Public education expenditures and socioeconomic performances

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A mes parents,

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L'Université de Paris I n'entend donner aucune approbation ou improbation aux opinions émises dans cette thèse. Ces opinions doivent être considérées comme propres à leur auteur.

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« … L'équité en matière d'accès à l'enseignement supérieur devrait supposer en premier lieu le renforcement et, au besoin, la réorientation, des liens avec tous les autres niveaux de l'éducation, en particulier avec l'enseignement secondaire. Les établissements d'enseignement supérieur doivent être considérés comme faisant partie - et doivent aussi s'employer à faire partie - d'un système continu qui commence avec l'éducation de la petite enfance et l'enseignement primaire et se poursuit tout au long de la vie ».

Déclaration mondiale sur l'enseignement supérieur pour le XXIe siècle : vision et actions, octobre 1998

Table des matières

Chapter II: An optimal dynamic program of human capital investment within a two-stage education model

Chapter III: Redistribution through education and tax policies under capital-market imperfections and uncertainty: a welfare analysis

Chapitre récapitulatif

Problématique de la thèse

Développées au cours de ces quinze dernières années, les nouvelles théories de la croissance enseignent que ce sont surtout l'innovation et l'adaptation technologique qui tirent la productivité dans les économies. Or celles-ci dépendent beaucoup de la capacité des systèmes éducatifs à former une main d'œuvre qualifiée. Dans ce contexte, la grande question pour les décideurs politiques est de mobiliser au mieux les ressources publiques pour rendre le système d'éducation le plus efficace possible. Il s'agit en particulier de s'assurer qu'à tous les cycles d'enseignement, les opportunités de scolarisation sont équitablement distribuées et que l'expansion des enseignements post-primaire ne soit pas au détriment de la qualité de l'éducation primaire.

Ces objectifs revêtent une importance de taille eut égard la nature hiérarchique de tout système d'éducation. En effet, pour investir dans les cycles supérieurs, il est indispensable aux individus d'achever avec succès les cycles de scolarisation inférieurs. Se crée ensuite une dépendance dynamique des niveaux de compétences accumulées aux cycles supérieurs vis-à-vis des stocks de connaissances formés au cours des cycles inférieurs.

Sans conteste, les opportunités de scolarisation ainsi que la qualité de l'éducation dépendent largement des ressources mises à disposition. Notre étude se focalise sur les dépenses publiques, la composante majeure des ressources allouées à l'éducation dans presque tous les pays. L'examen des statistiques de l'UNESCO portant sur ces dépenses révèle l'existence de différences drastiques entre les pays en matière de politiques de financement de l'éducation. Ces différences se situent non seulement dans les niveaux

des budgets publics destinés à l'éducation, mais surtout dans les schémas d'allocation de ces budgets entre les cycles de scolarisation.

A titre d'illustration et selon les dernières statistiques disponibles en 2002, lorsqu'en moyenne dans les pays de l'OCDE, 39 % des dépenses publiques sont allouées au cycle primaire qui compte 42 % de la population scolarisée, l'ensemble des PVD allouent en moyenne 40 % seulement de leurs budgets d'éducation pour ce cycle qui compte plus de 63 % de l'effectif scolarisé. De même, au moment où la population dans le supérieur dans les pays de l'OCDE qui représente 20 % de l'effectif total scolarisé, reçoit en moyenne 19 % des budgets d'éducation, plus de 20 % des budgets d'éducation sont destinés dans les PVD au financement de ce cycle dont la population ne dépasse pas les 7 % de l'effectif total scolarisé. Ce faisant, le ratio de dépenses publiques par élève et par an entre les enseignements supérieur et primaire est en moyenne aux alentours de 2 dans les pays de l'OCDE, alors qu'il dépasse largement 10 dans plusieurs pays en développement.

Compte tenu de la structure hiérarchique de l'investissement éducatif, il apparaît crucial d'analyser le lien entre la politique d'allocation des ressources publiques d'une part, et l'investissement dans les niveaux post-primaire et la croissance économique d'autre part dans aussi bien les pays développés qu'en développement. Ceci suggère une prise en considération de la structure interne du système éducatif ainsi qu'une adoption d'une vision plus désagrégée des dépenses investies dans l'enseignement.

L'objectif principal de cette thèse de doctorat est d'étudier théoriquement et empiriquement les effets macroéconomiques du financement public de l'éducation tout en mettant en avant le rôle de l'allocation des ressources publiques dans un système d'éducation hiérarchique. Plus précisément, nous essaierons d'y apporter des éléments de réponse analytiques et factuels à des questions jusque-là peu ou même non traitées dans la littérature telles que celles-ci: quels sont les effets dynamiques de la politique de

l'allocation des dépenses publiques d'éducation sur l'investissement dans les cycles supérieurs, la mobilité économique intergénérationnelle, et la distribution des richesses des pays? Comment organiser les arbitrages entre les investissements en capital humain réalisés aux différents cycles de scolarisation afin d'assurer une croissance économique soutenue à long terme? Est-ce que les politiques de financement public de l'éducation sont optimales si elles sont comparées avec les politiques de redistribution fiscales? Dans quelle mesure les politiques d'allocation des dépenses éducatives expliquent-elles les faibles taux de scolarisation dans les cycles post-primaire constatés dans la plupart des pays en développement? Quelle est l'ampleur de l'impact des dépenses publiques d'éducation par cycle de scolarisation sur la croissance économique des pays développés et en développement?

Cette thèse est organisée en cinq chapitres dont chacun d'entre eux traite dans l'ordre l'une des questions soulevées ci-dessus. Ces chapitres peuvent dans une large mesure se lire de façon indépendante. Par ailleurs, transversalement aux chapitres eux-mêmes, ce sont les questions de politiques éducatives en filigrane qui sont sans conteste les plus importantes.

Présentation des résultats fondamentaux

Chapitre I :

Dépenses publiques d'éducation, investissement en capital humain et mobilité intergénérationnelle: un modèle d'éducation à deux niveaux

L'objet de ce premier chapitre est d'offrir un cadre d'analyse théorique permettant de traiter deux questions majeures sous-jacentes au lien entre les inégalités des richesses matérielles et l'investissement en capital humain. La première question a

trait aux effets dynamiques de la répartition des richesses sur l'accumulation du capital humain et la mobilité économique intergénérationnelle. La deuxième question est relative aux impacts de court et de long terme des politiques de dépenses publiques d'éducation sur les grandeurs socio-économiques.

Le cadre théorique que nous proposons s'inspire de trois branches de la littérature existante. La première branche se penche sur l'examen de la relation entre l'inégalité des richesses matérielles, l'investissement éducatif, et la croissance. Ce lien a particulièrement été au cœur de la théorie des imperfections du marché de crédit. On y montre à l'unanimité que dans le contexte d'imperfections du marché du capital, une répartition inégalitaire des richesses constitue une contrainte à l'investissement en capital humain et à la croissance. L'étude de Loury (1981) a marqué le début d'une vague de travaux tentant de formaliser cette relation. Elle stipule qu'étant donné que les talents des individus sont distribués de manière aléatoire, l'allocation des ressources ne serait pas optimale lorsque certains parents sont privés d'investir dans l'éducation de leurs enfants vu que le marché de crédit leur est inaccessible.

Plus récemment, cette théorie a refait surface avec l'étude marquante de Galor et Zeira (1993) qui substitue l'hypothèse de l'indivisibilité de l'investissement éducatif à celle de l'hétérogénéité des talents. L'étude montre que sous cette hypothèse, la présence des imperfections sur le marché du capital entraîne un sous-investissement en capital humain au sein de la population pauvre. Plus important, Galor et Zeira (1993) montrent que ces imperfections conduisent à long terme à l'apparition des équilibres multiples, et que l'équilibre vers lequel une économie donnée converge, est déterminé par la répartition initiale des richesses. Ce résultat a suscité l'émergence d'une vague de travaux encore plus récents qui tendent dans l'ensemble à démontrer le phénomène de persistance des inégalités dans le contexte d'imperfections du marché du capital (Banerjee et Newman (1993), Aghion et Bolton (1997), et Piketty (1997)).

Une deuxième branche de la littérature a pour vocation l'étude des interactions entre la mobilité économique intergénérationnelle et la croissance économique (Galor et Tsiddon (1997), Owen et Weil (1998), Maoz et Moav (1999) et Iyigun (1999)). On montre ainsi que la mobilité économique est un facteur stimulateur de la croissance économique. Réciproquement, la mobilité économique s'accroît pendant les périodes de croissance; une conséquence de l'augmentation des ressources allouées vers le secteur de l'éducation.

La troisième et dernière branche de la littérature dont s'inspire l'étude menée dans ce chapitre, analyse l'impact des dépenses publiques d'éducation sur la croissance et l'inégalité des revenus. Il y est démontré que ces dépenses stimulent l'investissement en capital humain et la croissance et contribuent à réduire les inégalités de revenus. Toutefois, l'investissement éducatif est souvent modélisé comme étant indivisible et le secteur d'éducation se résume dans ce cas à un seul niveau de scolarisation. Ce faisant, les dépenses publiques d'éducation sont considérées dans leur forme agrégée, ce qui ne permet pas d'aborder la question des implications de l'allocation de ces dépenses entre les niveaux successifs de scolarisation.

Etudier cette question est d'une importance fondamentale parce que cela permettrait d'expliquer comment dans la majorité des pays en développement, de faibles taux de scolarisation dans les niveaux post-primaire, de fortes inégalités, et des faibles taux de croissance peuvent aller de pair avec d'importants budgets d'éducation. Les travaux théoriques qui tentent d'analyser le rôle de l'allocation des dépenses d'éducation sont rares (Lloyd-Ellis (2000) et Xuejuan Su (2003)). De plus, ils considèrent que les marchés de capitaux sont parfaits, et surtout, ils ne se penchent pas sur la question de la mobilité intergénérationnelle.

