pour la population dans son ensemble ne l'est pas pour chaque sous-groupe de la population peut conduire à de nombreuses conséquences. Il implique en terme économique que tout changement de taux d'intérêt n'est pas Pareto-optimal : tout changement positif pour un agent se fait au détriment d'un autre agent. Cela soulève des questions quant à la gouvernance des banques centrales.

Dans les pays qui ciblent l'inflation, les banques centrales sont généralement indépendantes des gouvernements. Ce ne sont pas des institutions démocratiques qui rendent des comptes directement au peuple, mais des institutions technocratiques (qui évaluent elle-même leurs performances sur la base de critères quantitatifs simples). Cette situation est justifiée par "l'arithmétique monétariste déplaisante" de Sargent & Wallace 1981. Cette théorie démontre que les décisions de politique monétaire doivent privilégier le long-terme. Il en est ainsi par exemple de la création monétaire, dont les heureux effets de court-terme (tel le financement de l'Etat) sont réduits à néant par les conséquences inflationnistes à long-terme. Parce que les politiciens élus ont naturellement une préférence pour des objectifs ayant un terme similaire à leur mandat, une banque centrale indépendante sera plus à même de prendre les "bonnes" décisions qu'une banque centrale sous contrôle de représentants du peuple, élus. Cette théorie, et l'ensemble du corpus d'idées auxquelles elle appartient, a conduit au transfert de la politique monétaire des autorités gouvernementales vers des institutions indépendantes. Nous pensons cependant que cette délégation de pouvoir a été rendu possible car il était également admis que la politique monétaire est davantage une question *technique* que politique. Cette idée s'incarne dans la conception qu'il existe une "bonne" politique monétaire, formulation qui implique que si la politique monétaire est bonne ou mauvaise, elle l'est pour l'ensemble de l'économie.

Ainsi, en affirmant que la politique monétaire n'est pas bonne ou mauvaise pour l'ensemble de la société, mais qu'elle favorise un groupe au détriment d'un autre, nous en refaisons un objet éminemment politique[7].

Bien sûr nos résultats ne s'appliquent qu'aux seules économies émergentes ou en développement. Ils semblent cependant à nouveau nous indiquer qu'il y a un véritable danger à vouloir appliquer les structures de politiques monétaires conçues pour les Etats-Unis ou l'Europe dans les économies émergentes ou en développement. Celles-ci doivent se doter d'institutions appropriées à leur réalité et leur fonctionnement, ce qui nécessite de disposer de théories qui leur soient adaptées. C'est précisément ce que nous avons cherché à réaliser tout au long de cette thèse.

[7] Nous appelons politique le lieu ou le mécanisme par lequel les forces représentant des intérêts ou des populations différentes confrontent leurs antagonismes dans le but de légitimer le fait qu'une décision unique soit appliquée à l'ensemble de l'économie.

Première partie

Inflation-Targeting and Foreign Exchange Rate Policy

CHAPTER 2

Inflation-Targeting and Foreign Exchange Interventions

Contents

Abstract:
Are emerging economies implementing inflation targeting (IT) with a perfectly flexible exchange-rate arrangement, as developed economies do, or have these countries developed their own IT framework? This paper offers a new method for assessing exchange-rate policies that combines the use of "indicator countries", providing an empirical definition of exchange-rate flexibility or rigidity, and clustering through Gaussian mixture estimates in order to identify countries' *de facto* regimes. By applying this method to 19 inflation-targeting emerging economies, I find that the probability of those countries having a perfectly flexible arrangement as developed economies do is 52%, while the probability of having a managed float system, obtained through foreign exchange market intervention, is 28%, and that of having a rigid exchange-rate system (similar to those of pegged currencies) is 20%. The results also provide evidence of two different monetary regimes under inflation targeting: flexible IT when the monetary authorities handle only one tool, the interest rate, prevailing in ten economies, and hybrid IT when the monetary authorities add foreign exchange interventions to their toolbox, prevailing in the remaining nine economies.

Keyword: Inflation-targeting, Foreign Exchange Interventions, Gaussian mixture model.

JEL: E31, E40, E58, F31.

2.1 Introduction

Exchange-rate volatility has long been described as the Achilles' heel of inflation-targeting (IT) regimes in emerging economies. Owing to the particularities of emerging economies and the fact that IT was generally intended to go hand in hand with a freely floating exchange rate, it was argued that IT as it is applied in developed economies would not be a panacea for emerging economies[1]. However, since New Zealand first adopted IT in December 1989, this framework has become a standard operating procedure, particularly in emerging economies. Today, of the 29 economies that fulfil the standard criterion that defines IT, 19 are emerging economies (see Hammond 2012). Based on these findings, this paper examines whether emerging economies implement similar IT strategies to developed economies or whether these countries adopt particular policies, especially towards exchange-rate flexibility. Is the exchange rate as flexible in IT emerging economies as in IT developed economies or is it less flexible or perhaps more controlled? Are foreign exchange market interventions more frequent in IT emerging economies than in IT developed economies or is there little difference?

It is generally agreed that the exchange rate plays a greater role - both as a tool and as a target - in monetary policy in emerging economies than in developed economies. This is due to the enhanced role played by exchange-rate channels in emerging economies, which are generally attributed to greater vulnerability to shocks, lower policy credibility and underdeveloped domestic financial markets (see Stone et al. 2009). The prominent role played by the exchange rate in emerging economies' monetary policy is also associated with two phenomena: the "fear of floating" (Calvo & Reinhart 2002) and the "fear of appreciation" (Levy-Yeyati et al. 2013). According to Cavoli (2009), the first phenomenon is justified by three factors: the fear of trade contraction due to higher exchange-rate volatility, a higher pass-through from the exchange rate to domestic prices in emerging economies than in developed economies, and balance sheet effects caused by currency mismatches and liability dollarisation. Levy-Yeyati et al. (2013) attribute the second phenomenon to concerns over losing competitiveness. Aghion et al. (2009) also demonstrate that exchange-rate volatility reduces growth in countries with relatively less developed financial sectors.

Therefore, even if they do not set a particular exchange-rate target, the monetary authorities in emerging economies are more concerned by the exchange rate than their counterparts in developed economies. This idea has been analysed in the literature in such a way so as to suggest that the central banks of emerging economies should give more weight to the exchange rate in their reaction function than developed economies. Hence, on the theoretical side, various models[2] have been developed to explain in which circumstances the central banks of emerging economies are justified in using a Taylor rule augmented by

[1] See Mishkin (2004).

[2] See Batini et al. 2003, Moron & Winkelried 2005, Cavoli & Rajan 2006, Yilmazkuday 2007, Cavoli 2008, Ravenna & Natalucci 2008, Roger et al. 2009, Stone et al. 2009, Bénassy-Quéré & Salins 2010 and Pavasuthipaisit 2010

the exchange rate while, on the empirical side, a large number of papers[3] have estimated such open-economy Taylor rules.

However, those papers in which exchange-rate policy is analysed using the Taylor rule argument only are missing the smoking gun: the most prominent policy is foreign exchange market intervention[4]. Surprisingly, foreign exchange market intervention under inflation targeting has not received much attention in the literature[5]. The main two reasons behind this are, first, macroeconomic models are not well suited to assessing the use of two instruments by one agent (both an interest rate instrument and foreign market intervention) and, second, the channel of foreign exchange market intervention is not yet clearly understood empirically or theoretically. However, the need to address foreign exchange market interventions is growing, as central banking practices increasingly seem to rely on a “two targets, two instruments” principle[6].

This paper aims to fill the gap in the literature: it offers a method for assessing central bank exchange-rate policy in emerging economies through exchange market interventions, rather than as an augmented Taylor rule. Based on the methodology developed by Levy-Yeyati & Sturzenegger (2005) for classifying exchange-rate arrangements, the degree of flexibility of an exchange rate is defined by the behaviour of both its nominal exchange rate and foreign exchange market interventions. Using a Gaussian mixture model, I compute the probability of any inflation-targeting emerging economy having a floating exchange-rate arrangement, an intermediate system or a fixed exchange-rate system. The definition of each regime is assessed by two pools of “indicator countries”, from which data are randomly selected to form a control sample in a bootstrapping loop. My results strongly support the existence of two distinct inflation-targeting regimes: a flexible inflation-targeting regime with a flexible exchange-rate as in developed economies, and a hybrid inflation-targeting regime under which the exchange rate is more controlled and less flexible. However, the share of hybrid inflation-targeters is small: 10 out of 19 inflation-targeting emerging economies (ITEE) have an exchange rate as flexible as that of inflation-targeting developed economies.

This paper is organised as follows: Section 2.2 presents and discusses the literature on deeds versus words exchange-rate regime classification; Section 2.3 offers a method for assessing exchange-rate control through foreign exchange market interventions, specifically designed to deal with inflation-targeting emerging economies; Section 2.4 describes the data; and section 2.5 presents the results. The last section briefly concludes.

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[3] See Corbo et al. 2001, Mohanty & Klau 2005, Edwards 2006, Aizenman et al. 2011 and Frömmel et al. 2011.

[4] As emphasized by Stone et al. (2009, page 25) “Foreign exchange interventions (...) is the main exchange-rate policy implementation tool”.

[5] With the notable exception of Berganza & Broto (2012) and Chang (2008).

[6] This was described by Ostry et al. (2012, page 13) as follows : “the central bank may opt for an IT regime, subordinating its monetary policy to achieving the inflation objective. If, as the discussion above suggests, emerging markets economies central banks also have available a second instrument (foreign exchange intervention), they can also limit temporary movements of the exchange-rate without prejudicing attainment of their primary target, the inflation rate.”

2.2 *Deeds vs words*: the need for *de facto* exchange-rate regimes classification.

Which economies have a floating exchange-rate and which ones have a stickier arrangement? This is a deceptively simple question. The basic and instinctive answer would be to look at monetary authorities' statements on the external value of their currencies. Until 1999, this official information was collected by the IMF and published in its *Annual Report on Exchange-Rate Arrangements and Exchange Restriction.* However, the fear of potential gaps between officially reported exchange-rate regimes and those which actually prevailed led to alternative *de facto* classifications of exchange-rate regimes being constructed in order to test whether the announced policy reflected the actual policy in place. Even if these papers differ in the conclusions reached at the country level, there is a clear consensus that, in practice, many exchange-rate regimes do not function according to the *de jure* rules.

Evidence for this initially involved fixed exchange-rate arrangements. One of the most prominent papers on the topic, Obstfeld & Rogoff (1995), argues that in the post-Bretton Wood environment, the concept of a fixed exchange rate is a "mirage"[7]. The idea was then extended to the floating arrangement when, in a nod to Obstfeld and Rogoff, Reinhart (2000) wrote "The Mirage of Floating Exchange Rates". Using the US dollar, the German deutschemark and the Japanese yen as benchmarks to define flexible exchange-rate arrangements, Reinhart reaches the following conclusions (p65): "Countries that say they allow their exchange-rate to float mostly do not; there seems to be an epidemic case of 'fear of floating'."[8]

Many *de facto* classifications, relying on a wide variety of econometrical and statistical methods, have followed. Therefore, exchange-rate classification methods have almost become a field of research in themselves, as described by Tavlas et al. (2008). The three main results of this literature are presented below.

First of all, the *de jure* classification predicts those classifications built on facts very badly. Table 2.1, page 35 summarises the correspondence among the official classification and three standard *de jure* classifications: Ghosh et al. (2000) (denoted by GGW), Levy-Yeyati & Sturzenegger (2005) (denoted by LYS) and Reinhart & Rogoff (2004) (denoted by RR). It displays the large discrepancy between the *de jure* regimes and any given *de facto* definition. This result also stresses the need to use a *de facto* classification while studying, for instance, the impact of exchange rate regimes on a macro variable like growth or the determinants of the choice of exchange-rate regime.

[7] Obstfeld & Rogoff (1995) : "aside from some small tourism economies, oil sheikdoms and highly dependent principalities, literally only a handful of countries in the world today have continuously maintained tightly fixed exchange-rates against any currency for five years or more." (p 87) Also, on the determinants of this evolution: "There is little question that the biggest single factor has been the dramatic evolution of world capital markets" and "shifting capital flows". (p77)

[8] She also notes that "The low variability of the nominal exchange-rate is not owing to the absence of real or nominal shocks in these economies." It is "the deliberate result of policy actions to stabilize the exchange-rate." Also "most of the episodes that come under the heading of floating exchange-rates look more like non credible pegs", underlining a credibility problem. Reinhart (2000, page 65)

	GGW	LYS	RR
IMF *de jure*	0.60	0.28	0.33

Table 2.1: *De jure* and *de facto* correlations.
Source: Frankel & Wei (2008b)

Second, building an exchange rate classification relying only on facts is not an easy task. Only very few classifications do not rely on any *de jure* component and, moreover, the various *de facto* regimes barely correspond any more closely to one another than to the official regime.

Finally, the definition of an exchange-rate regime is relative. It is almost impossible to define an exchange-rate regime as fixed or floating by applying a threshold or *ex ante* criterion on exchange-rate volatility or, indeed, on any other variable. The variables that define a policy have to be analysed jointly and carefully. *De facto* regimes also rarely correspond to the ideal view but are more likely to result from a negative inference: for example, a country does not have a flexible arrangement because its central bank never intervenes in the foreign exchange market, but rather because the central bank intervenes relatively less frequently than other central banks. The approach developed by Levy-Yeyati & Sturzenegger (2005) is, in this way, quite accurate. They propose a purely statistical classification methodology, which does not rely on any *de jure* component coming from an official source or any threshold left to the author's discretion. Economies are only ranked or classified in relation to their characteristics.

Among the various methods developed in the literature that of LYS distinguishes itself in that the number of currencies used to define a country's exchange rate is flexible. In the general case, one reference currency (the main trade and finance partner) is used, but where there is no such immediate reference currency, or where a basket peg is known, a weighted exchange-rate can also be used. The exchange-rate series considered are the official ones and not those from the parallel or black markets as in Reinhart & Rogoff (2004). As long as the classification is not used to study bilateral trade, this seems to be fair (see Shambaugh 2004). Both the exchange rate and some exchange-rate control instruments are used to define a regime, unlike in hard peg regime studies such as Frankel et al. (2001), Bénassy-Quéré & Coeuré (2002) and Bénassy-Quéré et al. (2006). LYS use foreign exchange reserves to measure foreign exchange interventions, as in Edwards & Savastano (1999), Reinhart (2000) and Edwards (2002). Their measure is a close substitute for the exchange market pressure proposed by Girton & Roper (1977) and used by Frankel & Wei (2008a), Frankel & Xie (2009) and Frankel & Xie (2010). The method adopted by LYS is purely statistical, as in Frankel & Wei (2008a) and Frankel & Xie (2010), and thus does not rely on any *de jure* information, contrary to Ghosh et al. (1997), Eichengreen & Leblang (2003) and Dubas et al. (2005), nor does it rely on the researcher's judgment, contrary to Bubula & Atker (2002).

LYS classification main features. LYS classify exchange-rate regimes according to the behaviour of three variables: interventions in the foreign exchange market, $\sigma(r)$, the volatility of the nominal exchange rate, $\sigma(e)$, and the volatility of nominal exchange-rate changes, $\sigma(\Delta e)$. Interventions in the exchange markets are measured through the volatility of central banks' foreign reserves. Idiosyncratic shocks may explain some of the nominal exchange-rate changes; therefore, a currency's stability has to be measured according to the volatility of its exchange rate relative to that of its reserves. The volatility of nominal exchange-rate changes is taken into account in order to consider policies with a medium-term exchange-rate target, achieved via short-term objective. In such a procedure, known as a crawling peg, a currency's exchange rate is periodically adjusted, but the exchange rate may remain fixed between one adjustment and the next. Therefore, exchange-rate volatility does not imply volatility of nominal exchange-rate changes, as opposed to what is observed with a freely floating exchange rate.

Every variable is expressed as a yearly average of monthly data, thus any observation is a three-dimensional object (one dimension for each variable), related to a given country and a given year. LYS then apply the K-means partitioning algorithm[9] to their dataset in order to group similar observations into clusters. Once the data have been grouped, each cluster is associated with an exchange-rate regime.

	$\sigma(e)$	$\sigma(\Delta e)$	$\sigma(r)$
Flexible	High	High	Low
Crawling Peg	High	Low	High
Fixed	Low	Low	High
Dirty float	High	High	High
Inconclusive	Low	Low	Low

Table 2.2: LYS classification criteria

To identify the policy regime, LYS assume "the cluster with high volatility of reserves and low volatility in the nominal exchange-rate identifies the group of fixers. Conversely, the cluster with low volatility in international reserves and substantial volatility in the nominal exchange-rate corresponds to countries with flexible arrangements" (LYS 2005, p 1605). The group with high volatility in the nominal exchange rate and international reserves but low volatility in nominal exchange-rate changes is made up of those countries with a "crawling peg". They add a fourth group, "dirty float", which "should be associated to the case in which volatility is relatively high across all variables, with intervention only partially smoothing exchange-rate fluctuations." (LYS 2005, p 1606). Last, the cluster in which every variable has low values is labelled "inconclusive". This group does not match up with any obvious regime and, therefore, is treated as a special case.

[9] This method, based on nearest centroid sorting, assigned individual cases to the cluster with the smallest distance between the case and the center of the cluster.

Strengths and weaknesses. The LYS classification method has three main advantages when compared with other methods. First, exchange-rate movements and foreign exchange interventions are both considered simultaneously. Second, it is a purely *de facto* classification; it does not rely on any *de jure* component from an official source or any component left to the author's discretion. Third, the LYS classification is based on relative definitions, as opposed to absolute definitions based on thresholds or specific *ex ante* measurements. Given that the message delivered by the literature on the "fear of floating" (Reinhart and others) is precisely that there is no right threshold to define a regime, this is a major factor to be taken into account when properly defining exchange-rate systems.

Though the LYS regimes classification has become a standard in exchange-rate policy studies, there are, nevertheless, some limitations that must be taken into account.

Firstly, the classification ends in 2005 and thus does not cover the years of IT sufficiently. Secondly, and more importantly, the LYS way of dealing with the "inconclusive" cluster is not convincing. This cluster contains 1,798 out of 2,860 observations. Therefore, more than 60% of the observations are not associated with a policy regime and are passed by in the initial classification. To resolve this issue, LYS proceed to a second classification: they apply the same method used for the whole sample during the first round on the single inconclusive group. However, there is no convincing argument suggesting that the observations labelled in the first round (for instance, "dirty float") are similar to those that were given the same label in the second round. This can be seen clearly when looking at the clusters' boundaries in the two rounds. Are the classifications produced from the two rounds really referring to the same policy realities? This is a major concern. In addition, even after the second round, a large number of observations (698) still remain in the "inconclusive" cluster. Hence, 25% of the initial dataset is simply left aside and is not associated with a policy regime[10].

Last, even though the K-means algorithm used by LYS to cluster the data has become a standard in the partitioning literature, it is also known to have several drawbacks. First, the number of clusters, k, is an input parameter that has to be defined ex ante. Therefore, it is not exact to say that "cluster analysis has the advantage of avoiding any discretion from the researcher"[11]; the researcher has to choose how many groups are to be found in the data.

Furthermore, LYS do not provide any information about the goodness-of-fit of the number of groups (k) or of the grouping itself. Another limitation of the partitioning algorithm is that the results are sensitive to data composition. In the case of LYS, removing

[10] Despite the limitations of the method, it seems that the high number of "inconclusive" cases is due to the partitioning algorithm and to the extremely large time period and country coverage chosen by the authors. Their dataset covers any country included in the IMF statistic from 1973 to 2005. Hence, it covers a wide variety of realities and includes a large number of outliers, most notably among the "inconclusive" observations. On the other hand, even though they left out less than one in four observations, with such a large coverage they obtain an interesting and useful classification, seen as a standard in the literature.

[11] Full quote: "cluster analysis has the advantage of avoiding any discretion from the researcher beyond that required to determine the classifying variables and to assign clusters to different exchange-rate regimes, once they are identified by the procedure." Levy-Yeyati & Sturzenegger (2005, page 1610)

only a few observations may modify the entire classification, which may explain why the inconclusive countries are not considered as outliers and are excluded from the sample[12]. Last, clusters formed by the K-means algorithm have a constrained variance-covariance matrix which gives them a spherical shape and a similar size (see Hennig 2011). This particularity may explain the large number of intermediate regimes they obtain.

[12] Similarly, k-means may converge to a local minimum, and thus their results are sensible to the initialization parameters.

2.3 An original method for assessing exchange-rate control

2.3.1 The approach.

My purpose is to examine whether emerging economies implement similar IT strategies to developed economies or adopt particular policies, especially with regard to exchange-rate control through foreign exchange intervention. Therefore, I propose a new classification method, specifically designed to assess the degree of flexibility of the currencies of inflation-targeting emerging economies (ITEE).

Two control samples. I consider that two fundamental elements of the LYS method are good and are to be retained when developing my own approach: first, the use of exchange rate volatility, the volatility of exchange-rate changes and interventions in the exchange market to characterise a policy and, second, a partitioning procedure to group the observations into consistent policy group. I focus on ITEE; therefore, these countries will constitute the core of my data sample. However, a good classification of exchange-rate arrangements has to be a relative classification[13]. Therefore, in order to access the exchange rate arrangement of ITEE, I must analyse their exchange-rate flexibility relative to that of some other economies. These control samples are hereafter referred to as "indicator countries" and constitute the counterfactual economies. However, I require two control samples, one for each polar policy: flexible and rigid arrangements. The flexible arrangement control sample is made up of developed IT economies; these economies act as the benchmark for inflation-targeting frameworks associated with a flexible exchange-rate regime. Hence, the sample shows whether the exchange rates of ITEE are as flexible as those of IT developed economies. The fixed arrangement control sample is made up of economies that have rigid regimes. Finally, my database is the sum of the ITEE observations, and the flexible and rigid indicator country samples.

Partitioning algorithm. I apply a partitioning algorithm to this database in order to split the whole set of observations into consistent groups. I show, in the next section, the advantage of using a Gaussian mixture approach over the K-means algorithm used by LYS. Data are split according to the likelihood that they belong to a given Gaussian distribution. All the observations belonging to a Gaussian form one cluster (or one group). Each distribution is then assumed to be produced by a unique process, which, in turn, is assumed to be a given exchange-rate regime. The optimal number of clusters and the cluster composition are defined by statistical criteria and each cluster is then associated with an exchange-rate policy.

Labeling policies. The indicator countries are used to label the groups, so as to associate a cluster to a monetary policy. For instance, in the case that there are two resulting

[13] As opposed to an absolute classification, which would be based on thresholds or specific measurements.

clusters, all observations in the group which includes the majority of floating exchange-rate indicator countries are labelled as *de facto* floating. Hence, any observation from an IT emerging economy included in this group will be considered as *de facto* floating. As there are generally more than two groups, an "intermediate" regime also has to be considered. The Gaussian model estimation gives the probability that any given observation belongs to any given cluster; this is therefore the probability that a given country on a given date has a given policy. Hence, as opposed to other classifications found in the literature, the aim of my classification scheme is not to state that a certain country has a certain arrangement: my final result shows the precise probabilities that a country has a flexible arrangement, a fixed system and a "dirty float".

Robustness. An important drawback of partitioning algorithms is their sensitivity to data composition: a slight change in the data can have a large impact on the results. This is particularly true in the presence of outliers. To address this issue and ensure the results' stability, I propose a bootstrapping approach with random sampling. At each iteration the observations for the ITEE remain in the dataset but the two sets of indicator countries change. The sets of indicator countries used for a given partition are randomly selected from all the control observations including both fixed and floating indicator countries. Therefore, the partition is made over a set of observations consisting in the ITEE, some randomly selected fixed indicator countries and some randomly selected floating indicator countries. At any iteration I compute the probability that an ITEE observation belongs to any given policy. My final result is the average of the probabilities of all iterations, that is, the average of the results of more than 50,000 partitions; in this way I ensure stability.

2.3.2 Partitioning through Gaussian mixtures

In order to cluster the observations into consistent group, I estimate a Gaussian mixture model.

Gaussian mixture definition. Let's think of the k policy groups obtained with the k-means clustering method by LYS. One can suppose that there is a Gaussian centered at any group' s mean. Thus each cluster can be characterized by a density function, and the overall dataset can be described by a mixture of all these density functions (plus the probability for a given observation to belong to one of them). This analysis of a dataset can be done through a Gaussian mixture model.

The univariate Gaussian distribution is given by

$$p(x|\mu, \sigma) = \frac{1}{\sqrt{2\pi\sigma^2}} exp\left(-\frac{1}{2\sigma^2}(x-\mu)^2\right) \tag{2.1}$$

where the mean $\mu \in \mathbb{R}$ and the variance $\sigma \in \mathbb{R}^+$ are the parameters of the distribution.

In my case I have three variables per observations (the nominal exchange-rate volatility, the interventions in the foreign exchange market and the volatility of nominal exchange-rate changes). Hence this is a "trivariate" case. When the Gaussian distribution is extended to more than one distribution, it is given by:

$$p(x|\mu, \Sigma) = \frac{1}{(2\pi)^{d/2}|\Sigma|^{1/2}} exp\left(-\frac{1}{2}(x-\mu)^\top \Sigma^{-1}(x-\mu)\right) \quad (2.2)$$

where d (equals 3) is the number of distributions. In the multivariate case the mean is a vector, $\mu \in \mathbb{R}^d$, and the covariance is a positive definite matrix, $\Sigma \in \mathbb{S}^d$.

For a given set of M observations, $x = \{x_1, ..., x_M\}$ that are assumed i.i.d and drawn from a multivariate Gaussian, the distribution's log-likelihood is:

$$p(x|\mu, \Sigma) = -\frac{Md}{2} log(2\pi) - \frac{M}{2} log|\Sigma| - \frac{1}{2}\sum_{m=1}^{M}(x_m-\mu)^\top \Sigma^{-1}(x_m-\mu) \quad (2.3)$$

By definition a Gaussian distribution is unimodal. If assuming k groups in the dataset, a combination of k Gaussians into a Gaussian Mixture Model is to be considered. With a mixing coefficient denoted by $\pi \in \mathbb{R}^K$ and satisfying any $\pi_k \geq 0$ and $\sum_{k=1}^{K} \pi_k = 1$, the Gaussian mixture model is then given by:

$$p(x|\pi, \mu, \Sigma) = \sum_{k=1}^{K} \pi_k \mathcal{N}(x|\mu_k, \Sigma_k) \quad (2.4)$$

where $\mu = \{\mu_1, ..., \mu_K\}$ and $\Sigma = \{\Sigma_1, ..., \Sigma_K\}$ are the mean and variance of the respective Gaussian distributions (denoted by $\mathcal{N}$, and defined as in equation (2.2)). [14]

The log-likelihood associated to this model (for m points, assuming independance) can be written as

$$log \;\; p(X|\pi, \mu, \Sigma) = \sum_{m=1}^{M} log \sum_{k=1}^{K} \pi_k \mathcal{N}(x_m|\mu_k, \Sigma_k) \quad (2.5)$$

Once the parameters estimates have been obtained, the *a posteriori* probability that an observation m belongs to the group k can be deduced:

$$\pi_{m,k} = \frac{\pi_k \mathcal{N}(x_m|\mu_k, \Sigma_k)}{\sum_{k'} \pi_{k'} \mathcal{N}(x_m|\mu_{k'}, \Sigma_{k'})} \quad (2.6)$$

In this paper, $\pi_{m,k}$ is the probability that an observation m, for example Brazil in 2010, belongs to a group k, for example free floating exchange-rate group. Also, the sum of $\pi_{m,k}$ and $\pi_{m,k'}$ equals 1. In that example, k' stands for fixed and intermediate exchange-rate groups.

[14] Since the observations are assumed to be independently distributed, equation (2.4) may be written as: $p(x|\pi, \mu, \Sigma) = \prod_{m=1}^{M} \sum_{k=1}^{K} \pi_k \mathcal{N}(x_m|\mu_k, \Sigma_k)$

Variance decomposition. This general expression of the Gaussian mixture model allows some sophistications. In particular, the covariance matrix can be decomposed into different variables on which a large set of constraints can be applied.

Following Banfield & Raftery (1993) a spectral decomposition of the covariance matrix is given by:

$$\Sigma_k = \lambda_k D_k A_k D_k^\top \tag{2.7}$$

for $k = 1, ..., K$ and where

- $(\lambda_{k1}, ..., \lambda_{kd})$ are the matrix eigenvalues with $\lambda = \Pi_{m=1}^{d}(\lambda_{mk})^{1/d}$.
- D_k is the matrice of eigenvectors .
- A_k is a diagonal matrix whose elements are proportional to the eigenvalues, that is $A_k = \frac{1}{\lambda_k}$ diag$(\lambda_{k1}, ..., \lambda_{kd})$ and det$A_k = 1$.

This decomposition of Σ_k allows to characterize the distribution: D_k gives the orientation of the covariance matrix, A_k specifies the shape of the density contours and λ_k determines the volume of the corresponding ellipsoid (or hypervolume). These three characteristics (orientation, volume and shape) can be estimated from the data, and can be allowed to vary between clusters, or constrained to be the same for all clusters can vary between clusters, or be constrained as the same for all clusters.

Table 2.3: Possible parameterizations of the covariance matrix Σ_j for multidimensional data.

Model name	Form	Distribution	Volume	Shape	Orientation
EII	λI	Spherical	Equal	Equal	NA
VII	$\lambda_j I$	Spherical	Variable	Equal	NA
EEI	λA	Diagonal	Equal	Equal	Coordinate axes
VEI	$\lambda_j A$	Diagonal	Variable	Equal	Coordinate axes
EVI	λA_j	Diagonal	Equal	Variable	Coordinate axes
VVI	$\lambda_j A_j$	Diagonal	Variable	Variable	Coordinate axes
EEE	λDAD^T	Ellipsoidal	Equal	Equal	Equal
EEV	$\lambda D_j A D_j^T$	Ellipsoidal	Equal	Equal	Variable
VEV	$\lambda_j D_j A D_j^T$	Ellipsoidal	Variable	Equal	Variable
VVV	$\lambda_j D_j A_j D_j^T$	Ellipsoidal	Variable	Variable	Variable

Source: Fraley & Raftery (2007, page 8).

Celeux & Govaert (1995) have described the different model that can be obtained by constraining the orientation, volume and shape of the covariance matrix. They also provide details on the EM algorithm for the maximum likelihood estimation of these models. Fraley et al. (2012) (see also Fraley & Raftery 2007) proposed a computational methodology for some of them. In this paper I focus on the multidimensional case considering three options: to be equal among clusters, to vary among clusters, to be given by the identity matrix. Also

I use Fraley et al. (2012) denomination system: a 3 letters code, with 1 letter for each of the 3 characteristics (volume, shape and orientation)[15]. The different model of the covariance matrix for which a computational method is known are summarized in Table 2.3 and I keep referring to this name system in the section dedicated to the results, in particular see Graph 2.2 page 48.

A criteria to choose the number of clusters. The choice of the number of components has to be done according to the quality of the fit of the estimated density and the detection of distinct groups. A particularly simple and viable method consists in choosing the value of K which minimizes the Bayesian Information Criterion (BIC), as difined by Schwarz (1978):

$$BIC = -2\,\widehat{l} + w\ log\ n \tag{2.8}$$

where $\widehat{l}$ is the estimated log-likelihood, n is the number of observations, and the term w corresponds to the number of parameters to be estimated ($w = 3K - 1$) in the bivariate case.

From k-means to Gaussian mixture. In the Appendix 2.A page 58, I show how the Gaussian mixture differs from the K-means algorithm used by Levy-Yeyati & Sturzenegger (2005). Indeed, the K-means used by LYS is similar to the Gaussian distribution, but there are two limitations: the covariance matrix is constrained and the probability of belonging to a given group is not computed. The covariance matrix constraint gives the clusters their spherical shape and all clusters are of a similar size; this may be a problem because it also creates policy groups of a similar size. Therefore, it can be argued that intermediate regimes are as important as polar regimes. This may be right; however, the algorithm used by LYS creates an important bias towards that result. Also, when adopting their approach, the probability of an observation belonging to a certain group is not computed. An observation either belongs to a group or it does not, whereas, in my approach, the clusters' shape is flexible and the precise probability of belonging to a group is computed. This avoids stating that a country has a fixed or floating arrangement and instead gives the probability that a country has a fixed or floating arrangement. All in all, the Gaussian mixture approach seems to be more flexible and robust than the K-means approach.

[15] For example EVI denotes a model in which the volumes of all clusters are equal (E), the shapes of the clusters may vary (V), and the orientation is the identity (I). Clusters in this model have diagonal covariances with orientation parallel to the coordinate axes.

2.4 Data

2.4.1 Data coverage.

My dataset is made up of 75 countries, including 28 IT countries, of which 19 are emerging economies and 9 are developed economies. I use the list of IT countries produced by the Bank of England (BoE) in a paper based on a broad set of indicators, which is very well documented (see Hammond 2012. Also related are Mishkin 2004 and Roger 2009, among others). The essential elements that define an inflation-targeting regime are:

- Price stability is explicitly recognised as the main goal of monetary policy;
- There is a public announcement of a quantitative target for inflation;
- Monetary policy is based on a wide set of information including an inflation forecast;
- Transparency;
- Accountability mechanisms.

To define the rigid regime indicator countries, I follow the IMF classification (see "Classification of Exchange Rate Arrangements and Monetary Policy Frameworks", IMF website). I consider two items: "currency board arrangements" and "other conventional fixed peg arrangements against a single currency"[16]. I obtain 47 indicator countries for the fixed exchange-rate benchmark. Information about the dataset is summarised in the Appendix 2.B page 62. The number of floating indicators and rigid indicators is balanced through the bootstrapping method, which selects similar subsamples.

I use monthly data from the IMF's International Financial Statistics over the period 1990-2012. This is the widest range possible since the first country which adopted IT, New Zealand, did so in December 1989. For every country, I only consider the years after IT was implemented. The starting dates of IT come from the BoE's Handbook on IT (Hammond 2012) and correspond, by and large, to the date declared by the central banks, also known as the "default starting dates" in Rose (2007)'s terminology. I follow **?** and Levy-Yeyati & Sturzenegger (2005) for the definition and computation of the three variables:

- Exchange-rate volatility, $\sigma(e)$, measured as the average of the absolute monthly log changes in the nominal exchange rate relative to the relevant anchor currency over the year.
- The volatility of exchange-rate changes, $\sigma(\Delta e)$, measured as the standard deviation of the monthly log change in the exchange rate.

[16] There are plenty of different rigid exchange rates families. My fixed exchange rates control sample takes a broad definition. It includes a lot of countries having various degrees of rigidity. Therefore, the robustness and stability of my result is insured through the boot-strapping estimation method.

- Interventions in the exchange markets, measured as central banks' foreign reserve volatility, $\sigma(r)$, that is, the average of the absolute monthly log change in dollar-denominated international reserves relative to the log change in the value of the monetary base.

A detailed description of variable computation can be found in the Appendix 2.B. Each variable is expressed as a yearly average (of monthly data), thus an observation is a three dimensional object related to a given country and a given year in the $(\sigma(e)\ ,\ \sigma(\Delta e)\ ,\ \sigma(r))$ space.