L'analyse menée dans ce chapitre tente donc de présenter une formalisation théorique originale qui étudie la problématique énoncée plus loin, et contribue par-là aux

trois branches de la littérature exposées. Ainsi, dans une première section de ce chapitre nous développons un modèle à générations imbriquées où le marché du crédit est imparfait à la Galor et Zeira (1993). L'accumulation du capital humain y est décrite comme étant un processus hiérarchique à deux niveaux de scolarisation, et non comme un investissement indivisible. En effet, une interprétation plus précise des faibles niveaux d'études de la population active observés dans plusieurs pays est d'envisager qu'une large fraction de cette population n'investit pas au-delà du primaire; enseignement obligatoire dans la plupart des pays. Un modèle à deux niveaux de scolarisation dont un est obligatoire (cycle de base) et l'autre facultatif (cycle supérieur) semble donc mieux adapté à la réalité dans la mesure où il permet de prendre en compte la caractéristique hiérarchique de l'investissement scolaire.

Dans le modèle, les individus avec un niveau de base ont la possibilité d'investir dans l'enseignement supérieur ou de quitter carrément le système éducatif. Les talents innés des individus ainsi que les montants de dépenses publiques allouées à chaque cycle de scolarisation déterminent les stocks individuels de capital humain accumulés aux différents cycles.

Nous montrons qu'en présence d'imperfections sur le marché de crédits, la fraction d'individus qui investit dans l'éducation supérieure est fonction, à court terme, non seulement de la répartition des talents individuels, mais aussi de la répartition initiale des richesses. Les dépenses publiques d'éducation ont toute leur importance dans la détermination de cette fraction qualifiée en influant sur les seuils de richesses et de talents qui départagent la population.

La deuxième section étudie l'évolution dynamique des richesses et des dynasties, et identifie les différentes possibilités de mobilité économique intergénérationnelle. On montre qu'il existe une multitude d'équilibres à long terme et celui vers lequel une économie donnée converge, dépend de la répartition initiale des richesses. Autrement

dit, des économies avec les mêmes préférences et paramètres technologiques, mais avec différentes répartitions initiales des richesses finissent à l'état stationnaire de long terme par atteindre différentes proportions de travail qualifié, différents degrés de mobilité et différents niveaux moyens de richesse. L'économie avec la répartition initiale la plus égalitaire converge vers l'équilibre le plus élevé.

La troisième section décrit l'évolution de l'économie au long de son processus de croissance. De par son effet sur les ressources consacrées au secteur de l'éducation, la croissance économique influe positivement sur la fraction de la population qui investit dans le supérieur. En effet, l'augmentation des ressources en faveur de l'éducation (tant dans le niveau de base que dans le supérieur) accroît l'incitation à investir dans le supérieur pour aussi bien les pauvres que les riches. Les pauvres voient leurs contraintes de liquidité s'assouplir, et les riches leurs revenus de travail futur augmenter. En outre, à mesure que l'économie croît, la mobilité économique nette s'intensifie ce qui accroît à long terme la fraction des riches dans la population. Enfin, le processus de croissance, est associé à long terme avec des niveaux de richesse plus élevés tant pour les riches que pour les pauvres, et par-là, avec une richesse moyenne plus importante.

Dans la quatrième et dernière section de ce chapitre nous analysons les implications de court et de long terme de deux politiques qui ont trait au financement public de l'éducation. La première politique consiste à augmenter le budget consacré à l'éducation via une hausse du taux de l'impôt sur les revenus. La deuxième politique envisage la réallocation des ressources publiques entre les cycles successifs de scolarisation tout en maintenant le taux d'imposition fixe. Nous trouvons qu'à moins que le taux de l'impôt soit 'très dissuasif', une hausse de cet impôt s'accompagne d'une plus grande mobilité économique, d'une proportion de travail qualifié plus élevée, et d'une richesse plus élevée à long terme pour aussi bien les pauvres que les riches. Nous trouvons aussi qu'il existe une allocation optimale des ressources publiques en faveur de

l'enseignement supérieur au-delà de laquelle, davantage de ressources allouées à ce cycle nuirait à la qualité de l'éducation de base et serait associée à long terme avec une faible mobilité économique, une faible proportion de la population qualifiée, et de faibles niveaux de richesse pour toutes les classes de population.

Chapitre II :

Un programme dynamique optimal d'investissement en capital humain dans le cadre d'un modèle d'éducation à deux niveaux

Dans ce deuxième chapitre un intérêt particulier est porté à la question de la distribution optimale du capital humain entre les différents niveaux d'éducation. Nous nous proposons précisément de déterminer la distribution optimale des stocks de capital humain accumulés aux différents niveaux de scolarisation au cours du processus de croissance d'une économie, et de caractériser les mécanismes permettant d'établir cette optimalité.

L'étude en profondeur de cette question s'impose dès lors que toute une littérature micro-économétrique -synthétisée par Psacharopoulos (1994) et actualisée par Psacharopoulos et Patrinos (2004)- montre que les rendements privés et sociaux de l'éducation diffèrent d'un cycle scolaire à l'autre avec une tendance à la supériorité du rendement marginal afférent à l'enseignement primaire. Toutefois, l'analyse des taux de rendement est inappropriée pour la détermination de la distribution optimale au cours du temps des différents stocks de capital humain, et ce pour au moins trois raisons.

Premièrement, dans presque toute la majorité des pays, l'éducation primaire est obligatoire. Il s'ensuit que tant que les taux de rendement liés aux niveaux scolaires post-primaire sont positifs, il serait toujours optimal pour un pays d'accroître la

proportion de la population qui y investit. Or, ce résultat laisse indéterminée la proportionnalité optimale entre les stocks de capital humain primaire et post-primaire.

Deuxièmement, comme ces taux de rendement sont des taux statiques, ils ne permettent pas de déterminer la distribution optimale de l'éducation au long du sentier de croissance étant donné l'interdépendance dynamique qui existe entre les différents stocks de capital humain. En ce sens, toutes choses égales par ailleurs, un accroissement de la proportion d'actifs ayant un certain niveau d'éducation devrait se traduire par une baisse du taux de rendement afférent à ce niveau d'éducation, et au même temps, par une hausse de ceux liés aux autres cycles d'enseignement. Malheureusement, la structure des taux de rendement ainsi estimée ne rend pas compte d'une telle interdépendance.

Finalement, au-delà de ces deux insuffisances, la structure estimée des taux de rendement est probablement biaisée. Weale (1993) affirme dans une étude critique que plusieurs biais peuvent entrer dans l'estimation des rendements de l'éducation, ce qui est de nature à sous-estimer ou surestimer leurs ampleurs. En effet, il est tout à fait possible de remarquer que tels qu'ils sont synthétisés dans les travaux de Psacharopoulos (1994) et Psacharopoulos et Patrinos (2004), les taux de rendement privés de l'éducation dans les régions en développement sont situés dans une fourchette de 13 à 37 % pour l'enseignement primaire, de 13 à 24 % pour le secondaire, et de 18 à 28 % pour le supérieur, qui sont des ordres de grandeur vraisemblablement surestimées.

Ainsi, au vu de ce nombre d'insuffisances qui incombent à la structure estimée des taux de rendement, nous avons songé à employer les outils de la théorie du contrôle optimal pour traiter la problématique que nous nous sommes fixée plus haut. A l'instar du premier chapitre, nous développons un modèle de croissance endogène à deux niveaux d'éducation dont un est obligatoire (l'enseignement de base) et l'autre facultatif (l'enseignement supérieur). Les stocks de capital humain individuels accumulés à chacun de ces deux niveaux sont fonction des durées d'études respectives, de la qualité

d'éducation donnée par les dépenses publiques éducatives, et de l'externalité liée au stock moyen de capital humain supérieur. Les individus disposent d'une unité de temps qu'ils allouent entre l'éducation et le travail. Au même titre que le capital humain, les individus accumulent aussi du capital physique qui est utilisé comme un input dans la fonction de production. A chaque instant, les individus avec seulement un enseignement de base choisissent la consommation qui maximise leur utilité inter-temporelle. Ceux qui décident d'investir dans le supérieur choisissent leur consommation et leur durée d'études à ce cycle scolaire.

La première section de ce chapitre est une revue critique de la littérature récente théorique et empirique qui a trait à la question de la distribution du capital humain. Nous retenons de cette revue que la majorité de travaux s'inscrivant dans cette littérature se focalise sur le rôle de la distribution du capital humain dans la croissance économique et laisse par-là indéterminée la distribution optimale entre les différents stocks. Dans la deuxième section nous présentons notre modèle théorique dans lequel les comportements des individus ainsi que l'évolution de l'économie agrégée sont analysés en employant les principes du contrôle optimal. La troisième section tâche de déterminer la distribution optimale à long terme des stocks de capital humain accumulés durant les cycles de base et supérieur, ainsi que de caractériser la dynamique transitoire vers l'équilibre stationnaire à l'aide des diagrammes de phase.

Nous montrons que les programmes individuels optimaux se traduisent à l'équilibre symétrique par une trajectoire de transition non-monotone vers la distribution d'équilibre stationnaire des stocks de capital humain. Plus particulièrement, en supposant qu'à la situation initiale, le capital humain supérieur d'une économie donnée est rare par rapport à celui de base, la durée d'études au niveau supérieur doit augmenter jusqu'à ce que la distribution optimale des stocks de capital humain soit atteinte. Quant à la consommation, celle-ci peut s'accroître, décroître ou même rester constante;

dépendant du paramètre de l'élasticité de substitution inter-temporelle de la consommation.

L'étude des caractéristiques de l'équilibre stationnaire montre que celui-ci est un point selle stable. En outre, le taux de croissance à long terme est d'autant plus fort que la durée d'études supérieures est longue. Cette durée est elle-même fonction croissante de la qualité d'éducation reçue à ce niveau scolaire.

Dans une quatrième et dernière section de ce chapitre nous discutons des implications de la variation de la qualité d'éducation (autrement dit, des dépenses publiques d'éducation) dans les deux cycles de scolarisation. Nous montrons que l'amélioration de la qualité de l'enseignement supérieur accroît le ratio du capital humain supérieur au capital humain de base tant au cours du sentier de transition qu'à l'état stationnaire de long terme. De plus, cette amélioration permet non seulement d'atteindre un taux de croissance plus élevé à long terme, mais aussi d'accélérer la vitesse de convergence vers ce taux.