Random sampling. After computing the three variables, I discarded an observation where I lacked data for at least one of the classifying variables. I obtain 1,035 country-year data points: 154 for floating exchange-rate indicator countries, 603 for fixed exchange-rate indicator countries and 278 for the inflation-targeting emerging economies.

The difference in size of the two control sample does not pose any problems because it will be corrected by a repetitive random sampling process. This approach consists in estimating the Gaussian mixture model multiple times, each time with a different counterfactual sample composed of observations randomly selected from the two indicator countries' datasets. Hence, the Gaussian mixture model is estimated using a sample made up of all points for inflation-targeting emerging economies, and $2x$ points for indicator countries, among which x points are randomly chosen from observations for floating exchange-rate indicator countries and x points are randomly chosen from those for fixed exchange-rate indicator countries. The variable x takes any value from 100 to the size of the smallest indicator country's sample. The process is complete after more than 50,000 iterations. In other words, the Gaussian mixture model is estimated with more than 50,000 different data samples.

2.4.2 Partitionning loop.

The classification process is based on the following loop:

- **Step 1:** Random composition of the control sample. A given number of observations are randomly selected among the two sets of indicator countries in order to create the control sample. When added to the ITEE observations, they make up the dataset for one iteration (see Graph 2.1 page 47).

- **Step 2:** Gaussian mixture model estimation. The Gaussian mixture model is estimated. The BIC criterion maximisation gives the best variance-covariance decomposition model and the optimal number of Gaussians that are mixed into the model (see Graph 2.2 and Graph 2.3 page 48). Only the optimal distribution is taken into account. The probability of any ITEE observation belonging to any Gaussian is computed.

- **Step 3:** Exchange-rate arrangement classification. All observations belonging to one Gaussian are assumed to form one group (or cluster). That cluster is then assigned to an exchange-rate regime according to the indicator countries' position (see Graph 2.4 page 49). The probability of any ITEE observation belonging to any Gaussian can now be read as the probability of having a monetary regime.

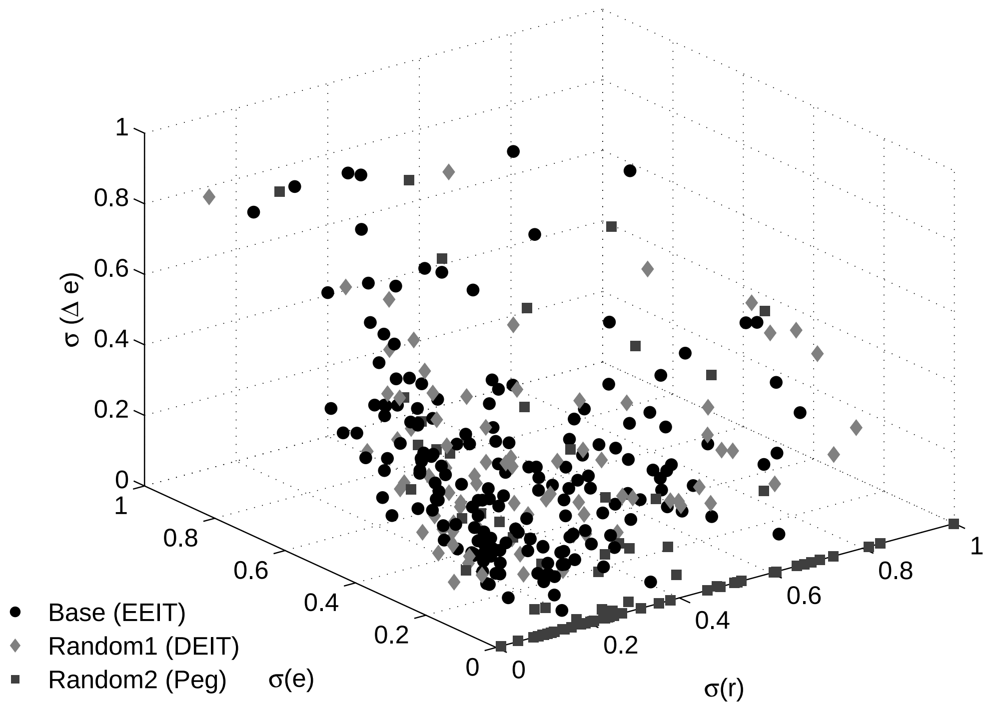

Figure 2.1: Random composition of the data sample (Step 1).

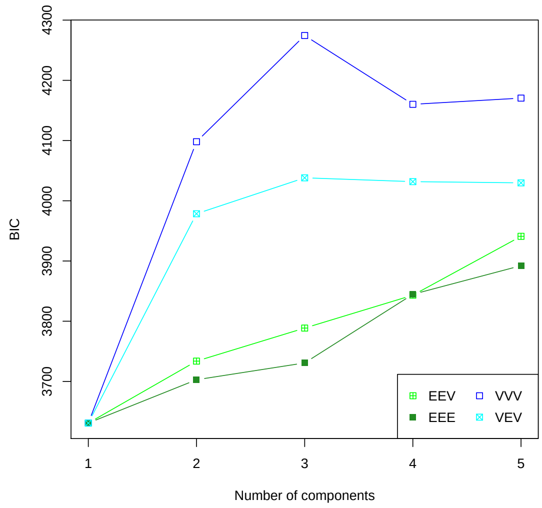

Figure 2.2: Identification of the optimal model and number of Gaussians (Step 2).

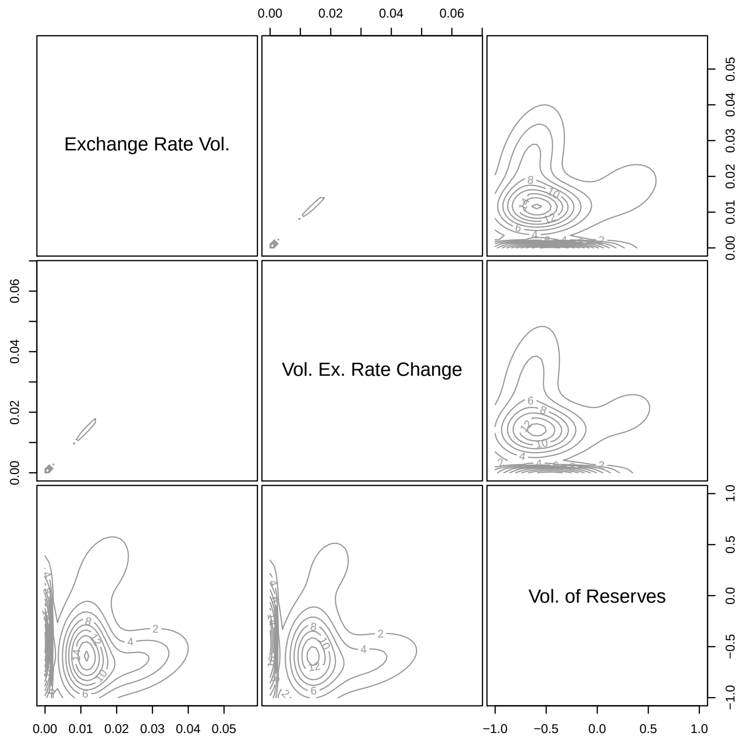

Figure 2.3: Correspondance between the optimal number of Gaussians and the number of modes appearing on the join density.

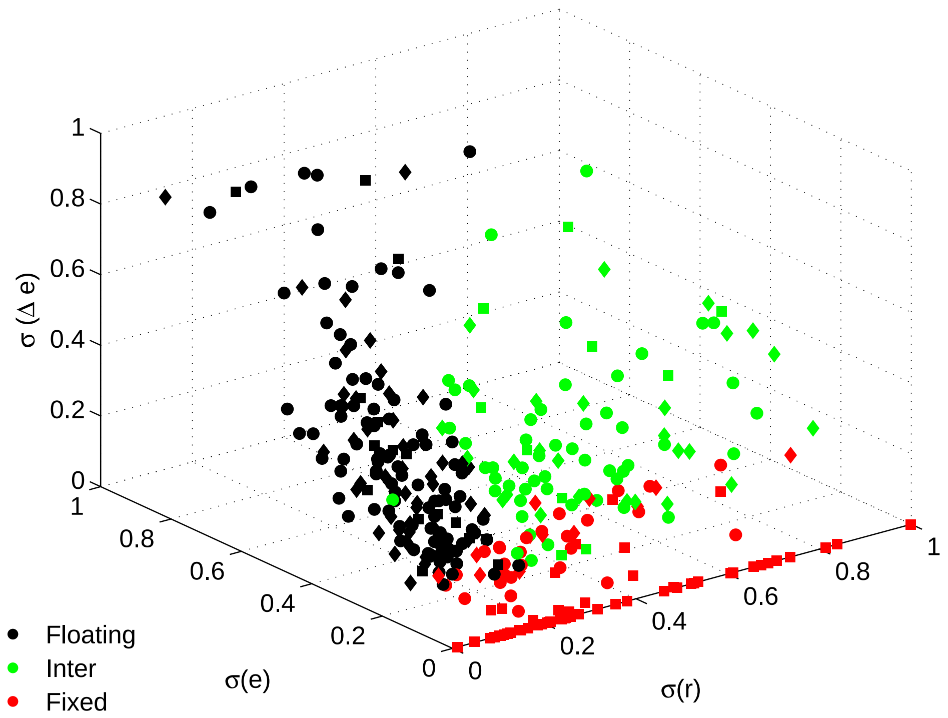

Figure 2.4: Labelling clusters as *de facto* regimes (Step 3).

2.5 Results

2.5.1 Three exchange-rate flexibility degrees: floating, intermediate and fixed.

When the Gaussian mixture model is estimated in step 2, it gives the optimal number of partitions (generally three). Therefore, three degrees of exchange-rate flexibility are to be considered in step 3 when labelling the clusters as fixed, floating or intermediate exchange-rate arrangements. The procedure is the following: if the majority of a Gaussian's elements come from the floating exchange-rate indicator countries, the Gaussian label is "*de facto* floating exchange-rate arrangement", and the probability of any observation belonging to that Gaussian is seen as the probability of having a *de facto* floating exchange-rate arrangement. The same reasoning holds for fixed exchange-rate arrangements. If there is a third group, it is labelled as "*de facto* intermediate exchange-rate arrangement". As we will see below, this group stands for managed floating or "dirty float" regimes[17]. The process described above is repeated thousands of times with different, randomly composed, indicator country samples and the final result (shown below) is, for any observation, the average probability of each iteration.

Table 2.4: Classification: summary statistics

	Fixed		
	$\sigma(e)$	$\sigma(\Delta e)$	$\sigma(r)$
min	0.2	0.2	0.2
mean	1.0	1.0	1.0
max	1.7	1.7	2.1
std	1.0	1.0	1.0
	Intermediate		
	$\sigma(e)$	$\sigma(\Delta e)$	$\sigma(r)$
min	0.1	0.1	1.4
mean	1.9	1.9	2.4
max	3.8	3.9	4.6
std	2.1	2.3	1.7
	Floating		
	$\sigma(e)$	$\sigma(\Delta e)$	$\sigma(r)$
min	0.5	0.1	0.2
mean	3.4	3.1	1.2
max	8.8	9.6	4.4
std	4.2	4.5	2.2

Values are expressed relatively to the mean and std of the fixed exchange rate arrangement group.

[17] It may happen that the BIC criterion maximization gives 2 or 4 gaussians, and the exact algorithm used to label the clusters is presented in greater detail in Appendix (2.B).

Table 2.4 summarises the main statistics that characterise the three policy groups. Values are expressed relative to the mean (and standard deviation) of the fixed exchange-rate arrangement group for each variable. For example, looking at the means in first column, we can see that the nominal exchange-rate volatility, $\sigma(e)$, in the intermediate group is, on average, 90% greater than in the rigid exchange rate group, whereas it is 3.5 times higher in the floating group than in the rigid exchange-rate group. The standard deviation captures the average distance between the observations of a cluster and the cluster's centroid (or centre). The fixed exchange rate arrangement group displays the lowest standard deviation value for $\sigma(e)$, which means that countries in this group have similar nominal exchange rate volatilities. On the other side, the floating arrangement cluster has a large standard deviation for $\sigma(e)$, meaning that exchange-rate volatilities in this group are much more heterogeneous.

The second column shows the values for the volatility of exchange-rate changes, $\sigma(\Delta e)$. The ranking and values are quite similar to those in the first column, which indicates the possibility of a strong correlation between the two variables. The absence of a cluster with large $\sigma(e)$, and $\sigma(r)$, and low $\sigma(\Delta e)$ (as in Table 2.2 page 36) indicates that there is no such behaviour as a crawling peg. This also supports the argument that the intermediate group should be seen as a "dirty-float" or "managed-float" system, or, in other words, a floating system with frequent interventions in the foreign exchange market.

This idea is confirmed by the figures in the third column, dedicated to $\sigma(r)$, the intervention in the foreign exchange market. The mean values for the floating and fixed arrangement groups are almost the same, while the mean of the intermediate group is very large. Once again, this indicates that the intermediate group matches up with a managed float strategy where there are large-scale exchange market interventions.

2.5.2 Results at the country level

The results for individual countries are given in the Appendix 2.C page 66. For instance, in 1999, there is a 98% probability of Chile having a floating exchange rate according to Table 2.C.5 (page 68). Consistently, there is a 2% probability of it having an intermediate exchange-rate arrangement (page 67) and a null probability (0%) of it having a fixed exchange rate (page 66). In other words, the probability of Chile's exchange rate being as flexible as that of developed IT economies in 1999 was 98%, while the probability of it being as controlled as that of fixed exchange-rate economies was null. This does not mean that Chile never tried to control its exchange rate or that foreign exchange market interventions never happened in Chile. Chile's monetary authorities may have intervened in the foreign exchange market, but the results seem to indicate that if they did, they did it to a similar extent as IT developed central banks. Another example is given by the same country seven years later. In 2006, the probability of Chile having a fixed exchange rate arrangement was still very low: 2%. Therefore, Chile's exchange rate policy was, by no comparison, similar to that of the monetary authorities of the pegged currencies.

However, the most probable arrangement is no longer the same: the probability of having a floating system has decreased to below one third (27%), while the probability of having an intermediate exchange-rate arrangement has risen to 71%. This does not mean that Chile had a controlled exchange rate in 2006, but rather it indicates that there is strong evidence to show that Chile's exchange market interventions were carried out on a broader scale than in developed countries.

An overview of the results at the country level is presented in Table 2.6 page 54 and Table 2.5 page 53.

Table 2.6 gives, for any country, the average probabilities of the three degrees of exchange-rate flexibility (for all years since the country adopted IT). The most probable exchange rate arrangement is a floating system. As can be seen in the last row of the table, the probability of an inflation-targeting emerging economy having a floating exchange rate is 52%. This figure may appear quite balanced. However, looking at the country level clearly indicates that the most probable degree of flexibility is that of having a floating arrangement: across the 19 ITEE, the probability of having a floating arrangement is the highest for 14 countries. Only three countries are most likely to have a fixed exchange rate arrangement: Albania, Guatemala and Peru (with an overall probability of 20%). Finally, Brazil and Hungary are most likely associated with an intermediate system (with an overall probability of 28%).

The finding that most observations show a floating exchange rate was to be expected. Theoretically, the definition of inflation-targeting implies that the focus is only on price stability and, therefore, the exchange rate is allowed to float. The finding that 28% of the observations are associated with an intermediate arrangement is also not surprising: a large body of literature has shown that monetary authorities try to reduce exchange rate volatility, most notably in emerging economies. This is the well-known "fear of floating" phenomenon. However, the share of the most rigid arrangements, 20%, is unexpectedly high. One in five ITEE exchange-rate observations is most probably as rigid as an exchange rate with a peg. Theoretically speaking, the issue of inflation-targeting under such circumstances should be questioned.

Focusing on the highest probability for each year, Table 2.5 page 53 summarises the number of years associated with each degree of flexibility for all countries. The table portrays the same phenomenon as the previous one: a floating system appears to be the most probable arrangement. It is associated with approximately half of the sample: 101 observations out of 197. This result is emphasised at the country level; floating arrangements occur most often in 12 out of 19 countries.

Table 2.5: Exchange-rate arrangements occurrences

	Number of years with			Years Covered
	Fix	Intermediate	Float	
ALBANIA	3	1	0	4
ARMENIA	0	1	6	7
BRAZIL	0	6	8	14
CHILE	0	4	10	14
COLOMBIA	2	2	10	14
CZECH REPUBLIC	3	2	9	14
GHANA	2	1	3	6
GUATEMALA	6	2	0	8
HUNGARY	0	9	3	12
INDONESIA	1	3	4	8
MEXICO	1	5	6	12
PERU	7	2	2	11
PHILIPPINES	5	4	2	11
POLAND	0	4	10	14
ROMANIA	4	1	3	8
SERBIA, REPUBLIC OF	1	3	3	7
SOUTH AFRICA	0	1	12	13
THAILAND	6	4	3	13
TURKEY	0	0	7	7
Total	41	55	101	197

Exchange-rate flexibility degree based on the most probable regime.

2.5.3 From flexibility degrees to IT regimes

While looking at the main results on the three degrees of flexibility, it may appear paradoxical that the overall probability of having a floating system is approximately one half, while it is the most probable arrangement for three-quarters of the countries considered. To reconcile these two dimensions, I propose to focus on the monetary regime implied by exchange-rate flexibility. The sample is made up of countries that fulfil the standard criterion defining IT: explicitly committing to a publicly announced inflation target. Therefore, the main question to be asked in order to define the monetary regime of these countries is: do these countries have only one target, price stability, or do they also target exchange-rate stability?

To answer this question, I will consider two inflation-targeting regimes, distinguished by the role played by the exchange rate: flexible inflation-targeting and hybrid inflation-targeting.

Flexible inflation-targeting corresponds to the standard definition: a monetary framework in which price stability is explicitly recognised as the main goal of monetary policy. Within this framework, the Tinbergen's principle holds: the central bank has one objective and only one instrument, the interest rate. Although "flexible" inflation-targeting refers to Svensson's well-known IT definition[18], in the context of this paper, "flexible" also refers to

[18] "Flexible inflation-targeting means that monetary policy aims at stabilizing *both* inflation around the

the degree of flexibility.

Proposition: Under *hybrid inflation-targeting*, aside from the goal of price stability and the tool with which to achieve this goal, interest rate setting, the central bank aims to manage the exchange rate through exchange market interventions.

Table 2.6: Inflation-targeting regime based on exchange-rate flexibility degree.

	Arrangement probability			IT regime
	Fix	Intermediate	Float	
ALBANIA	0.59	0.28	0.13	Hybrid IT
ARMENIA	0.04	0.29	0.67	Flexible IT
BRAZIL	0.04	0.51	0.45	Hybrid IT
CHILE	0.04	0.32	0.64	Flexible IT
COLOMBIA	0.13	0.17	0.70	Flexible IT
CZECH REPUBLIC	0.28	0.17	0.55	Flexible IT
GHANA	0.32	0.28	0.41	Hybrid IT
GUATEMALA	0.62	0.21	0.16	Hybrid IT
HUNGARY	0.10	0.51	0.39	Hybrid IT
INDONESIA	0.19	0.25	0.56	Flexible IT
MEXICO	0.20	0.29	0.51	Flexible IT
PERU	0.56	0.20	0.24	Hybrid IT
PHILIPPINES	0.35	0.29	0.37	Hybrid IT
POLAND	0.05	0.27	0.68	Flexible IT
ROMANIA	0.38	0.21	0.42	Hybrid IT
SERBIA, REPUBLIC OF	0.11	0.33	0.56	Flexible IT
SOUTH AFRICA	0.03	0.21	0.76	Flexible IT
THAILAND	0.32	0.26	0.42	Hybrid IT
TURKEY	0.02	0.22	0.76	Flexible IT
All countries	0.20	0.28	0.52	

To distinguish countries under the flexible IT regime from those under hybrid IT[19], the following rule is assumed: if the probability of having a flexible system is higher than the sum of the probabilities of all other systems, the country has a flexible inflation-targeting regime; otherwise, it has a hybrid IT regime.

The results are given in the last column of Table 2.6 page 54. Ten countries are found to have a flexible inflation-targeting regime: Armenia, Chile, Colombia, the Czech Republic, Indonesia, Mexico Poland, Serbia, South Africa and Turkey. The remaining nine have a

inflation target and the real economy, whereas strict inflation-targeting aims at stabilizing inflation *only*, without regard to the stability of the real economy, what Mervyn King (1997) has described as being an "inflation nutter". " in Svensson (2010b, page 1).

[19] "Hybrid inflation-targeting regimes" is also the title of a paper by Roger et al. (2009). In this paper, the authors examine whether including the exchange rate explicitly in the central bank's reaction function can improve macroeconomic performance using a DSGE model. They call hybrid inflation-targeting regimes those in which the central bank reacts to the exchange rate or controls the exchange rate, as opposed to "plain vanilla IT".

hybrid IT regime: Albania, Brazil, Ghana, Guatemala, Hungary, Peru, the Philippines, Romania and Thailand.

The large number of hybrid IT regimes confirms that inflation-targeting cannot be implemented in emerging economies in the same way as it is implemented in developed countries. Countries with a hybrid IT regime have adapted IT to suit their specific requirements. However, the large number of flexible IT regimes confirms the theoretical views on inflation-targeting: IT may lead to greater exchange-rate flexibility than that generally seen in emerging economies.

2.6 Conclusion

In this paper, I ask whether emerging economies implement a “flexible” inflation-targeting strategy, with one goal (price stability) and one tool (short interest rate), or a “hybrid” IT strategy, mixing two goals (price stability and exchange rate stability) and two instruments (short interest rate and foreign exchange market interventions).

In answer to this question, this paper offers a new exchange-rate regime classification method, which relies on three variables: the nominal exchange-rate volatility, the volatility of nominal exchange-rate change and interventions in the foreign exchange markets.

This method shows a clear improvement on the existing one and on that proposed by Levy-Yeyati & Sturzenegger (2005). I show that the LYS method is a constrained form of the algorithm I use. This constraint creates a bias towards intermediate regimes in the LYS paper, whereas my approach is more flexible and relies on an explicit criterion to define the quality of fit and the number of policy groups observed in the data.

The stability and robustness of my results is ensured through a bootstrapping loop using a random sample composition process. Move from statistical characteristics to policy behaviour, I use two control samples: one with IT developed countries and flexible exchange rates and another with countries with controlled exchange rates. A Gaussian mixture model is estimated to cluster the data into consistent groups and the control samples are used to label the different groups of IT emerging economies.

Across the 19 emerging economies that have adopted inflation targeting, I find clear evidence that 12 have an exchange rate which is as flexible as that of the IT developed economies. This does not mean that these countries never intervene in the foreign exchange market, but rather that if they do ever intervene, the impact on their exchange rate is similar to that on the rate in developed economies. Among the remainders, three have a managed float arrangement while the remaining four have an exchange-rate system as rigid as the standard peg currencies.

The probability of a country having a perfectly flexible arrangement is 52%, while the probability of having a managed float system obtained through foreign exchange market intervention is 28%, and that of having a rigid exchange-rate system (similar to those of pegged currencies) is 20%.

The results can also been sumarized by seeing evidence of two different monetary regimes under inflation targeting: flexible IT when the monetary authorities handle only one tool, the interest rate, and hybrid IT when the monetary authorities add foreign exchange interventions to their toolbox. Finally, flexible inflation-targeting prevails in ten countries and appears to be the main strategy.

Last, the probability of the exchange rate regime computed for the emerging economies that target inflation and presented in this paper can be used for many other purposes. For example, the database created for this paper can be used to test the relevance of the currency mismatches hypothesis (see Eichengreen et al. 2007 and Hausmann & Panizza 2011) as a determinant of exchange rate regime choice in emerging economies. Also, the probability of having a floating exchange rate can be seen as one of the Trilemma variables, that goes along Chinn & Ito (2008) capital openness index and Aizenman et al. (2010) monetary independence index.

Appendix

2.A Methodological Appendix: From k-means to Gaussian mixture

In this methodological appendix, I show how the Gaussian mixture model used in this paper differ from the K-means alogorithm used by Levy-Yeyati & Sturzenegger (2005). LYS' k-means is closed to the Gaussian approach, but it assumes two technical limitations that may have a large impact on the final results and on their interpretations.

Technically, the covariance matrix is constrained and the probability of belonging to a group is led to a binary variable. This constraint on the covariance matrix gives to their clusters a circular shape, and all clusters are being of similar size. This may create an important bias for their results. In particular, because all groups are large and of similar size, they can only conclude that the intermediate group is as big as the other groups, and reject the bipolar theory. In my approach the clusters' shape is flexible and therefore it avoids constraining the groups to be of similar size

Also, in LYS approach, a country is for example either floating or pegging[20]. In my classification scheme, a precise probability to belong to a group is computed. Therefore, a country is not either floating or pegging, but it has a probability of being floating and a probability of being pegging. All in all, the Gaussian mixture approach I propose is more flexible and robust than those with k-means.

K-means cluster analysis

The K-means algorithm is a clustering method, which is used to divide a set of objects into groups, called clusters, such that objects within a group tend to be more similar, or closed, to one another as compare to objects belonging to different goups. As simply said by Wu & Kumar (2010, page 21) "clustering algorithms place similar points in the same cluster while placing dissimilar points in different clusters". It was independently discovered by Steinhaus (1956) and Lloyd (1982) (Unpublished Bell Lab. Note of 1957, see Jain (2010) for a wider historical perspective).

Let $X = x_1, x_2, ..., x_M$ be a set of M d-dimensional points, to be clustered into a set of K clusters, denoted by $C = c_1, c_2, ..., c_K$. K-means algorithm finds a partition such that the within-cluster sum of squares is minimized. Let μ_k be the mean of cluster c_k. The default measure of closeness is the Euclidean distance. Thus, the squared error between μ_k and the points in cluster c_k is given by:

$$J(c_K) = \sum_{x_m \in c_k} ||x_m - \mu_k||^2 \tag{2.9}$$

[20] There are more precisely 4 alternative policies in LYS approach.

The K-means algorithm minimizes the within-cluster sum of squares over all K clusters:

$$arg\ \ min \sum_{k=1}^{K} \sum_{x_m \in c_k} ||x_m - \mu_k||^2 \tag{2.10}$$

The cluster means, μ_k with $k = 1, 2..., K$, also called cluster centroids, allow to represents each of the k clusters by a single point in $\mathcal{R}^d$ As described by Levy-Yeyati & Sturzenegger (2005, page 8), "K cases in the data file, where K is the number of clusters requested, are selected as temporary centers. As subsequent cases are processed, a case replaces a center if the smallest distance to a center is greater than the distance between the two closest centers. The center that is closer to the case is replaced. A case also replaces a center if the smallest distance from the case to a center is larger than the smallest distance between the center and all other centers. Again, it replaces the center closest to it. The procedure continues until all cases are classified."

The K-means algorithm clusters in an iterative fashion, alternating between reassigning the cluster of all points, and updating the empirical mean of each cluster. The main steps of K-means algorithm are as follows (see Jain & Dubes 1988)

- Select an initial partition with K clusters,
- Assignment step: generate a new partition by assigning each observation to the cluster with the closest mean

$$C_k^{(t)} = \{x_m : ||x_m - \mu_k|| \leq ||x_m - \mu_{k*}^{(t)}|| \tag{2.11}$$

  where (t) represents the iterative step, for all $k^* = 1, ..., K$

- Update step: Calculate the new means to be the centroid of the observations in the cluster.

$$\mu_k^{(t+1)} = \frac{1}{c_k^{(t)}} \sum_{x_m \in c_k^{(t)}} x_m \tag{2.12}$$

- Repeat assignment and update steps until cluster membership stabilizes.

The algorithm converges when the assignments, and hence the centroids values, no longer change. One can show that the objective function defined in equation (2.10) will decrease whenever there is a change in the assignment or the relocation steps, and convergence is guaranteed in a finite number of iterations.

From k-means to Gaussian mixture

The k-means are similar to the Gaussian mixture model, but it supposed a constained covariance matrix and a bi-modal probability of belonging to a group.

Following Vishwanathan (2011), let assume that the covariances of the mixture components are given by $\Sigma_m = \epsilon Id$, where $\epsilon > 0$ and Id denotes the identity matrix. In this case the univariate Gaussian distribution given by equation (2.1) reduces to

$$\mathcal{N}(x|\mu, \epsilon I) = \frac{1}{\sqrt{2\pi\epsilon}} exp\left(-\frac{1}{2\epsilon}||x-\mu||^2\right) \tag{2.13}$$

Then, equation (2.6) can be written as :

$$\pi_{m,k} = \frac{\pi_k \ exp\left(-\frac{1}{2\epsilon}||x_m - \mu_k||^2\right)}{\sum_{k'} \pi_{k'} \ exp\left(-\frac{1}{2\epsilon}||x_m - \mu_{k'}||^2\right)} \tag{2.14}$$

Let $\mu_{k'}$ denotes the μ that minimizes $||x_m - \mu||$ (that is $\mu_{k'}$ is the closest μ to x_m. If one assume $\epsilon \to 0$ then $\pi_{m,k} \to 0$ for all k except for k', and $\pi_{m,k'} \to 1$ for j' .

Let $r_{m,k}$ be defined as:

$$\pi_{m,k} = \begin{cases} 1 & \text{if} k = argmin_{k'}||x_m - \mu_{k'}||^2 \\ 0 & \text{otherwise} \end{cases}$$

Then, we can rewrite equation (2.9) which minimizes within-cluster sum of square over all cluster k, in term of Gaussian mixture model's equation (2.4), as:

$$J(\pi, \mu) = \sum_{m=1}^{m} \sum_{k=1}^{K} \pi_{m,k}||x_m - \mu k||^2 \tag{2.15}$$

This is equivalent to add a binary parameter in the minimizing within-cluster sum of squares, as defined by equation (2.9) and (2.10) and thus, this is equivalent to the K-means algorithm .

To resume, I have express the k-means algorithm as a form of Gaussian mixture model. This was done by assuming that the covariance matrice of the mixture components was constrained, with equal variance among the groups. This is equivalent to the model EII in Table 2.3. Therefore, I can consider that the k-means problem as defined by Levy-Yeyati & Sturzenegger (2005) for grouping monetary regimes, is a particular case of the more general gaussian mixture problem I handle here. Futhermore classifying exchange-rate regimes using the Gaussian mixture model approach, gives, first, a criterium to determine the number of clusters, and then, the best fit among various model. In particular it allows my clusters to be ellipsoidal and not constraint to circles like in LYS. To illustrate this outcome, I plot on Graph 2.A.1 page 61 the clusters obtained with LYS approach, using exactly the same sample as in Section 2.4, Graph 2.4 page 49

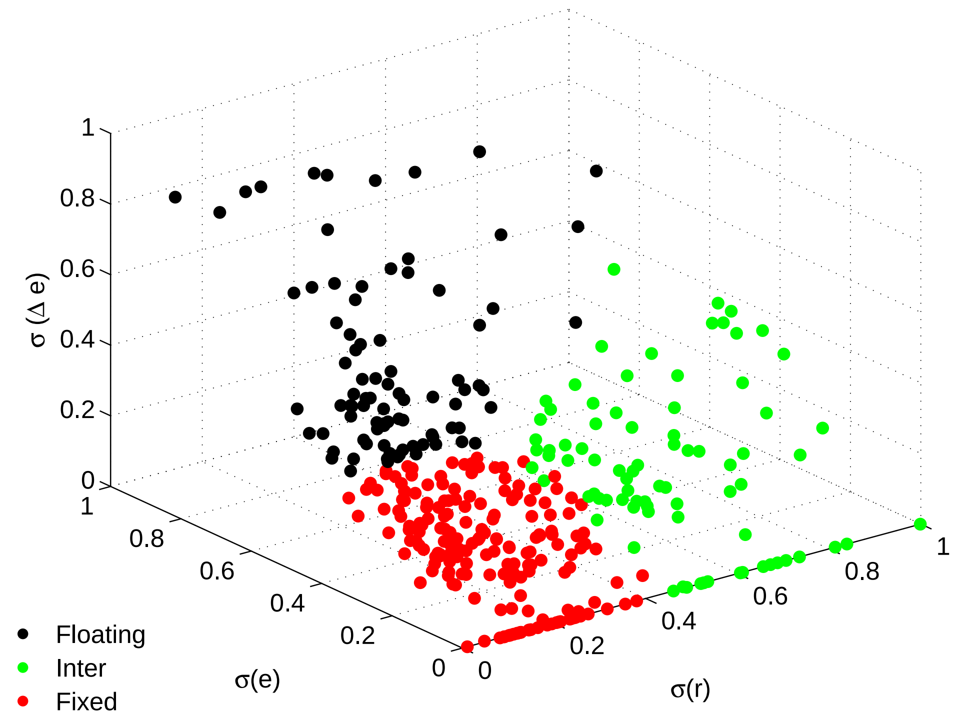

Figure 2.A.1: Step 3 following Levy-Yeyati & Sturzenegger (2005) approach.

2.B Data Appendix

Data set

The currency of reference of each country is used as numeraire to express the nominal exchange rate value. It is either the US dollar or the Euro. The list of inflation targeting countries consists of emerging economies (Status = emerging) and developed economies (Status = developed). Developed economies are used in the control sample as indicator of flexible exchange-rates policies while we assess emerging economies exchange-rate arrangement. Fix exchange-rate countries are the counterpart of developed IT countries: they are used in the control sample as indicator of fix exchange-rates policies (and they display how flexible can be an exchange rate arrangement in an IT country).

Table 2.B.1: Inflation targeting countries

Country	IT adoption	Status	Numeraire
Albania	2009	emerging	EUR
Armenia	2006	emerging	EUR
Australia	1993	developed	USD
Brazil	1999	emerging	USD
Canada	1991	developed	USD
Chile	1999	emerging	USD
Colombia	1999	emerging	USD
Czech Rep.	1998	emerging	EUR
Ghana	2007	emerging	USD
Guatemala	2005	emerging	USD
Hungary	2001	emerging	EUR
Iceland	2001	developed	EUR
Indonesia	2005	emerging	USD
Israel	1997	developed	USD
Korea	2001	developed	USD
Mexico	2001	emerging	USD
New Zealand	1990	developed	USD
Norway	2001	developed	EUR
Peru	2002	emerging	USD
Philippines	2002	emerging	USD
Poland	1998	emerging	EUR
Romania	2005	emerging	EUR
Serbia	2006	emerging	EUR
South Africa	2000	emerging	USD
Sweden	1993	developed	EUR
Thailand	2000	emerging	USD
Turkey	2006	emerging	USD
United Kingdom	1992	developed	EUR

Table 2.B.2: Fix exchange-rate countries

Country	Numeraire	Country	Numeraire
Aruba	USD	Lesotho	USD
Bahamas, The	USD	Lithuania	EUR
Bahrain, Kingdom of	USD	Macedonia, FYR	EUR
Barbados	USD	Malaysia	USD
Belize	USD	Maldives	USD
Bhutan	USD	Namibia	USD
Bolivia	USD	Nepal	USD
Bosnia & Herz.	EUR	Netherlands Antilles	USD
Brunei Dar.	USD	Oman	USD
Bulgaria	EUR	Qatar	USD
Cape Verde	USD	Saudi Arabia	USD
China	USD	Seychelles	USD
Comoros	USD	Slovenia	EUR
Croatia	EUR	Suriname	USD
Djibouti	USD	Swaziland	USD
Eritrea	USD	Syrian Arab Rep.	USD
Estonia	EUR	Tanzania	USD
Guinea	USD	Turkmenistan	USD
Hong Kong	USD	Ukraine	USD
Iraq	USD	United Arab Emirates	USD
Jordan	USD	Venezuela, Rep.	USD
Kazakhstan	USD	WAEMU	EUR
Kuwait	USD	Zimbabwe	USD
Lebanon	USD		

Variables computation.

The three variables are computed as follows:

- Exchange-rate volatility

$$\sigma e_t = \sum_{t=1}^{T} \frac{|log(e_t) - log(e_{t-1})|}{T}$$

  With e the price of a reference currency in terms of local currency, and t takes values during a calendar year. The nominal exchange-rate is given in IMF's International Financial Statistics. The reference currency for each country is presented in Table 2.B.1.

- Volatility of exchange-rate changes

$$\sigma_{\Delta et} = std\left(|log(e_t) - log(e_{t-1})|\right)$$

- Volatility of reserves

$$\sigma r_t = \sum_{t=1}^{T} |\frac{log(Res_t) - log(Res_{t-1})}{log(MB_t) - log(MB_{t-1})}|/T$$

  Where Res is defined as $Res_t = FA_t - FL_t - Gov_t$, with MB is the monetary base, FA are the foreign assets, FB are the foreign liabilities and Gov the central government deposits. Following Levy-Yeyati & Sturzenegger (2005, page 1608) we use IMF's International Financial Statistics line 14, 11, 16c and 16d respectively. All variables are expressed in US dollars.

Classification scheme.

The exact procedure to label the clusters is the following. The number of components, or number of Gaussians, is given by the maximisation of the Bayesian information criterion (BIC). We present two cases :

In case BIC indicates three Gaussians, a cluster is simply defined as one Gaussian.

- The clusters with the smallest average nominal exchange-rate, $min\ \bar{\sigma e}$, is *de facto* fix.
- Among the two remainding clusters, the one with the majority of floating indicators countries is *de facto* floating.
- For the last cluster:
  - If the average reserves volatility , $min\ \bar{\sigma r}$, is higher than the average reserves volatility of the *de facto* floating cluster, this cluster is *de facto* intermediate.
  - If the average nominal exchange-rate volatility, $min\ \bar{\sigma e}$, is higher than the average nominal exchange-rate volatility of the *de facto* floating cluster, this cluster is *de facto* floating.
  - Else as I'm not able to label such a cluster, the procedure is rejected.

In case the BIC maximization indicates four Gaussians, two Gaussians are merged into one cluster, or one policy group:

- The Gaussian with the smallest average nominal exchange-rate, $min\ \bar{\sigma e}$, is *de facto* fix.
- Among the three remaining Gaussians, the one with the smallest average reserves volatility, $min\ \bar{\sigma r}$, is *de facto* floating.
- Among the two remaining Gaussians, the one with the highest average reserves volatility, $min\ \bar{\sigma r}$, is *de facto* managed floating.
- The last group of observation is labelled as *de facto* floating (fixed) if it contains a majority of floating (fixed) indicator countries.

If the optimal number of Gaussian is higher than 4, then the procedure is rejected.

2.C Results Appendix

Table 2.C.3: Probability of having a fix exchange-rate arrangement

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
ALBANIA											0	90	58	90
ARMENIA								1	1	2	5	2	0	19
BRAZIL	0	9	4	5	4	0	3	9	0	5	5	9	3	2
CHILE	0	5	0	12	0	0	13	2	14	5	1	1	8	2
COLOMBIA	0	0	56	0	27	0	88	2	0	4	0	0	3	1
CZECH REPUBLIC	1	23	17	12	76	100	43	11	20	1	0	43	19	32
GHANA									100	4	2	0	79	4
GUATEMALA							88	96	100	43	17	12	53	88
HUNGARY			8	24	10	16	17	3	17	0	2	14	0	6
INDONESIA							2	18	9	5	0	31	53	35
MEXICO			9	100	0	26	30	11	36	5	0	15	2	6
PERU				76	84	100	17	71	5	0	7	92	65	100
PHILIPPINES				61	12	18	61	0	0	2	53	21	74	79
POLAND	1	0	1	0	2	1	18	12	15	3	0	2	2	11
ROMANIA							0	66	9	1	1	76	67	81
SERBIA, REPUBLIC OF								44	17	1	1	0	16	0
SOUTH AFRICA		0	0	1	5	5	1	5	8	5	5	0	0	1
THAILAND		0	15	48	40	2	51	1	79	21	78	14	17	54
TURKEY								2	3	5	0	0	4	0

De facto regime probability, such that for a country and for a year, the probability of having a fixed + an intermediate + a floating arrangement = 1. Period displayed: after IT adoption.

Table 2.C.4: Probability of having an intermediate exchange-rate arrangement

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
ALBANIA											100	1	7	2
ARMENIA								7	6	13	37	14	100	23
BRAZIL	0	64	41	36	40	100	46	64	100	36	34	49	47	56
CHILE	2	8	3	61	100	5	18	71	60	35	6	29	40	7
COLOMBIA	4	2	5	5	10	1	2	51	5	43	0	3	69	36
CZECH REPUBLIC	16	52	57	34	2	0	16	6	11	15	6	7	9	8
GHANA									0	43	55	15	10	43
GUATEMALA							1	1	0	32	43	62	29	3
HUNGARY			65	9	64	58	57	8	57	6	62	60	100	67
INDONESIA							5	49	12	36	4	45	5	42
MEXICO			16	0	3	47	6	63	37	36	5	60	18	59
PERU				7	10	0	26	3	52	100	12	1	3	0
PHILIPPINES				4	62	59	5	2	100	8	11	53	11	2
POLAND	6	3	10	5	49	64	52	10	59	48	0	8	8	62
ROMANIA							100	4	32	10	8	2	4	5
SERBIA, REPUBLIC OF								33	58	12	65	1	58	4
SOUTH AFRICA		4	0	11	36	35	6	38	63	36	36	4	3	7
THAILAND		1	59	18	37	7	11	68	6	49	4	61	7	6
TURKEY								16	46	35	6	3	41	7

De facto regime probability, such that for a country and for a year, the probability of having a fixed + an intermediate + a floating arrangement = 1. Period displayed: after IT adoption.

Table 2.C.5: Probability of having a floating exchange-rate arrangement

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
ALBANIA											0	9	35	8
ARMENIA								92	92	85	58	85	0	58
BRAZIL	100	27	54	59	56	0	51	26	0	59	61	42	50	42
CHILE	98	87	97	27	0	94	68	27	26	59	93	71	52	91
COLOMBIA	96	98	39	95	63	99	10	47	94	53	100	97	28	63
CZECH REPUBLIC	83	25	26	54	22	0	41	83	69	84	94	50	72	60
GHANA									0	54	43	85	10	54
GUATEMALA							11	3	0	25	40	26	18	8
HUNGARY			27	67	27	26	26	89	26	93	36	26	0	27
INDONESIA							93	32	78	59	96	24	41	23
MEXICO			75	0	96	27	64	26	27	59	95	26	80	35
PERU				17	6	0	57	26	42	0	81	7	32	0
PHILIPPINES				34	26	23	34	98	0	90	36	26	15	19
POLAND	93	97	89	95	49	35	30	78	26	49	100	90	90	27
ROMANIA							0	30	58	90	91	21	29	14
SERBIA, REPUBLIC OF								23	26	87	34	99	26	95
SOUTH AFRICA		96	100	88	59	59	93	57	29	59	59	96	97	93
THAILAND		99	26	34	23	91	38	31	15	30	18	25	76	41
TURKEY								82	51	59	93	96	55	93

De facto regime probability, such that for a country and for a year, the probability of having a fixed + an intermediate + a floating arrangement = 1. Period displayed: after IT adoption.

Table 2.C.6: Inflation Targeting Regime

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
ALBANIA											Hybrid	Hybrid	Hybrid	Hybrid
ARMENIA								Flexible	Flexible	Flexible	Flexible	Flexible	Hybrid	Flexible
BRAZIL	Flexible	Hybrid	Flexible	Flexible	Flexible	Hybrid	Flexible	Hybrid	Hybrid	Flexible	Flexible	Hybrid	Flexible	Hybrid
CHILE	Flexible	Flexible	Flexible	Hybrid	Hybrid	Flexible	Flexible	Hybrid	Hybrid	Flexible	Flexible	Flexible	Flexible	Flexible
COLOMBIA	Flexible	Flexible	Hybrid	Flexible	Flexible	Flexible	Hybrid	Hybrid	Flexible	Flexible	Flexible	Flexible	Hybrid	Flexible
CZECH REPUBLIC	Flexible	Hybrid	Hybrid	Flexible	Hybrid	Hybrid	Hybrid	Flexible	Flexible	Flexible	Flexible	Flexible	Flexible	Flexible
GHANA									Hybrid	Flexible	Hybrid	Flexible	Hybrid	Flexible
GUATEMALA							Hybrid	Hybrid	Hybrid	Hybrid	Hybrid	Hybrid	Hybrid	Hybrid
HUNGARY			Hybrid	Flexible	Hybrid	Hybrid	Hybrid	Flexible	Hybrid	Flexible	Hybrid	Hybrid	Hybrid	Hybrid
INDONESIA							Flexible	Hybrid	Flexible	Flexible	Flexible	Hybrid	Hybrid	Hybrid
MEXICO			Flexible	Hybrid	Flexible	Hybrid	Flexible	Hybrid	Hybrid	Flexible	Flexible	Hybrid	Flexible	Hybrid
PERU				Hybrid	Hybrid	Hybrid	Flexible	Hybrid	Hybrid	Hybrid	Flexible	Hybrid	Hybrid	Hybrid
PHILIPPINES				Hybrid	Hybrid	Hybrid	Hybrid	Flexible	Hybrid	Flexible	Hybrid	Hybrid	Hybrid	Hybrid
POLAND	Flexible	Flexible	Flexible	Flexible	Flexible	Hybrid	Hybrid	Flexible	Hybrid	Flexible	Flexible	Flexible	Flexible	Hybrid
ROMANIA							Hybrid	Hybrid	Flexible	Flexible	Flexible	Hybrid	Hybrid	Hybrid
SERBIA, REPUBLIC OF								Hybrid	Hybrid	Flexible	Hybrid	Flexible	Hybrid	Flexible
SOUTH AFRICA		Flexible	Flexible	Flexible	Flexible	Flexible	Flexible	Flexible	Hybrid	Flexible	Flexible	Flexible	Flexible	Flexible
THAILAND		Flexible	Hybrid	Hybrid	Hybrid	Flexible	Hybrid	Hybrid	Hybrid	Hybrid	Hybrid	Hybrid	Flexible	Hybrid
TURKEY								Flexible	Flexible	Flexible	Flexible	Flexible	Flexible	Flexible

De facto regime based on highest probability for three possible arrangements: "Float" for perfectly floating exchange-rates, "Inter" for intermediate or managed float exchange-rate arrangements and "Fix" for rigid systems.

CHAPTER 3

On the Determinants of Exchange-rate Arrangements

Contents

Abstract:
In this paper, I analysis the determinants of exchange-rate regime choice in inflation targeting (IT) emerging-economies . I consider two main approaches: the general theories that apply for IT and non IT countries, such as the impossible Trinity or the currency mismatches views, and the hypothesis specific to the IT framework, relying on the political view and on the need for a nominal anchor. I use the broad theories to constitute a set of control variables, and I test whereas central banks' lack of credibility may justify to adopt a more rigid exchange-rate arrangement. My results indicates that once an inflation targeting framework has been officially adopted, the exchange-rate arrangement is independent from the price stability achievement, and from the people perception of the central bank. However, the proximity to IT adoption is a key determinants of choosing a floating arrangement, supporting the view that a floating arrangement is a condition *prior* to inflation targeting implementation.

Keyword: Inflation-targeting, Exchange-rate policy, Policy Trilemma, Currency Mismatches.

JEL: E31, E40, E58, F31.

3.1 Introduction

This chapter is the second part of my inquiry on the exchange-rate policies adopted by inflation-targeting emerging economies (ITEE). The previous chapter offers a new methodology to assess exchange-rate regimes. Therefore, I'm able to distinguish countries with a floating exchange-rate, from those with a more rigid arrangement. In this chapter the exchange-rate regime choice is assumed to be endogenous to the local and global economic contexts. Using the probability of having a floating arrangement defined in the previous chapter as a dependent variable, I identify empirically which are the determinants for an ITEE to let floating its exchange-rate, or to intervene in the foreign exchange market.

Among the large body of theoretical works that provides the key insights on the potential determinants of the regime choice, I considered two approaches: the general theories and those specific to inflation-targeting economies.

- The general and standard literature on the choice of exchange-rate regimes relies on four main hypothesis: the optimal currency area, the impossible trinity, the financial development and the currency mismatches. Even if some aspects of these theories are somehow controversial, these theories are, by large, considered as having a great explanatory power of monetary authorities' exchange-rate regimes choice. They are not specific to a particular policy or to a particular group of countries and are convincing when stressing the conditions shared by all monetary authorities in choosing their exchange-rate arrangement.
- I consider a second bunch of exchange-rate regime determinants specific to IT economies: I test the possibility for monetary authorities to use the exchange-rate policy as a "policy crutch" to the IT policy. The question asked is apart from the standard determinants of exchange-rate regime arrangement, is there some determinants associated to the price stability commitment?

Therefore, my approach is the following. In the first part of this paper, I identify a few variables relative to each of the 4 alternative general theories. I test whereas the underlying concept really matter in explaining exchange-rate arrangement choice in ITEE. My results give strong supports to the currency mismatches and the financial development theories, mitigated supports to the optimal currency area theory, and absolutely no support to the impossible trinity hypothesis. In the second part of the paper, I focus on IT economies particularities when choosing a monetary regime. Hence, I use the relevant variables in explaining the general theories (the significant one) to define my set of control variables, and I test whereas the exchange-rate policy can be seen as a "policy crutch" for the inflation targeting authorities, or if it remains independent from the commitment to price stability.

My results give strong support for refusing the "policy crutch" hypothesis. More precisely, I find that, once an inflation-targeting framework has been officially implemented in a country, the exchange-rate arrangement is independent from the price stability achievement, from the expectations management, or to put it broader from the central bank's credibility. Thus, these results lead to reject the hypothesis that central banks with low credibility may be willing to use the exchange-rate as an alternative anchor or as an additional tool to tame inflation expectations. As an additional result, when extending the analysis to the period prior IT adoption, the data indicates that the proximity to IT adoption is a key factor to choice floating arrangement. This last result supports the view that a floating arrangement is a *pre-* condition of inflation targeting implementation.

To my knowledge, that work is the first to explore empirically the determinants of inflation targeting economies exchange-rate arrangements before and after IT adoption. Most of the empirical papers about the determinants of regime choice focus on a particular theory (such as Eichengreen et al. 2002 about the original sin hypothesis) or assess the relative importance of the alternative theories from a broad perspective (or focusing on industrial *versus* non-industrial countries (as in Levy-Yeyati et al. 2010) and therefore are not enlightening ITEE particularities.

The paper proceeds as follows. Section 2 documents the database and the estimation techniques. Section 3 presents the partial test of the variables associated to non-IT specific theories. Section 4 questions the determinants of the exchange-rate regime choice in an IT perspective. Section 5 concludes.

3.2 Data and estimation technique

My purpose is to identify the determinants of exchange-rate regime choice in ITEE. Hence, in the following analysis, the dependent variablestands for the regime choice: it is the probability of having a floating arrangement, as computed in the previous chapter. A high value indicates that the country is most likely having a floating exchange-rate regime, while a low value indicates that the country is more probably having a rigid arrangement, either a fix regime or an intermediate regime, such as "dirty float" with frequent interventions on the foreign exchange market in order to manage the exchange-rate volatility.

On the independent variables side, I consider two bunches of variables: those specific to IT economies, and those coming from the standard theories that can be applied to all countries at all times. Hence, I adopt a two-steps strategy. In the first step, I identify a few variables relative to the broad standard theories and I test their relevance for the ITEE case. In the second step, I focus on the hypothesis related to IT policies and test whereas the exchange-rate policy is a "policy crutch" for the IT policy or a "separated policy". Also, in the second step specification, those most significant variables in explaining the standard theories are used as control variables.

The dataset covers all emerging economies that have an inflation targeting framework, as in the previous chapter. However, because too many data are missing for Serbia, this country is excluded from the baseline regression. Finally, the panel covers 18 countries, with annual data from 1990 to 2012.

A panel least squares Prais-Winsten model is used, with AR(1) residuals. Standard errors are corrected for unbalanced heteroskedasticity and panel correlation.

Two time periods are considered: from 1990 to 2012 and from IT adoption to 2012. The starting dates of IT come from Hammond 2012 and correspond, by and large, to the date declared by the central banks, also known as the "default starting dates" in Rose (2007)'s terminology. The first time period is the widest possible, while the second time period covers the years of IT experiences. Hence, in the results tables any regression appears twice, once for each period definition. As for the baseline regression (see below), the number of observations is 335 for the overall sample and 186 for times of IT.

Information regarding the data used are summarized in Table 3.1, page 77.

Table 3.1: Panel statistics.

Country	IT adoption	Data coverage
ALBANIA	2009	1999 - 2012
ARMENIA	2006	1999 - 2012
BRAZIL	1999	1990 - 2012
CHILE	1999	1990 - 2012
COLOMBIA	1999	1990 - 2012
CZECH REPUBLIC	1998	2001 - 2012
GHANA	2007	2007 - 2012
GUATEMALA	2005	1990 - 2012
HUNGARY	2001	2000 - 2011
INDONESIA	2005	1990 - 2012
MEXICO	2001	1990 - 2012
PERU	2002	1990 - 2012
PHILIPPINES	2002	1990 - 2012
POLAND	1998	1999 - 2011
ROMANIA	2005	1999 - 2012
SOUTH AFRICA	2000	1990 - 2012
THAILAND	2000	1990 - 2012
TURKEY	2002	1993 - 2012

Number of observations = 335.
Number of groups = 18.
Observations per group: min = 6 ; avg = 18.6 ; max = 23.

3.3 Independent variables: a broad view

3.3.1 Optimal currency area

After the works of Mundell (1961) and Fleming (1962), the optimal currency area theory relates the choice of exchange-rate arrangement to the country's trade features (openness, size and geographical aspects) and to the characteristics of the shocks the economy is subject to. In this view, real exchange-rate flexibility is seen as a shock adjuster in the presence of nominal rigidities, while fixed exchange-rates are to be preferred when real shocks are the main source of disturbance in the economy.

In order to test the relevance of the optimal currency area theory arguments among the determinants of IT emerging-economies exchange-rate arrangement choice, the following variables are considered:

- Trade openness (denoted by *openness*) measured by the sum of imports and exports as a percentage of GDP. *openness* is expected to be negatively correlated to the probability of floating for two reasons: 1) A more open economy have bigger trade gains from stable bilateral exchange-rate. 2) A more open economy is less vulnerable to sudden stop (see Cavallo & Frankel 2008) which eventually reduces the benefits of flexibility.

- Country size (*size*) is expected to be positively correlated to floating arrangements, since a larger economy creates higher incentives for the use of a national unit of account. A standard measure for the size of an economy is its GDP; however GDP would be too correlated with the other independent variables to be used, and therefore the country's total population is preferred here.

- Terms of trade volatility (TOT) computed as the standard deviation of terms of trade changes over five years (we follow Levy-Yeyati et al. 2010). Terms of trade volatility measures the real shocks that affect the economy. According to the Mundell-Flemming framework[1], it provides an incentive to float, and should be positively correlated to the dependent variable.

The results of the regression for the partial test with the variables associated to the currency view[2] are given in Table 3.2, page 79, for the whole sample and for the period since IT adoption. The expected sign is recalled in the first column. Terms of trade volatility (TOT) enters in the regression with a lag in order to eliminate any simultaneity bias between terms of trade shocks and exchange-rate instability. The expected sign is

[1] On the exchange-rate as a "shock absorber" view, see Edwards & Levy Yeyati 2005.

[2] As an other determinant of the regime choice, I considered incorporating in the model the current account composition, captured by the oil balance (net oil balance over GDP). It does not appear in the final specification because the results were not statistically significant and because the economic meaning was not relevant enough.

shown for *openness* and TOT but not for *size*; however *size* is not statistically significant. These results provide mixed supports to the optimal currency area theory, and finally only *openness* and TOT enter in the baseline specification (in next section).

Table 3.2: Regression: currency view

	expected sign	all times	IT years
		floating	floating
openness	-	-0.32***	-0.37***
		(0.11)	(0.12)
size	+	-0.00	-0.00
		(0.00)	(0.00)
TOT1	+	0.02***	0.03***
		(0.01)	(0.01)
constant		0.08	-0.03
		(0.19)	(0.20)
R-squared		0.19	0.32
Observations		335	186
Groups		18	18

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

3.3.2 Impossible trinity

The "impossible trinity" theory, also known as the "policy Trilemma", refers to the Mundell-Fleming framework, which assumes that capital mobility implies uncovered interest rate parity. Therefore, in that framework it is impossible to implement simultaneously capital mobility, monetary policy (independandly) and fixed exchange-rate. Policymaker can choose only two of the three policies. Eichengreen (1994) and Fischer (2001) among others have argued that as financial globalization deepened in last decades, capital mobility has increased, making intermediate regime less viable in open economies. However, Aizenman et al. (2008) and Aizenman et al. (2012) have emphasized that even if the policy Trilemma continues to be a valid macroeconomic framework, emerging economies have often added financial stability and international reserves management as fourth policy goal. The reserves management policy goal is sometimes seen as a way to escape from the impossible trinity.This role is also sometimes associated to the macro-prudential policy, as in Rey (2013). In this recent paper, Rey argues that the Trilemma no longer holds in today's global economy, and that the trade off is now a "dilemma" between independent monetary policies and capital account management.

In order to test the impossible trinity theory, I examine a variable for financial openness, *KAOpen*, and two alternative measures of monetary independence, *MI* and *PTI gap*.

- Financial openness (*KAOpen*) is captured by Chinn & Ito (2008)'s measure of capital account openness. *KAOpen* is based on information regarding restrictions in the IMF's *Annual Report on Exchange Arrangements and Exchange Restrictions* (AREAER). Specifically, *KAOpen* is the first standardized principal component of the variables that indicate the presence of multiple exchange-rates, restrictions on current account transactions, on capital account transactions, and the requirement of the surrender of export proceeds. The index is normalized between zero and one. Higher values of this index indicate that a country is more open to cross-border capital transactions.

- *MI* denotes Aizenman et al. (2010)'s monetary independence index. It is defined as the reciprocal of the annual correlation of the monthly interest rates between the home country and the base country. The money market rates are used for the interest rates (see Aizenman et al. 2012, page 7). By construction, the maximum and minimum values are 1 and 0, respectively. Higher values of the index mean more monetary policy independence. Because the impossible trinity is a theory of instrument scarcity, it implies a trade-off for policy makers between monetary independence and exchange-rate stability. More monetary independence is supposed to be associated to less exchange-rate stability (assuming capital mobility). Therefore, a positive sign is expected.

- As an alternative to *MI* a second metric for monetary independence is proposed: *PTI gap*, the spread between the actual nominal exchange-rate, and the PTI rate. The PTI rate is the value given by the uncovered interest rate parity formula, when the exchange-rate and the interest rate in the base country are known. When monetary policy is fully dependent, monetary authorities in the domestic country is assumed to follow the interest rate settings of the base country. Thus, higher values of *PTI gap* are assumed to reflect more monetary independence. Large monetary independence is assumed to reflect in high values of *PTI gap*. Once again, more monetary independence is supposed to be associated to less exchange-rate stability (assuming capital mobility) and an higher probability for floating regime. Therefore, a positive sign is expected.

Examining the relevance of the impossible theory is challenging for two reasons: first, there are two countervailing aspects that associate capital mobility to the choice of an exchange-rate regime, and then, the impossible trinity theory implies the three dimension are binding at the same time.

1. According to the impossible trinity theory, capital mobility should be negatively associated to exchange-rate stability and thus positively associated to floating arrangements if one assumes monetary independence. However, the literature on currency mismatch has stressed the opposed relation between integration to the capital markets and exchange-rate stability: countries with more open capital account are more

impacted by sharp nominal depreciation of the currency because of the currency effects on balance sheets' solvency. Therefore, these countries are more prone to manage their exchange-rate, and a negative correlation between $KAOpen$ and the floating probability is expected.

2. The impossible trinity theory implies the three dimensions, or the three vertex of the triangle, at the same time. The correlation between monetary independence and exchange-rate regime relies on the assumption of capital mobility. And similarly, the correlation between financial openness and exchange-rate regime is obtained by assuming monetary independence.

In order to address these two challenges, the variable for capital openness and for monetary independence enters as an interaction term in the regression. According to the trilemma theory, when policy makers choice to have a great financial integration and a large monetary independence, they no longer have the possibility to stabilize the exchange-rate; therefore, the interaction term is expected to be positively correlated with the probability of floating.

Table 3.3, page 82 shows the results of our partial test for the impossible trinity variables, for the whole sample as well as sample restricted to IT. Measures of monetary independence enter in the regression with a lag in order to eliminate any simultaneity bias. The capital account openness variable is strongly negatively correlated with the probability of floating exchange-rate. Therefore, the currency mismatches hypothesis seems to prevailed over the impossible trinity theory.

There is no evidence that monetary independence should enter the baseline specification: alone or in interaction with capital openness, the two alternative measures of monetary independence are not statistically significant (except for one metric when the sample is restricted to IT).

Finally, data in Table 3.3 do not provide any support for any aspect of the impossible trinity. It seems that the hypothesis underlining this theory should be questioned. I address this issue in a paper to come.

Table 3.3: Regression: currency view

	expected sign	all times	IT years	all times	IT years	all times	IT years	all times	IT years
		floating	floating	floating	floating	floating	floating	floating	floating
kaopen	+	-0.05***	-0.05***	-0.05***	-0.04**				
		(0.02)	(0.02)	(0.02)	(0.02)				
MI1	+	0.05	0.10						
		(0.11)	(0.11)						
PTIgap1	+			-0.01	0.02*				
				(0.01)	(0.01)				
kaopen * MI1	+					0.03	0.03		
						(0.02)	(0.03)		
kaopen * PTIgap1	+							-0.02	0.01
								(0.01)	(0.01)
constant		0.49***	0.50***	0.54***	0.48***	0.47***	0.49***	0.51***	0.48***
		(0.06)	(0.06)	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)
R-squared		0.15	0.20	0.14	0.21	0.12	0.17	0.10	0.20
Observations		339	170	349	190	339	170	349	190
Groups		18	18	18	18	18	18	18	18

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

3.3.3 Financial development

In the impossible trinity view (also known as "policy trilemma"), financial innovation and financial deepening reduce the effectiveness of capital control and therefore imply more flexible arrangements. Inverting this argument, it can be argued that without financial development, firms can not find financial products or financial edge to insure them-self against exchange-rate risk, justifying central banks' fear of floating. Indeed, it has been shown that financial development is a necessary condition to avoid exchange-rate volatility's negative outcomes on growth. Aghion et al. (2009) give empirical evidences that real exchange-rate volatility can have a significant impact on productivity growth. Héricourt & Poncet (2012) show how exchange-rate volatility (negatively) impacts (financially vulnerable) firms and conclude that financial development limits these negative impacts.

The influence of financial development on the choice of exchange-rate regime is tested through two alternative variables: *M3* and *deposits*.

- *M3* is the ratio of liquid liabilities (also known as broad money, or M3) to GDP. It is a standard measure of financial development. Without financial development, domestic agents can't edge them-self against FX volatility; thus the monetary authorities have less willingness to let the exchange-rate float. Therefore, a positive sign is expected.

- *deposits* is the ratio of the financial system deposits to GDP. Demand, time and saving deposits in deposit money banks and other financial institutions are included. This metric is coming from the World Bank Global Financial Development Database. The same reasoning as for *M3* holds; thus a positive sign is expected.

Table 3.4, page 84 displays the results of our partial test for the financial development hypothesis. As before, the dependent variable is a country's probability of choosing a flexible regime. Because of strong country specificities, the independent variables include dummies for Armenia, Colombia and Thailand. As can be seen, the financial development hypothesis is strongly supported by the data: for the two alternative measures, *M3* and *deposits*, coefficients are positive and significant[3].

3.3.4 Currency mismatches

Eichengreen et al. (2007) and Hausmann & Panizza (2011) among others have stressed the deleterious impact of exchange-rate depreciation on balance sheets for countries with foreign currency denominated external liabilities and currency mismatches. Therefore, large foreign liabilities may create an incentive in favor of fixed exchange-rate arrangements.

[3] As an other determinant of the regime choice, I also considered incorporating in the model financial stress captured by the VXO index (which measures stock market volatility on the basis of the Chicago Board options Exchange Market Volatility Index). It appeared to be strongly and positively associated to the floating probability. However, because VXO is a unique variable for all countries, it may be seen as a time fix effects, and its interaction with the other variables remains unclear. Hence, it does not appear in the final regression

Table 3.4: Regression: financial development

	expected sign	all times	IT years	all times	IT years
		floating	floating	floating	floating
deposits	+	0.27*	0.21		
		(1.68)	(1.18)		
M3	+			0.24**	0.21*
				(2.04)	(1.67)
constant		0.36***	0.39***	0.36***	0.38***
		(0.06)	(0.07)	(0.06)	(0.06)
R-squared		0.21	0.33	0.21	0.32
Observations		328	167	341	178
Groups		19	19	19	19

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Currency mismatches hypothesis is approached by three variables: a measure of capital openness and two alternative measure of the external debts.

- As for the Trilemma, capital openness is captured by Chinn & Ito (2008)'s *KAOpen* index, which indicates if a country is open to to cross-border capital transactions. The literature on currency mismatches has emphasized that countries with more open capital account are more impacted by sharp nominal depreciation of the currency because of the currency effects on balance sheets' solvency. Thus, monetary authorities should be less prone to let the exchange-rate floats and we expect a negative sign.

- A first measure of external debt is given by *fgn claims*, the foreign claims of BIS-reporting banks to GDP. Following the "currency mismatches" hypothesis and assuming external debts to be denominated in foreign currency, the bigger the external debt, the worst exchange-rate volatility for balance sheets. Therefore, these countries are more prone to manage their exchange-rate, and a negative correlation between *fgn claims* and the floating probability is expected.

- An alternative measure of external debt is given by *int debt*, the outstanding amount of international debt securities expressed as a share of GDP. As for *fgn claims*, a negative sign is expected.

Table 3.4, page 84 reports the results from our partial test of the currency mismatches hypothesis, for the whole sample as well as IT period subsample. The expected sign is shown in for *KAOpen* and *int debt*, and these coefficients are highly significant. These results strongly support the theory.

Table 3.5: Regression: currency mismatch

	expected sign	all times	IT years	all times	IT years
		floating	floating	floating	floating
kaopen	-	-0.05***	-0.05**	-0.05***	-0.05***
		(0.02)	(0.02)	(0.02)	(0.02)
fgn claims	-	0.11	0.09		
		(0.11)	(0.12)		
int debt	-			-0.75**	-0.70**
				(0.31)	(0.35)
constant		0.49***	0.51***	0.64***	0.62***
		(0.04)	(0.04)	(0.04)	(0.05)
R-squared		0.13	0.18	0.28	0.27
Observations		341	172	229	151
Groups		18	18	16	16

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

3.4 An IT perspective

In the previous section, I've tested the relevance of the main theories on exchange-rate regimes choice. Focusing on emerging economies with an inflation targeting strategy, my results give strong supports to the currency mismatches and the financial development theories, mitigated supports to the optimal currency area theory, and absolutely no support to the impossible trinity hypothesis. In the present section, I focus on the determinants of exchange-rate regime choice in an IT perspective. In other words, my purpose is to identify if the exchange-rate regime choice should be seen as part of the IT strategy or as a different policy. For example, in countries with low institutional credibility, convincing the public of their commitment to price stability may be a hard task for central banks. Therefore, monetary authorities may adopt a rigid exchange-rate arrangement as a “policy crutch” (Levy-Yeyati et al. 2010, page 664) to tame inflationary expectations. In such a case, the exchange-rate policy is fully contributing to the price stability objective, and therefore the determinants of the exchange-rate regime are endogenous to the implementation of an inflation targeting framework.

As an alternative, it is worth noting that from a theoretical point of view IT should imply the central bank to focus only on price stability (see Mishkin (2004) among others). Therefore, the exchange-rate arrangement choice may be excluded from the central bank's decision committee agenda. Hence, the exchange-rate regime does not appear as a policy crutch for IT, but as perfectly separated choice, exogenous to the IT framework. For example, in countries with low central banks' credibility, the inflation expectations may deviate from the target, and a large inflation rate may prevail. This high rate of price change may fuel large exchange-rate depreciation, and increase exchange-rate volatility, which, in turns, characterizes floating exchange-rate arrangement.

Therefore, we have two alternative views: exchange-rate regime choice as a policy crutch for IT, or exchange-rate regime choice as a separated policy.

3.4.1 Methodological strategy

To analysis the relevance of this approach, sometimes known as the "political view", a test that indicates which of the two alternative prevails is required: exchange-rate regime choice as a "policy crutch" for IT or exchange-rate regime choice as a separated policy. That test is obtained by a regression in which the dependent variable is the probability of having a floating exchange-rate regime, and the independent variables are a measure of central banks' credibility as well as a set of control variables.

The test relies upon the sign of the central banks' credibility variable. Following the "policy crutch" hypothesis, that coefficient should be positive. Otherwise, if the "two separated policies" hypothesis prevails, that coefficient should be negative. The testable predictions are summarized in Table 3.6, page 86.

Table 3.6: Testable prediction

Hypothesis:	policy crutch	separated policies
Characteristic:	FX regime endogenous to the IT strategy	FX regime exogenous to the IT strategy
Mechanism:	Low credibility →large inflation and large deviation from the target	
	→ need for a complementary tool to tame inflation expectation	→ large impact of price change on the currency nominal value
	→ FX management	→ floating FX
Testable prediction:	The correlation between CB's credibility and a floating regime probability is	
	positive	negative

The set of control variables is taken from the previous section. These variables are those displaying the right sign and an highly significant coefficient, when looking for the relevance of the currency mismatches, the financial development or the optimal currency theories. Namely, the control variables are trade openness (*openness*), term of trade volatility (TOT) and capital account openness (*kaopen*) [4].

The set of credibility related variables consists in 4 credibility measures associated to the price stability commitment: the IT framework age, the Svensson's central bank credibility, the inflation rate, and the deviation to the Taylor rule.