Quant à l'amélioration de la qualité de l'éducation de base, bien qu'elle soit -dans le modèle- sans effet sur le taux de croissance à long terme, elle est de nature à accélérer la vitesse de convergence vers ce taux.

Pour conclure, il importe de souligner que les travaux qui utilisent les outils de la théorie de contrôle optimal pour déterminer une solution dynamique à l'investissement optimal en capital humain sont très rares. Parmi ces travaux, nous évoquons ceux de Driskill et Horowitz (2002) et Rajhi (1996). L'étude de Driskill et Horowitz (2002) utilise ces outils pour déterminer l'allocation optimale des dépenses éducatives du point de vue du planificateur social dans un modèle à deux niveaux d'éducation. Toutefois, il faut noter que ce modèle n'est pas un modèle de croissance endogène puisqu'il repose implicitement sur l'hypothèse d'exogénéité de l'investissement en capital humain. Il s'ensuit que ce travail ne permet pas d'identifier les mécanismes qui déterminent la

distribution optimale des stocks. De plus, ce type de modèle ne permet pas d'offrir une analyse des facteurs qui affectent la croissance de long terme ainsi que la vitesse de convergence vers l'équilibre stationnaire.

L'étude de Rajhi (1996) est un autre exemple intéressant qui s'inscrit dans la même logique que la nôtre. Elle emploie les techniques du contrôle optimal pour déterminer le sentier d'investissement optimal en capital humain. Il existe un seul niveau d'éducation qui permet l'accumulation de ce capital. A l'instar de notre modèle, la durée d'étude et la consommation sont deux variables de contrôle permettant d'établir l'équilibre. Mais, contrairement à notre analyse, l'étude de Rajhi (1996) a pour objet de déterminer la proportionnalité optimale de transition et de long terme entre le capital physique et le capital humain, et non celle entre les stocks de capital humain de base et supérieur.

Chapitre III :

Redistribution par l'éducation et par la fiscalité: une analyse des effets sur le bien-être social

Ce chapitre prolonge l'analyse conduite dans les chapitres précédents en se focalisant sur l'influence de la politique de financement public de l'éducation et des politiques de redistribution fiscales sur la distribution des qualifications et des revenus, l'efficacité économique, et le bien-être social.

Précisément, dans une première partie du chapitre, les effets de la politique de subvention de l'éducation sont comparés avec ceux de deux politiques fiscales de redistribution des revenus. La première est l'impôt négatif où tous les revenus sont taxés à un même taux, et les recettes ainsi collectées sont uniformément redistribuées. La deuxième politique est la subvention du salaire non qualifié via la taxation du travail qualifié.

Dans le souci de garder une structure théorique semblable à celle développée dans le premier chapitre, nous proposons ici un modèle qui reprend les hypothèses de l'imperfection du marché de capital à la Galor et Zeira (1993) et de l'hétérogénéité des individus dans leurs talents et dans la richesse de leurs parents. Dans ce modèle, l'investissement dans l'éducation est un choix à risque étant donné l'incertitude quant à la finalité de cet investissement. L'hypothèse de l'hétérogénéité des talents permet parfaitement de rendre compte de cette incertitude dans la mesure où différents niveaux de talents impliquent différentes chances de réussir son éducation. Ainsi pour être qualifié au cours de sa seconde période de vie, un individu doit non seulement investir en éducation, mais doit aussi réussir à la compléter.

Il s'ensuit, que la distribution des talents -en conjonction avec la distribution initiale des richesses- détermine aussi bien la fraction des individus qui investit dans l'éducation, que les proportions respectives des populations qui réussissent et qui échouent à compléter leur éducation.

En prenant en considération l'aspect de l'incertitude quant à la finalité de l'investissement éducatif, notre analyse met l'accent sur un phénomène important lié à la politique de subvention de l'éducation. En ce sens, un financement public plus élevé du coût de l'éducation permet à un plus grand nombre d'individus d'investir dans l'éducation. Or, le risque associé à cet investissement implique en conséquence qu'un plus grand nombre d'individus est confronté à l'échec. Autrement dit, une taxe qui finance davantage l'éducation, finance au même temps un taux d'échec marginal plus élevé. Il s'ensuit que l'efficacité marginale de la politique de subvention de l'éducation décroît avec le taux de la taxe.

Les différentes politiques étudiées sont évaluées en termes de leurs effets sur la distribution des qualifications, l'efficacité économique, les inégalités, et enfin le bien-être social. L'efficacité est mesurée par l'utilité agrégée de l'économie. Les inégalités

sont appréciées par l'indice de Gini de la distribution des utilités individuelles. Quant au bien-être social, nous l'évaluons par une fonction iso-élastique basée sur les utilités individuelles et le degré d'aversion à l'inégalité.

Lors de l'évaluation des retombées des différentes politiques, nous tenons à distinguer les évaluations *ex-ante* et *ex-post*. Par *'*évaluation *ex-ante'*, nous entendons l'évaluation des retombées avant que les ajustements des taux de salaires sur le marché de l'emploi aient eu lieu. De tels ajustements accompagnent les décisions des individus en matière d'investissement scolaire. L'évaluation '*ex-post'* repose sur les retombées observées une fois que ces ajustements se sont produits. Cette analyse montre que les effets associés aux politiques considérées diffèrent selon le type d'évaluation adopté.

La première section de ce chapitre présente d'abord le modèle théorique dans la situation de référence (c'est-à-dire, en l'absence de l'intervention publique). Elle détermine ensuite les taux d'investissement, de succès et d'échec scolaires sous les régimes de la subvention de l'éducation, de l'impôt négatif, et de la subvention du salaire des non qualifiés.

Dans la deuxième section, les implications de ces trois régimes sont comparées en faisant recours tant aux formulations analytiques qu'aux solutions numériques. On peut retenir de cette comparaison ce qui suit. *Ex ante*, comparées avec la situation de référence, les trois politiques s'accompagnent d'un plus faible degré d'inégalités, et c'est la politique de subvention du salaire non qualifié qui est la plus à même de réduire ces inégalités. Toutefois, *ex-post*, les inégalités augmentent sous les régimes de l'impôt négatif et la subvention du salaire non qualifié alors qu'elles se compriment sous le régime de la subvention du coût de l'éducation.

Ainsi, contrairement à certaines études qui mettent l'accent sur l'importance de l'effet de la redistribution réversible lié à la subvention de l'éducation, notre analyse montre que cet effet est négligeable lorsque l'on évalue les inégalités *ex-post*. En effet,

dans la mesure où les deux types de travail, qualifié et non qualifié, sont complémentaires dans la fonction de production, le système de subvention de l'éducation bénéficie aussi au travail non qualifié étant donné que le salaire relatif de ce type de travail augmente suite à la hausse de l'offre de travail qualifié.

En terme du bien-être social, nous montrons que la politique de subvention de l'éducation est optimale pourvu que le degré d'aversion aux inégalités soit fort et le taux de l'impôt soit faible. En effet, cette politique réduit en même temps les inégalités et l'efficacité économique, ce qui conduit à un arbitrage entre les objectifs de l'égalité et de l'efficacité.

Au-delà de cet arbitrage qui s'impose sous la politique de la subvention de l'éducation, celle-ci ne permet ni d'éliminer la contrainte de liquidité à laquelle font face les pauvres, ni de réduire le risque associé à la décision de l'investissement éducatif. Il devient donc naturel de se poser la question de savoir s'il existe un meilleur mécanisme de financement de l'éducation. La deuxième partie de ce chapitre a pour objet de répondre à cette question.

Plusieurs études évoquent la politique du prêt public à l'éducation comme une solution permettant de lever la contrainte financière résultant des imperfections du marché du crédit. Nous montrons que les implications d'une telle politique sur les grandeurs socio-économiques sont tributaires de la manière dont le système de prêt est instauré. Ceci est démontré en envisageant trois scénarios possibles: i) le prêt pur où tous ceux qui désirent investir dans l'éducation empruntent ce prêt et le remboursent quand ils sont actifs et ce, quel que soit leur niveau de qualification acquis ; ii) la combinaison entre le prêt pur et la subvention de l'éducation où cette subvention est financée via la taxation du travail qualifié ; et iii) le prêt avec remboursement conditionnel où seuls ceux qui ont réussi à terminer leur éducation -donc qualifiés- doivent rembourser le prêt contracté.

La comparaison entre ces trois scénarios est illustrée dans la troisième section de ce chapitre. Par la même occasion, nous confrontons les retombées résultant de ces scénarios à celles des trois politiques étudiées dans la première partie de ce chapitre. Les résultats les plus importants de cette comparaison peuvent être résumés en trois points.

Premièrement, comparée à la situation concurrentielle (sans l'intervention de l'Etat), la politique du prêt pur élimine complètement la contrainte de crédit et engendre plus d'égalité, sans toutefois nuire à l'efficacité. Cette politique élimine donc l'arbitrage entre les objectifs de l'égalité et de l'efficacité. Toutefois, le sous-investissement dans l'éducation demeure important sous cette politique vu le risque toujours présent associé à cet investissement. Ce risque est même plus important que sous le régime de la subvention de l'éducation. Par conséquent, la fraction de la population qui investit dans l'éducation est plus faible sous le régime de prêt que sous le régime de la subvention.

Deuxièmement, en combinant la politique de prêt avec celle de la subvention, ce risque s'amenuise ce qui se traduit par une plus grande proportion de la population qui investit dans l'éducation comparée à celle qui résulte sous le régime du prêt pur. Une telle combinaison permet de réduire davantage le degré des inégalités, mais au coût d'une perte en terme d'efficacité. Ainsi, relativement à toutes les autres politiques considérées dans cette étude, la politique qui combine le prêt pur et la subvention du coût de l'éducation, s'accompagne du niveau de bien-être social le plus élevé pourvu que le degré d'aversion à l'inégalité soit assez élevé. Dans le cas contraire, la politique de prêt pur est optimale.