- *age* measures the number of years between an observation and the adoption of the IT framework. That variable simply is the IT strategy age. It takes positive values for years after IT adoption, and negative values for years before IT. The IT starting dates come from the well documented BoE's Handbook on IT (Hammond 2012) and correspond by large to the dates declared by central banks, also known as the "default starting dates" in Rose (2007)'s terminology. I assume central banks' credibility to results from a complex process, involving communication aspects and transparency of the decisions mechanisms, in order to make clear that the short-run implemented policies are consistent with the long-run official policy goal. Therefore, credibility results from a time consuming process and central banks need time to reach a high credibility level. Thus, following the "policy crutch" hypothesis, *age* is expected to be positively correlated to the choice of a floating arrangement. In that view, intermediate regime may also appear as transition regime from peg to full-fledged IT. Otherwise, it should enters negatively.

- Central banks' credibility (*credibility*) is measured by the proximity of private-sector inflation expectations to the inflation targets. As underlined by Svensson (2009, page 27): "The closer the expectations are to the target, the higher the degree of credibility". Also, it is worth noting that expectations below the target are not better than expectation above the target. Such expectations could, for instance, lead to higher structural unemployment (see Svensson 2013) or (if extremely low) to deflation. This is why credibility is calculated as the square difference between the central bank inflation target and the expected inflation rate. Then, the credibility index is inversed and normalized between 0 and 1. Thus, higher values of the credibility index indicates an higher central bank's credibility. Private-sector inflation expectations are given by the WES survey[5].

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[4] I drop M3 and International Debt from the control variable, because they less significant and because too many observations are missing for these two variables, restricting the sample size. However, including *M3* or *intl debt* in the regression lets the results unchanged.

[5] The CESifo World Economic Survey is a publication by the Center for Economic Studies and Ifo Institute. It "assesses worldwide economic trends by polling transnational as well as national organizations worldwide on current economic developments in their respective countries. Its results offer a rapid, up-to-date assessment of the economic situation prevailing around the world. In January 2013, 1,169 economic experts in 124 countries were polled." The time horizon is the next year. There are several characteristics why the data set of the CESifo WES forecast poll is suitable for this analysis. First, the survey participants work with the private-sector in the respective country and hence, one can be confident they have accurate idea concerning

As explained above, if the "policy crutch" hypothesis prevail, *credibility* is expected to enter positively in the determinants of floating exchange-rates. Otherwise, a negative sign would indicates that the "two separated policies" hypothesis is more likely to hold.

- A measure of inflation can be seen as a proxy, or an alternative metric, for *credibility*. Two alternative definitions of price dynamics are proposed: inflation (*inflation*) and inflation exceeding the central bank's target (*excess infl*) . Inflation is measured as the year-on-year change in the Consumer Price Index . The inflation rate is a major macroeconomic indicator for an IT central bank. However, the goal of an inflation-targeting central bank is not to have zero inflation, but to keep inflation as close as possible to an announced target. Thus, monetary policy assessment should be done on the basis of inflation deviation from the targeted rate. Excess inflation denotes the deviation of inflation from the targeted rate. Series of inflation targets have been collected form the national monetary authorities' websites. When the historical series were not provided in free access, I referred to the announced strategy published in monthly bulletin or others official publications. If ever a central bank does not announce a point target but a range target, the range's mean is used. High inflation rates and large deviation from the target, may justify exchange-rate control to tame expectations and therefore a negative sign would support the "policy crutch" hypothesis, while a negative sign will support the "two separated policies" hypothesis.

- Taylor rule gap (*TR gap*) refers to the spread between the observed short nominal interest rate and a virtual rate predicted by a simple Taylor rule. The Taylor rule values are computed assuming central banks to give identical weight to inflation deviation from the target and to output gap. *TR gap* gives a degree of IT implementation. Also, *TR gap* measures the predictability of central bank's reaction function, which is a key feature of expectations management. Finally, large *TR gap* may be seen as a signal of weak adhesion of monetary authorities to the "one target, one instrument" principle, and may reveal central banks' preferences for other instruments. Hence, following the "policy crutch" hypothesis, *TR gap* is expected to be negatively correlated to floating arrangement.

the future economic development. Also using private-sector forecasts is also of advantage compared to the projections of international institutions like the IMF, the OECD or the central banks themselves: the latter might have an incentive to report strategic forecasts consistent with their macroeconomic policy, as shown by Dreher et al. (2008), while the private-sector should have an incentive to provide an accurate forecast rather than a strategic forecast, as shown by Batchelor (2001). Second, the forecasts are not revised. Hence, they are not exposed to the real-time data critic. Orphanides (2001) has shown how important it is to distinguish between real-time and revised data to correctly assess the information set on which the central bank sets its interest rate. Lastly, the data set allows me to compare the results among all countries since it does not suffer from problems resulting from different reporting standards.

3.4.2 Results

An overview.

Table 3.7, page 90 shows the results for the specification associated to the political view. The dependent variable is the probability of having a floating exchange-rate regime, and the independent variables are the full set of control variables (coming from the analysis done in Section 3.3) as well as the central banks' credibility measures. The same estimation techniques as in the previous section are used. Credibility related variables enter with a lag. By definition, the computation of *excess inflation*, *credibility* and *TR gap* require a value for the central bank's inflation target which is available only after IT adoption. Hence, when one of these variables enters in the estimated specification, the sample is constrained to the IT years. The only variable that exists for the restricted IT period as well as the overall sample is *inflation*. Also, it appears twice: one regression for each time specification.

The expected signs, given by to the two alternative predictions, are recalled in the first columns of Table 3.7. As can be seen, the "two separated policy" hypothesis is strongly supported by the data. All coefficients show the sign predicted by the "two separated policy" hypothesis and are highly significant. Consistently, the sign predicted by the "policy crutch" hypothesis never appear. Finally, the test for the political view give clear indication that the "policy crutch" hypothesis can not be accepted as a determinant of the exchange-rate regime choice by emerging IT .

Floating arrangement as a $pre-$**condition for IT adoption**

Table 3.8, page 92 gives the results when the *age* variable enters the specification. As before, the dependent variable is the probability of having a floating arrangement, and the first columns display the expected signs according to the two alternative hypothesis.

The first regression is done over the whole sample (the sample covers the years before and after IT adoption), and the *age* variable has a highly significant positive coefficient. It indicates that the probability of having a floating arrangement is positively correlated to the age of the IT framework. Therefore, it seems to be consistent with the "policy crutch" hypothesis. However, to disentangle if this effects prevails before IT, when the monetary authorities are on the road of IT adoption, or after IT adoption, when the authorities are building up their speeches and credibilities, I run the regression over two sub-samples. The first sub-sample is limited to the years before IT, while the second sub-sample covers the years after IT adoption. The resulting coefficient is positive in both case but significant only for the period before IT adoption. Therefore, it seems to indicate that, once an IT framework is implemented, the age of the IT strategy, or the experience of the monetary authorities in implementing an IT framework does not matter for the choice of the exchange-rate regime. But these results also indicates that the probability of choosing a floating exchange-rate is increasing when the IT adoption date is getting closer. Therefore,

Table 3.7: Regression: political view

	expected sign		all times	IT years	IT years	IT years	IT years
	policy crutch	separated policies	floating	floating	floating	floating	floating
openness			-0.14	-0.18*	-0.21*	-0.19	-0.17
			(0.11)	(0.11)	(0.12)	(0.12)	(0.12)
TOT1			0.02***	0.02***	0.02**	0.02***	0.02***
			(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
kaopen			-0.04***	-0.03*	-0.04**	-0.04**	-0.04**
			(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
inflation1	-	+	0.00***	0.01			
			(0.00)	(0.00)			
excess inflation1	-	+			0.02**		
					(0.01)		
credibility1	+	-				-0.43*	
						(0.22)	
TR gap1	-	+					0.01***
							(0.00)
constant			-0.10	-0.12	0.22	-0.01	0.05
			(0.17)	(0.21)	(0.20)	(0.20)	(0.19)
R-squared			0.27	0.30	0.32	0.32	0.33
Observations			335	190	172	177	177
Groups			18	18	18	18	18

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

it supports the idea that monetary authorities turn to a floating exchange-rate regime **before** implementing IT. This results also support the view that a floating arrangement is a *pre-* condition, or a condition *prior* IT implementation.

To insure the robustness of this result, the same model is estimated with a dummy interacting with the *age* variable. That dummy, denoted by *dumIT*, equals 1 when an observation's year is higher than the adoption year; else it equals 0. As shown in the last column of Table 3.8, the results support the idea that a floating arrangement is a *pre*−condition for IT adoption, but once the IT framework has been implemented, the regime choice is independent of the IT momentum.

Table 3.8: Regression: age

	expected sign		all times	before IT	IT years	all times	all times	all times	all times
	policy crutch	separated policies	floating	floating	floating	floating	floating		
openness			-0.26**	-0.54**	-0.20**	-0.22**	-0.21**	-0.30***	-0.27**
			(0.12)	(0.22)	(0.11)	(0.12)	(0.12)	(0.12)	(0.12)
TOT1			0.02***	0.01	0.02***	0.02***	0.02***	0.02***	0.02***
			(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
kaopen			-0.05***	-0.06**	-0.04**	-0.05***	-0.05***	-0.05***	-0.04***
			(0.02)	(0.03)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)
age	+	-	0.01**	0.02***	0.00				
			(0.00)	(0.01)	(0.01)				
age*dumIT	+	-				0.01			
						(0.01)			
$(\text{age*dumIT})^2$	+	-					0.00		
							(0.00)		
age*(1-dumIT)	+	-						0.02***	
								(0.01)	
$(\text{age*(1-dumIT)})^2$	-	+							-0.00***
									(0.00)
constant			0.05	0.53	-0.01	0.03	0.05	0.09	0.08
			(0.18)	(0.33)	(0.20)	(0.18)	(0.18)	(0.18)	(0.18)
R-squared			0.25	0.32	0.29	0.23	0.23	0.28	0.27
Observations			335	145	190	335	335	335	335
Groups			18	15	18	18	18	18	18

Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

3.5 Concluding remarks

In this paper, I have examined the determinants of exchange-rate arrangement choice in the 18 emerging economies that have an inflation-targeting strategy. My results are quite revealing.

First, my results indicate that the currency mismatches and the financial development theories are the most important factors in explaining ITEE exchange-rate arrangement choice. The currency mismatches theory relates the choice of the exchange-rate regime to the potential effects of currency depreciation on balance sheets. Therefore, my results link the exchange-rate regime choice to the financial structure of an economy, the outstanding share of foreign-currency denominated bonds or the share of foreign banks' loans among the total debt. The financial development hypothesis also questions the financial structure of an economy, but associates financial development to the ability of micro level - individual agents to edge them-self against undesirable effects of exchange-rate volatility. In that view, supported by my data, monetary authorities in countries with highly developed financial system are more willing to let the exchange-rate float, and less subject to the "fear of floating".

The trade and geographical aspects of an economy, which come into the optimal currency area theory, seem to enter in the exchange-rate regime determinants, but in a smaller extend. Last, the Impossible Trinity hypothesis does not seem to hold in the case of ITEE countries. This last result is consistent with recent work by Aizenman et al. (2012), who emphasizes that even if the "policy Trilemma" holds by large, some of the emerging economies have used the external reserves as a fourth pillar to avoid policy makers to face instrument scarcity (thus escaping the Trinity impossibilities).

When turning to an IT perspective in the second part of the paper, I focus on questions related to the political view, the definition by the central bank of price stability as a nominal anchor, and its need to control inflation expectations. More precisely, I consider whereas the exchange-rate policy can be seen as a "policy crutch" for IT central banks, or if the exchange-rate policy and the IT policy should be seen as "two separated policies". For this second step of the paper, I use a specification that includes the most significant variables of the standard theories tested in the first step, as a set of control variables. My results provide evidence that once inflation targeting has been adopted, the "two separated policies" hypothesis dominates the "policy crutch" hypothesis. Hence, the often heard view that central banks in emerging economies with inflation targeting manage the exchange-rate through foreign exchange market interventions, in order to improve their credibility or to tame inflationary expectations is not supported by our data[6] .

Also, while extending the analysis to the period before IT adoption, I find that the proximity of the IT framework official adoption date is one of the key determinants for choosing a floating arrangement. This should be seen as an additional evidence that a

[6] For an interesting discussion on monetary and exchange-rate policies in emerging economies, see Ostry et al. (2012).

floating arrangement is a prior condition for implementing an inflation targeting framework.

Finally, to the question: is the goal of exchange-rate management (done through FX markets interventions) to support the IT policy, that paper gives a negative answer. Hence, apart from the explanations given by the currency mismatches and the financial development views, the purpose of exchange-rate management in these countries remains a question. An avenue for future research may to be found in the interactions of the IT policies and the use of exchange-rate reserves (mostly after the Asian crisis) as a macro-prudential or macro-stability tool.

Appendix

Table 3..1: Variables definitions.

Label	Variable	Definition
age	IT startegy's age	Years since IT adoption. (Source: IT adoption year from CBs' official websites and Hammond (2012))
credibility	CB's credibility	Absolute deviation of inflation expectations from central banks' targets. (Source: Expectations by WES Inflation Expectation Survey on access from Reuters EcoWin, CBs' targets from CBs' official websites)
deposits	Financial development (2)	Financial system deposits to GDP (%) (Source: World Bank Global Financial Development Database, GFDD.DI.08)
excess inflation	Inflation gap	Inflation exceeding the central bank's target. (Source: Inflation by IMF International financial Statistics, CBs' targets from CBs' official websites)
fgn claims	Foreign claims	Foreign claims to GDP (%) (Source: World Bank Global Financial Development Database, GFDD.OI.12)
int debt	International debt	International Debt Securities (Amt Outstanding) to GDP (%) (Source: World Bank Global Financial Development Database, intldebt)
inflation	Inflation	CPI year on year change. (Source: IMF's International financial Statistics)
kaopen	Financial openness	Chinn and Ito capital openness index; (Source: http://web.pdx.edu~ito/Chinn-Ito_website.htm)
MI	Monetary independence	Aizenman, Chinn and Ito monetary independence measure for testing the impossible trilemma. (Source: http://web.pdx.edu~ito/trilemma_indexes.htm)
M3	Financial development	Liquid liabilities (broad money, or M3) to GDP (%) (Source: World Bank Global Financial Development Database, GFDD.DI.05)
openness	Trade openness	Imports plus exports over GDP. (Source: IMF International financial Statistics)
PTI gap	Monetary independence (2)	Spread between the prevailing short interest rate and the virtual rate given by the uncovered interest rate parity formula. (Source: Policy rate and exchange-rate from IMF's International financial Statistics,)
size	Country size	Population, Total. (Source: World Bank World Development Indicators)
TOT	Terms of trade volatility	Standard deviation of terms of trade changes over five years corrected by openness. (Source: World Bank Global Financial Development Database, NY.EXP.CAPM.KN)
TR-gap	Taylor Rule Gap	Absolute deviation from the observed policy rate to a virtual rate predicted by a simple Taylor rule. (Source: Output-gap from IMF's World Economic Outlook, completed with HP detrended GDP, inflation expectations by WES Inflation Expectation Survey, CBs' targets from CBs' official websites, policy rate by IMF's International financial Statistics)

Part II

On the Definition of the Optimal Monetary Policy

CHAPTER 4

Monetary Policy and Food Prices

Contents

Abstract:
The two episodes of food price surges in 2007 and 2011 have been particularly challenging for developing and emerging economies' central banks and have raised the question of how monetary authorities should react to such external relative price shocks. We develop a new-Keynesian small open-economy model and show that non-food inflation is a good proxy for core inflation in high-income countries, but not for middle-income and low-income countries. Although, in these countries we find that associating non-food inflation and core inflation may be promoting badly-designed policies, and consequently central banks should target headline inflation rather than non-food inflation. This result holds because non-tradable food represents a significant share in total consumption. Indeed, the poorer the country, the higher the share of purely domestic food in consumption and the more detrimental lack of attention to the evolution in food prices.

Keyword: Monetary Policy, Commodities, Food prices, DSGE models.

JEL: E32, E52, O23.

This chapter has been written with Dramane Coulibaly and Benjamin Carton, during an internship at the CEPII.

4.1 Introduction

The last few years have been intensely challenging for central bankers. The financial crisis has had tremendous negative effects on developed economies and major spillover effects on emerging economies (large capital inflows and outflows). At the same time central bankers had to manage the dramatic rise in food prices. According to the United Nations Food and Agriculture Organization (FAO), in the period 1996 to 2006, world food prices rose on average by only 0.05% per semester in real terms; from 2007 to 2011 they have risen by an average of 2% per semester, that is, by 25 times more. The period beginning in 2006 (or post-great moderation) has been characterized by two price surges: the FAO price index increased by 54% between January 2006 and June 2008, declined of 34% between June 2008 and December 2008, then rose by 53% before stabilizing in December 2010.

The most frequently mentioned causes of food price volatility include: extreme weather conditions, increased demand from emerging countries caused by growth in incomes, increased costs to farmers due to high oil prices, rapid development of biofuels, adoption of restrictive trade policies by major net exporters of key foods products such as rice, and speculation in commodity markets. So, for the monetary authorities of almost all small open economies, these shocks were perfectly exogenous from their policies or their own country situations, and were unanticipated.

The high fluctuation in food prices is questioning how monetary policy should react to these external shocks. The present paper tries to find some answers. Specifically, we examine how monetary authorities in developing countries should respond to food price shocks. The case of developing countries is interesting for two main reasons.

First, in low-income and emerging economies, food consumption represents a significant share of household expenditure. Table 4.1 shows that food budgets represent around 50%, 30% and 20% of the household budgets in low-income, middle-income and high-income countries respectively. Therefore, in these countries, changes in food prices will induce significant variations in their headline inflation.

Second, low and middle-income countries are characterized by a large share of non-tradable products in their food consumption. For instance, even if a country is an exporter of a given agricultural product, the domestically consumed variety is often of a different (e.g. lower) quality, is produced in different fields and does not share the logistics infrastructure of the exported variety. Different cultures induce different diets, some cereals and tubers are country specific and not traded. Even if volumes of agricultural imports are large, they represent at most half of the country's food consumption (see Table 4.1).

Thus, developing economies are characterized by a large domestic food sector. This is a crucial aspect of this analysis of the effects of a world price shock on a small open economy. Since the domestic food sector is country specific, it evolves with the domestic environment. Pricing strategies do not reflect directly the world market. But since domestic and tradable food goods are highly substitutable, the domestic food sector is impacted on by the evolution in the world market. So, in studying the pass-through from the world market price to the domestic overall consumer price index (CPI), a major issue is the passage from the tradable food goods price to the non-tradable food goods price. This channel is a striking feature of developing economies and a major concern for monetary authorities.

Table 4.1: Food budget shares

	Low-income	Middle-income	High-income
Food in consumption	48%	31%	20%
Tradables in food	37%	59%	81%

Source: International Comparison Program (ICP) (World Bank, 2005), tradable shares (FAO, 2007) and own calculations. Note: Tradable share is defined as the percentage of the food products documented by the 2007 FAO Food Balance Sheet database for which the sum of import and export is less than 5 % of domestic consumption. The 144 countries covered by the 2005 ICP and The 162 countries covered by the 2007 FAO Food Balance Sheet database are divided into low-, middle-, and high-income countries, based on their income relative to that of the United States. Low-income, middle-income and high-income countries represent those with real per capita income less than 15 percent, between 15 and 45 percent, and greater than 45 percent of the U.S. level, respectively.

In this study, we examine particularly the performance of an inflation targeting framework to manage food price shocks in developing countries. By definition, an inflation targeting framework requires the choice of a measure of inflation as the target. Targeting countries generally use core inflation as the target. There are several methods used to compute core inflation. The most common approach, which is exploited by many countries, is the exclusion method, which computes core inflation by removing the prices of a fixed, pre-specified set of items from the CPI basket. The excluded components are chosen because they are considered either volatile or susceptible to supply disturbances; they typically consist of food and energy items. The exclusion method is based on the idea that these excluded items are prone to supply shocks that are beyond the control of the central bank, and is used by Canada, New Zealand, Peru, Thailand and the United Kingdom among others. The other approach is a statistically-based method that removes extreme price changes or outliers (both positive and negative) from the overall inflation rate. In the statistics-based method, the set of excluded items changes each period, depending on which items show extreme price movements. For example, Chile uses a statistics-based approach and computes its core inflation by excluding the 20 percent largest negative price changes and the 8 percent largest positive price changes. This method is more sophisticated but is also more costly to implement, since the list of the goods included in core inflation need continuous updating.

In order to analyze the response of monetary policy to food price shocks, we construct a small open economy model where food can be produced domestically or imported. More precisely, the consumption bundle consists of food and manufactured goods, where each kind of good consists of two varieties: one is non-tradable (domestically-produced and sold in a monopolistic competition market) and one is tradable (both imported and produced at home, and sold in a competitive market under the law of one price). This allows us to assume that food price volatility is related to both technological shocks (such as weather) and imported price shocks (such as world price hikes). Therefore our model allows us to decompose the channel from the world price to the overall CPI, through the effects on domestic food prices, food and non-food substitutability, and exchange rate effects on non-food tradable goods competitiveness.

We consider three important issues:

- Firstly, we model an economy in which the non-tradable food share in consumption is large, implying a non-negligible part of non-tradable food prices in the CPI. Thus, monetary authorities cannot look at food price shocks as short term volatility only. World food price movements impact on domestic non-tradable sticky prices in food and non-food sectors, implying long-run effects.

- Secondly, our model allows us to distinguish three price indices: overall consumer price inflation, true core inflation index based on sticky prices, and a proxy core inflation index based on non-food prices (as in the exclusion method). Therefore, we estimate the welfare cost of confusing non-food inflation and core inflation.

- Thirdly, we examine whether the fact that food is a first necessity matters for the ranking of monetary policy rules. In this case, we employ a Klein-Rubin form with minimum amount of consumption.

We show that food prices should not be entirely excluded from the core inflation index. This implies not distinguishing between non-food inflation and core inflation may result in ill-designed policies, especially in countries with large food domestic sectors. Thus our results suggest that in low-income and emerging countries central bank should target CPI rather than core inflation index based on the method of exclusion of food prices. We demonstrate that this result does not hold for high-income countries where the share of food prices in core inflation is low enough to make non-food inflation a good proxy for core inflation.

Many studies focus on oil price rather than food price shocks. Some analyze the choice of index (core or headline inflation) to target in the presence of oil price shocks. Bodenstein et al. (2008) use a stylized Dynamic stochastic general equilibrium (DSGE) model with an energy sector to study the optimal monetary policy response to an adverse energy supply. They find that policies that react to a forecast of headline inflation following a temporary energy shock induce different effects from policies that react to a forecast of core inflation, with the former causing greater volatility in core inflation and the output gap. Batini & Tereanu (2009), using a small open-economy DSGE model to design an appropriate response from inflation targeting countries to oil price shocks, find that the optimal response of inflation targeting central banks is an aggressive increase in real interest rates in order to close the inflation gap with the minimum efficient policy horizon. This focus on oil price shocks (see e.g. Blanchard & Galí (2007), Gomez-Lopez & A.Puch (2008) or **?** among other) is of limited help in an analysis of food price shocks. They focus mainly on shocks to the input price, while food price shocks are more likely to be shocks to consumption goods with extremely low elasticity of substitution with other goods. This applies to the paper by Anand & Prasad (2010) which proposes a model of a closed developing economy in which food producers are credit constraints. Anand & Prasad (2010) show that overall CPI targeting is the best policy in the presence of financial restrictions. Since they model a closed economy, the volatility of food prices is due only to technological shocks. Thus, their model does not allow analysis of the monetary policy response to a world price shock. Our paper is related also to the study by Catão & Chang (2010) which examines how monetary policy should react to imported food price shocks. Similar to our approach, they assume that food price shocks are relative price shocks. These authors propose a small open economy in which all food is imported. They find that broad CPI targeting is welfare-superior to alternative policy rules once the variance in food price shocks is as large as in real world data. The restriction that food is only imported (and not domestically produced) does not capture the pass-through mechanism from the world to the domestic food price, as is the case in our paper. Moreover, low and middle-income countries are sometimes importers and sometimes exporters, but there is no net trend in the data to characterize them as net food importers.

The remainder of the paper is organized as follows. Section 4.2 describes the model whose calibration is presented in Section 4.3. The simulation results are presented in Section 4.4. Section 4.5 introduce fixed consumption. Finally, Section 4.6 sums up the results and discusses some policy implications.

4.2 The model

The small open economy is populated by infinitely-lived households. They consume C and supply labor L. The consumption bundle consists of food F and non-food M. Each kind of good consists of two varieties: a non-tradable one N (domestically-produced and sold in a monopolistic competition market) and a tradable good T (both imported and produced at home, and sold in a competitive market under the law of one price). Households can own domestic firms and can accumulate foreign assets in the form of one-period risk-free bonds in the world currency. Domestic bonds are available but are not internationally traded.

4.2.1 Households

The representative household maximizes the following utility

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(C_t, L_t) \qquad \text{with} \qquad U(C,L) \equiv \frac{C^{1-\rho}}{1-\rho} - \psi \frac{L^{1+\chi}}{1+\chi}$$

where $0 < \beta < 1$, $\mathbb{E}$ is the expectation operator, $\rho > 0$ is the inverse of intertemporal elasticity of substitution, $\chi > 0$ the inverse of elasticity of labor supply and$\psi > 0$ is a scale parameter.

The consumption bundle can be written as (we skip the t subscript for simplicity)

$$C \equiv \left[(1-\gamma)^{\frac{1}{\theta}}(C^M)^{\frac{\theta-1}{\theta}} + (\gamma)^{\frac{1}{\theta}}(C^F)^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}}, \tag{4.1}$$

where θ is the intratemporal elasticity of substitution between food and non-food goods, and γ is the share of food in consumption. C^M and C^F can be written as

$$C^M \equiv \left[(1-\gamma_M)^{\frac{1}{\theta_M}} C^{MN\frac{\theta_M-1}{\theta_M}} + \gamma_M^{\frac{1}{\theta_M}} C^{MT\frac{\theta_M-1}{\theta_M}}\right]^{\frac{\theta_M}{\theta_M-1}}, \tag{4.2}$$

$$C^F \equiv \left[(1-\gamma_F)^{\frac{1}{\theta_F}} \left(C^{FN}\right)^{\frac{\theta_F-1}{\theta_F}} + \gamma_F^{\frac{1}{\theta_F}} \left(C^{FT}\right)^{\frac{\theta_F-1}{\theta_F}}\right]^{\frac{\theta_F}{\theta_F-1}}. \tag{4.3}$$

Given the price of each good P^{FN}, P^{FT}, P^{MN} and P^{MT}, and introducing the convenient aggregate prices relative to food P^F, non-food P^M and aggregate consumption P,

$$P^F \equiv \left[(1-\gamma_F)P^{FN^{1-\theta_F}} + \gamma_F P^{FT^{1-\theta_F}}\right]^{\frac{1}{1-\theta_F}}, \tag{4.4}$$

$$P^M \equiv \left[(1-\gamma_M)P^{MN^{1-\theta_M}} + \gamma_M P^{MT^{1-\theta_M}}\right]^{\frac{1}{1-\theta_M}}, \tag{4.5}$$

$$P \equiv \left[(1-\gamma)P^{M^{1-\theta}} + \gamma P^{F^{1-\theta}}\right]^{\frac{1}{1-\theta}}. \tag{4.6}$$

The demand for food and non-food goods is given as

$$C^F = \gamma\left(\frac{P^F}{P}\right)^{-\theta} C \tag{4.7}$$

$$C^M = (1-\gamma)\left(\frac{P^M}{P}\right)^{-\theta} C \tag{4.8}$$

Then, the demand for each variety is given by

$$C^{FT} = \gamma_F\left(\frac{P^{FT}}{P^F}\right)^{-\theta_F} C^F \tag{4.9}$$

$$C^{FN} = (1-\gamma_F)\left(\frac{P^{FN}}{P^F}\right)^{-\theta_F} C^F \tag{4.10}$$

$$C^{MT} = \gamma_M\left(\frac{P^{MT}}{P^M}\right)^{-\theta_M} C^M \tag{4.11}$$

$$C^{MN} = (1-\gamma_M)\left(\frac{P^{MN}}{P^M}\right)^{-\theta_M} C^M \tag{4.12}$$

The non-tradable (food and non-food) good is assumed to be a composite of a continuum of differentiated goods, $c_t(i)$ with $i \in [0,1]$, via the aggregative CES function

$$C^N \equiv \left(\int_0^1 c^N(i)^{1-\frac{1}{\eta_N}}\,\mathrm{d}i\right)^{\frac{1}{1-\frac{1}{\eta_N}}}, \tag{4.13}$$

where $N = FN$ (for non-tradable food) or $N = MN$ (for non-tradable non-food), η_N is the elasticity of substitution across varieties. Let $P_t^N(i)$ be the nominal price of variety i at time t. The aggregate price in the sector is defined by

$$P^N = \left(\int_0^1 P^N(i)^{1-\eta_N} \mathrm{d}i \right)^{\frac{1}{1-\eta_N}}. \tag{4.14}$$

The consumer minimizes its total expenditure for any given level of consumption of the composite good, subject to the aggregation constraint. The optimal level of $c^N(i)$ is then given by

$$c^N(i) = \left(\frac{P^N(i)}{P^N} \right)^{-\eta_N} C^N. \tag{4.15}$$

The representative household enters each period with holdings of domestic bonds, denoted by B_{t-1}, and foreign bonds denominated in units of foreign currency, denoted by B^*_{t-1}, purchased from the previous period, and purchases the respective amounts B_t and B^*_t. To avoid a multiplicity of steady-states, the household is assumed to face an interest rate that is increasing in the country's net foreign debt (following Schmitt-Grohé & Uribe (2003)). The interest rate perceived by the household, denoted by $i^\star_t$ is the sum of the world interest rate, i^w_t, and a risk premium that depends on the net foreign asset position:

$$i^\star_t = i^w_t + \zeta(e^{-B^*} - 1)$$

where $\zeta > 0$ is a parameter of bond adjustemnt cost.

Let S denotes the nominal exchange rate, the representative household faces the following budget constraint, expressed in units of domestic currency

$$\begin{aligned} &S_t B^*_t + B_t + P_t C_t \\ &\quad = S_t \left(1 + i^\star_{t-1}\right) B^*_{t-1} + (1 + i_{t-1}) B_{t-1} + W_t L_t + \Pi_t. \end{aligned} \tag{4.16}$$

where Π_t denotes profit. Let $d_{t,t+k}$ be the nominal stochastic discount factor between dates t and $t+k$, which is given by

$$d_{t,t+k} = \beta^k \frac{P_t}{P_{t+k}} \left(\frac{C_{t+k}}{C_t} \right)^{-\rho}. \tag{4.17}$$

Therefore, the first order conditions related to domestic and foreign bonds holdings and labor supply are given by

$$1 = \mathbb{E}_t \left\{(1+i_t)d_{t,t+1}\right\} \tag{4.18}$$

$$1 = \mathbb{E}_t \left\{\frac{S_{t+1}}{S_t}\left(1+i_t^\star\right)d_{t,t+1}\right\} \tag{4.19}$$

$$\frac{W_t}{P_t} = \psi L_t^\chi C_t^\rho \tag{4.20}$$

4.2.2 Firms

Firms produce according to a decreasing return to scale function. Non-wage income implicitly remunerates land (in the food sector) or capital (in the non-food sector).

Tradable goods producers

The production technology for tradable goods is given by

$$Y_t^T = A_t^T \left(L_t^T\right)^{1-\alpha_T} \tag{4.21}$$

where $T = FT$ (for tradable food) or $T = MT$ (for tradable non-food), L_t^T is the unit of labor employed and A_t^T is the level of technology.

The firm takes the price and the wage as given, and chooses the quantity produced and the labor required to maximize its profit.

$$\Pi_t^T = P_t^T Y_t^T - W_t L_t^T \tag{4.22}$$

The optimal condition of this program implies the usual equation that links labor productivity and real wages

$$W_t L_t^T = (1-\alpha_T)P_t^T Y_t^T. \tag{4.23}$$

Together with the production function we get demand for labor

$$L_t^T = \left((1-\alpha_T)A_t^T \frac{P_t^T}{W_t}\right)^{1/\alpha_T} \tag{4.24}$$

Non-tradable goods producers

In the non-tradable sector, the variety i of each good is produced by a single firm according to a technology common across sector firms and using labor as the only input. The production technology is given by

$$Y_t^N(i) = A_t^N \left(L_t^N(i)\right)^{1-\alpha_N}, \tag{4.25}$$

where $N = FN$ (for non-tradable food) or $N = MN$ (for non-tradable non-food) and A_t^N is productivity in the non-tradable sector N.

Firms are allowed to set prices according to a stochastic time-dependent rule as in Calvo (1983): in each period, a firm faces a probability ϕ_N of not being able to re-optimize its price. All firms that reset their price at t will choose the same $P^N_{t|t}$ in order to maximize the expected present discounted value of profits, under the constraint that the firm must satisfy demand at the posted price. Thus, the firm program is given by

$$\max_{P^N_{t|t}} \quad \mathbb{E}_t \sum_{k=0}^{\infty} d_t^{t+k} {\phi_N}^k \left[P^N_{t|t} Y^N_{t+k|t} - \Psi^N_{t+k|t} \right]$$

$$\text{subject to} \quad \begin{cases} Y^N_{t+k|t} = \left(\frac{P^N_{t|t}}{P^N_{t+k}} \right)^{-\eta_N} C^N_{t+k} & \text{(demand)} \\ \Psi^N_{t+k|t} = W_{t+k} \left(\frac{Y^N_{t+k|t}}{A^N_{t+k}} \right)^{\frac{1}{1-\alpha_N}} & \text{(cost)} \end{cases}$$

The first order conditions, optimal price setting, evolution of inflation and aggregate production function in the non-tradable food and the non-tradable manufactured sectors are set out in the Appendix 4.B.

4.2.3 The balance of payments

The trade balance is given by the sum of food tradable and manufacture tradable exports. The balance of payments is obtained by

$$P_t^{FT}(Y_t^{FT} - C_t^{FT}) + P_t^{FT}(Y_t^{FT} - C_t^{FT}) - S_t \left(B_t^\star - i^w_{t-1} B^\star_{t-1} \right) = 0 \tag{4.26}$$

4.2.4 Monetary policy

Since our focus is on the performance of inflation targeting to deal with food price shocks, we consider monetary policy rules in which central bank moves interest rates systematically as a function of price inflation. These interest rate rules take the following forms:

- Headline inflation targeting: $log\,(i/\bar{i}) = \Phi \log{(\Pi)}$
- Non-food inflation targeting: $log\,(i/\bar{i}) = \Phi_M \log \left(\Pi^M\right)$
- Core inflation targeting: $log\,(i/\bar{i}) = \Phi_{FN} \log \left(\Pi^{FN}\right) + \Phi_{MN} \log \left(\Pi^{MN}\right)$

where $\bar{i}$ is steady-state level of interest rate i.