Enfin, la politique de prêt où le remboursement est soumis à la condition de la réussite scolaire, éradique le risque associé à l'échec scolaire de manière à ce que tous les individus investissent dans l'éducation. Néanmoins, ce sur-investissement nuit dramatiquement à l'efficacité économique puisqu'il s'accompagne d'une compression

drastique du taux de salaire de la main d'œuvre qualifiée. Ainsi, bien qu'elle réduise significativement les inégalités, cette politique ne peut être optimale.

Chapitre IV:

Scolarisation post-primaire : les effets de la contrainte de crédit et des dépenses publiques d'éducation

Ce chapitre a vocation empirique. Nous y testons l'hypothèse de la contrainte de crédit utilisée dans les chapitres I et III de cette thèse et y évaluons la contribution des dépenses publiques d'éducation à l'explication des écarts de scolarisation entre enfants dans les niveaux post-primaire.

Tester l'hypothèse de la contrainte de crédit revêt une importance cruciale eut égard au débat qui émerge lors de l'interprétation de l'effet du revenu parental sur le niveau d'éducation des enfants. En effet, deux interprétations qui ne sont pas mutuellement exclusives peuvent être avancées. La première repose sur l'argument de la contrainte de liquidité selon laquelle les enfants issus des familles pauvres sont privés d'investir dans l'éducation -notamment dans les niveaux supérieurs- étant donné que celles-ci ne peuvent pas emprunter sur le marché financier.

La deuxième interprétation envisage le rôle des facteurs socio-culturels associés avec les niveaux élevés de richesses matérielles. L'exemple fréquemment avancé est celui de l'éducation parentale. En ce sens, comme le montant de la richesse financière des parents est souvent corrélé avec le niveau d'études de ceux-ci, les enfants issus des parents riches sont aussi ceux les plus à même de pouvoir investir dans les cycles d'enseignements supérieurs. En effet, il est bien probable que les enfants des riches héritent de leurs parents les talents, la personnalité et les préférences qui ont permis à ces derniers d'acquérir un niveau d'études élevé.

Sur le plan des vérifications micro-empiriques, la question de l'importance des deux arguments est jusque-là non résolue. Un premier ensemble de travaux trouve que l'effet de la richesse matérielle parentale sur le niveau d'études des enfants est non significatif comparativement à celui exercé par l'éducation parentale. Ces travaux concluent alors à la non-pertinence de l'argument de la contrainte de crédit, et attribuent aux facteurs socio-culturels le plus grand rôle dans l'explication de l'écart de scolarisation des enfants. Ellwood et Kane (2000), Cameron et Heckman (1999, 2001), Carneiro et Heckman (2002, 2003), Keane et Wolpin (2001) et Shea (2000) sont des exemples d'études menées sur les Etats-Unis et qui s'inscrivent dans cette lignée de travaux.

Un second ensemble d'études qui concerne aussi les Etats-Unis établit un lien positif entre les dépenses publiques d'éducation et le grade de scolarisation atteint par les élèves, ainsi qu'une plus grande sensibilité du taux de scolarisation à ces dépenses au sein des pauvres (Kane (1994), Dynarski (1999) et Ellwood et Kane (2000)…). Il s'ensuit que ce résultat est de nature à renforcer l'argument de la contrainte de liquidité.

Nous avons utilisé au long de ce chapitre des données de l'UNESCO sur les taux de scolarisation bruts en secondaire et en supérieur portant sur un large échantillon de pays développés et en voie de développement et sur la période 1970-2000. L'objectif étant de tester l'argument de la contrainte de crédit tout en contrôlant l'influence des facteurs socio-culturels. Tester cet argument sur des données de comparaison internationale nous semble intéressant dans la mesure où les résultats de ce test nous permettraient d'appréhender si la faible contribution de la richesse matérielle au fossé de scolarisation des enfants -telle que soulignée dans les travaux cités en haut- est spécifique aux pays développés, ou peut-elle même être généralisée aux pays en développement.

Des études récentes comme celles de De Gregorio (1996), Li, Squire et Zou (1998), Flug, Spilimbergo et Wachtenheim (1998), Checchi (2000) et Clarke, Xu et Zou (2003) tendent à prouver l'importance du phénomène du rationnement financier en utilisant des données de comparaison internationale, mais celles-ci sont sujettes à un certain nombre d'insuffisances qu'il importe d'y remédier.

Premièrement, ces travaux tendent à confirmer la thèse de la contrainte de crédit en se référant à la relation négative constatée entre l'investissement éducatif et l'indice de Gini des revenus; un indicateur du degré d'inégalité dans la distribution des richesses parentales. Toutefois, ces études ne contrôlent pas dans leurs régressions l'effet de la différence dans les facteurs socio-culturels. Omettre cet effet surestimerait l'impact de la distribution de la richesse matérielle et tendrait même à compromettre la robustesse de l'argument de la contrainte de crédit.

Deuxièmement, ces études ne testent pas la robustesse de cet argument à la composition de l'échantillon des pays. L'étude de Flug et al. (1998) constitue une exception puisqu'elle tend à confirmer l'importance de la contrainte de crédit dans aussi bien les pays industrialisés que dans les pays en développement. Néanmoins, étant donné que l'analyse menée dans ce travail ne tient pas en compte l'effet des différences dans les facteurs socio-culturels, la robustesse de la thèse de la contrainte de crédit doit être réexaminée.

Troisièmement, il est commun dans ces travaux d'utiliser la part des dépenses publiques d'éducation dans le PIB comme une variable explicative de l'investissement éducatif. Or, cette variable agrégée sort le plus souvent non significative, ce qui laisse envisager qu'elle est tout simplement inappropriée. Notre étude désagrège les dépenses publiques en dépenses allouées en primaire, en secondaire et en supérieur. Cette désagrégation permet de mieux comprendre les mécanismes par lesquels se transmettent les effets des dépenses publiques aux taux de scolarisation. Aussi, il est possible d'en

tirer des recommandations en termes de politiques d'allocation des ressources entre les différents cycles de scolarisation.

L'analyse menée dans ce chapitre doit être vue comme complémentaire aux travaux mentionnés plus loin. Nous y explorons davantage l'importance de la contrainte de crédit, sa robustesse, et la contribution des dépenses publiques à l'explication de la variance des taux de scolarisation.

La première section de ce chapitre expose les données utilisées et la méthode des estimations. Les deux variables dépendantes considérées sont les taux bruts de scolarisation en secondaire et en supérieur respectivement. L'indice de Gini associé à la distribution des revenus ainsi que la part dans le PIB des crédits aux ménages octroyés par les banques commerciales sont les deux variables explicatives utilisées pour tester la thèse du rationnement financier. Nous contrôlons l'effet de la différence des milieux socio-culturels sur les taux de scolarisation par l'indice de Gini associé à la distribution de l'éducation. La robustesse de l'hypothèse du rationnement financier est aussi testée en incluant dans les régressions les variables de dépenses publiques d'éducation. Les estimations sont effectuées tant en coupe transversale (cross-section) que sur données de panel. Les premiers résultats d'estimations sont présentés dans la seconde section.

Dans la troisième section, les effets des dépenses publiques d'éducation dans leur forme désagrégée sont examinés. On construit ainsi des données internationalement comparables sur les dépenses publiques annuelles par élève/étudiant et par cycle de scolarisation. Enfin, la quatrième section évalue la contribution relative de chacune des variables utilisées dans cette étude aux fossés des taux de scolarisation entre les pays de l'Afrique sub-saharienne et de l'Amérique Latine d'une part, et les pays de l'OCDE d'autre part.

Nos estimations présentent plusieurs résultats qui corroborent l'importance du phénomène de contraintes de crédit. Premièrement, tout en contrôlant l'effet du niveau

de développement économique et celui de la distribution de l'éducation, les taux de scolarisation post-primaire sont négativement corrélés avec l'indice des inégalités de revenus et positivement corrélés avec le degré de développement financier. Deuxièmement, ces corrélations sont robustes à la méthode d'estimation employée, à la composition de l'échantillon de pays, et à l'ajout des variables de dépenses publiques d'éducation. Finalement, ces dépenses exercent des effets significatifs sur les taux de scolarisation.

La distinction entre les pays développés et en voie de développement révèle un autre fait majeur: les effets marginaux associés aux facteurs matériels et socio-culturels sont plus élevés dans le premier groupe de pays que dans le second groupe. Par conséquent, une plus grande égalité dans les distributions des revenus et de l'éducation, ainsi qu'une accessibilité accrue des pauvres au marchés financiers stimuleraient davantage l'investissement éducatif dans les pays développés que dans les pays en développement.

En outre, la désagrégation des dépenses publiques d'éducation a permis de mettre en évidence la nature hiérarchique de l'investissement en capital humain discutée dans les chapitres théoriques précédents. En effet, les taux de scolarisation en secondaire et en supérieur sont affectés non seulement par les dépenses directement allouées à ces niveaux, mais aussi par celles allouées aux enseignements antérieurs. Les pays qui consacrent peu de ressources aux niveaux scolaires les plus bas ont aussi de faibles taux de scolarisation dans les cycles les plus élevés. Cette conclusion est aussi confirmée par l'utilisation dans les régressions des taux de scolarisations, des indicateurs du degré d'inégalité dans l'allocation des ressources publiques entre les niveaux d'études.

Enfin, la comparaison interrégionale des taux de scolarisation montre que les inégalités dans les revenus et dans l'éducation, l'étendue de la contrainte de crédit, et l'allocation des dépenses publiques éducatives, ensemble, capturent entre 94 et 96 % du

gap observé dans les taux de scolarisation dans l'enseignement supérieur entre les pays de l'Afrique sub-saharienne et de l'Amérique Latine d'une part, et ceux de l'OCDE d'autre part. Dans le secondaire, ces pourcentages sont entre 87 et 98 %.

Chapitre V :

Impacts du capital humain et des dépenses publiques d'éducation sur la croissance: une analyse empirique désagrégée

L'analyse menée dans le chapitre précédent a mis en évidence les contributions respectives des facteurs matériels et socio-culturels à l'investissement en capital humain. Ce dernier chapitre offre un prolongement à cette analyse en étudiant empiriquement l'impact du capital humain sur la croissance économique. Cette étude est au cœur tant des approches néoclassiques qui ont principalement émergé suite au travail de Mankiw, Romer et Weil (1992), que des théories de la croissance endogène dont les travaux de Lucas (1988) et Romer (1990) sont les précurseurs. Toutefois sur le plan empirique, l'estimation d'une fonction de production macroéconomique incluant l'éducation comme variable explicative présente un ensemble de problèmes jusqu'ici non résolus.

Nous nous focalisons dans cette étude sur deux de ces problèmes majeurs. Le premier problème est que les variables d'éducation utilisées dans l'équation de croissance sortent souvent non significatives et parfois même de signe négatif. Ce résultat est particulièrement saillant lorsque la régression de l'équation 'capital humain-croissance' est réalisée en différences premières ou en panel. Ce résultat a ainsi suscité toute une vague de travaux qui considèrent différentes raisons possibles de la faible contribution de l'accumulation du capital humain à la croissante.

Le deuxième problème a trait aux indicateurs du capital humain utilisés dans l'équation de croissance. En effet, il est généralement commun dans cette littérature

empirique d'utiliser le nombre moyen d'années d'études de la population âgée de plus de 15 ou 25 ans comme proxy du stock du capital humain dont dispose une économie. Or, une telle mesure agrégée ne permet pas de déterminer le schéma optimal d'allocation des ressources publiques entre les différents enseignements. Il serait donc intéressant d'étudier l'impact du capital humain formé aux différents cycles de scolarisation sur la croissance afin de surmonter ce problème.

A notre connaissance, l'étude de Gemmell (1996) est l'unique étude à avoir fait ce genre de raisonnement. En utilisant des données internationales en coupe transversale (cross-section), Gemmell (1996) estime l'effet du stock et de l'accumulation du capital humain formé en primaire, en secondaire, et en supérieur sur la croissance économique. Le principal résultat qui en ressort est que les enseignements primaire et secondaire ont leurs plus grands effets sur la croissance économique dans les pays en développement à faible et à moyen revenus, respectivement. Toutefois, c'est l'éducation supérieure qui est la plus à même de promouvoir la croissance dans le cas des pays développés.

Quoique, ce résultat doit être traité avec précaution puisque, i) l'étude en question ne fait pas de comparaisons complètes des effets des différents stocks et flux de capital humain entre les pays développés et en développement ; ii) elle n'explique pas par quel mécanisme l'éducation primaire peut stimuler la croissance dans les pays en développement à faible revenus ; et iii) elle reporte un effet négatif de l'éducation secondaire sur la croissance de ces pays, ce qui est un résultat difficile à interpréter.

Ce faisant, ce résultat suscite un certain nombre de questions. L'investissement dans le supérieur n'est-il pas bénéfique dans les pays en développement ? Le résultat selon lequel la croissance est davantage stimulée par l'investissement en supérieur dans les pays développés implique-t-il que de plus faibles ressources doivent être allouées au niveau d'enseignement de base dans ces pays ?

Au-delà de ces questions, les travaux empiriques précédents ne fournissent pas d'estimations de l'impact des dépenses publiques allouées entre les trois niveaux de scolarisation sur la croissance. Or, ces estimations peuvent être d'une grande utilité à l'action publiques dans la mesure où elles peuvent proposer des éléments pour l'organisation de l'allocation des ressources.

L'analyse menée dans ce chapitre tente donc d'apporter des éléments de réponses aux questions soulevées ci-dessus. Pour ce faire, nous procédons en deux étapes. Premièrement, nous estimons les impacts du capital humain dans sa forme désagrégée sur la croissance, et comparons ces impacts entre les pays développés et de l'OCDE. Deuxièmement, les effets des dépenses publiques allouées aux trois niveaux de scolarisation sur la croissance sont estimés et comparés entre les deux groupes de pays.

La première section présente les résultats d'estimations en cross-section de l'effet de la croissance du capital humain mesuré par le nombre moyen d'années d'études sur la croissance du PIB par tête. Nous montrons que les résultats contre-intuitifs discutés plus loin peuvent être dus à un biais de variable omise. En particulier, le stock de capital humain initial est un déterminant du taux de croissance du PIB par tête, et est en même temps corrélé avec le taux d'accumulation du capital humain. Ne retenir dans la régression de l'équation de croissance que la variable décrivant l'accumulation du capital humain peut entraîner des résultats d'estimation biaisés. En contrôlant l'effet du stock initial, nos estimations montrent une élasticité du PIB/tête par rapport au capital humain de 9.5 % en moyenne dans les PVD et de 6.7 % dans les pays de l'OCDE. Ces résultats confirment l'une des idées essentielles de la nouvelle théorie de la croissance selon laquelle le stock de capital humain conditionne l'aptitude d'un pays à innover et/ou à rattraper les pays plus développés.

Dans la deuxième section, nous réestimons l'équation de croissance en considérant le capital humain dans sa forme désagrégée. Les proportions de la

population avec respectivement une éducation primaire, secondaire, et supérieure sont utilisées comme des indicateurs des différents stocks de capital humain formés durant les trois cycles de scolarisation.

Contrairement à l'étude de Gemmell (1996), notre analyse montre que tant l'éducation secondaire que supérieure affectent positivement le taux de croissance dans les deux groupes de pays, et que l'impact marginal de ces formes de capital humain est plus élevé dans les PVD que dans les pays de l'OCDE. Ceci sous-tend une étroite corrélation entre le capital humain formé durant les niveaux d'enseignement post-primaire et le progrès technologique ; source de croissance économique. Le capital humain formé dans le primaire est, lui, exclu des sources de stimulation de la croissance. Ce résultat suscite donc la question de savoir comment doit être le schéma optimal d'allocation des ressources entre les niveaux de scolarisation.

C'est ainsi que dans la troisième section, les flux de dépenses publiques annuelles par élève/étudiant et par cycle de scolarisation sont utilisés comme variables explicatives dans l'équation de croissance au lieu des taux d'accumulation du capital humain dans les différents cycles. Les résultas d'estimations de cette équation montrent que les rendements marginaux des dépenses publiques d'éducation sont *décroissants* par rapport au niveau de scolarisation dans les pays en développement. Il serait donc optimal d'accroître davantage les ressources publiques en direction des cycles de base dans l'ensemble de ces pays. En effet, bien que l'éducation primaire, elle-même, ait de faible effet sur la croissance, davantage de ressources publiques doit être alloué en faveur du niveau d'enseignement primaire dans les PVD vu que ce cycle d'éducation est pré-requis pour l'accumulation du capital humain dans les cycles suivants. En ce sens, l'investissement en capital humain est hiérarchique, et cette hiérarchie crée une interdépendance entre les niveaux consécutifs de scolarisation. Davantage de ressources en faveur du primaire améliorerait donc la qualité de l'éducation à ce niveau et

accélèrerait son universalisation dans les pays en développement. Ceci se répercuterait positivement sur les taux d'investissements dans le secondaire et le supérieur, et ce qui serait de nature à stimuler la croissance. Toutefois et à la différence des PVD, dans les pays de l'OCDE les dépenses publiques éducatives sont allouées de manière plus égalitaire entre les cycles d'études ce qui a permis la généralisation des enseignements primaire et secondaire. Il en a ainsi découlé une large diffusion de l'enseignement supérieur, source de progrès techniques et de croissance économique. Ce constat est confirmé dans la dernière section de ce chapitre où l'on a introduit dans la régression du taux de croissance l'indice de Gini relatif à la distribution des dépenses publiques d'éducation entre les cycles scolaires. Le résultat qui en ressort mène à conclure que les pays dont les allocations des dépenses publiques sont biaisées en défaveur des cycles scolaires de base ont de faibles taux de croissance.

En outre, les estimations du taux de croissance révèlent que ceux-ci sont d'autant plus forts que l'inégalité de la distribution initiale des stocks de capital humain est plus faible. Ce résultat est de nature à renforcer la conclusion émise plus loin sur l'impact positif des stocks initiaux de capital humain accumulés dans les cycles post-primaire, sur la croissance économique. En ce sens, une forte inégalité dans la distribution des différents stocks d'éducation va de pair avec un faible stock de capital humain supérieur, et un faible taux de croissance.

Conclusion Générale

La présente thèse est principalement motivée par l'existence de disparités drastiques entre les pays en matière de l'effort de financement public de l'éducation et de l'allocation des dépenses publiques entre les différents cycles de scolarisation. Dans ce contexte, étudier l'impact des politiques de dépenses publiques d'éducation sur les

performances socio-économiques des pays est particulièrement important. Cinq chapitres, aux approches théorique et empirique, ont permis de mener cette étude.

En développant un modèle d'éducation où les dépenses publiques éducatives sont désagrégées en dépenses allouées respectivement aux enseignements de base et supérieur, le *chapitre I* a mis en avant le rôle de la répartition initiale des richesses matérielles comme facteur déterminant à long terme de l'investissement en supérieur, de la mobilité économique, et de la richesse agrégée. Nous avons en ce sens montré que lorsque le marché de crédits est imparfait, il peut exister une multitude d'équilibres stationnaires à long terme, et celui vers lequel un pays donné converge, dépend du degré d'(in)égalité de la répartition initiale de ses richesses matérielles.

En influant tant sur le seuil minimal de richesse matérielle que sur celui des talents individuels -au-delà desquels l'investissement dans le supérieur devient possible-, les politiques de dépenses éducatives permettent aux pays de se placer sur la trajectoire de transition vers l'un de ces différents équilibres. En particulier, tant que le taux de la taxe sur les revenus n'est pas excessif, l'augmentation du budget de l'éducation financée par ladite taxe exerce aussi bien à court qu'à long terme des effets positifs sur l'investissement dans le supérieur, la mobilité intergénérationnelle, et la richesse des différentes dynasties de la population. Nous avons également trouvé qu'il existe une allocation optimale des dépenses publiques entre les enseignements de base et supérieur, au-delà de laquelle, davantage de dépenses destinées en faveur du supérieur inhiberait la qualité de l'éducation de base, et est associée à long terme avec une faible mobilité économique, une faible fraction de travail qualifié, et une faible richesse pour aussi bien les riches que les pauvres.