For each interest rate rule, the value of the parameters is set in order to maximize the welfare associated with this rule (see Section 4.4). Note that the second rule corresponds to what is generally used by central banks as a proxy for core inflation: excluding food prices from the CPI. This proxy for core inflation is the inflation of non-food goods. In the third rule the target is the exact definition of core inflation, which is an index of sticky prices.

4.2.5 Shocks

There are two kinds of perturbations: shocks to productivities, A^{FT}, A^{FN}, A^{MT} and A^{MN} and shocks to foreign prices, $P^{FT\star}$, $P^{MT\star}$ and i^w.

- Productivity shocks are assumed to evolve exogenously over time, following an AR(1) process $x_t = \rho^x x_{t-1} + \epsilon_t^x$, where $0 < \rho^x < 1$ and $\epsilon^x \sim N(0, \sigma_\epsilon)$, for $x = A^{FT}$, A^{FN}, A^{MT}, A^{MN}.

- Foreign variables $(P^{FT\star}, P^{MT\star}, i^w)$ follow a VAR(2) process (see Appendix 4.C).

4.3 Calibration

Table 4.2: Parameters calibration

Description	Symbol	Value
Utility function		
Discount factor	β	0.99
Inverse of intertemporal elasticity of substitution	ρ	2
Inverse of elasticity of labor supply	χ	0.83
Share of tradable in non-food consumption	γ^M	0.5
Elasticity of substitution between food and non-food good	θ	0.3
Elasticity of substitution between food T and N	θ^F	1.4
Elasticity of substitution between non-food T and N	θ^M	1.4
Food sector		
Probability of domestic food price non-adjustment	ϕ^F	0.5
Monopoly power	η^F	6
Scale effect on labor, non-tradable	α^{FD}	0.25
Scale effect on labor, tradable	α^{FT}	0.35
Non-food sector		
Probability of non-food price non-adjustment	ϕ^M	0.75
Monopoly power	η^M	6
Scale effect on labor, non-tradable	α^{MD}	0.25
Scale effect on labor, tradable	α^{MT}	0.25
Adjustment cost		
Parameter of bonds adjustment cost	ζ	0.001
Shocks persistence		
Productivity, domestic food sector	$\rho, \sigma_\epsilon^{a^{FD}}$	$0.25, 0.03$
Productivity, tradable food sector	$\rho, \sigma_\epsilon^{a^{FT}}$	$0.25, 0.03$
Productivity, domestic non-food sector	$\rho, \sigma_\epsilon^{a^{MD}}$	$0.8, 0.02$
Productivity, tradable non-food sector	$\rho, \sigma_\epsilon^{a^{MT}}$	$0.8, 0.02$

Most of the parameters are set according to the typical values in the literature; some are set in order to reproduce some basic ratios, mainly food sector size (see Table 4.2).

Table 4.3: Calibration per country type

Description	Symbol	Value
Low-income Countries		
Share of food in consumption	γ	0.48
Share of tradable in food consumption	γ^F	0.37
Middle-income Countries		
Share of food in consumption	γ	0.31
Share of tradable in food consumption	γ^F	0.59
High-income Countries		
Share of food in consumption	γ	0.20
Share of tradable in food consumption	γ^F	0.81

The model is solved numerically up to second-order approximation using DYNARE (see Adjemian et al. (2011)).

The representative household is assumed to have no foreign debt at equilibrium ($B^* = 0$). We assume also that both the food and the manufacturing sectors have a closed economy steady-state ($Y^{FT} = C^{FT}$ and $Y^{MT} = C^{MT}$).[1] All relative prices are set to 1 at the steady-state ($P^s = 1$, $\forall s$). Similarly, the parameter that weights labor in utility (ψ) is set such that total values for labor and consumptions at the steady-state are equal to unity ($L = 1$ and $C = 1$).

The quarterly discount factor β is set equal to 0.99 which implies a yearly real world interest rate of 4% at the steady-state. The risk-aversion parameter is set to $\rho = 2$, which means an intertemporal elasticity of substitution of 0.5, as is usual in the literature (see for instance Devereux et al. (2006), Schmitt-Grohé & Uribe (2007) and De Paoli (2009)).

The share of food in consumption, γ, is calibrated according to International Comparison Program (ICP) data that cover 144 countries. Depending on the group to which the country belongs (low-, middle- or high-income countries) it is set to 48%, 31% and 20% respectively (see Table 4.3) and the share of tradable goods in food consumption is set to 37%, 59% and 81%.

The elasticity of substitution between food and non-food goods, θ, is a key parameter in our model. Because the demand for food is inelastic, θ is lower than 1. To our knowledge Anand & Prasad (2010) is the only study to provide a clear calibration [2]. We follow Anand & Prasad (2010) and set elasticity in utility at $\theta = 0.3$. The elasticity of substitution between tradable and non-tradable goods θ^F and θ^M, is set to 1.4, as estimated for developing countries by Ostry & Reinhart (1992).

[1] In low-income and middle-income group, countries can experience surplus or deficit in the agricultural balance. On average, the data know no systematic imbalance.

[2] Anand & Prasad (2010) write page 26: *Since the demand for food is inelastic, we set [elasticity of substitution] = 0.6 as the baseline case. With a subsistence level of food consumption, this parameter choice implies a price elasticity in demand for food of about -0.3 at the steady-state, which is close to the USDA estimate.* In our case, we have no subsistence level of food consumption as a baseline (this assumption is removed in section 4.5). Thus, for this parameter we set the elasticity in utility at $\theta = 0.3$.

At the steady-state, agricultural sector value added represents around one-third of total GDP (which is a key feature of emerging economies, as seen in Table 4.4). Labor in the agricultural sector represents around one-third of total employment.

Table 4.4: Sectors shares

	Value added (% of total)			Employment (% of total)		
	Agriculture	Industry	Services	Agriculture	Industry	Services
Low income	23	29	48	40	18	42
Middle income	7	35	59	16	26	58
High income	2	32	66	4	26	69
All countries	14	31	56	16	24	60

Source: World Bank. Note: Calculations form the authors of the mean for 144 countries, divided into low-, middle-, and high-income countries, based on their income relative to that of the United States. Low-income countries represent those with real per capita income less than 15 percent of the U.S. level, middle-income countries are those with real per capita income between 15 and 45 percent of the U.S. level, and high-income countries with have per capita income equal to or greater than 45 percent of the U.S. level.

Generally, the literature on Calvo-style pricing behavior sets the probability of price non-adjustment at around $\phi = 0.75$, which implies that on average price adjustments occur every four quarters. Empirical studies show that food prices are less sticky than the prices of manufactured goods (see Loupias & Ricart (2004), Bils & Klenow (2004) and Baudry et al. (2005)). Thus, we set $\phi^F = 0.5$ for the food sector and $\phi^M = 0.75$ for the manufactured sector. The scale effect on labor equals 0.75 for each sector ($\alpha^s = 0.25$).

The persistence of shocks on productivity in the non-food sectors (ρ^{MT} and ρ^{MN}) is set at 0.8. The associated standard deviation (σ_ϵ) is set at 0.02. These values are in line with those in Ravenna & Natalucci (2008) or Gali & Monacelli (2005), and average those in the international business cycle literature. Productivity shocks in the food sectors (mainly weather events) are calibrated following Anand & Prasad (2010): persistences (ρ^{FT} and ρ^{FN}) are set at 0.25, and standard deviation (σ_ϵ) at 0.03.

We estimate a VAR model in order to calibrate variances and covariances in world food price shocks, the world manufacturing (non-food) price shocks and the world interest rate shocks. The results are given in appendix 4.C.

For the described structure of shocks and the low-income countries calibration, the variance decomposition of the main variables of the model is given in Table 4.D.3 in Appendix 4.D.

4.4 Welfare and model's response under alternative monetary policy rules

4.4.1 Welfare calculation

Monetary policy analysis based on a welfare criterion has improved dramatically in recent years. In most studies of optimal monetary policy in economies with nominal rigidities, it is assumed that government can access a subsidy to factor inputs, financed from lump-sum taxes, aimed at dismantling the inefficiency introduced by imperfect competition. Since this assumption is clearly unrealistic we do not introduce this mechanism in our model. It follows that the solution to the model is a distorted steady-state equilibrium (Schmitt-Grohé & Uribe, 2007). In this case, a second-order welfare approximation is needed.

Because the solution to our model is a distorted steady-state equilibrium, calculation of a Ramsey policy would imply re-writing the model without inefficiency. There is no reason to believe that a comparison between our model and such a corrected copy would make sense. In our case, no policy is a good benchmark. Thus our purpose is not to measure the distance of a given policy from the benchmark, but to rank different policies.

To our knowledge, Faia & Monacelli (2007) is the only reference that gives the exact criterion underlying the welfare computation. We use the following criterion:

$$\mathcal{W} = \mathbb{E}_{-1}\left\{\sum_{t=0}^{\infty}\beta^t u(C_t, L_t)\right\}\Bigg|_{x_0=\bar{x}}$$

where x denotes the set of predetermined variables. Following Schmitt-Grohé & Uribe (2004) and Adjemian et al. (2011) the second-order welfare approximation takes the form of the following conditional expectation:

$$\mathcal{W} = \mathbb{E}_{-1}\left\{\mathcal{W}_0\right\}\big|_{y_{-1}=\bar{y}} = \bar{\mathcal{W}} + \frac{1}{2}[g_{\sigma\sigma}] + \frac{1}{2}\mathbb{E}_0\left\{[g_{uu}(u_1 \otimes u_1)]\right\},$$

where $\bar{\mathcal{W}}$ denotes the welfare value at the (non-stochastic) steady-state, $g_{\sigma\sigma}$ is the second derivative of the policy function (g) with respect to variance in the shocks, and g_{uu} is the Hessian of g with respect to the shock vector u.

We present the results in terms of the percentage conditional welfare gains associated with each policy choice. Welfare gains are defined as additional perpetual consumption needed to make the level of welfare under strict non-food price inflation targeting identical to that under the evaluated policy. Thus, a positive number indicates that welfare is higher under the alternative policy than under strict non-food price inflation targeting policy.

4.4.2 Discussion over alternative monetary-policy rules

Figure 4.1 displays the model's response to a shock to the world food price for a typical low-income country. We consider an unanticipated one percentage point transitory increase in the world food price. Inflationary pressure leads the central bank to tighten its monetary policy. Aggregate consumption drops and the currency appreciates. Whatever the monetary policy rule, around two-third of the shock passes through domestic prices, while one-third is absorbed by exchange rate appreciation. The increase in the domestic price of tradable food leads to a large fall in domestic demand for this good. Because tradable and non-tradable food goods are substitutable ($\theta^F = 1.4$) this fall in tradable food consumption is partly compensated for by an increase in non-tradable food consumption.

Figure 4.1: IRF under alternative monetary policy rules: low-income countries

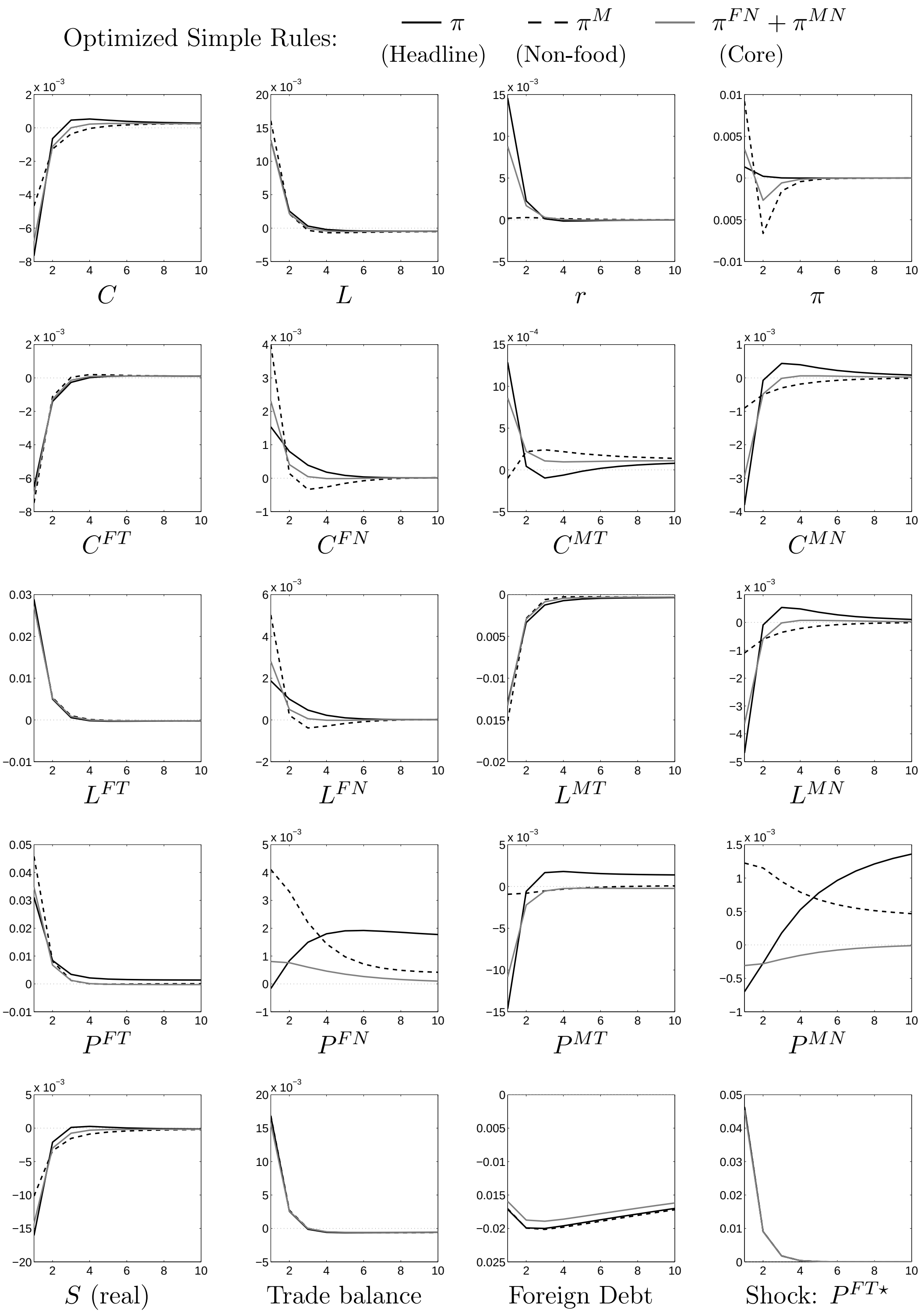


Table 4.5: Taylor Rules: calibration that maximizes welfare

Target	Optimal Rule	$\mathcal{W}$	Rank
Low-income Countries			
Headline inflation	$log\,(i/\bar{i}) = 56\; log\,(\Pi)$	0.03	2
Non-food inflation	$log\,(i/\bar{i}) = 52\; log\,(\Pi^M)$	0.00	3
Core inflation	$log\,(i/\bar{i}) = 712\; log\,(\Pi^{FN}) + 287\; log\,(\Pi^{MN})$	0.11	1
Middle-income Countries			
Headline inflation	$log\,(i/\bar{i}) = 115\; log\,(\Pi)$	0.01	2
Non-food inflation	$log\,(i/\bar{i}) = 58\; log\,(\Pi^M)$	0.00	3
Core inflation	$log\,(i/\bar{i}) = 882\; log\,(\Pi^{FN}) + 117\; log\,(\Pi^{MN})$	0.08	1
High-income Countries			
Headline inflation	$log\,(i/\bar{i}) = 151\; log\,(\Pi)$	-0.01	3
Non-food inflation	$log\,(i/\bar{i}) = 66\; log\,(\Pi^M)$	0.00	2
Core inflation	$log\,(i/\bar{i}) = 963\; log\,(\Pi^{FN}) + 36\; log\,(\Pi^{MN})$	0.09	1

Thus the price of non-tradable food also increases despite the monetary policy. Appreciation of the currency makes the tradable non-food goods cheaper, and causes demand for them to rise. Consumption of non-tradable non-food goods decreases while consumption of tradable non-food goods rises. The increase in food exports dominates the fall in non-food exports such that the trade balance becomes positive, and the net foreign position is cleared through ownership of more foreign assets.When the central bank targets the overall CPI, the interest rate increases at the time of the shock. The price of non-tradable goods does not increase, firstly because wages are a constraint, secondly because the exchange rate appreciation reduces the pass-through. During the transition, the interest rate decreases, and global demand, wages and prices rise. Thus non-tradable prices increase progressively, and domestic inflation is spread over a long period.

When the central bank excludes food prices from its target, the interest rate does not move with world food price hikes. Thus, the food price shock heats the domestic economy more heavily. The shock is absorbed less by the exchange rate appreciation. Wages and non-tradable goods prices increase dramatically. During the transition, the relative price of tradable food falls gradually because of nominal rigidity. Since our model includes tradable food and non-food goods, the exchange rate turns to be a key channel for the transmission of monetary policy. If the central bank raises its interest rates following a world food price shock, this will cause appreciation of the domestic currency and will reduce the relative price of tradable non-food goods. This keeps inflation in non-food goods at a low rate.

The result in Table 4.5 show that for any country category, the best policy is to target sticky prices (in other words, the exact core inflation index). This result is consistent with previous studies and especially with Aoki (2001). Table 4.5 presents the weights that maximize each policy rule. Note that the poorer the country, the bigger the weight on non-tradable food in core inflation. These weights reflect the relative sizes of the two sticky price sectors in the economy. The share of non-tradable food in core inflation is around 4% in high-income countries, 12% in middle-income countries and 30% in low-income countries. This explains the ranking of the other rules: in high income countries, the optimal share of non-tradable food in core inflation is extremely low, thus it can be virtually neglected by the monetary authorities with the consequence that targeting non-food inflation is more effective than targeting headline inflation. Thus, in high income countries, non-food inflation, the proxy for core inflation calculated with the exclusion method, is a better target than headline inflation. However, in middle income countries, the optimal share of non-tradable food in core inflation is higher than in high-income countries, and thus it cannot be neglected by the monetary authorities. Consequently, in middle-income countries targeting non-food inflation is less effective than targeting headline inflation. This result is even stronger in low-income countries, where the gap between the welfare cost of shocks under headline inflation and the welfare cost of shocks under non-food inflation represents a perpetual utility loss of 0.03% of consumption. Our results suggest that the confusion between non-food inflation and core inflation may be causing badly designed policies in low and middle-income countries. This result implies that central bank would do better to target CPI than to target a proxy core inflation index based on non-food prices.

When the non-tradable food share in consumption is large, core inflation must include food as well as non-food sticky prices. Therefore, the relative share of the two indexes in the monetary-relevant inflation is far from obvious. Many central banks use a proxy for core inflation that is based on non-food prices rather that the true core index. As Table 4.5 shows, this is justified in high-income countries where the share of food in consumption is low and consist mainly of tradable goods. However, in low and middle-income countries targeting non-food inflation leads to ill-designed policies. Food prices are more volatile, which explains their exclusion from the measure of core inflation. Nevertheless, in low and middle-income countries, a surge in imported food prices generates inflationary pressures in the large non-tradable food sector. Thus, the trade-off between headline and non-food inflation differs for middle and high-income countries. This results is robust to changes in the calibration of the main parameters of the model (see Table 4.E.4 in Appendix 4.E).

4.5 Fixed consumption and monetary policy

Food is not a good like other goods: it is basic consumption need. Some might argue that because food is a good of first necessity, a food price shock will not spread to the economy in the same ways as other relative price shocks. Consumption cannot decrease freely. A part of consumption is not related to relative prices and thus is inelastic. In this section, we examine whether the fact that food is a first necessity influences the ranking of monetary rules. We can conclude that our results are robust to a change in the definition of food in the utility function.

Following Anand & Prasad (2010), to account for food being a necessity, households must consume a minimum amount of each kind of food in order to survive, denoted $\bar{C}^{FN}$ and $\bar{C}^{FT}$, respectively. We assume also that the household always has enough income to buy the subsistence level of food. Thus, the food index in utility is given by a generalized Klein-Rubin utility function (see e.g. Gollin et al. (2002)). Therefore, the consumption bundle given in equation (5.3) becomes:

$$C^F \equiv \left[(1-\gamma_F)^{\frac{1}{\theta_F}} \left(C^{FN} - \bar{C}^{FN}\right)^{\frac{\theta_F - 1}{\theta_F}} + \gamma_F{}^{\frac{1}{\theta_F}} \left(C^{FT} - \bar{C}^{FT}\right)^{\frac{\theta_F - 1}{\theta_F}}\right]^{\frac{\theta_F}{\theta_F - 1}}. \tag{4.27}$$

Notice that C_t^F is not the amount of food consumed by the household, but the household's utility value of food consumption. The household consumes C_t^{FN} and C_t^{FT}. But since food is a necessity, we considerer that consumption does not deliver pleasure (or utility) to the household before the *minimum* level is reached. This means that its utility starts to increase only when food consumption overtakes this *subsistence* level.

Demand for each food variety (previously given by equation (4.9) and (4.10)) can be rewritten as

$$C^{FT} = \gamma_F \left(\frac{P^{FT}}{P^F}\right)^{-\theta_F} C^F + \bar{C}^{FT} \tag{4.28}$$

$$C^{FN} = (1-\gamma_F) \left(\frac{P^{FN}}{P^F}\right)^{-\theta_F} C^F + \bar{C}^{FN} \tag{4.29}$$

Thus, in this case, the total consumption expenditure is given by

$$P_t C_t + P_t^{FN} \bar{C}^{FN} + P_t^{FT} \bar{C}^{FT}$$

The representative household now faces the following budget constraint (previously given by equation (4.16)) expressed in units of domestic currency

$$\begin{aligned} S_t B_t^* + B_t + P_t C_t + P_P^{FD} \bar{C}^{FD} + P_P^{FT} \bar{C}^{FT} \\ = S_t \left(1 + i_{t-1}^\star\right) B_{t-1}^* + (1 + i_t) B_t + W_t L_t + \Pi_t. \end{aligned} \tag{4.30}$$

We introduce fixed consumption in food and restrict the change in the utility function such that the economy's steady-state is maintained. This implies introducing minimum consumption in Equation (4.27) and rescaling the share of food in the consumption bundle in Equation (5.1) according to $\bar{\gamma} = \gamma(1-\mathcal{A})$ with $\mathcal{A}$ the food subsistence level in proportion to total food consumption at the steady-state.

Even with the introduction of fixed consumption, ceteris paribus, it has a major effect on the elasticity of substitution between goods. The model's elasticity, denoted by θ, is no longer the perceived elasticity of substitution, denoted by $\mathcal{E}$. The perceived elasticity of substitution is a linear function of the model's elasticity of substitution and fixed consumption: $\mathcal{E} = \mathcal{A}\theta$. This means that when fixed consumption rises to near 100 % of consumption, the elasticity of substitution falls to zero.

The model described in Section 4.2 is taken as a baseline. In order to add the subsistence amount of food consumption, we need to redefine all the variables that are dependent on

Figure 4.2: Welfare associated to the main policy rules for different subsistence level

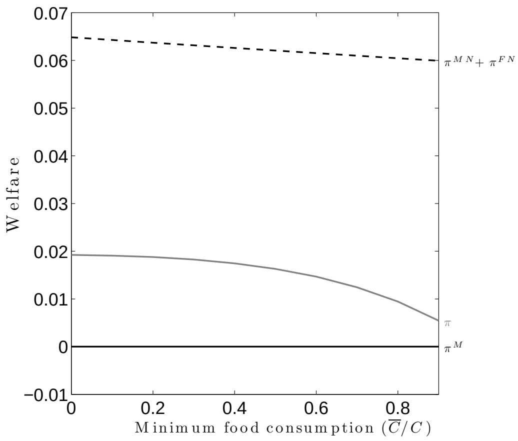
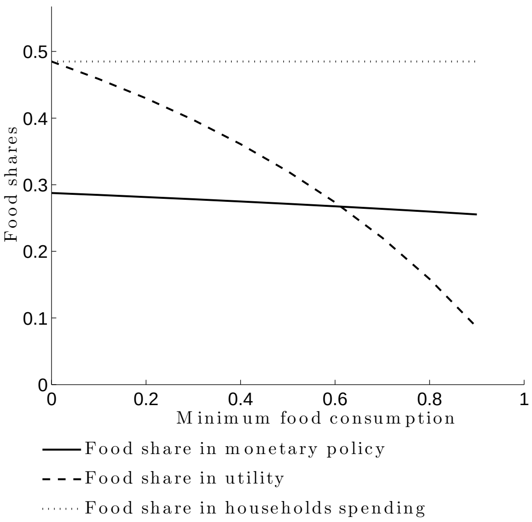


Figure 4.3: Variations of food shares in consumption, utility and monetary policy.



the utility function, as described above. We add subsistence levels of 5, 10, 15, etc. up 95% of the food consumption. We repeat the tasks described in Section 4.4 for welfare.

The welfare cost of shocks obtained by a given rule for a given value of fixed food consumption should not be compared to the welfare value obtained by the same rule for another value of fixed consumption, because it does not come from the same utility function. Since the utility function has changed, it does not allow for welfare comparison. However, for a given value of fixed consumption we can compare different policies and rank them according to their welfare. We can also compare the rankings from one fixed consumption value to another. Our main result is that the rankings do not change. Graphically this is represented by the fact that in Figure 4.3 the lines never cross. Thus the results described in Section 4.4 are ongoing: (i) targeting sticky prices is the best option; (ii) targeting overall CPI is better than targeting a proxy for core inflation given by non-food inflation.

If we examine the best monetary policy more closely, that is, the rule combining inflation in non-tradable food and non-tradable non-food sectors, we can define the relative weight of food in the optimized policy rule. For any subsistence level we can calculate the weighting that minimizes the welfare cost of shocks. We find that the relative weight of the two inflation indexes does not change while the subsistence levels of food increase. On the graph in 4.3 we plot the food share according to this rule, which is the weight associated with non-tradable food inflation divided by the sum of the weights of non-tradable food and non-tradable non-food inflation. Once again, the ranking of monetary policy rules does not change whatever the subsistence level. Therefore, the fact that food is a necessity does not change the way monetary policy should react to food prices.

4.6 Conclusion

In this paper, we examine how central banks react to food price shocks. In particular, we analyze the performance of an inflation targeting regime to deal with a shock to the world price of food products. We developed a small open economy New Keynesian model. We consider that both food and non-food goods are made of tradable and non-tradable goods, and we calibrate our model on real data. We defined a non-tradable food good as a product that is produced at home and whose price does not depend directly upon the world market. This set up allowed us to describe the channel between the world market and domestic consumer prices, through the relative demand for tradable goods and purely domestic varieties. It is well-known that central banks cannot calculate the exact core inflation indices of their economies because they generally lack micro level data on prices behaviors, particularly in less-developed and emerging economies. They tend to use a proxy for core inflation that is based on excluding oil and food prices from the CPI.

We showed how confusion between core inflation and non-food inflation can lead to badly formulated policies. This result holds for low-income and middle-income countries, where the share of food goods in the CPI, and particularly the share of non-tradable food goods, is large. In high-income countries, the share of non-tradable food in consumption is small enough to be ignored by central banks in their definition of core inflation. Thus, our results suggest that in low and middle income countries central banks should target headline inflation rather than a core inflation index that excludes food prices.

This finding holds not because food is a first necessity, but because non-tradable food represents a significant share in total consumption. When food is described as a first necessity good the ranking of monetary rules does not change. In fact, a high share of non-tradable food in consumption, implies a non-negligible part of sticky food prices in the CPI, giving room for monetary policy action toward food price shocks.

Therefore, the results from our work provide important policy recommendation for countries that are inflation targeting and intend to implement such policies in the future. For high-income countries, food prices can be virtually ignored in the target index. For low and middle income countries where non-tradable food is not negligible, central bank should not ignore food price evolution and should target headline inflation .

Appendix

4.A Food consumption and economic development

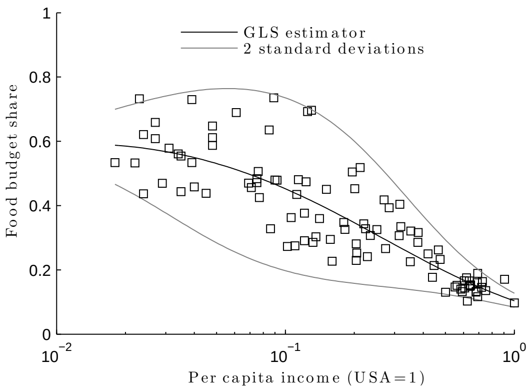


Figure 4.A.1: Food in households basket.

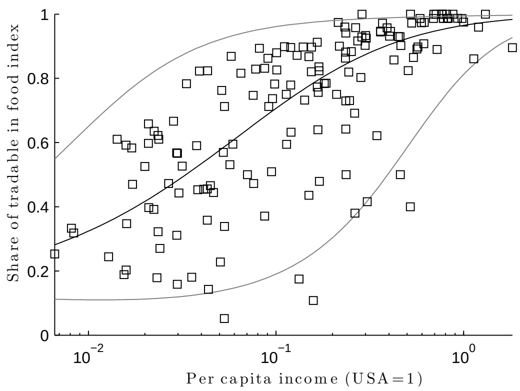


Figure 4.A.2: Share of tradable goods in food consumption.

We estimate the equation

$$\log\left(\frac{S_i}{1-S_i}\right) = \alpha_1 \log(GDP_i) + \alpha_2 \log(GDP_i)^2 + \alpha_3$$

where S is either the share of food in the consumption bundle or the share of tradable goods in food consumption, using GLS (to take into account heteroscedasticity).

4.B Non-tradable food and manufactured goods sectors

Optimal price setting and inflation dynamic

We skip the s superscript for convenience (i.e. P_t denotes P_t^s and π_t denotes π_t^s). From the demand function, Equation (4.15), one has $\frac{\partial Y_{t+k|t}}{\partial P_{t|t}} = -\eta \frac{Y_{t+k|t}}{P_{t|t}}$. The first order condition is given by

$$\mathbb{E}_t \sum_{k=0}^{\infty} d_t^{t+k} \phi^k Y_{t+k|t} \left[P_{t|t} - \frac{\eta}{\eta-1} \frac{\partial \Psi_{t+k|t}}{\partial Y_{t+k|t}} \right] = 0.$$

Let $\mathrm{mc}_t = \frac{1}{1-\alpha} A_t^{\frac{-1}{1-\alpha}} Y_t^{\frac{\alpha}{1-\alpha}} \frac{W_t}{P_t}$. One has

$$\frac{1}{P_{t+k}} \frac{\partial \Psi_{t+k|t}}{\partial Y_{t+k|t}} = \mathrm{mc}_{t+k} \left(\frac{Y_{t+k|t}}{Y_{t+k}} \right)^{\frac{\alpha}{1-\alpha}}.$$

The FOC is given by

$$\left(\frac{P_{t|t}}{P_t}\right)^{\frac{1-\alpha+\eta\alpha}{1-\alpha}} = \frac{\eta}{\eta-1} \frac{\mathbb{E}_t \sum_{k=0}^{\infty} d_t^{t+k} \phi^k Y_{t+k} \left(\frac{P_{t+k}}{P_t}\right)^{\frac{1-\alpha+\eta}{1-\alpha}} \mathrm{mc}_{t+k}}{\mathbb{E}_t \sum_{k=0}^{\infty} d_t^{t+k} \phi^k Y_{t+k} \left(\frac{P_{t+k}}{P_t}\right)^{\eta}} = \frac{\eta}{\eta-1} \frac{\mathcal{X}_t}{\mathcal{Y}_t}.$$

$\mathcal{X}_t$ and $\mathcal{Y}_t$ have the following recursive expressions

$$\mathcal{X}_t = Y_t \text{mc}_t + \phi \mathbb{E}_t \left\{ d_t^{t+1} \pi_{t+1}{}^{\frac{1-\alpha+\eta}{1-\alpha}} \mathcal{X}_{t+1} \right\}, \tag{4.31}$$

$$\mathcal{Y}_t = Y_t + \phi \mathbb{E}_t \left\{ d_t^{t+1} \pi_{t+1}{}^{\eta} \mathcal{Y}_{t+1} \right\}. \tag{4.32}$$

Given the definition of the consumption bundle, inflation dynamic in the sector is given by

$$\pi_t^{1-\eta} = \phi + (1-\phi) \left(\frac{P_{t|t}}{P_t} \right)^{1-\eta}. \tag{4.33}$$

Price dispersion and aggregate production function

Price dispersion in a given sector induces misallocation of factors and decreases the productivity at the aggregate level comparing to productivity at the firm level. Schmitt-Grohé & Uribe (2006) develops the calculus in the constant return to scale case. We propose here the decreasing return to scale case. Labor demand from firm i is given by

$$L_t(i) = \left(\frac{P_t(i)}{P_t} \right)^{\frac{-\eta}{1-\alpha}} \left(\frac{Y_t}{A_t} \right)^{\frac{1}{1-\alpha}}.$$

Integrating over firms of the sector gives

$$L_t = \left(\frac{Y_t}{A_t} \right)^{\frac{1}{1-\alpha}} \int_0^1 \left(\frac{P_t(i)}{P_t} \right)^{\frac{-\eta}{1-\alpha}} \mathrm{d}i$$

The effect of price dispersion on productivity, given by the term $\mathcal{S}_t = \int_0^1 \left(\frac{P_t(i)}{P_t} \right)^{\frac{-\eta}{1-\alpha}} \mathrm{d}i$, is given by

$$\begin{aligned}
\mathcal{S}_t &= (1-\phi) \left(\frac{P_{t|t}}{P_t} \right)^{\frac{-\eta}{1-\alpha}} + \int_{P_t(i)=P_{t-1}(i)} \left(\frac{P_t(i)}{P_t} \right)^{\frac{-\eta}{1-\alpha}} \mathrm{d}i \\
&= (1-\phi) \left(\frac{P_{t|t}}{P_t} \right)^{\frac{-\eta}{1-\alpha}} + \phi \left(\frac{P_{t-1}}{P_t} \right)^{\frac{-\eta}{1-\alpha}} \mathcal{S}_{t-1} \\
&= (1-\phi) \left(\frac{P_{t|t}}{P_t} \right)^{\frac{-\eta}{1-\alpha}} + \phi \pi_t{}^{\frac{\eta}{1-\alpha}} \mathcal{S}_{t-1}
\end{aligned} \tag{4.34}$$

4.C Estimation of exogenous shocks

We estimated a VAR model on the three exogenous variables of our model which values are given by shocks on "the world economy".

- tradable food goods price, $P_t^{FT\star}$, proxied by Reuter's DataStream food commodities composite price index.

- tradable non-food goods price, $P_t^{MT\star}$, proxied by Reuter's DataStream world export index.
- world interest rate, i_t^w, proxied by the yield on one year US tresory bonds.

Datas range from 1980 first quarter to 2011 last quarter. We consider two lags, according to the correlograms shape. We have also estimated other models, like VARMA, and had similar results.