Dans le *chapitre II,* nous avons cherché à déterminer la distribution optimale des stocks de capital humain au long du processus de transition économique dans une économie à deux niveaux d'éducation. La nouveauté de ce travail réside dans la

formalisation théorique explicite de la dynamique transitionnelle et de l'équilibre de long terme de l'économie dans le contexte d'un modèle de croissance endogène qui emploie les techniques de contrôle optimal.

Nous avons montré qu'à l'équilibre symétrique, la trajectoire de transition vers le ratio d'équilibre stationnaire entre les stocks de capital humain de base et supérieur est non monotone. Autrement dit, en supposant une situation initiale de rareté relative du capital humain supérieur, la durée d'études à ce cycle de scolarisation doit augmenter jusqu'à atteindre son niveau stationnaire qui correspond au ratio d'équilibre de long terme entre les stocks de capital humain de base et supérieur. A cet équilibre, le taux de croissance régulière de l'économie est fonction croissante de la durée d'études en supérieur, qui est elle-même fonction croissante du niveau des dépenses publiques allouées à ce cycle d'enseignement. Ce deuxième chapitre suggère aussi que l'accroissement des dépenses d'éducation en faveur du cycle supérieur stimulerait le taux de croissance à long terme et accélèrerait la vitesse de convergence vers ce taux. Toutefois, accroître les dépenses publiques au niveau de l'enseignement de base n'affecte pas le taux de croissance à long terme, mais serait de nature à accélérer la convergence vers ce taux.

Les impacts des politiques de dépenses éducatives sur l'investissement scolaire et la croissance étant analysés, il est intéressant de les comparer avec ceux des politiques de redistribution fiscale. Cette comparaison a été l'objet du *chapitre III,* où les effets de la politique de subvention de l'éducation sont confrontés à ceux associés avec la politique de l'impôt négatif, la politique de la subvention du salaire non qualifié, et enfin, la politique de prêt public à l'éducation. Cet exercice a montré en particulier que lorsque ces effets sont évalués *ex-post*, l'inégalité des revenus est plus importante sous les deux politiques de subvention du salaire non qualifié et de l'impôt négatif que sous celle de la subvention de l'éducation. Toutefois, au moment où la politique de subsides à

l'éducation réduit les inégalités *ex-post*, elle nuit à l'efficacité économique vu qu'elle engendre des effets de distorsion ainsi qu'un taux marginal élevé d'échec scolaire. Il s'ensuit que cette politique est optimale -en matière de bien-être social- seulement si le degré d'aversion à l'inégalité est assez important et que l'impôt sur les revenus n'est pas élevé.

Un prêt public pur à l'éducation est de nature à éliminer l'arbitrage égalité/efficacité qui incombe à la politique de subvention de l'éducation puisque davantage d'égalité dans la distribution des revenus peut se réaliser sans aucun effet de distorsion. La combinaison entre le prêt public pur et la subvention du coût de l'éducation permet d'accroître encore plus les gains en terme d'égalité. Néanmoins, ces gains sont réalisés au prix d'effets de distorsion. C'est pourquoi, comparée avec toutes les politiques étudiées dans ce chapitre, cette combinaison prodigue le maximum de bien-être social à condition que le degré d'aversion à l'inégalité soit suffisamment élevé. Toutefois, pour de faibles degrés d'aversion à l'inégalité, la politique de prêt public pur est optimale.

Le *chapitre IV* de cette thèse a vocation empirique. Il a pour objectifs de tester l'hypothèse de la contrainte de crédits employée dans les chapitres I et III, et d'évaluer la contribution des dépenses publiques d'éducation dans l'explication des fossés entre pays en matière d'investissement dans l'enseignement post-primaire. Tester la robustesse de l'hypothèse de la contrainte de crédits est d'une importance cruciale vu la polémique que soulève la corrélation positive entre le revenu parental et le niveau d'éducation des enfants. Les tests économétriques effectués aussi bien en coupe transversale (cross-section) que sur données de panel sont univoques: le phénomène de la contrainte de crédits est bien pertinent et robuste. Il permet d'expliquer dans une large mesure les variations internationales dans les taux de scolarisation post-primaire. En outre, les résultats d'estimations de l'impact des dépenses éducatives suggèrent que les pays dont

l'allocation de ces dépenses est biaisée en défaveur des niveaux scolaires les plus bas ont aussi de faibles taux de scolarisation dans les cycles les plus élevés. Ainsi l'accent excessif mis par plusieurs pays d'Amérique Latine ou de l'Afrique sub-saharienne sur l'éducation supérieure au détriment de l'éducation primaire et secondaire a-t-il pu renforcer les effets néfastes des fortes inégalités et de la contrainte financière sur l'investissement dans les enseignements post-primaire dans ces pays. Un tel choix politique contribue ainsi à expliquer pourquoi ces pays ont des taux de scolarisation dans les cycles supérieurs plus faibles que les pays de l'OCDE ou même d'Asie du Sud-Est où l'organisation de l'éducation s'est faite sur des principes beaucoup moins élitistes. Cette dernière conjecture confirme l'analyse théorique menée dans le chapitre I de cette thèse, et est aussi renforcée par l'étude économétrique développée dans le *chapitre V*.

Ce dernier chapitre de la thèse s'est en effet proposé d'évaluer l'impact des dépenses publiques d'éducation dans leur forme désagrégée sur le taux de croissance des pays. L'étude a été conduite en trois étapes. Tout d'abord, l'effet de l'accroissement moyen du capital humain sur le taux moyen de croissance du PIB par habitant est estimé sur données de comparaison internationale. En contrôlant l'effet du stock initial de capital humain dans l'équation de croissance, nos résultats d'estimations montrent en moyenne une élasticité du PIB/tête par rapport au capital humain de 9.5 % dans les pays en voie de développement, et de 6.7 % dans les pays de l'OCDE.

Dans une deuxième étape de cette étude, le stock de capital humain est désagrégé en stock primaire, secondaire, et supérieur afin de déceler la contribution relative de chaque type d'éducation à la croissance. Nous trouvons que dans les deux groupes de pays, la croissance économique est tirée par le capital humain formé dans le secondaire et le supérieur, et non par celui accumulé dans le primaire. La dernière étape de cette analyse cherche alors à dégager des recommandations en terme de politiques d'allocation des dépenses éducatives entre les différents cycles d'enseignements. En

introduisant successivement dans l'équation de croissance les dépenses publiques par élève et par an correspondant à chaque cycle de scolarisation, et l'indice d'inégalité dans l'allocation de ces dépenses, les résultats d'estimations mènent à conclure que davantage de ressources financières publiques doit être mobilisé en faveur des cycles inférieurs dans les pays en développement. En effet, étant donné que le capital humain formé en primaire est préalable à tout investissement dans les cycles postérieurs, assurer une qualité d'éducation suffisante à ce niveau scolaire est d'une importance stratégique comme l'avait mis en avant le chapitre IV. Il est alors indispensable pour les pays en développement de mettre en place des politiques qui favorisent davantage le financement de l'éducation de base afin d'assurer la continuité de l'investissement en capital humain et de stimuler la croissance.

Cette thèse de doctorat a examiné théoriquement et empiriquement l'influence des dépenses éducatives publiques sur les performances socio-économiques des pays sous des angles jusque-là peu ou non traités dans la littérature. L'aspect novateur de chacun des thèmes étudiés appelle nécessairement des prolongements théoriques et empiriques. Une voie de recherche particulièrement prometteuse est l'étude des déterminants de l'allocation des budgets d'éducation entre les cycles scolaires.

Par exemple, Xuejuan Su (2006) explique les disparités drastiques dans l'allocation des budgets entre les pays développés d'une part et ceux en développement d'autre part, par les mécanismes de pouvoir politique. Par son élitisme, la classe riche dans les PVD qui maintient le pouvoir politique tend à privilégier une politique axée sur le financement de l'enseignement supérieur au détriment de l'enseignement de base. Au contraire, dans les pays riches, le pouvoir politique tend à être partagé entre les classes riches et moyennes de la population, ce qui permet d'instaurer des politiques plus

égalitaires en matière de financement de l'éducation. Il serait alors intéressant d'approfondir cette piste de raisonnement en la testant empiriquement, par exemple.

Une autre piste de recherche qui mérite d'être considérée est d'étudier non pas la contribution de l'enseignement supérieur aux performances économiques et sociales des pays, comme nous l'avons suggéré dans notre thèse, mais plutôt les actions politiques à mettre en oeuvre permettant de concrétiser cette contribution. En effet, à l'heure du rythme actuel du changement mondial, un des défis majeurs auxquels l'enseignement supérieur est confronté est l'employabilité des diplômés de cet enseignement. Pour une économie moderne, relever ce défi sous-tend la mise en application des politiques permettant l'adaptation continuelle du système de l'enseignement supérieur aux besoins du marché de travail.

PULIC EDUCATION EXPENDITURES

AND

SOCIOECONOMIC PERFORMANCES

General Introduction

The recently emerged “new growth economics” theories emphasise innovation and adoption of technologies as the prime engine for increasing productivities. These activities, however, depend on the ability of the education systems to produce high skills and knowledge.

In this context, the crucial challenge for the policy-maker is to mobilize financial resources in order to make the education system most efficient. Precisely, this challenge includes both ensuring that educational opportunities are equitably distributed at all levels of schooling, and that the expansion of higher levels of education does not come at the expense of lowering the quality of primary education. This is of great importance, especially because of the hierarchical nature of any educational system. Indeed, individuals must be required to finish lower levels successfully before they can enter higher levels, and their academic achievements in the lower stages determine their level of preparation and qualification for the higher stages.