Table 4.C.1: Estimated VAR

	i_t^w	$P_t^{FT\star}$	$P_t^{MT\star}$
i_{t-1}^w	0.99	-1.64	
	(11.3)	(-2.7)	
i_{-2}^w	-0.20	1.76	
	(-2.7)	(2.9)	
$P_{t-1}^{FT\star}$	0.03	1.03	
	(2.5)	(12.6)	
$P_{t-2}^{FT\star}$	-0.02	-0.42	
	(-1.9)	(-5.16)	
$P_{t-1}^{MT\star}$			1.11
			(13.5)
$P_{t-2}^{MT\star}$			-0.42
			(-5.07)
R-2	0.71	0.60	0.68
D-W	2.00	1.81	1.91
Obs.	126	126	126

t-stat in parenthesis.

Table 4.C.2: Estimated Residuals Matrix

Shocks correlation			
	i^w	$P^{FT\star}$	$P^{MT\star}$
i^w	1		
$P^{FT\star}$	0.089	1	
$P^{MT\star}$	-0.023	0.56	1
Shocks covariance			
	i^w	$P^{FT\star}$	$P^{MT\star}$
i^w	3.8e-5		
$P^{FT\star}$	2.4e-5	1.8e-3	
$P^{MT\star}$	-3.4e-6	5.7e-4	5.6e-4

4.D Main statistics of the model

Table 4.D.3: Variance decomposition (in percent)

Variables	A^{FN}	A^{FT}	A^{MT}	A^{MN}	i^w	$P^{FT\star}$	$P^{MT\star}$
C	0.24	0.10	1.78	3.43	37.30	45.86	11.28
L	0.04	2.73	7.66	0.54	37.51	40.66	10.87
Y	0.67	8.05	25.15	5.10	26.04	27.43	7.57
Y^{FN}	29.50	0.82	7.50	2.47	11.04	11.62	37.06
Y^{FT}	0.01	29.23	6.41	0.12	8.20	50.05	5.98
Y^{MT}	0.03	3.30	54.22	0.31	15.46	1.35	25.33
Y^{MN}	0.42	0.19	2.39	42.89	10.55	41.72	1.84
Π	0.19	0.01	0.07	0.33	33.30	55.61	10.49
Π^F	2.14	0.01	0.01	1.12	10.18	57.11	29.43
Π^M	1.67	0.01	0.04	0.60	11.18	65.39	21.10

4.E Impulse-response function

Figure 4.E.3: IRF under alternative monetary policy rules: middle-income countries

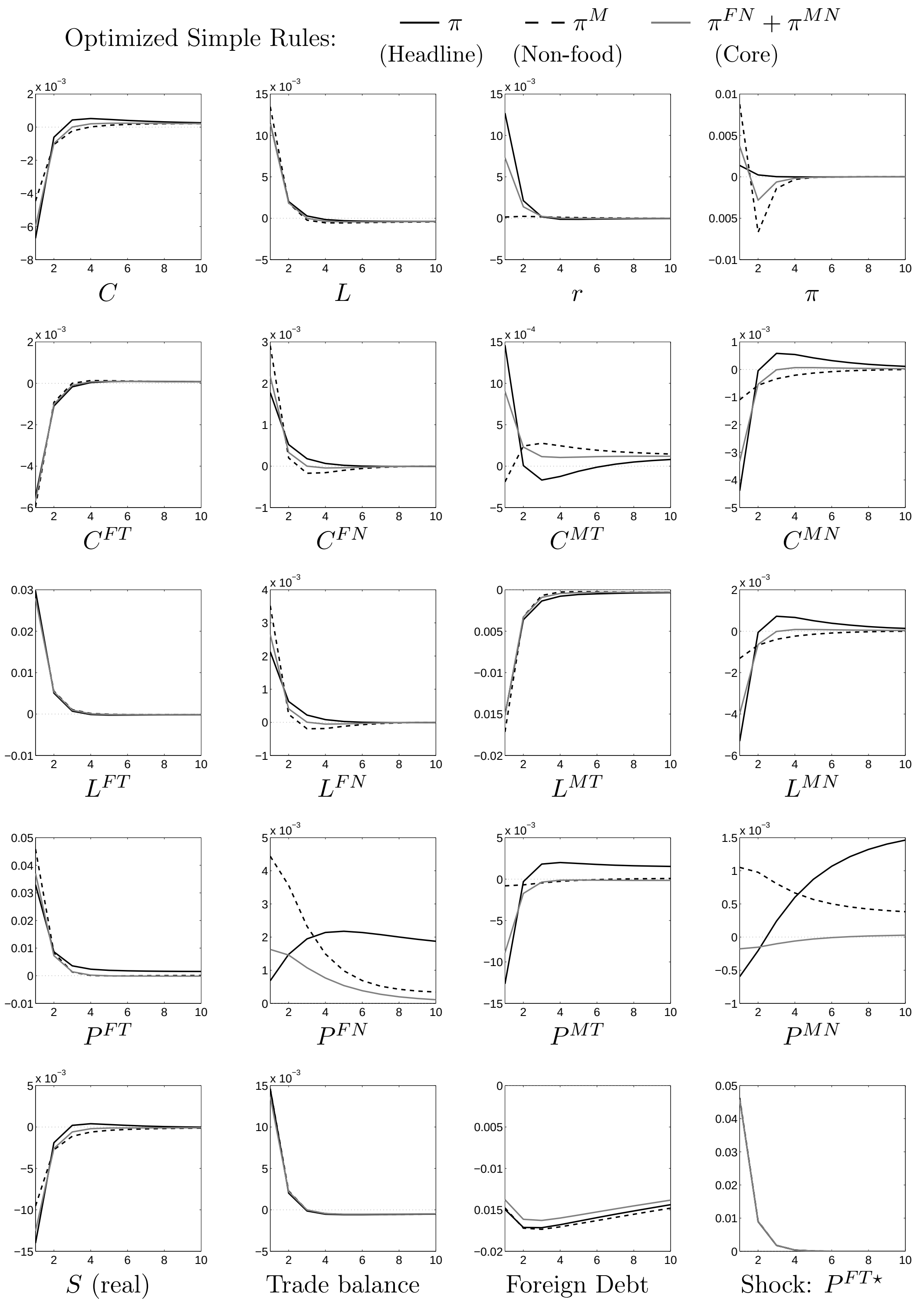


Figure 4.E.4: IRF under alternative monetary policy rules: high-income countries

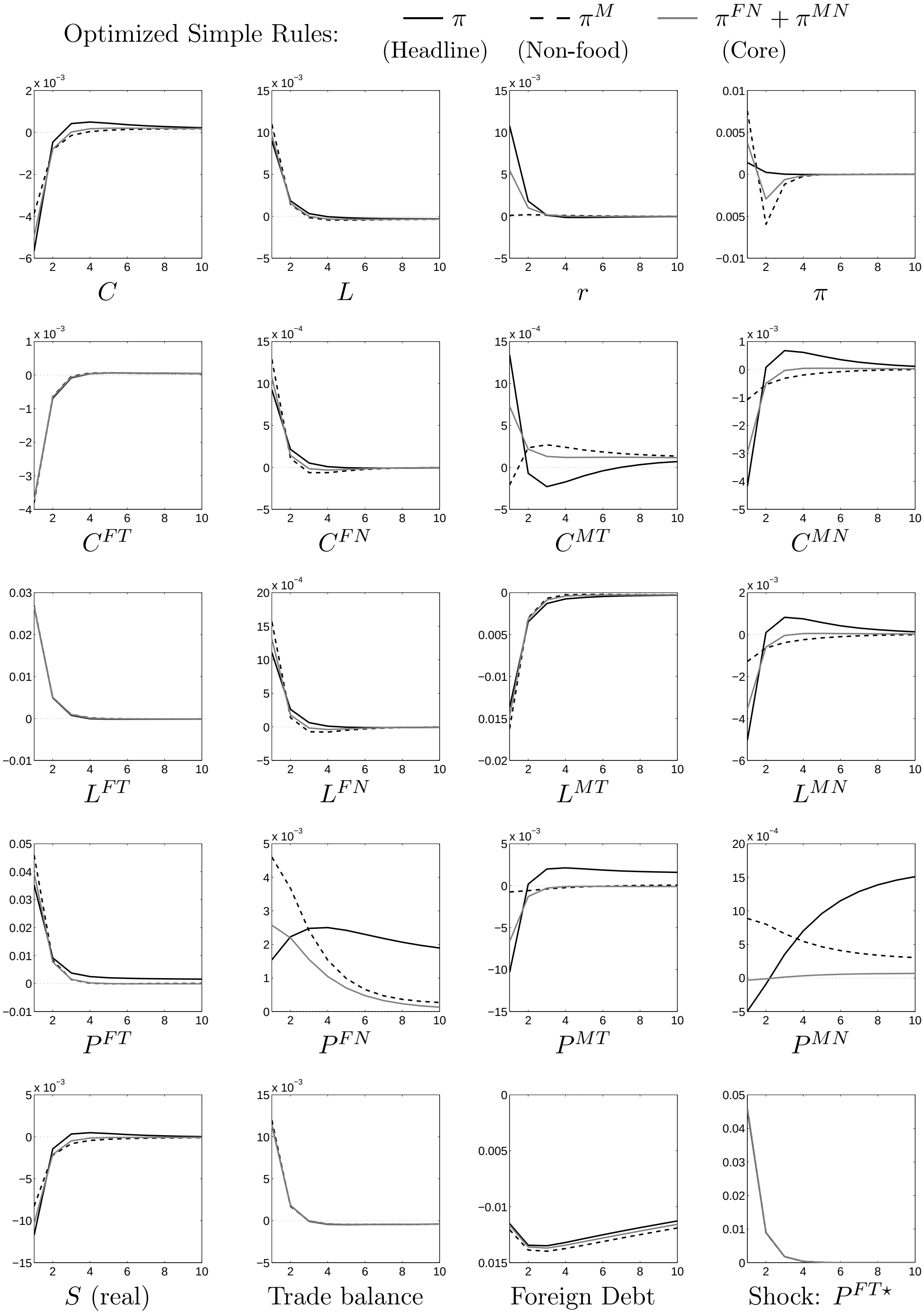


Table 4.E.4: Rubustess test: static comparative on welfare maximizing' Taylor Rules

(low income countries case)

Optimal Rule	$\mathcal{W}$	Rank
Baseline		
$log\left(i/\bar{i}\right) = 56\ log\left(\Pi\right)$	0.03	2
$log\left(i/\bar{i}\right) = 52\ log\left(\Pi^{M}\right)$	0.00	3
$log\left(i/\bar{i}\right) = 712\ log\left(\Pi^{FN}\right) + 287\ log\left(\Pi^{MN}\right)$	0.11	1
Share of food in consumption $\gamma = 0.2$ (baseline = 0. 48)		
$log\left(i/\bar{i}\right) = 61\ log\left(\Pi\right)$	0.01	2
$log\left(i/\bar{i}\right) = 81\ log\left(\Pi^{M}\right)$	0.00	3
$log\left(i/\bar{i}\right) = 901\ log\left(\Pi^{FN}\right) + 99\ log\left(\Pi^{MN}\right)$	0.10	1
Share of tradable in food consumption $\gamma^{F} = 0.1$ (baseline = 0.37)		
$log\left(i/\bar{i}\right) = 28\ log\left(\Pi\right)$	0.09	2
$log\left(i/\bar{i}\right) = 114\ log\left(\Pi^{M}\right)$	0.00	3
$log\left(i/\bar{i}\right) = 646\ log\left(\Pi^{FN}\right) + 354\ log\left(\Pi^{MN}\right)$	0.16	1
Nominal rigidities domestic food price $\phi^{F} = 0.75$ (Baseline = 0.5)		
$log\left(i/\bar{i}\right) = 80\ log\left(\Pi\right)$	0.03	2
$log\left(i/\bar{i}\right) = 189\ log\left(\Pi^{M}\right)$	0.00	3
$log\left(i/\bar{i}\right) = 460\ log\left(\Pi^{FN}\right) + 526\ log\left(\Pi^{MN}\right)$	0.13	1
Inverse of the intertemporal elasticity of substitution $\rho = 0.5$ (Baseline = 2)		
$log\left(i/\bar{i}\right) = 19\ log\left(\Pi\right)$	0.05	2
$log\left(i/\bar{i}\right) = 1001\ log\left(\Pi^{M}\right)$	0.00	3
$log\left(i/\bar{i}\right) = 708\ log\left(\Pi^{FN}\right) + 292\ log\left(\Pi^{MN}\right)$	0.21	1
Elasticity of substitution between F and non-F $\theta = 0.9$ (Baseline = 0.3)		
$log\left(i/\bar{i}\right) = 59\ log\left(\Pi\right)$	0.03	2
$log\left(i/\bar{i}\right) = 49\ log\left(\Pi^{M}\right)$	0.00	3
$log\left(i/\bar{i}\right) = 715\ log\left(\Pi^{FN}\right) + 285\ log\left(\Pi^{MN}\right)$	0.11	1
Elasticity of substitution between food T and N $\theta^{F} = 2.5$ (Baseline = 1.4)		
$log\left(i/\bar{i}\right) = 53\ log\left(\Pi\right)$	0.04	2
$log\left(i/\bar{i}\right) = 38\ log\left(\Pi^{M}\right)$	0.00	3
$log\left(i/\bar{i}\right) = 701\ log\left(\Pi^{FN}\right) + 299\ log\left(\Pi^{MN}\right)$	0.11	1
Scale effect on labor $\alpha^{FT,FN,MT,MN} = 0.01$ (Baseline = 0.25)		
$log\left(i/\bar{i}\right) = 155\ log\left(\Pi\right)$	0.03	2
$log\left(i/\bar{i}\right) = 19\ log\left(\Pi^{M}\right)$	0.00	3
$log\left(i/\bar{i}\right) = 733\ log\left(\Pi^{FN}\right) + 267\ log\left(\Pi^{MN}\right)$	0.06	1

CHAPTER 5

Credit Access and the Redistributive Impact of Monetary Policy

Contents

Abstract:
We investigate how introducing credit-constrained households in the standard new-keynesien DSGE model modifies the optimal monetary policy. When the economy is hit by a shock, such a world food price shock, credit constrained households can not smooth their consumption as ricardian households do. Hence, the standard monetary policy transmission channel through consumption-saving choice is inexistent. However, by affecting prices, the monetary authorities have a direct impact on credit constrained households' real wage. The presence of such rule-of-thumb consumers generate a new trade off for monetary policy: monetary policy has distributives impacts. However it does not modifies significantly the optimal policy.

Keyword: Monetary Policy, Commodities, DSGE models.

JEL: E32, E52, E38, O23.

This chapter is a part of a join project on households heterogeneity in DSGE modeling, with Benjamin Carton, CEPII.

5.1 Introduction

The previous chapter has investigated, in a representative agent model, how two features of low-income and middle income economies may challenge the common view that monetary authorities should take into account core (non-food) inflation in its policy rule instead of headline inflation. A higher share of food in the consumption basket and the higher share of non-tradable goods in the food basket both increase the relative welfare gain of a headline-based monetary rule comparing to a core-based monetary rule if the economy is hit by productivity and world-price shocks. As a result, low-income economies clearly benefits from a headline-based policy rule, whereas middle-income moderately benefit from such a rule.

Low-income and emerging economies also differs from advanced economies as financial markets and social safety nets are less developed, so the ability of households to hedge against idiosyncratic risks is much lower. Furthermore, incomplete labor mobility between urban areas and the country side avoid large workers flows if the relative price between food and non-food goods varies. Food price volatility creates large income redistribution shocks without institutional framework to limit them. We thus wonder if monetary policy should take into account the effect of world-price shocks on income redistribution between the different class of agents and curb its policy-rule accordingly. Does the presence of a high share of credit-constrained agents change the monetary policy trade-off?

Our approach relies upon the standard new-keynesian model. However, we introduce a distinction between two types of agents: some have access to credit, whereas some are credit-constrained. The later are a fraction of consumers who do not borrow or save in order to smooth consumption, but instead simply consume their current labor income each period. They are sometimes known as rule-of-thumb consumers or non-Ricardian consumers, as in Gali et al. (2004).

Indeed, credit constraints are key features of emerging markets. While introducing it in the new-keynesian standard model, we find that when a small open economy is hit by a world price shock, the question faced by monetary authorities is no longer "*how*"to accommodate shocks, but *on "who*" to spread the welfare loss implied by macroeconomic volatility. In addition to the factor allocation argument to stabilize the inflation rate, heterogeneous agents introduce a redistribution issue for monetary policy. Our contribution to the literature consists in taking into account redistribution issues in the design of the monetary policy when the economy faces term-of-trade or productivity shocks that impact the relativeï¿$\frac{1}{2}$ real income of different agents. In order to give a real substance to these mechanisms, we apply this set up to the study of what should monetary authorities do when food price hikes.

This question turns to be a major issue for emerging economies authorities after the two astonishing shocks that happened in 2008 and 2010. While the food price measured by the Food and Agriculture Organization (FAO) index remained constant in average from 1990 to 2006, it increased by 54% between January 2006 and June 2008. After a short period of decline, a second shock happened from June to December 2010: within 6 months, prices were boosted by 33% (see Graph 5.A.1 page 156).

In in the previous chapter we developed a small-open economy new-keynesian model specifically dedicated to the question of food prices and the optimal policy in emerging economies. Focusing on the right definition of the central bank's inflation target, we emphasized the danger of having a bad proxy for core inflation. More precisely, we showed that core inflation can easily and safely been proxy by non-food prices in developed countries, but not in emerging economies where the share of food in consumption is large and where households have preferences for purely domestic food varieties that are not internationally traded.

In the present paper, we keep the same structure for the economy and for the shocks as in the previous chapter. However, we introduce credit-constrained households. The economy is populated by two household types: some are agricultural households and some are manufacture workers. Also, a fraction of each household type is credit-constrained. The two labor markets are separated and therefore they have different wages. Food and manufacture goods consists of two varieties: one is non-tradable (domestically-produced and sold in a monopolistic competition market) and one is tradable (imported and produced at home, and sold in a competitive market under the law of one price). This framework allows us to assume that food price volatility is related to both technological shocks (such as weather) and imported price shocks (such as world price hikes).

We show that the central bank faces a trade-off between optimizing the farmers' welfare or optimizing the manufacture workers' welfare. Indeed, the question faced by the central bank is how to spread the volatility implied by the world shock over the alternative domestic variables . The optimal answer for credit-constrained farmers is to absorb the shock through exchange-rate volatility; while the optimal policy for credit-constrained manufacture workers is to maintain the volatility in the food sector by asking the domestic tradable food price to hike has much as the world price.

The remainder of the paper is organized as follows. Section 5.2 reviews the literature. Section 5.3 lays out the the model. Section 5.4 presents the calibration. Section 5.5 contains an analysis of the equilibrium dynamics, with a special emphasis on the redistributive impacts of the monetary policy. Section 5.6 examines the robustness of those results. Finally, Section 5.7 sums up the results and concludes.

5.2 Literature review

A standard result of the New-Keynesian literature on optimal monetary policy is that following a relative price shock, the central bank maximizes the social welfare (overall population welfare) by targeting inflation of the sticky prices. This result has been most notably emphasized by Aoki (2001) and Benigno (2004). By keeping the inflation rate under control, the central bank controls (and possibly vanish) the negative impact of price dispersion on welfare. Therefore, this literature concludes that targeting the stickiest prices, or in other word targeting core inflation, is the optimal policy.

Credit-constrained households have been first introduced in this standard New-Keynesian framework by Amato & Laubach (2003) and Gali et al. (2004). They study how having credit constrained or rule-of-thumb consumers in the economy impacts the definition of the monetary policy rule. They find that the Taylor principle is no longer a sufficient condition to insure Blanchard-Kahn conditions (Blanchard & Kahn, 1980) in an economy with credit-constrained households and capital accumulation.

In an attend to study the monetary policy optimal reaction to food price shocks, Catão & Chang (2013) extend that literature to a two sectors economy, food and non-food, with incomplete market. They show the optimal policy may not be to target sticky prices if assuming simultaneously: (1) all nominal rigidities are in the non-food sector; (2) all food producers are credit constrained (while all non-food producers can smooth their consumption through credit and saving); (3) the elasticity of substitution between food goods and non-food is almost null. Under that framework, a negative productivity shock increases food price (because of the extremely low elasticity of substitution, consumers keep buying food even when the prise rise) and therefore increases farmers incomes. Thus, there is a large redistribution effect from non-food producers to food producers. And then, the optimal policy is the one that can limit the extend of that these income changes. However, the effects of monetary policy on consumers is all but expected: when the central bank tightens its policy, the Ricardian household consumes more whereas the credit-constrained household consumes less. The mechanism leading to that result remains unclear. Also, this results holds as long as the monetary policy is calibrated to react not too strongly to food price shock.

In Anand & Prasad (2010) paper, food volatility is seen as a purely domestic issue (generated for example by bad weather condition) modeled as productivity shocks in a closed economy. Anand & Prasad (2010) introduce households that are credit constrained in a two sectors closed economy and discuss the type of monetary rule that maximizes the social welfare. Assuming that constrained households belongs to the agricultural sector in which prices are flexible, a monetary rule that links the interest rate to headline inflation (including both food and non-food inflation) Pareto dominates a rule that reacts to core inflation (non-food inflation only). This results, that deviates from the standard representative-agent model, appears if the elasticity of substitution between food and non-food goods is low and if food price volatility is generated by labor productivity shocks.

While Anand & Prasad (2010) analyzes food price shocks as purely domestic events, Catão & Chang (2010) and Catão & Chang (2013) proposed a study of food price volatility based on the terms of trade literature. Considering the large swings in world food prices in recent years, Catão & Chang (2013) analysis how monetary policy authorities in small open economy should react to imported price shocks. In order to emphasize the role of real exchange rate they study two polar cases: perfect risk sharing and financial autarky. They find that targeting broad CPI is optimal in an economy integrated to the world capital market while PPI targeting does better in economy with closed capital account.

5.3 The model

We model a two sector small open economy (Home) with farming and manufacturing production. The two labor markets are segmented and therefore households are either farmers or manufacture workers. Each sector is divided into two sub-sectors: a tradable one and a non-tradable one with perfect labor mobility between them. Home is price-taker on the world market. Thus, tradable food prices and tradable manufacture prices are exogenously determined in international currency. Firms in the non-tradable food and non-tradable non-food sectors produce differentiated products and thus have pricing power (monopolistic competition). Each household consumes the four types of goods.

Among the two populations, only a fraction of the households have the opportunity to buy domestic and foreign bonds and to hedge against idiosyncratic shocks, whereas the others are credit constraint. The later are *ruled-of-thumb* consumers as in Gali et al. (2004).

The remainder of this section first describes the consumption basket, budget constraint and first order conditions for households. Then, price-setting by firms and the model calibration are presented.

5.3.1 Households

Home is a small open economy, populated by a continuum of households, indexed by $i \in [0,1]$. The labor market is segmented such that a fraction $\lambda^{\mathcal{F}}$ of the population work in the food sector (the so-called "agricultural households"), and the remanding $1-\lambda^{\mathcal{F}}$ households are manufacture workers. We denote by the subscript $\mathcal{F}$ the agricultural households and by $\mathcal{M}$ the manufacture workers households. Among the two populations, a fraction $1-\lambda^{\mathcal{R}}$ is financially constrained, i.e. has no access to financial markets to smooth consumption intertemporally. Therefore, they are "ruled-of-thumb consumers" as in Gali et al. (2004) and consume all their current income. They are denoted by the subscript $\mathcal{K}$. The remaining population has full access to financial markets, and can buy both domestic and foreign one-period, risk-free, nominal bonds. They are denoted by the subscript $\mathcal{R}$,for Ricardian households. Finally, because credit constrained households are present among farmers and manufacture workers populations, the economy is populated by four households types who differ by the origin of incomes and financial constraints ($\mathcal{FR}, \mathcal{MR}, \mathcal{FK}$ and $\mathcal{MK}$).

Households maximize the following utility

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(C_t, L_t) \qquad \text{with} \qquad U(C,L) \equiv \frac{C^{1-\rho}}{1-\rho} - \psi \frac{L^{1+\chi}}{1+\chi}$$

where $0 < \beta < 1$, $\mathbb{E}$ is the expectation operator, $\rho > 0$ is the inverse of intertemporal elasticity of substitution, $\chi > 0$ the inverse of elasticity of labor supply and$\psi > 0$ is a scale parameter.

The consumption bundle

The consumption baskets is composed of four goods: food tradable and non-tradadable goods, manufacture tradable and non-tradable goods. The consumption bundle is

$$C \equiv \left[(1-\gamma)^{\frac{1}{\theta}}(C^{\mathrm{M}})^{\frac{\theta-1}{\theta}} + (\gamma)^{\frac{1}{\theta}}(C^{\mathrm{F}})^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}}, \tag{5.1}$$

where γ is the share of food in consumption and θ is the intratemporal elasticity of substitution between food goods and non-food goods. Food consumption, C^{F}, and manufacture goods consumption, C^{M}, include tradable goods, C^{MT} and C^{FT}, that may be consumed at home and abroad, and non-tradable goods, C^{MN} and C^{FN}, that are purely domestic. Hence, C^{M} and C^{F} are defined as

$$C^{\mathrm{M}} \equiv \left[(1-\varrho_{\mathrm{M}})^{\frac{1}{\vartheta}} {C^{\mathrm{MN}}}^{\frac{\vartheta-1}{\vartheta}} + {\varrho_{\mathrm{M}}}^{\frac{1}{\vartheta}} {C^{\mathrm{MT}}}^{\frac{\vartheta-1}{\vartheta}}\right]^{\frac{\vartheta}{\vartheta-1}}, \tag{5.2}$$

$$C^{\mathrm{F}} \equiv \left[(1-\varrho_{\mathrm{F}})^{\frac{1}{\vartheta}} \left(C^{\mathrm{FN}}\right)^{\frac{\vartheta-1}{\vartheta}} + {\varrho_{\mathrm{F}}}^{\frac{1}{\vartheta}} \left(C^{\mathrm{FT}}\right)^{\frac{\vartheta-1}{\vartheta}}\right]^{\frac{\vartheta}{\vartheta-1}}. \tag{5.3}$$

Given the price of each goods, P^{FN}, P^{FT}, P^{MN} and P^{MT}, and introducing the convenient aggregate prices[1] relative to food, P^{F}, non food, P^{M}, and aggregate consumption, P,

$$P^{\mathrm{F}} \equiv \left[(1-\varrho_{\mathrm{F}}){P^{\mathrm{FN}}}^{1-\vartheta} + \varrho_{\mathrm{F}}{P^{\mathrm{FT}}}^{1-\vartheta}\right]^{\frac{1}{1-\vartheta}}, \tag{5.4}$$

$$P^{\mathrm{M}} \equiv \left[(1-\varrho_{\mathrm{M}}){P^{\mathrm{MN}}}^{1-\vartheta} + \varrho_{\mathrm{M}}{P^{\mathrm{MT}}}^{1-\vartheta}\right]^{\frac{1}{1-\vartheta}}, \tag{5.5}$$

$$P \equiv \left[(1-\gamma){P^{\mathrm{M}}}^{1-\theta} + \gamma{P^{\mathrm{F}}}^{1-\theta}\right]^{\frac{1}{1-\theta}} \tag{5.6}$$

Demand for each variety is then

$$C^{\mathrm{FT}} = \gamma\varrho_{\mathrm{F}}\left(\frac{P^{\mathrm{FT}}}{P^{\mathrm{F}}}\right)^{-\vartheta}\left(\frac{P^{\mathrm{F}}}{P}\right)^{-\theta} C \tag{5.7}$$

$$C^{\mathrm{FN}} = \gamma(1-\varrho_{\mathrm{F}})\left(\frac{P^{\mathrm{FN}}}{P^{\mathrm{F}}}\right)^{-\vartheta}\left(\frac{P^{\mathrm{F}}}{P}\right)^{-\theta} C \tag{5.8}$$

$$C^{\mathrm{MT}} = (1-\gamma)\varrho_{\mathrm{M}}\left(\frac{P^{\mathrm{MT}}}{P^{\mathrm{M}}}\right)^{-\vartheta}\left(\frac{P^{\mathrm{M}}}{P}\right)^{-\theta} C \tag{5.9}$$

$$C^{\mathrm{MN}} = (1-\gamma)(1-\varrho_{\mathrm{M}})\left(\frac{P^{\mathrm{MN}}}{P^{\mathrm{M}}}\right)^{-\vartheta}\left(\frac{P^{\mathrm{M}}}{P}\right)^{-\theta} C \tag{5.10}$$

The non-tradable (food and non-food) good is assumed to be a composite of a contin-

[1] Notice that food shares in consumption are assumed to be equal for farmers and for manufacture workers (all households have the same γ). It follows that for a given set of (disaggregated) prices $\{P^{\mathrm{FN}}, P^{\mathrm{FT}}, P^{\mathrm{MN}}, P^{\mathrm{FT}}\}$, all households have the same aggregated indexes P, P^{F} and P^{M}.

uum of differentiated goods, $c^{\mathrm{N}}(i)$ with $i \in [0,1]$, via the aggregative CES function

$$C^{\mathrm{N}} \equiv \left(\int_0^1 c^{\mathrm{N}}(i)^{1-\frac{1}{\eta}} \mathrm{d}i\right)^{\frac{1}{1-\frac{1}{\eta}}}, \tag{5.11}$$

where N = FN (for non-tradable food) or N = MN (for non-tradable non-food), η is the elasticity of substitution across varieties. Let $P^{\mathrm{N}}(i)$ the nominal price of the variety i at time t. The aggregate price in the sector is defined by

$$P^{\mathrm{N}} \equiv \left(\int_0^1 P^{\mathrm{N}}(i)^{1-\eta} \mathrm{d}i\right)^{\frac{1}{1-\eta}}. \tag{5.12}$$

The consumer minimizes its total expenditure for any given level of consumption of the composite good, subject to the aggregation constraint. The optimal level of $c^{\mathrm{N}}(i)$ is then given by

$$c^{\mathrm{N}}(i) = \left(\frac{P^{\mathrm{N}}(i)}{P^{\mathrm{N}}}\right)^{-\eta} C^{\mathrm{N}}. \tag{5.13}$$

Households that have access to financial markets

Ricardian households can purchase domestic bonds, denoted by B_t, and foreign bonds denominated in units of foreign currency, denoted by B_t^*. Consistently, Ricardian households enter each period with holdings of domestic and foreign bonds purchased from the previous period (denoted by B_{t-1} and B_{t-1}^* respectively). To avoid a unit-root in the dynamics, the households are assumed to face an interest rate that is increasing in the country's net foreign debt (following Schmitt-Grohé & Uribe (2003)). The interest rate perceived by the households, denoted by $i_t^\star$ is the sum of the world interest rate, i_t^w, and a risk premium[2] $\mathcal{P}(B^*)$ given by:

$$\begin{aligned}
i_t^\star &= i_t^w + \mathcal{P}(B^*) \\
i_t^w &= \rho^i(\beta-1)^{-1} + (1-\rho^i)\epsilon_t^i \\
\epsilon_t^i &\sim N(0, \sigma_{\epsilon^i}) \\
\mathcal{P}(B^*) &= \xi(e^{-B^*} - 1)
\end{aligned}$$

Thus, Ricardian households face the following budget constraint, expressed in units of domestic currency

$$\begin{aligned}
&S_t B_t^* + B_t + P_t C_t \\
&\qquad = S_t\left(1 + i_{t-1}^\star\right) B_{t-1}^* + (1 + i_{t-1})B_{t-1} + W_t L_t + \Pi_t.
\end{aligned} \tag{5.14}$$

[2] The premium holds on the debt level (negative value of B^*) when its departs from the steady-state value $\bar{B^*}$. We have $\mathcal{P}(B^*) = \xi(e^{-B^*} - e^{-\bar{B^*}})$, where $\bar{B^*}$ is assumed to be zero.

where S_t is the exchange rate, Π_t is the net profits, and with W_t denoting either W^{F}, the farmers wage, or W^{M}, the manufacture workers wage. We denotes $d_{t,t+k}$ the nominal stochastic discount factor between dates t and $t+k$

$$d_{t,t+k} = \beta^k \frac{P_t}{P_{t+k}} \left(\frac{C_{t+k}}{C_t} \right)^{-\rho}. \tag{5.15}$$

The first order conditions related to domestic and foreign bonds holding and labor supply write

$$1 = \mathbb{E}_t \left\{ (1+i_t) d_{t,t+1} \right\} \tag{5.16}$$

$$1 = \mathbb{E}_t \left\{ \frac{S_{t+1}}{S_t} \left(1+i_t^{\star}\right) d_{t,t+1} \right\} \tag{5.17}$$

$$\frac{W_t}{P_t} = \psi L_t^{\chi} C_t^{\rho} \tag{5.18}$$

In order to insure the uniqueness of the equilibrium, we assume perfect risk sharing between all Ricardian households.

Financially constrained households

Each period financially constrained households solve a static problem : they maximize their period utility subject to the constraint that they consume their whole income. Their budget constraint is

$$PC = WL + \Pi \tag{5.19}$$

where Π is denoting profits. The FOC is given by:

$$\frac{W}{P} = \psi L^{\chi} C^{\rho} \tag{5.20}$$

The introduction of financially-constrained households modifies the analysis of optimal monetary policy. Monetary policy impacts the behavior of non-constrained households through the Euler equation, i.e. the optimal inter-temporal consumption choice. Without an access to financial markets, constrained households are not affected by this channel. However, they are indirectly affected through the real wage. We simplify the model to make clearer how monetary policy affects the welfare of a constrained household by assuming no profits ($\Pi = 0$). The budget constraint and the optimal labor supply determines consumption and labor supply:

$$C_t = \psi^{-1/(\chi+\rho)} (W_t/P_t)^{(1+\chi)/(\chi+\rho)}$$
$$L_t = \psi^{-1/(\chi+\rho)} (W_t/P_t)^{(1-\rho)/(\chi+\rho)}$$

The instantaneous utility of constrained households is therefore given by

$$\begin{cases} \log(U_t) &= \frac{(1+\chi)(1-\rho)}{\chi+\rho}\log(W_t/P_t) + \text{Const.} & \text{if} \quad \rho < 1, \\ U_t &= \log(W_t/P_t) + \text{Const.} & \text{if} \quad \rho = 1, \\ \log(-U_t) &= -\frac{(1+\chi)(\rho-1)}{\chi+\rho}\log(W_t/P_t) + \text{Const.} & \text{if} \quad \rho > 1. \end{cases}$$

where ρ is the inverse of the intertemporal elasticity of substitution[3]. The utility of constrained households is determined by the level of the real wage. A monetary policy rule that aims to maximize the expected welfare of constrained households will tend to stabilize the real wage. The implication for the tradeoff of monetary policy and redistribution issues will be developed in section devoted to optimal monetary policy.

5.3.2 Firms

Tradable food and non-food goods can be both imported and domestically produced, and sell in a competitive market with the law of one price. Their price in domestic currency is given by the international price times the nominal exchange-rate. Non-tradable food and non-food goods are only domestically-produced and sell in a monopolistic competition market. Their price is sticky and set in domestic currency. We assume labor to be perfectly mobile across tradable and non-tradable production for a given sector (for the agricultural sector or for the manufacture sector) but not across sectors: in other words, a farmer cannot work in a factory and a manufacture worker can't fine his way to the fields. Consequently we have two disctinct wages, W^{F} and W^{M} for farmers wage and manufacture workers wage respectively, that satisfy

$$W^{\mathrm{FN}} = W^{\mathrm{FT}} = W^{\mathrm{F}}$$
$$W^{\mathrm{MN}} = W^{\mathrm{MT}} = W^{\mathrm{M}}$$

The production technology has constant return to scale in any sector and is given by

$$Y^i = A^i L^i \tag{5.21}$$

where i stands for FT, MT, FN and MN, with L^i denoting unit of labor employed and A^i is the sector specific technology.

Tradable goods producers

Firms in the tradable goods sector are in a competitive market. Thus,

$$W^{\mathrm{T}} = A^{\mathrm{T}} P^{\mathrm{T}} \tag{5.22}$$

[3] ρ is assumed to be higher than 1 in the baseline calibration.

where T = FT or MT. Also, because we model a small economy, we assume domestic producer to be price taker on the world market. Hence the domestic price of tradable goods is given by the law of one price, and we can define the wage as a function of the international price scaled by the nominal exchange rate. We can rewrite Equation 5.22 as:

$$W^{\mathrm{T}} = A^{\mathrm{T}} S P^{T\star} \tag{5.23}$$

Where S is the nominal exchange rate and $P^{T\star}$ the world price, denominated in foreign currency.

Non-tradable goods producers

Firms in the non-tradable goods sector set prices according to a stochastic time-dependent rule as in Calvo (1983): in each period, a firm faces a probability ϕ_{N} of not being able to re-optimize its price. Firms that reset their price at t will all choose the same $P^{\mathrm{N}}_{t|t}$ in order to maximize the expected present discounted value of profits, under the constraint that the firm must satisfy demand at the posted price. As labor is perfectly mobile in each good sector (mobiliy across food tradable and non-tradable and mobility across manufacture tradable and non-tradable) and the technology has a constant return to scale, the marginal cost in the non-tradable sector depends on the price of the tradable good and the relative productivity:

$$\mathrm{MC}^{\mathrm{FN}} = \frac{A^{\mathrm{FT}}}{A^{\mathrm{FN}}} P^{\mathrm{FT}} \qquad\qquad \mathrm{MC}^{\mathrm{MN}} = \frac{A^{\mathrm{MT}}}{A^{\mathrm{MN}}} P^{\mathrm{MT}}$$

Once again, the domestic price of tradable goods is given by the low of one price. Hence the marginal cost is also given by:

$$\mathrm{MC}^{\mathrm{FN}} = \frac{A^{\mathrm{FT}}}{A^{\mathrm{FN}}} S P^{\mathrm{FT}\star} \qquad\qquad \mathrm{MC}^{\mathrm{MN}} = \frac{A^{\mathrm{MT}}}{A^{\mathrm{MN}}} S P^{\mathrm{MT}\star}$$

The first order conditions and the price dynamic are explained in greater details is Appendix 5.C page 160.

The resulting Phillips curves are given by the log-linearized relationships:

$$\pi^{\mathrm{FN}} = \frac{(1-\phi)(1-\beta\phi)}{\phi}(\hat{a}^{\mathrm{FT}} - \hat{a}^{\mathrm{FN}} + \hat{s} + p^{\mathrm{FT}\star}) + \beta\mathbb{E}(\pi^{\mathrm{FN}}_{t+1}) \tag{5.24}$$

$$\pi^{\mathrm{MN}} = \frac{(1-\phi)(1-\beta\phi)}{\phi}(\hat{a}^{\mathrm{MT}} - \hat{a}^{\mathrm{MN}} + \hat{s} + p^{\mathrm{MT}\star}) + \beta\mathbb{E}(\pi^{\mathrm{MN}}_{t+1}) \tag{5.25}$$

These Phillips curves define the present inflation rate in the non-tradable sectors as a function of the technological spread between tradable and non-tradable goods production, the nominal exchange rate, the exogenous world price and the anticipated inflation rate. It is mainly through this relationship that a shock on the world food price $P^{\mathrm{FT}\star}$, will fuel the domestic non-tradable food inflation.

5.3.3 The balance of payments

The trade balance is given by the sum of food tradable and manufacture tradable exports. The balance of payments is obtained by

$$P_t^{\mathrm{FT}}(Y_t^{\mathrm{FT}} - C_t^{\mathrm{FT}}) + P_t^{\mathrm{FT}}(Y_t^{\mathrm{FT}} - C_t^{\mathrm{FT}}) - S_t\left(B_t^{\star} - i_{t-1}^{w}B_{t-1}^{\star}\right) = 0 \qquad (5.26)$$

5.3.4 Monetary policy

The monetary policy consists in an interest rate rule : the central bank moves the interest rate systematically in response to some prices' inflation. We consider the three following rules:

- Headline inflation targeting:

$$\log\left(i/\bar{i}\right) = \Upsilon \log\left(P_t/P_{t-1}\right)$$

- Non-food inflation targeting:

$$log\left(i/\bar{i}\right) = \Upsilon^{\mathrm{M}} \log\left(P_t{}^{\mathrm{M}}/P_{t-1}{}^{\mathrm{M}}\right)$$

- Sticky prices inflation targeting:

$$log\left(i/\bar{i}\right) = \Upsilon^{\mathrm{FN}} \log\left(P_t^{\mathrm{FN}}/P_{t-1}^{\mathrm{FN}}\right) + \Upsilon^{\mathrm{MN}} \log\left(P_t^{\mathrm{MN}}/P_{t-1}^{\mathrm{MN}}\right)$$

where $\bar{i}$ is steady-state level of interest rate i.

The first rule targets the developments in the consumer price index. The second rule looks after the dynamic of the non-food prices. It is computed by excluding food prices from the CPI, or to put it simply it is the manufacture prices. Note that non-food inflation is by large used in central banking as a proxy for core inflation. In the last rule, the target is the theoretical definition of core inflation, which is an index of prices with nominal rigidities.

For each interest rate rule, the value of the parameters is set in order to maximize the welfare associated with this rule (see Section 5.5).

5.3.5 Shocks

There are two kinds of perturbations: shocks to productivities, A^{FT}, A^{FN}, A^{MT} and A^{MN} and shocks to foreign prices, $P^{\mathrm{FT}\star}$, $P^{\mathrm{MT}\star}$ and i^w.

- Productivity shocks are assumed to evolve exogenously over time, following an AR(1) process $x_t = \rho^x x_{t-1} + \epsilon_t^x$, where $0 < \rho^x < 1$ and $\epsilon^x \sim N(0, \sigma_\epsilon)$, for $x = A^{\mathrm{FT}}$, A^{FN}, A^{MT}, A^{MN}.

- Foreign variables $(P^{\mathrm{FT}\star}, P^{\mathrm{MT}\star}, i^w)$ follow a VAR(2) process (see Appendix 5.B).

5.4 Calibration

Table 5.1: Parameters calibration

Description	Symbol	Economies	
		Emerging	Advanced
Population			
Farmers in population	$\lambda^{\mathcal{F}}$	0.4	0.2
Ricardian consumers in sub-population	$\lambda^{\mathcal{R}}$	0.7	0.9
Utility function			
Discount factor	β	0.99	0.99
Inverse of intertemporal elasticity of substitution	ρ	2	2
Inverse of elasticity of labor supply	χ	0.8	0.8
Share of food in consumption	γ	0.4	0.2
Share of tradable in food consumption	ϱ_{F}	0.4	0.6
Elasticity of sub. between F and M	θ	0.3	0.3
Elasticity of sub. between T and N	ϑ	1.4	1.4
Food sector			
Probability of domestic food price non-adjustment	ϕ^{F}	0.5	
Monopoly power	η^{F}	6	
Non-food sector			
Probability of non-food price non-adjustment	ϕ^{M}	0.75	
Monopoly power	η^{M}	6	
Adjustment cost			
Parameter of bonds adjustment cost	ξ	0.001	
Shocks persistence			
Productivity, domestic food sector	$\rho, \sigma_{\epsilon}^{a^{\mathrm{FN}}}$	0.25,0.03	
Productivity, tradable food sector	$\rho, \sigma_{\epsilon}^{a^{\mathrm{FT}}}$	0.25,0.03	
Productivity, domestic non-food sector	$\rho, \sigma_{\epsilon}^{a^{\mathrm{MN}}}$	0.8,0.02	
Productivity, tradable non-food sector	$\rho, \sigma_{\epsilon}^{a^{\mathrm{MT}}}$	0.8,0.02	

We set the parameters either in order to reproduce some stylized facts or according to the typical values in the literature, and then we solve numerically the model up to second-order approximation using DYNARE (see Adjemian et al. (2011)).

The economy at the steady-state.

The ricardian households are assumed to have no foreign debt at equilibrium ($B^* = 0$). Both the food and the manufacturing sectors are assumed to have a closed economy steady-state ($Y^{\mathrm{FT}} = C^{\mathrm{FT}}$ and $Y^{\mathrm{MT}} = C^{\mathrm{MT}}$)[4]. Also, all relative prices are set to 1 at the steady-state ($P^s = 1, \forall s$). Last, even if the two larbor markets are clearly separated, we assume some porosity at long run. Hence at the steady-state $W^{\mathrm{F}} = W^{\mathrm{M}}$ and the parameter that

[4] In low-income and middle-income group, countries can experience surplus or deficit in the agricultural balance. On average, the data know no systematic imbalance.

weights labor in utility (ψ) is set such that all households have the same labor offer at the equilibrium.

The quarterly discount factor β is set equal to 0.99 which implies a yearly real world interest rate of 4% at the steady-state. The risk-aversion parameter is set to $\rho = 2$, which means an intertemporal elasticity of substitution of 0.5, as is usual in the literature (see for instance Devereux et al. (2006), Schmitt-Grohé & Uribe (2007) and De Paoli (2009)).

Emerging and advanced economies

We propose two set of parameters, that give two versions of the model. The first is a stylized representation of an "emerging" economy, where a large share of households are credit constrained and food is an important spending for househods. The second calibration portrays an "adavanced" economy: households have by large access to credit facilities, the share of the agricultural employement and production is low, and households mostly consum goods of inerntional standard.

These parameters are set according to actal data. The share of food in consumption, γ, is calibrated according to International Comparison Program (Table 5.2) data that cover 144 countries. Depending on the group to which the country belongs (emerging or advanced economies) it is set to 40% and 20% respectively and the share of tradable goods in food consumption is set to 40% and 60%. Also, in order to solve the model, we have to assume that the share of tradable goods in manufacture consumption is identical to the share of food tradable. Similarly, the share of food in consumption determines the share of farmers in the population. These values are consistent with the labor share in the agricultural sector observed in the different countries group (see in Data Appendix, Table 5.A.1).

The share of non-optimizing households in total population is calibrated in order to reproduced observed credit constraints in emerging and advanced economies. Key facts on that topic are summarized in Table 5.3. Also, consistently with parametrization in papers by Gali et al. (2004) and Roger et al. (2009), we set $\lambda^{\mathcal{R}}$ at 0.7 and 0.9 fo emerging and developed economies respectively. In other words, 30% of the households are credit-constaint in the emerging economy model version, while they are 10% of the developed economy version.

Elasticities

The elasticity of substitution between food and non-food goods, θ, is a key parameter in our model. Because the demand for food is inelastic, θ is lower than 1. Anand & Prasad (2010, page 26) provide a clear calibration, based on USDA estimates. Thus, we follow them and set the elasticity of substitution between food and non-food goods in utility at $\theta = 0.3$. The elasticity of substitution between tradable and non-tradable goods θ^{F} and θ^{M}, is set to 1.4, as estimated for developing countries by Ostry & Reinhart (1992).

Table 5.2: Food budget shares (γ and ϱ_{F})

	Low-income	Middle-income	High-income
Food in consumption	48%	31%	20%
Tradables in food	37%	59%	81%

Table 5.3: Credit constraints (1-$\lambda^{\mathcal{R}}$)

Country	Accounts	Savings	Borrowing	Credit lines
Low income	26	10	8	29
Middle income	54	17	9	33
High income	82	38	14	66
All countries	56	18	10	31

Source: World Bank Global Financial Development Database.
Definitions: Accounts: Adults with an account at a formal fin. inst. to total adults (%). Savings: Adults saving at a fin. inst. in the past year to total adults (%). Borrowing: Adults borrowing from a formal fin. inst. in the past year to total adults (%). Credit lines: Small firms with line of credit to total small firms (%).
Note: Calculations form the authors of the mean for 203 countries, divided into low-, middle-, and high-income countries, based on their income relative to that of the United States. Low-income countries represent those with real per capita income less than 15 percent of the U.S. level, middle-income countries are those with real per capita income between 15 and 45 percent of the U.S. level, and high-income countries with have per capita income equal to or greater than 45 percent of the U.S. level.

Nominal rigidities

Generally, the literature on Calvo-style pricing behavior sets the probability of price non-adjustment at around $\phi = 0.75$, which implies that on average price adjustments occur every four quarters. Empirical studies show that food prices are less sticky than the prices of manufactured goods (see Loupias & Ricart (2004), Bils & Klenow (2004) and Baudry et al. (2005)). Thus, we set $\phi^{\mathrm{F}} = 0.5$ for the food sector and $\phi^{\mathrm{M}} = 0.75$ for the manufactured sector. The scale effect on labor equals 0.75 for each sector ($\alpha^s = 0.25$).

Shocks

The persistence of shocks on productivity in the non-food sectors (ρ^{MT} and ρ^{MN}) is set at 0.8. The associated standard deviation (σ_ϵ) is set at 0.02. These values are in line with those in Ravenna & Natalucci (2008) or Gali & Monacelli (2005), and average those in the international business cycle literature. Productivity shocks in the food sectors (mainly weather events) are calibrated following Anand & Prasad (2010): persistences (ρ^{FT} and ρ^{FN}) are set at 0.25, and standard deviation (σ_ϵ) at 0.03.

We estimate a VAR model in order to calibrate variances and covariances in world food price shocks, the world manufacturing (non-food) price shocks and the world interest rate shocks. The results are given in appendix 5.B.

5.5 The design of monetary policy

5.5.1 Economic consequences of a world food price shock

How would a large shock on the world food price impacts the domestic economy?

Due to the law of one price in the tradable sector, a world food price shock translates into a term of trade shock in the domestic economy. Because the tradable sector is assumed to be perfectly competitive, while facing an higher price producers massively increase their labor demand. This produces a new equilibrium in the labor market, at a higher wage. Also, because labor is perfectly mobile between tradable food and non-tradable food sectors, the wage (and hence the marginal costs) in the non-tradable food sector increases too. Thus, non-tradable food price increases following the rise in farmers nominal wage (w^{F}), but to a limited extend due to nominal rigidities.

Impact on households.

Constrained and unconstrained households react differently to the shock. In the agricultural sector, the real wage hike makes constrained households work less, as they have no alternative to consume all their additional labor income each period. The same real wage hike makes unconstrained households work more in order to save the additional income. In other words, optimizing farmers see the increase in the world food price has an opportunity to make more money for future use and thus they work more now, while credit constrained farmers couldn't make plans for future spendings and therefore simply enjoy to work less during the present time.

In the manufactured sector, the increase in food prices negatively impacts the real wage of manufacture workers. Consequently, constrained households increases their labor supply in order to compensate the effect of real wage decrease on consumption. Thanks to perfect risk-sharing hypothesis between the two types of unconstrained households, the consumption of unconstrained manufacture workers increases and thus their labor supply decreases.

The optimal monetary policy.

The way monetary policy should react to a food price hike depends on the weight of each household's type in the monetary-policy objective: credit constrained farmers, credit constrained manufacture workers and unconstrained households. To illustrate how the monetary authorities may impact any household welfare, let's consider each case on by one:

- Let's first assume, as an example, a corner case in which only the unconstrained households enters the central bank's objective[5]. The ability of unconstrained households to smooth their consumption inter-temporally insulates their welfare from real

[5] to put it in another way, the central bank cares only about unconstrained households.

wage variations. Hence, to maximize their welfare, the monetary policy should implement an equilibrium as close as possible to the efficient factors allocation. The problem monetary policy faces is the same as in the standard new-keynesian model (see Benigno 2004 or De Paoli 2009). To avoid an inefficient allocation of factors due to price dispersion in the sticky price sector, the central bank should precisely target the sticky prices inflation. In our case, sticky prices are located in the two non-tradable sectors. Consequently, the optimal interest rate rule that maximizes the welfare of unconstrained households relies the interest rate setting to non-tradable food and non-tradable manufacture inflation.

- Let's now assume a second corner case for which the central bank's policy is fully dedicated to the credit constrained farmers' welfare maximization. Because credit-constrained households do not have any consumption smoothing opportunity, the optimal policy is to stabilize their purchasing power, i.e. the farmers real wage (w^{F}/P). This outcome may be achieved through an exchange rate appreciation larger than the world shock. Because the world food price shock occurs on the world market where prices are denominated in world currency (let's say the US dollar), the world shock impact on the domestic price of tradable food goods is scaled by the nominal exchange rate. An exchange rate appreciation as large as the world shock would reduce the impact of the world shock to zero once tradable food price is expressed in domestic currency. Hence, prices and wages in the food sector wouldn't be modified by the shock. However, a large domestic currency appreciation would lower the tradable manufacture goods domestic price, hence lowering the CPI and the farmers real wage. This is the reason why the optimal policy in a farmer perspective, is to appreciate the currency by more than the shock. Such a policy would lead to a fall in the price of tradable food goods, and subsequently a fall in the nominal wage of food producers. With the food and manufacture prices decreasing, the CPI would decrease too, and in turn the real wage would remain constant. However, this outcome is not implementable with the set of simple rules we focus on (a positive reaction of the interest rate to variations of domestic sticky prices). At best, by tightening its policy, the central bank is able to let the exchange rate appreciate as much as world food hikes. This second-best outcome is implementable through non tradable food price targeting. Such a policy would insure no inflation for non tradable food prices, and therefore a constant nominal wage in the agricultural sector. Also, because the nominal wage is a function of the domestic price of tradable goods, a shock on the foreign price translates into a depreciation.

- The last corner case is when the central bank maximizes only the welfare of credit-constrained manufacture workers. Because all households consume food goods, a world food price shock always implies real wage to drop. In the credit-constrained manufacture workers perspective, the optimal policy consists in vanishing this purchasing power loss. This result can be achieved through currency depreciation: when the domestic currency depreciates, the tradable goods become relatively more expensive than the non-tradable goods. Because the tradable good market is competitive, an higher price also means an higer wage. The manufacture workers nominal wage increases relatively to the price of their consumption basket price, which is equivalent to an increase in the real wage. As in the previous case, this outcome is not implementable through a simple interest rate rule, because it would imply the central bank to give a negative weight to food inflation as well as an astonishingly big weight to non-tradable manufacture goods inflation. At best monetary policy is able to keep the nominal exchange rate constant through non tradable manufacturing price targeting.

Interaction between Ricardian and credit-constrained households.

Having described how a large shock on the world food price would impacts each household, and what should the optimal central bank's reaction be, we can now consider how these effects should be aggregated when looking at the overall population.

The optimal monetary policy for unconstrained households is to target an index of the two sticky prices: non-tradable food and non-tradable manufacture inflation. This rule, which is optimal for the unconstrained households also is optimal for the overall population. Actually, the relative weight of food and manufacture in this rule is relying on the relative size of the two sticky prices sector in the economy and not on the share of credit constrained households in the two labor markets. The relative size of the two sticky prices sector matters because it defines how large are the nominal rigidity costs. Also, the presence of credit constrained households on the labor market is impacting the definition of non-credit constrained optimal policy: the more credit-constrained households, the more volatile the labor market, the weaker the optimal policy reaction. Hence, for a large share of credit constrained farmers in the population, the optimal policy for ricardian farmers should have a small weight on food prices (and similarly for manufacture workers). Finally, when looking at the population as a whole, we have two opposed effects: more credit constrained farmers in the population means more households asking to target food prices (the credit constrained farmers themselves) but also some other households (the ricardian farmers) now asking to reduce the central bank reaction to food price shocks. All in all, these two effects being opposed, the impact of credit constrained households on the optimal monetary policy is undetermined. That's why we now turn to numeric simulations to evaluate the relative weight of food inflation and manufactured inflation in the monetary policy rule.

5.5.2 How to weigh food in the optimal monetary policy?

Welfare calculation

To compute the households' welfare, we use a criterion defined after Faia & Monacelli (2007) and given by:

$$\mathcal{W} = \mathbb{E}_{-1}\left\{\sum_{t=0}^{\infty}\beta^t u(C_t, L_t)\right\}\Bigg|_{x_0=\bar{x}}$$

where x denotes the set of predetermined variables. Following Schmitt-Grohé & Uribe (2004) and Adjemian et al. (2011) the second-order welfare approximation takes the form of the following conditional expectation:

$$\mathcal{W} = \mathbb{E}_{-1}\left\{\mathcal{W}_0\right\}|_{y_{-1}=\bar{y}} = \bar{\mathcal{W}} + \frac{1}{2}[g_{\sigma\sigma}] + \frac{1}{2}\mathbb{E}_0\left\{[g_{uu}(u_1 \otimes u_1)]\right\},$$

where $\bar{\mathcal{W}}$ denotes the welfare value at the (non-stochastic) steady-state, $g_{\sigma\sigma}$ is the second derivative of the policy function (g) with respect to variance in the shocks, and g_{uu} is the Hessian of g with respect to the shock vector u.

The welfare is defined at the individual household level. Hence, the overall population's welfare, $\mathcal{W}$, is given according to the respective share of each household in the economy:

$$\begin{array}{lll}
\mathcal{W} = & \lambda^{\mathcal{F}}\lambda^{\mathcal{R}}\ \ \mathcal{W}^{\mathcal{FR}} & \textit{(ricardian farmers)} \\
 & +\lambda^{\mathcal{F}}(1-\lambda^{\mathcal{R}})\ \ \mathcal{W}^{\mathcal{FK}} & \textit{(credit-constrained farmers)} \\
 & +(1-\lambda^{\mathcal{F}})\lambda^{\mathcal{R}}\ \ \mathcal{W}^{\mathcal{MR}} & \textit{(ricardian manufacture workers)} \\
 & +(1-\lambda^{\mathcal{F}})(1-\lambda^{\mathcal{R}})\ \ \mathcal{W}^{\mathcal{MK}} & \textit{(credit-constrained manufacture workers)}
\end{array}$$

Optimal monetary policy at the country level

Let's assume the central bank objective is to maximize the overall population welfare, $\mathcal{W}$. In that case each household received a weight in monetary policy equivalent to its weight in the population. We present in Table 5.4 the welfare associated with each of the three alternative policy rules, when applying for the baseline calibration. The parameters of the policy rules are those that maximize the welfare. Welfare gains are defined as additional perpetual consumption needed to make the level of welfare under headline inflation targeting identical to that under the evaluated policy. Thus, a positive (negative) number indicates that welfare is higher (lower) under the alternative policy than under headline inflation targeting policy.

Table 5.4: Policy rules: calibration that maximizes welfare

Target	Parameters	Welfare	Rank
Headline inflation	(36)	0%	2
Non-Food inflation	(129, 870)	-12%	3
Sticky prices inflation	(33)	45%	1

The optimal policy targets sticky prices. The welfare loss du to shocks and monetary policy, is 12% higher if monetary policy target non-food inflation that if she targets headline inflation. The literature has emphasized after Aoki (2001) that the optimal policy always is to target the stickiest prices, when the economy face relative price shocks. The introduction of credit constrained households in the model does not modify it. The reason why such a policy is optimal simply relies on the welfare gains obtained by reducing the nominal frictions in these sectors. More precisely, by keeping these sticky prices under control, the central bank reduces the dispersion of the observed prices, hence maximizing factor allocation and welfare.

Let's now how this optimal policy rule affects each household.

Optimal monetary policy at the household level

Rearranging the monetary policy equations defined in Section 5.3.4, we can write the optimal interest rate rule for as follow:

$$log\left(i/\bar{i}\right) = \Psi\left[\Phi \log\left(P_t^{\mathrm{FN}}/P_{t-1}^{\mathrm{FN}}\right) + (1-\Phi)\log\left(P_t^{\mathrm{MN}}/P_{t-1}^{\mathrm{MN}}\right)\right] \tag{5.27}$$

where $\Psi > 1$ defines Taylor'principle, and $\Phi \in [0, 1]$ is the share of non-tradable food prices in the optimal rule. Table 5.5 release the value of Φ that maximizes the social welfare ($\mathcal{W}$) or the welfare of any given household type ($\mathcal{W}^{\mathcal{FR}}$, $\mathcal{W}^{\mathcal{MR}}$, $\mathcal{W}^{\mathcal{FK}}$ and $\mathcal{W}^{\mathcal{MK}}$) for the baseline calibration.

Table 5.5: Optimal definition of core inflation

Welfare maximized	Optimal Weights	
	Φ	$(1-\Phi)$
$\mathcal{W}$	0.13	0.87
$\mathcal{W}^{\mathcal{FR}}$	0.13	0.87
$\mathcal{W}^{\mathcal{MR}}$	0.13	0.87
$\mathcal{W}^{\mathcal{FK}}$	1	0
$\mathcal{W}^{\mathcal{MK}}$	0	1

Since constrained households utility directly relies upon their real wage, the policy that maximizes their welfare is the one that minimizes their real wage volatility. Simulations confirm that, in order to optimize credit constrained farmers' welfare, monetary policy should react only to food prices. Similarly, monetary policy should react only to manufacture prices in order to stabilize manufacture workers real wage and therefore to maximize their welfare. The policy rule that is socially optimal (first line, $\mathcal{W}$) does not maximize the welfare of each individual household: the absence of market-based risk-sharing mechanisms raises redistribution issues for monetary policy.

5.5.3 Monetary policy in practice

In practice, monetary policy generally reduces to the simple question: should the central bank target headline inflation or non-food inflation? As seen above, the optimal policy consists in targeting a weighted average of food sticky prices and manufacture sticky prices. However, the exact definition of sticky prices is quite hard to handle in practice. Also, central banks do not have such perfect information that allows distinguishing between tradable consumer goods inflation and non-tradable consumer goods inflation. This is true in developed economies, but this is even more relevant in developing or emerging economies. Hence, the exact question faced by central bankers is: should the central bank react to a food price shock, or not?

To solve that question we compare the welfare get by each households when two strict IT rules are implemented: headline IT (with $\Pi = 1$) and non-food IT (with $\Pi^{\mathrm{M}} = 1$). We run the model for two set or parameters: one calibration for middle-income countries where the share of food goods in consumption and production is large, and one calibration standing for high-income countries where food is a relatively small item in the consumers' basket. The results are given in Table 5.6, and parameters' calibration are described in Section 5.1.

Table 5.6: Optimal policy choice

Countries	Credit-constrained households		Ricardian households
	Farmers	Manufacturers	
Low-income	Headline IT	Non-Food IT	Headline-IT
High-income	Headline IT	Non-Food IT	Non-Food-IT

Results are in line with the analysis done in the previous section. The optimal policy for credit-constrained farmers consists in stabilizing their real wage. Hence, an increase in the short interest rate as the central bank's answer to a food price shocks would be welcomed by these credit-constrained farmers. Such a policy would increase the exchange rate role as shock absorber and would reduce the domestic price developments. Therefore, the credit-constrained farmers would prefer the central bank to target headline inflation than non-food inflation. These mechanism are working whatever the size of the food sector in consumption or production. Hence, this results holds for high-income countries as well as middle or low income countries.

The optimal policy for credit-constrained manufacture workers is not to tighten monetary policy when food price hikes. Hence, from a credit-constrained manufacture workers perspective non-food IT policy that implies the central bank not to react when a food price shock occurs, does better than headline IT policy. Once again, the results about credit-constrained households do not rely on the share of food in consumption, and therefore are holding for all kind of countries.

The best policy choice from a Ricardian household's perspective is a bit more complex.

As seen above, the optimal policy for ricardian households consists in targeting an index of sticky prices. Hence, the ricardian households preference for Headline IT or for Non-food IT is depending on where the sticky prices are located. In our case, we assume sticky prices to be only in the non-tradable sectors, where the prices are determined by the domestic momentum, the producers cost and margin, and not by the low of one price as in the tradable sector. It follows that the choice between headline IT and non-food IT relies on the size of the non-tradable food sector relatively to the non-tradable manufacture sector. If the non-tradable food good production represents a large share of the economy, hence targeting non-food prices generates large welfare loss and headline IT is to be preferred. This is precisely the case for low and middle income countries. In these countries, both the share of food goods in consumption and the share of purely domestic goods in food consumption are large. This is the reason why targeting headline inflation is better than targeting non-food inflation in these countries, as shown in the previous chapter. In the other hand, the high-income economies are characterized by a very small share of food goods in households spending. Also, in high-income countries, consumption goods are of international varieties, most often traded in the international markets, where their prices are determined. Hence, in these countries the weight given to domestic food prices in the sticky prices index is very small, and non-food inflation is a good proxy for sticky prices inflation. Therefore, in high-income countries, targeting non-food inflation should be preferred to headline IT.

All in all, what should the central bank do ? As emphasized earlier, if the central banks give to each households a weight in its objective function equivalent to the households weight in the population, it follows that the optimal policy for Ricardian households is similar to the optimal policy for the total population. However, what our result is enlightening, is that such a policy won't be optimal for all households. In particular, targeting headline inflation in middle and low income countries would maximize farmers welfare at the expense of credit-constrained manufacture workers' welfare. On the contrary, in high income countries, targeting non-food IT would maximize manufacture workers' welfare, at the expense of credit-constrained farmers. Because of the large redistributive effects of the monetary policy, the central bank's choice implies some social justice consideration.

5.6 Robustness

In order to insure the robustness of the results, we run the model for various set of parameters. Here are the results obtained.

5.6.1 Credit constrained farmers in population

The graphs on Figure 5.2 answer to the question: how the central bank optimal policy evolves while credit constrained households share in the population increases?

We consider the optimal share of food in the monetary policy rule (this is denominated by the parameters Φ in Equation 5.27 page 148) when the share of credit constrained households among the farmers households ($\lambda^{\mathcal{FK}}$) take any value from 0 to (almost) 1.

The Φ values are computed in order to maximize the overall population welfare ($\mathcal{W}$) as well as the welfare of four individual households ($\mathcal{W}^{\mathcal{FK}}$, $\mathcal{W}^{\mathcal{MK}}$, $\mathcal{W}^{\mathcal{FR}}$ and $\mathcal{W}^{\mathcal{MR}}$)

5.6.2 Credit constrained househods in central bank objective

As the analysis of the optimal policy has emphazised the redistributive impacts of monteray policy on households welfare, we provide an analysis of the optimal monetary policy as a function weight given to the credit constrained farmers relatively to the credit constrained manufacture workers, in the central bank objective. Hence, when the x axis equals zero the central bank maximize only the credit-constrained manufacture workers' welfare, and when it equals one, the central bank maximizes only the credit-constrained farmers' welfare. The optimal weight given to food clearly relies on the share of credit constrained farmers in the objective welfare.

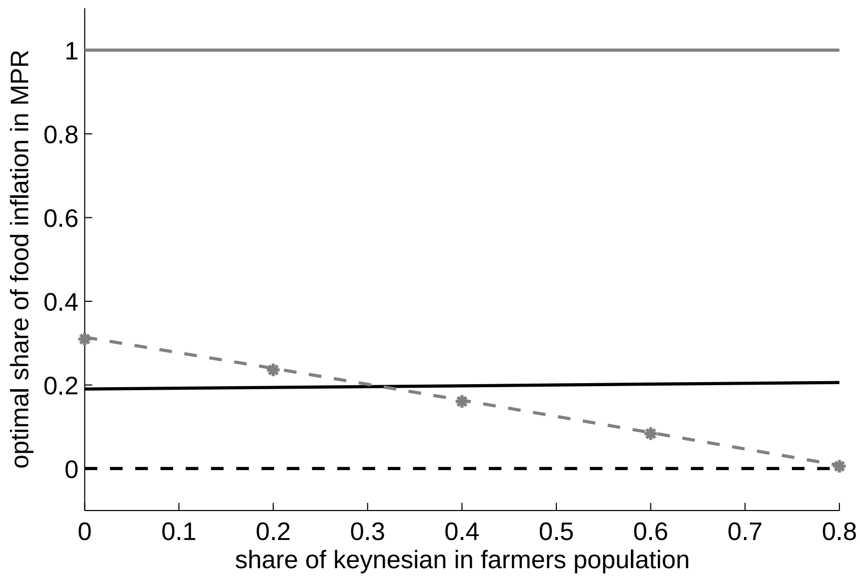
We generalize this result by considering a central bank that maximizes either the famers' welfare (that is the weighted sum of credit constrained and ricardian famers' welfare) or the manufacture workers' welfare. The results are similar to those for credit constained households only. However, the presence of perfect risk sharing ricardian households reduce the tradeoff. This result is of important interest because it may be seen as the policy for a central bank who maximizes either the rural area inhabitants' welfare, either the cities' populations' welfare.