The goals of expanding the education systems and maintaining equitable access to education are inextricably linked to the financial resources invested in this sector. Our thesis focuses on public education funds which comprise most of the total education expenditure in almost all countries. The UNESCO database shows that countries differ drastically in their education funding policies, not only in the amount of public budget dedicated to education but, more importantly, in the allocations of these budgets across the stages of education. For instance, according to the last statistics available in 2002, in OECD countries, primary school level accounts for 42% of total school enrolments, and an average of 39% of public expenditures allocated to education on this level. In

contrast, however, developing countries allocate only 40% of their education budgets to this stage of education which accounts for more than 63% of their total enrolments.

Similarly, while in OECD countries, students at the higher education, which represents, on average, 20% of total enrolments receive 19% of the education budgets, more than 20% of the education budgets in developing countries are allocated to this stage although the enrolled population does not exceed 7% of total enrolments. So, whereas the ratio of public expenditures per-pupil between higher and primary education remains close to 2 in developed countries, it rises beyond 10 in some less developed economies.

International differences in the allocation policy of public education expenditures imply that the quality of schooling at different stages of education exhibits a wide range of variation, which raises the main issue of our research. In fact, given the hierarchical nature of the educational system, it is crucial to study the implication of the public funds allocation policy for the investment in the post-primary education levels and economic growth, for both developing and developed countries. This suggests that we take into account both the internal structure of the educational system and public expenditures, in a more disaggregated way.

In this thesis, we aim to study both theoretically and empirically the macroeconomic effects of public provision of education with a special focus on the role of the allocation policy in the context of a hierarchical education system. More precisely, we address some issues that have not been sufficiently studied in the literature of the field such as the following. What are the dynamic effects of the allocation of public funds across educational stages on investment in higher education levels, intergenerational mobility, and the country's distribution of wealth? What is the optimal distribution of human capital stocks accumulated at the successive educational levels which ensure sustained economic growth in the long run? Are education provision

policies optimal when compared to fiscal redistribution policies? What is the magnitude of the contribution of the allocation funds policy to the low schooling enrolment rates in post-primary education that are observed in most developing countries? What is the magnitude of the impact of public expenditure on economic growth by level of schooling and by stage of development?

Our thesis is structured in five chapters which successively study the questions raised above. Each one of these chapters can be read independently. However, all of these chapters share one most important feature; they offer guidance in terms of education provision policies.

Chapter I

Public education expenditures, human capital investment and intergenerational mobility: a two-stage education model

Introduction

This chapter develops an overlapping-generations model with a two-stage education sector, which allows for a study of the dynamical relationship between educational investment, wealth inequality, and intergenerational economic mobility. This model is also applied to examine the short and long-run implications of the public education provision policies.

This study combines three existing strands of literature. The first strand focuses on the relation between inequality, human capital investment, and growth. This relation has been particularly prominent in the credit-market imperfections theory, where it has been commonly shown that unequal distributions of income combined with credit-market imperfections are constraints to investment and growth. This kind of analysis was firstly formulated in Loury (1981), who argued that the endowments in innate abilities are random, so an inefficient allocation of resources results when some parents' investments in their children's education are constrained by income.

More recently, Galor and Zeira (1993) assumed identical abilities of individuals and showed that indivisibilities in human capital investments combined with credit-constraints result in multiple long-run wealth distributions and the possibility of poverty traps. In this study, since the poor cannot invest in human capital, they must use an

inferior production technology, and generation after generation remains poor. A similar conclusion was also made by Banerjee and Newman (1993), Aghion and Bolton (1997), and Piketty (1997), among others [1].

Whereas the works mentioned above have not studied intergenerational economic mobility, another strand of literature has recently focused on this issue in order to analyse the interactions between economic growth and economic mobility. For instance, Galor and Tsiddon (1997) studied the effect of technological progress on intergenerational mobility and wage inequality. They assumed that capital markets are perfect and, therefore, the effectiveness of credit-constraints is independent of income inequality. Their main result is that in a period of major technological inventions, the return to ability increases and the relative importance of initial conditions declines, leading to higher mobility. Hence, inventions raise both inequality and mobility.

Owen and Weil (1998) provided another interesting example in their study of mobility in the presence of capital-market imperfections and heterogeneity in individuals' abilities. In this study, mobility increases as a result of changes in the wage structure that accompany economic growth. In particular, in contrast to Galor and Tsiddon (1997), the increases in the fraction of the labour force that is educated reduce the wage gap between educated and uneducated workers, thus raising the probability that the children of uneducated workers will be able to afford an education. Conversely, economic growth occurs as intergenerational mobility allows a more efficient allocation of resources.

Maoz and Moav (1999) study the dynamics of inequality and mobility along the growth path under the assumptions of an imperfect credit-market and individual heterogeneity.

1: We refer the reader to Chapter IV of this thesis for a review of the empirical literature on the evidence of credit-constraints.

They show that mobility promotes economic growth via its effect on the accumulation and allocation of human capital. In turn, growth influences mobility via its effect on incentives to acquire education as well as on liquidity constraints that bind poor individuals. Hence, in the process of development, mobility increases and the distribution of education becomes better correlated with ability.

In the same line of research, Iyigun (1999) considered a model in which admission to schools is competitive and capital markets are perfect. The study shows that an increase in the fraction of educated parents has two offsetting effects. First, by increasing total output, it expands the supplies of educational services. This would make admissions to school less competitive and would increase economic mobility. Second, an increase in the fraction of educated parents implies that some members of the younger generation have greater academic potential. This would make admissions to school more competitive, lowering mobility.

The third strand of literature on which our model is based on focuses on the implications of increasing public resources toward the education sector for human capital accumulation, inequality, and growth. Most theoretical studies in this strand of literature are based on the idea that additional expenditures on education enhance human capital accumulation and economic growth, and reduce income inequality [2]. As far as human capital investment is assumed to be indivisible in these studies, the education sector has only one schooling level, and public expenditures are considered in their aggregated form.

2: Some well-known examples are Glomm and Ravikumar (1992), Saint. P and T. Verdier (1993), Bénabou (1996), and Fernandez and Rogerson (1997, 1999).

However, by focusing on the implications of the educational expenditures in their aggregated form, previous studies have left untreated the fundamental question of how different allocations of public funds across the successive schooling levels affect the economy. Tackling this issue is crucial because it may contribute to a better understanding of why, in spite of the continuous increments in the educational budgets of many developing countries, namely countries in Africa and Latin America, post-primary schooling enrolment rates are still too low and income inequality is too high. Gupta, Honjo and Verhoeven (1997), Benedict (1997), Birdsall (1999), and Gupta, Verhoeven, and Tiongson (2002) are excellent examples providing evidence on such paradoxical association.

Very few studies in recent years have emphasized the implications of the allocation of educational expenditures for the economy. For instance, Lloyd-Ellis (2000) shows -in the context of a two-stage education model- that a reallocation of expenditures from basic to higher education reduces enrolments in higher education and increases income inequality. Furthermore, the impact of the allocation of public resources on growth reflects a tension between the trickle-down effects of higher education and the positive enrolment effects of high-quality basic education and reduced parental income inequality. Another interesting study with similar results was conducted by Xuejuan Su (2003). The author demonstrates that, since basic education is a prerequisite for attending advanced education, there exists a lower bound on funding basic education. It follows that allocation policies below this lower bound are strictly Pareto dominated. In addition, while an allocation policy favouring basic education generates the usual redistribution from top to bottom, a policy favouring advanced education may result in reverse redistribution from bottom to top.

The two studies discussed above assume that capital markets are perfect, and therefore, the schooling decisions are independent from the distribution of wealth. In

addition, they have not explicitly considered the mobility issue. The analytical framework we develop in this chapter fills these gaps. Credit-markets are assumed imperfect, and the study of economic mobility is allowed by assuming heterogeneity in individuals' abilities and the possibility for some poor individuals to borrow. As in Lloyd-Ellis (2000) and Xuejuan Su (2003), we model human capital accumulation as a two-stage process, and not as one indivisible level. Indeed, one accurate interpretation of the low levels of average schooling of the working population observed in many countries is that a large fraction of this population does not acquire education beyond the primary level, which is compulsory in almost all countries.

We consider that all individuals must invest in the compulsory basic education (primary schooling), and should, at the end of this level, decide whether to acquire advanced education (secondary and higher education). Individuals base their decisions on the level of their ability endowments and their parental financial transfers. The analysis of the dynamics of wealth transfers shows that the distributions of abilities and initial wealth play a role in the acquisition of advanced education in the long-run. This analysis also enables us to detail the possibilities of upward and downward economic mobility. We find that there is a possibility of multiple steady-state equilibriums with different levels of investment in advanced education, mobility, and average wealth, and the specific one the economy converges to, depends on the distribution of initial wealth. Another crucial result that emerges from analysing the dynamics of the model concerns the evolution of investment in advanced education, economic mobility, and the distribution of wealth along the growth process. We show that, by raising public provisions allocated towards all levels of education, the growth process fosters aggregate investment in the advanced level, raises net mobility, and increases the long-run levels of wealth of all dynasties.

Our model has also been applied to study the implications of two public policies: an increase in the total budget of education by raising the income tax rate; and the reallocation of public funds across basic and advanced education while holding the total budget fixed. We find that unless the financing of the education budget is highly distorsive, increasing the income tax rate affects positively the long-run size of the skilled population, economic mobility, and the levels of wealth of both rich and poor dynasties. Furthermore, the effects of reallocating public funds from basic to advanced education on the acquisition of advanced education depend on the interplay between two forces of opposite signs: the negative effect on the liquidity constraints for the poor, and the positive effect on the quality of education received at the advanced level for the rich. We show that above a certain allocation of expenditures in favour of advanced education, additional transfers of resources from basic to higher education results in the long-run in a lower fraction of skilled population, a lower net mobility, and lower levels of wealth that are held by rich and poor dynasties.

This chapter is organized as follows. In section I, the analytical model is presented and the optimal individual's behaviours are discussed. Section II analyses the dynamics of wealth transfers and examines the possibilities of intergenerational economic mobility. Section III extends the dynamic analysis to the study of the evolution of the economy along the growth process. In section IV, the implications of the education provision policies for the economy are studied in both the short and the long-run.