Figure 5.1: Optimal policy as a function of the credit constrained farmers in the population

legend: the central bank is maximizing

—— $\mathcal{W}$ —— $\mathcal{W}^{\mathcal{FK}}$ – – $\mathcal{W}^{\mathcal{MK}}$ – – $\mathcal{W}^{\mathcal{FR}}$ $*\mathcal{W}^{\mathcal{MR}}$

Emerging economies:



Advanced economies:

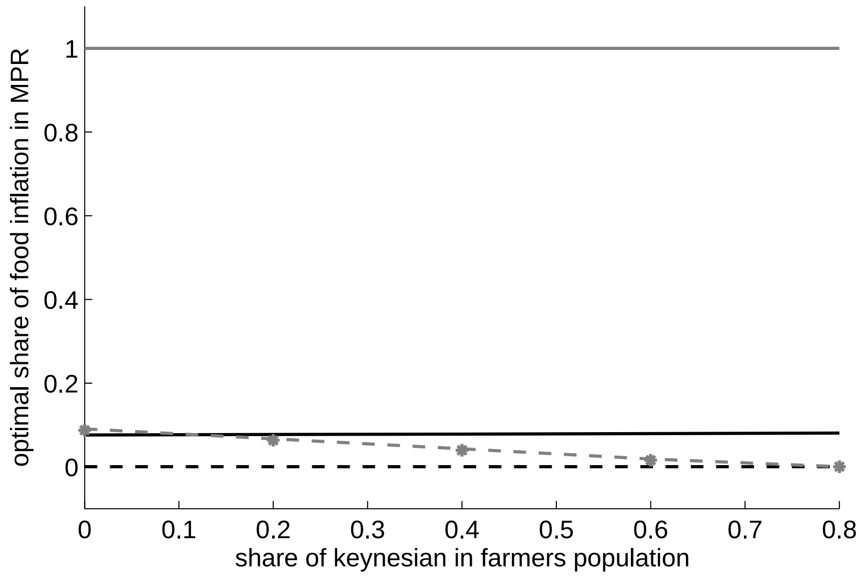
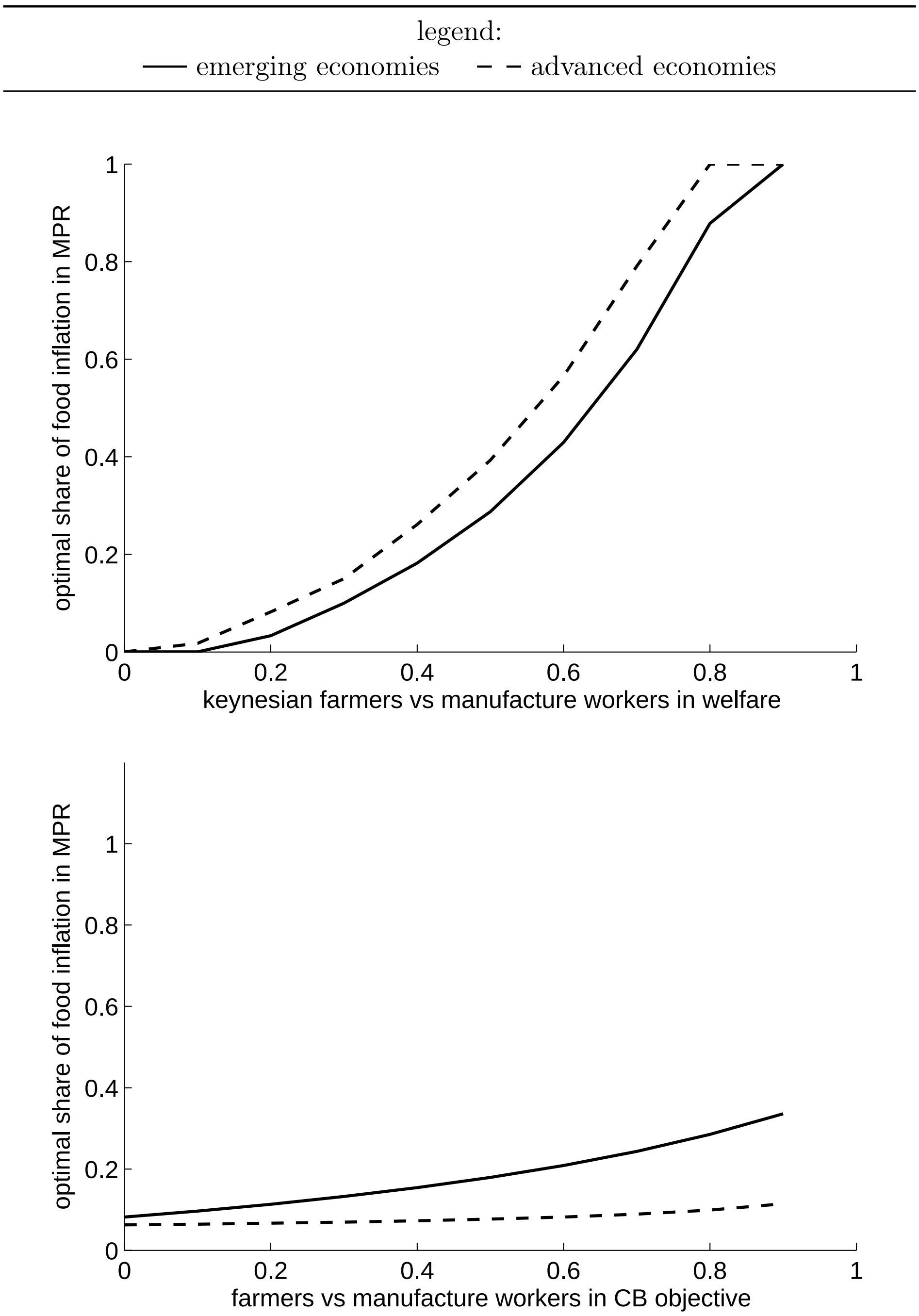


Figure 5.2: Optimal policy as a function of population in the central bank objective



5.7 Concluding remarks

What should monetary authorities do when food price hikes ? The standard New-keynesian litterature have generally concluded that the central bank would have better not to do anything. In this paper we show that conlcusion does not hold for emerging or developing economies. They are two reasons behind this. First, in these economies food represent a large share of households spending and employement. Hence, because the domestic food sector is large, to neglect the price development is this sector is detrimental for factor allocation. This idea was developed in the previous chapter and is again a key factor in this chapter. Second, in these economies a large proportion of the population is credit constrained. For those large population whose income relies only on food products (between 16 and 40% of the labor force) to be credit constrained means not be protected by any insurance mechanism. Hence, a shock on the world food price have a great impact on these households. However, this lack of insurance mechanism may be compensated by monetary policy, if the central bank implement a greater stability of these prices once denominated in domestic currency. Such a policy is optimal for the overall population in emerging economies (because of food share in consumption). Also, even if having credit constrained households in the population does not change the optimal policy, it clearly modifies the redistributive impacts of the policy stance. If the central bank wishes to compensate the lack of consumption smoothing mechanism for credit-constrained households, she has to stabilize their real wage. This result is obtained with an headline inflation targeting policy. Also, non-food inflation targeting is to be avoid.

The need for insurance mechanism and the definition of monetary policy is a major issue in the litterature. For instance, in Bernanke et al. (1998) 's financial accelerator model, monetary policy has redistributive impacts on investors and households' wealth. Monetary policy modifies asset prices relatively to good prices, hence redistributing wealth between households and investors (finnally impacting investment du to inverstors constaints). Monetary policy also have redistributive impacts on the social welfare in overlapping-generation models. As shown by Carton (2012) among others, in these models a trade-off appears between inflation and the level of inequalities between young and old households, through asset prices. In this paper, the monetary policy has an impact on credit constained households' real wages, hence on their purchasing power and welfare. Because all household do not have the same wage, by implementing price stability the central bank have a redistributive impact. It follows that what is positively perceived by an household is negatively perceived by an other household. Because of credit constraints, a monetary policy achieves welfare gains for one household at the cost of welfare loss for another household. Therefore, credit constraints implies an economy policy analysis of monetary policy. For example, this may be done with the analysis of a central banker with Rawls motives. In our model, Rawls motives should lead the central banker to minimize the maximal welfare loss, that is the welfare loss of credit-constrained farmer household.

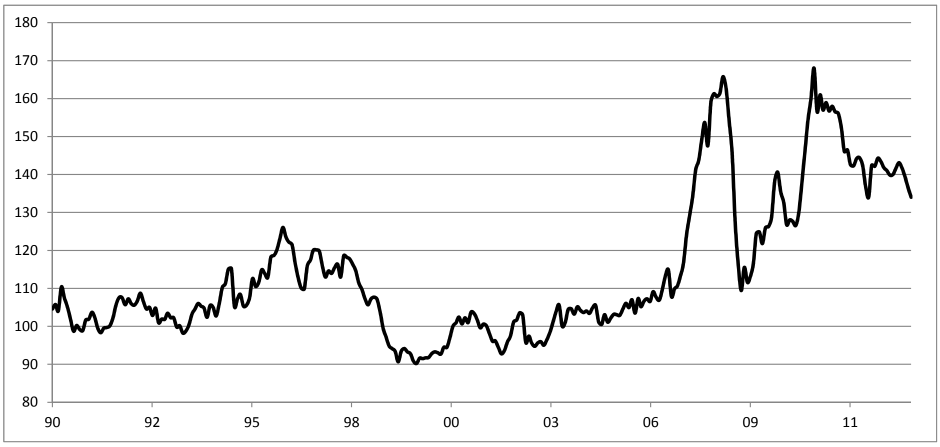
Appendix

5.A Data

Food prices

The FAO Food Price Index is a measure of the monthly change in international prices of a basket of food commodities. It consists of the average of five commodity group price indices. After a long period during which food prices remained close to the mid-run trend, the FAO food price hikes dramatically in 2007 and 2010.

Figure 5.A.1: FAO Real Food Price Index.



Source: FAO. The FAO real price index is the FAO index deflated by the World Bank manufacture unit value index (base 2002).

Agriculture in GDP

Table 5.A.1 illustrates the correlation between the size of the agricultural sector in the economy and the country income classe.

Table 5.A.1: Agricultural households ($\lambda^{\mathcal{F}}$)

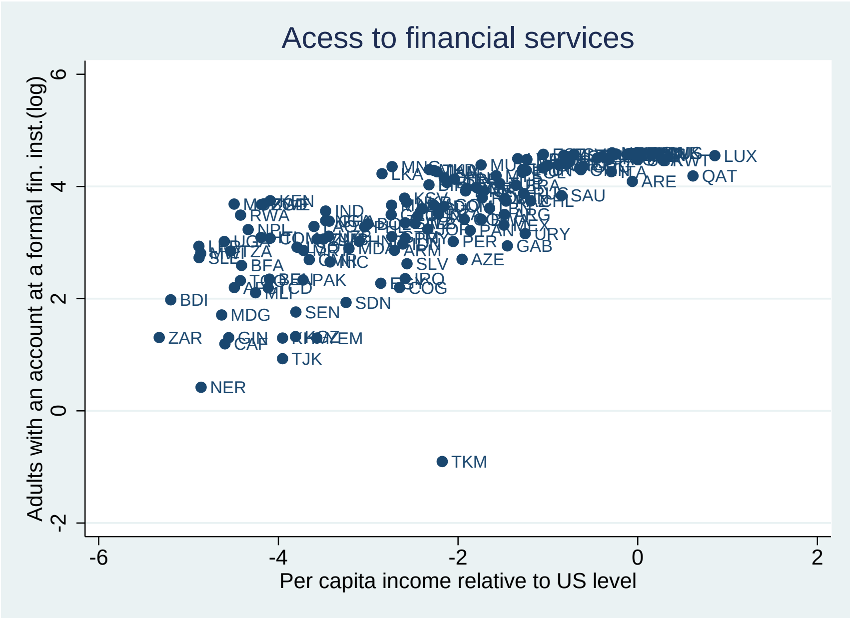
Countries	Agriculture	Industry	Services
Low income	40	18	42
Middle income	16	26	58
High income	4	26	69
All countries	16	24	60

Source: World Bank. Note: Calculations form the authors of the mean for 144 countries, divided into low-, middle-, and high-income countries, based on their income relative to that of the United States. Low-income countries represent those with real per capita income less than 15 percent of the U.S. level, middle-income countries are those with real per capita income between 15 and 45 percent of the U.S. level, and high-income countries with have per capita income equal to or greater than 45 percent of the U.S. level.

Credit constraints

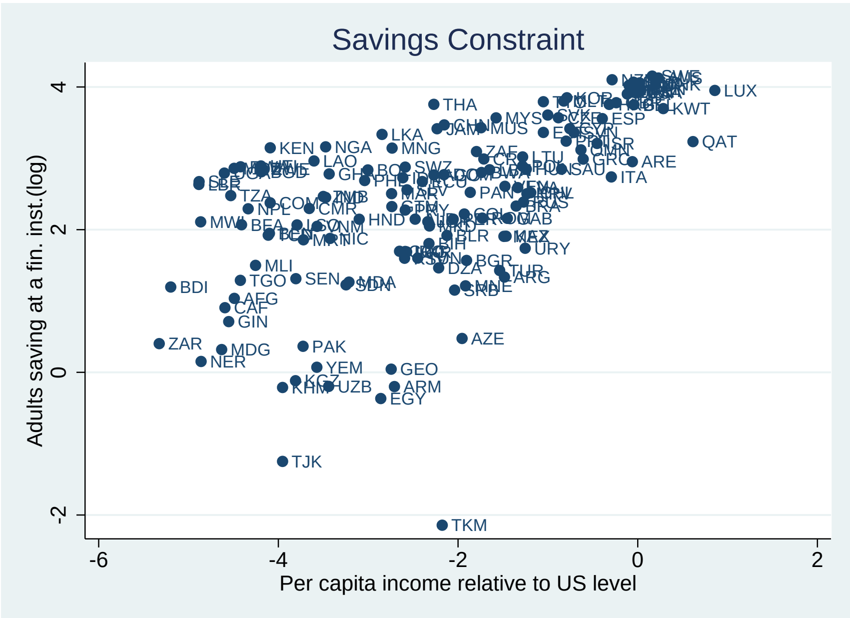
Figure 5.A.3 and Figure 5.A.3 illustrates how important are credit constraints for households in low and middle-income countries.

Figure 5.A.2: Access to a banking account.



Source: World Bank Global Financial Development Database, adults with an account at a formal financial institution to total adults (%).

Figure 5.A.3: Saving constraints



Source: World Bank Global Financial Development Database, adults saving at a financial institution in the past year to total adults (%).

5.B Estimation of exogenous shocks

We estimated a VAR model on the three exogenous variables of our model which values are given by shocks on "the world economy".

- tradable food goods price, $P_t^{FT\star}$, proxied by Reuter's DataStream food commodities composite price index.
- tradable non-food goods price, $P_t^{MT\star}$, proxied by Reuter's DataStream world export index.
- world interest rate, i_t^w, proxied by the yield on one year US tresory bonds.

Datas range from 1980 first quarter to 2011 last quarter. We consider two lags, according to the correlograms shape. We have also estimated other models, like VARMA, and had similar results.

Table 5.B.2: Estimated VAR

	i_t^w	$P_t^{FT\star}$	$P_t^{MT\star}$
i_{t-1}^w	0.99	-1.64	
	(11.3)	(-2.7)	
i_{-2}^w	-0.20	1.76	
	(-2.7)	(2.9)	
$P_{t-1}^{FT\star}$	0.03	1.03	
	(2.5)	(12.6)	
$P_{t-2}^{FT\star}$	-0.02	-0.42	
	(-1.9)	(-5.16)	
$P_{t-1}^{MT\star}$			1.11
			(13.5)
$P_{t-2}^{MT\star}$			-0.42
			(-5.07)
R-2	0.71	0.60	0.68
D-W	2.00	1.81	1.91
Obs.	126	126	126

t-stat in parenthesis.

Table 5.B.3: Estimated Residuals Matrix

Shocks correlation			
	i^w	$P^{FT\star}$	$P^{MT\star}$
i^w	1		
$P^{FT\star}$	0.089	1	
$P^{MT\star}$	-0.023	0.56	1
Shocks covariance			
	i^w	$P^{FT\star}$	$P^{MT\star}$
i^w	3.8e-5		
$P^{FT\star}$	2.4e-5	1.8e-3	
$P^{MT\star}$	-3.4e-6	5.7e-4	5.6e-4

5.C Nominal rigidities

In non-tradable sectors, each good's variety i is produced by a single firm according to a technology common across firms of the sector. The production technology is given by

$$Y^{\mathrm{N}}(i) = A^{\mathrm{N}} L^{\mathrm{N}}(i), \tag{5.28}$$

where N=FN for non-tradable purely domestic food, or N=MN for non-tradable manufacture goods.

Firms are allowed to set prices according to a stochastic time-dependent rule as in Calvo (1983): in each period, a firm faces a probability ϕ^{N} of not being able to re-optimize its price. Firms that reset their price at t will all choose the same $P^{\mathrm{N}}_{t|t}$ in order to maximize the expected present discounted value of profits, under the constraint that the firm must satisfy demand at the posted price. Thus, the firm program is given by

$$\begin{array}{ll} \max\limits_{P^{\mathrm{N}}_{t|t}} & \mathbb{E}_t \sum\limits_{k=0}^{\infty} d_t^{t+k} \phi^{\mathrm{N}k} \left[P^{\mathrm{N}}_{t|t} Y^{\mathrm{N}}_{t+k|t} - \Psi^{\mathrm{N}}_{t+k|t} \right] \\ \text{subject to} & \begin{cases} Y^{\mathrm{N}}_{t+k|t} = \left(\frac{P^{\mathrm{N}}_{t|t}}{P^{\mathrm{N}}_{t+k}} \right)^{-\eta} C^{\mathrm{N}}_{t+k} & \text{(demand)} \\ \Psi^{\mathrm{N}}_{t+k|t} = W_{j,t+k} \frac{Y^{\mathrm{N}}_{t+k|t}}{A^{\mathrm{N}}_{t+k}} & \text{(cost)} \end{cases} \end{array}$$

Skipping $^{\mathrm{N}}$ subscript, the associated first order conditions (in a recursive form) are given by

$$\begin{aligned} \frac{P_{t|t}}{P_t} &= \frac{\varepsilon}{\varepsilon - 1} \frac{\mathbb{E}_t \left\{ \sum_{k=0}^{\infty} \mathcal{F}_t^{t+k} \left(\frac{P_{t+k}}{P_{t|t}} \right)^{\varepsilon+1} \frac{W_{t+k}}{A_{t+k} P_{t+k}} Y_{t+k} \right\}}{\mathbb{E}_t \left\{ \sum_{k=0}^{\infty} \mathcal{F}_t^{t+k} \left(\frac{P_{t+k}}{P_{t|t}} \right)^{\varepsilon} Y_{t+k} \right\}} \\ \mathcal{X}_t &= \frac{\varepsilon}{\varepsilon - 1} \frac{W_t}{A_t P_t} Y_t + \mathbb{E}_t \left\{ \mathcal{F}_t^{t+1} \left(\frac{P_{t+1}}{P_t} \right)^{\varepsilon+1} \mathcal{X}_{t+1} \right\} \\ \mathcal{Y}_t &= Y_t + \mathbb{E}_t \left\{ \mathcal{F}_t^{t+1} \left(\frac{P_{t+1}}{P_t} \right)^{\varepsilon} \mathcal{Y}_{t+1} \right\} \end{aligned}$$

Finally, inflation dynamic in the sector is given by

$$\pi_t^{1-\eta} = \phi + (1-\phi) \left(\frac{P_{t|t}}{P_t} \right)^{1-\eta}. \tag{5.29}$$

5.D Impulse response functions

In order to have a better understanding of the underlining mechanisms that explain the redistributive impact of monetary policy, we plot Figure 5.D.5 the model's response to a shock to the world food price for a typical emerging economies. We consider three possible central bank' preferences: in the first column, we assume the central bank to maximize $\mathcal{W}^{\mathcal{FK}}$, the welfare of the credit constrained farmers population; in the second column, we assume the central bank to maximize $\mathcal{W}$, the overall population welfare; and in the last column we assume the central bank to maximize $\mathcal{W}^{\mathcal{MK}}$ the welfare of the credit constrained manufacture workers. We consider an unanticipated one percentage point transitory increase in the world food price.

Let's first consider the baseline case, when the central bank follow a core inflation targeting strategy, with a policy rule defined in order to maximize the overall population welfare (2nd column).

The two optimizing households, farmers and manufacture workers, behave similarly. Their reaction is the following: Inflationary pressure leads the central bank to tighten its monetary policy (i). Aggregate consumption drops and the currency appreciates (FX). Around one-third of the shock passes through domestic prices, while two-third is absorbed by exchange rate appreciation. The increase in the domestic price of tradable food (P^{FT}) leads to a large fall in domestic demand for this good. Because tradable and non-tradable food goods are substitutable, this fall in tradable food consumption is partly compensated for by an increase in non-tradable food consumption. Appreciation of the currency (FX) makes the tradable manufacture goods cheaper (P^{MT}), and causes demand for them to rise. Consumption of non-tradable manufacture goods decreases while consumption of tradable manufacture goods rises. Food exports increase (X^{FT}), the trade balance becomes positive, and the net foreign position is cleared through ownership of more foreign assets (B^{*}).

Credit-constrained households

Credit-constrained households are impacted by the shock in a different way than optimizing households.

Because credit-constrained households have to consume all their income each period, their aggregate consumption depend on their real wage ($w^{(i)}/P$) . As we have seen, farmers nominal wage (w^{F}) increase at the same rate than the domestic price of tradable food goods (P^{FT}). The overall consumer index (P) increases less than P^{FT}, because non-tradable food prices (P^{FN}) are sticky, and because the currency appreciation leads to a decrease in the tradable manufacture goods prices. Hence the credit-constrained farmers' real wage (w^{F}/P) increases. Manufacture workers wage has no reason to follow the way up of the cpi and thus, manufacture workers real wage declines.

Since credit-constrained households have to consume all their income each period, credit-constrained farmers aggregate consumption increases with the shock. Also, while the optimizing farmers are working more, credit-constrained households work less. Indeed, optimizing farmers are working more in order to save more and to consume more latter; while credit-constrained households work less because they need less hours worked to have a large consumption now. In other words, optimizing farmers see the increase in the world food price has an opportunity to make more money for future use and thus they work more now, while credit constrained farmers couldn't make plans for future spendings and therefore simply enjoy to work less during the present time.

Policy choice

The first and last column in Table 5.D.5 display the economy's response to a world food price shock that would be optimal for credit constrained farmers and manufacture workers respectively. The applied interest rate rule weights are those exhibited in Table 5.5.

In the view of credit constrained farmers, the optimal policy is to react strongly - and only - to food prices. In contrast, the optimal policy rule edicted by credit constrained manufacture workers, is to react only to manufacture prices. Therefore, when a food price shock occur, the manufacture workers' optimal policy rule lead the central bank to keep is interest rate unchanged (i). It follows that the foreign exchange rate remain stable (FX), and so do the price of tradable manufacture goods (P^{FT}). Since the nominal wage (w^{F}) is being determined by the tradable good price (P^{FT}), the real wage (w^{F}/P) drops only by the extend of the CPI increase (P). Thus, when the central bank does not respond to the world food price shock the real wage (w^{F}/P) and therefore the welfare ($\mathcal{W}^{\mathcal{MK}}$) of credit constrained manufacture workers is less impacted than when the central bank wants to keep prices under control.

The monetary policy rule that's optimal in the credit-constrained farmers' perspective targets food prices. Hence, in reaction to the world food price shock, the central bank harshly tighten its monetary policy (i). Consecutively to the interest rate increase, the foreign exchange rate (FX) appreciates enough to vanish the shock pass through to domestic prices. Hence, prices and wages in the food sector remain unchanged (P^{FT}, hence w^{F}, hence P^{FN}). However, the sharp currency appreciation leads to a fall in the tradable manufacture price (P^{MT}). The usual intra-sectoral effects apply, and thus the wage in the manufacture sector (w^{M}) and the price of non-tradable manufacture goods (P^{MN}) decline. Albeit the farmers wage remain constant (w^{F}), the sharp decline in the manufacture goods prices (P^{MT} and P^{MN}) induces a fall in CPI (P), and therefore an increase in farmers' real wage (w^{F}/P). All in all, the farmers' real wage volatility observed here is smaller than the volatility induced by a softer monetary policy reaction.

Redistributive impact

Finally, in this section dedicated to the analysis of the optimal policy monetary we have emphasized a redistributive impact of monetary policy's reaction to the shock. Therefore, the central bank faces a tradeoff between optimizing the (credit-constrained) farmers' welfare or optimizing the (credit-constrained) manufacture workers' welfare. Also, it is worth noting that our welfare criterion is such that what matters for households is the world price shock impact on income volatility - and not the impact on income level. Hence, the question faced by the central bank is how to spread the volatility implied by the world shock over the alternative domestic variables . The (credit-constrained) farmers answer is to fuel the exchange-rate volatility; while the (credit-constrained) manufacture workers answer is to maintain the volatility in the food sector (by asking the domestic tradable food price to hike has much as the world price). Hence, when a shock occurs on the world food market, if the central bank does not adopt an accommodative policy stance, it externalizes the farmers pricing problem to the overall population.

Figure 5.D.4: World food price shock

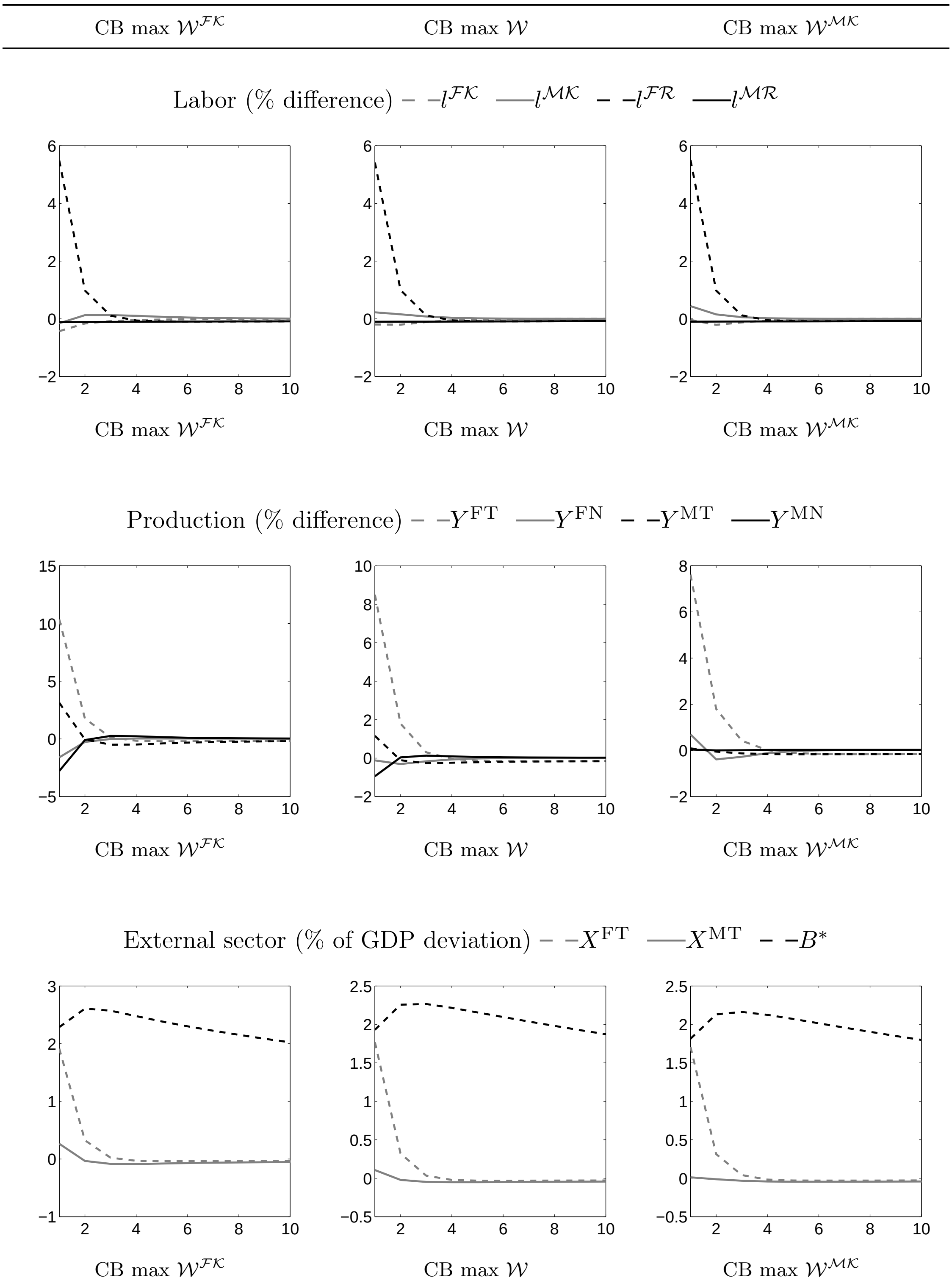
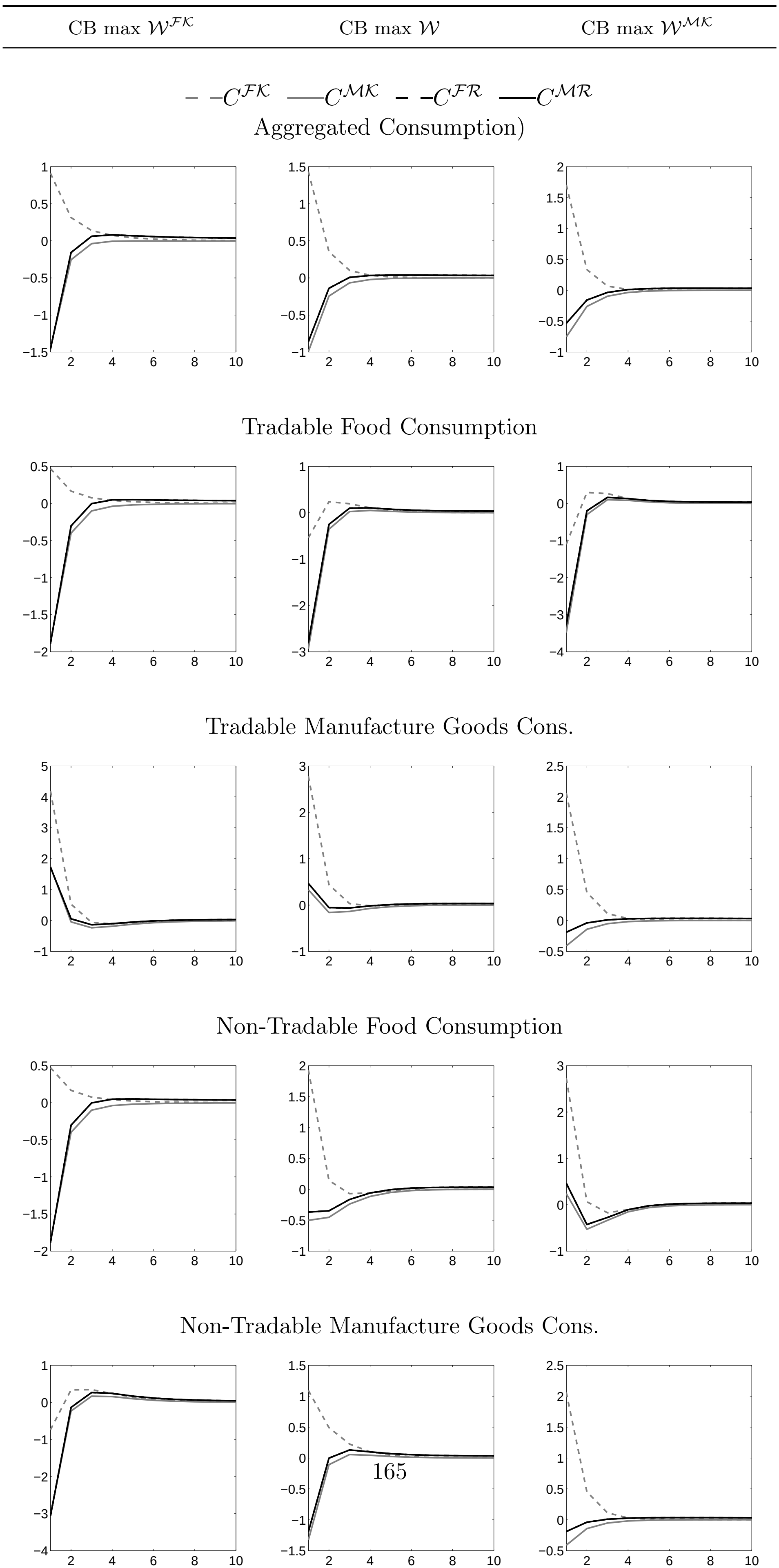


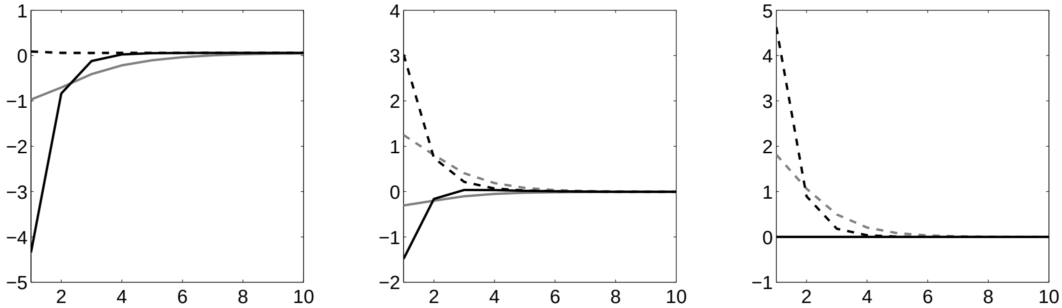
Figure 5.D.5: Consumption (% difference)



CB max $\mathcal{W}^{\mathcal{FK}}$	CB max $\mathcal{W}$	CB max $\mathcal{W}^{\mathcal{MK}}$

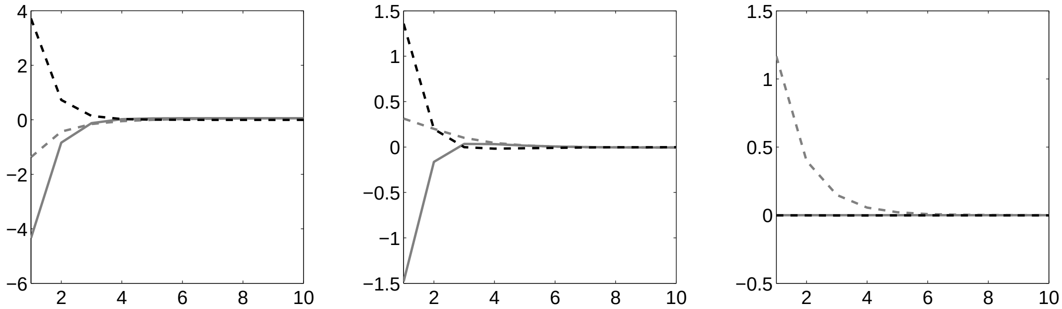
Nominal variables

$- -P^{\mathrm{FN}}$ —P^{MN} $- -P^{\mathrm{FT}}$ —P^{MT} (level)



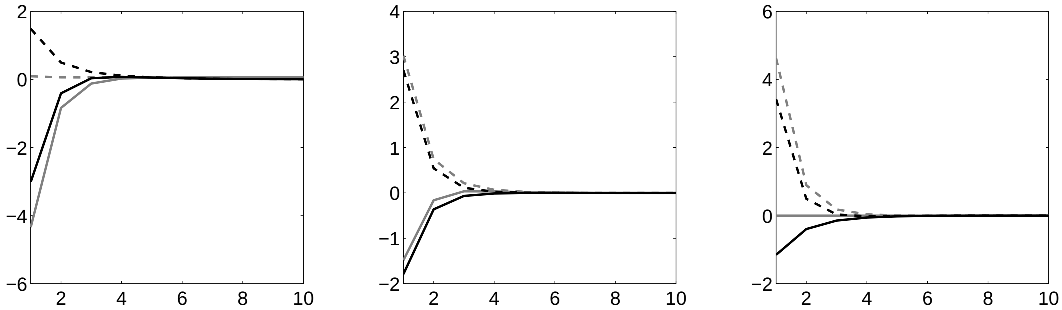
CB max $\mathcal{W}^{\mathcal{FK}}$ CB max $\mathcal{W}$ CB max $\mathcal{W}^{\mathcal{MK}}$

$- -P$ —FX (level) $- -i$ (difference)



CB max $\mathcal{W}^{\mathcal{FK}}$ CB max $\mathcal{W}$ CB max $\mathcal{W}^{\mathcal{MK}}$

$- -w^{\mathrm{F}}$ —w^{M} $- -w^{\mathrm{F}}/P$ —w^{M}/P (level)



CB max $\mathcal{W}^{\mathcal{FK}}$ CB max $\mathcal{W}$ CB max $\mathcal{W}^{\mathcal{MK}}$

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