I - A two-stage education model

I-1 Description of the economy

I-1-1 The households

Consider overlapping generations with heterogeneous individuals. Individuals in each generation differ in two respects: they inherit different financial supports from their parents and have different talents (or abilities to benefit from education). Financial inheritances are noted by $x \in [\underline{x}, \bar{x}]$ with the density function of $f(x)$. Abilities noted by (a) evolve in the interval $[\underline{a}, \bar{a}]$ and are assumed to have an exogenous probability density function, $g(a)$. For tractability of the analysis, ability endowments are defined as the set of talents that individuals are born with, and are therefore assumed to be distributed independently from parental wealth [3]. We use the subscript t in the model to index the generations. Each generation lives for three periods, during which individuals invest in education and work.

Education is accumulated in a hierarchical way. We model this hierarchy as a two-stage dependent process. In the first period, all individuals are enrolled in the compulsory basic education. In the second period, the human capital stock from basic education is used as an input for the accumulation of advanced education.

3: While one can argue that abilities are not strictly and independently distributed from wealth, one can agree that the inherent association, if any, is not strong. In fact, although the material wealth one is born with has a determining effect on how one's abilities are developed and how successful one is later in life, it is not always true that the level of abilities one is endowed with at an early age is conditional on the parental material wealth, and vice versa.

Less able individuals cannot benefit from advanced education even if they are born to rich parents. These individuals join the labour market and work during their second and third periods as unskilled workers. Only individuals with both sufficient abilities and parental financial supports can invest in advanced education. These individuals work in their third period of life as skilled workers. In addition to public expenditures, investment in advanced education involves a 'private' cost, which is assumed to be fixed at ϕ for all individuals. Individuals consume in the third period only. At the end of life, each individual is replaced by one offspring, such that the population remains constant. The size of each generation is assumed to be unity.

Let h_{Bt} and h_{At} note the unskilled and skilled workers' human capital stocks (or incomes), respectively. Indexes B and A refer, respectively, to basic and advanced educational levels. The stock of basic education depends on the level of the individual's ability and the quality of public education received at this stage. In turn, the basic human capital stock and the quality received at the advanced schooling level are inputs in the accumulation function of advanced human capital. We formally assume the following relations:

$$\begin{cases} h_{Bt} = h_{Bt}(a,\ E_{Bt}) = a\,E_{Bt}^{\alpha} \\ h_{At} = h_{At}(h_{Bt}\ ,\ E_{At}) = h_{Bt}\,E_{At}^{\gamma} \end{cases} \tag{1}$$

where a represents the individual's ability and E_{Bt} and E_{At} are respectively the quality of public education at the basic and advanced educational stages. This quality is simply proxied by the amount of public resources invested in each schooling level. The parameters α and γ are in the $[0\ ,\ 1]$ interval.

The assumed functional form captures one key characteristic of the production function of human capital: there are complementarities between the ability effect and public expenditures (i.e., $\partial^2 h_j / \partial a \partial E_j > 0 \ \forall \ j$, $j = B, A$). Such complementarities assumption is consistent with the formulation presented in Lucas (1988), Bénabou (1996), Loury (1981), S.Pinera and M. Selowsky (1981), S.Paul and Verdier (1993), Glomm and Ravikumar (1992) and Glomm and Kaganovich (2003). However, by contrast to these studies where the quality of education is assumed to be the same for all students, our model suggests that this quality differs with respect to the educational stage.

Individuals derive utility both from consumption and from bequests to their offspring. That is, there is intergenerational altruism taking the form of parents having the joy of giving to their offspring. The following utility function is assumed:

$$V_t = \rho \ Log \ C_t + (1-\rho) \ Log \ x_{t+1} \qquad (2)$$

where C_t is consumption of the generation t and x_{t+1} is the parent's bequest to his child. $1-\rho$ denotes the importance of the bequest in the utility function. Individuals' lifetime wealth is allocated between own consumption and bequest to the offspring.

I-1-2 The government

It is assumed that the government collects tax revenue from one generation, and allocates the public funds between the basic and advanced stages of education for the next generation. If we note by Y_{t-1} the aggregated income of parents, and by τ the income tax, then total expenditures are τY_{t-1}. The shares of expenditures allocated to basic and advanced education are constant and are given by e_B and $(1-e_B)$

respectively. Hence, the quality of education at the basic level may be formulated as follows:

$$E_{Bt} = e_B \tau Y_{t-1} \tag{3}$$

At the advanced level, the quality of education is given by:

$$E_{At} = (1 - e_B) \tau Y_{t-1} \tag{4}$$

I-1-3 The credit-market

There are several ways to model credit-market imperfections. Credit markets can be considered as either completely absent (the extreme case), or individuals should be sufficiently endowed with initial wealth to borrow. Eventually, individuals can obtain a credit, but, have to pay an interest rate which covers the lender's interest rate and the borrower's cost of possible default.

We adopt the last form of imperfections as in Galor and Zeira's (1993) model. The economy we consider is small and open to the world capital-market. The world rate of interest is equal to $r > 0$ and is assumed to be constant over time. Borrowers have the possibility to evade debt payments by moving to other places and so on, but this activity is costly. Lenders can avoid defaults by keeping track of borrowers, but such precautionary measures are also costly. The borrower's cost of evasion is assumed to be higher than the lender's cost of keeping track of borrowers. These costs create capital-market imperfections, so that individuals can borrow only at an interest rate i, which is higher than r, the lender's interest rate (i.e., $i > r$).

Such imperfections make borrowing costly, and may prevent some poor individuals, although with high abilities, from borrowing [4].

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I-1-4 Definition of equilibrium

Given a density function of wealth, $f_t(x)$, a density function of individuals' abilities $g(a)$, exogenous parameters of public policy and credit-market (τ, e_B, r, i), and the cost of education ϕ, a period t equilibrium is defined as a vector $\{C_t^*, x_{t+1}^*, S_t\}$ so that:

- The government balances its budget: $E_{Bt} + E_{At} = \tau Y_{t-1}$.

- Individuals determine their consumption, C_t^*, and the bequests to their offspring, x_{t+1}^*, that maximize utility (Equation 2) subject to Equations (1), (3) and (4).

- Individuals' decisions whether to invest in advanced education determine the fraction of skilled individuals in period t, S_t.

I-2 Optimal behaviour

Consider an individual who inherits an amount x_t in first period of life. We should distinguish three types of decisions:

a- If $(1 + r)\, x_t < \phi$, and the individual does not invest in advanced education, he will be an unskilled worker with a lifetime utility given by:

4: Galor and Zeira (1993) argue that under any other specification of credit-market imperfections, as long as borrowing is not fully free and costless, those who inherit large amounts have easier access to investment in human capital than those with small bequests.

$$V_{Bt} = Log\left[(1-\tau)(2+r)h_{Bt}(a) + x_t\,(1+r)^2\right] + \xi \qquad (5)$$

where: $\xi = \rho\ Log\ \rho + (1-\rho)\ Log\ (1-\rho)$

This worker has a consumption of:

$$C_{Bt}(x_t\ ,\ a) = \rho\left[(1-\tau)(2+r)\ h_{Bt}(a) + x_t\ (1+r)^2\right] \qquad (5a)$$

He will leave a bequest of size:

$$B_{Bt}(x_t\ ,\ a) = x_{t+1} = (1-\rho)\left[(1-\tau)(2+r)h_{Bt}(a) + x_t\,(1+r)^2\right] \qquad (5b)$$

b- If $(1+r)\ x_t < \phi$, and the individual decides to invest in advanced education, he is borrower and will be a skilled worker in his last period of life. His lifetime utility is:

$$V_{At} = Log\left[(1-\tau)\ h_{At}(a) + (1+i)\left[(1+r)\ x_t - \phi\right]\right] + \xi \qquad (6)$$

This worker has a consumption of:

$$C_{At}(x_t\ ,\ a) = \rho\left[(1-\tau)\ h_{At}(a) + (1+i)\left[(1+r)\ x_t - \phi\right]\right] \qquad (6a)$$

He will leave a bequest of:

$$B_{At}(x_t\ ,\ a) = x_{t+1} = (1-\rho)\left[(1-\tau)\ h_{At}(a) + (1+i)\left[(1+r)\ x_t - \phi\right]\right] \qquad (6b)$$

c- If $(1+r)\ x_t \geq \phi$, and the individual decides to invest in advanced education, he is lender and will be a skilled worker with a lifetime utility of:

$$V_{At} = Log\left[(1-\tau)\ h_{At}(a) + (1+r)\left[(1+r)\ x_t - \phi\right]\right] + \xi \qquad (7)$$

He has a consumption of:

$$C_{At}(x_t, a) = \rho\left[(1-\tau)\, h_{At}(a) + (1+r)\left[(1+r)\, x_t - \phi\right]\right] \tag{7a}$$

He will leave a bequest of:

$$B_{At}(x_t, a) = x_{t+1} = (1-\rho)\left[(1-\tau)\, h_{At}(a) + (1+r)\left[(1+r)\, x_t - \phi\right]\right] \tag{7b}$$

One can deduce from Equations (5) and (6) that borrowers invest in advanced education as long as $V_{At} \geq V_{Bt}$. Using the relations in Equation (1), this condition yields the following threshold level of financial wealth:

$$x_t^*(a) = \frac{\left[(1+i)\,\phi - (1-\tau)\, a\, E_{Bt}^{\alpha}\left[E_{At}^{\gamma} - (2+r)\right]\right]}{(1+r)(i-r)} \tag{8}$$

The fact that this threshold depends on "a" implies that there is a critical level of financial wealth for each level of ability. One can easily point out that the higher the individual's ability, the lower is the wealth critical level of that individual. Furthermore, for a given level of ability, this threshold is increasing in the private cost of education, ϕ, and decreasing in public expenditures that are invested in both stages of education.

Lenders decide to invest in advanced education as far as their lifetime utility is higher than the one of the unskilled workers. This holds only for lenders that are endowed with at least an ability of:

$$a^* = \frac{\phi\,(1+r)}{(1-\tau)\, E_{Bt}^{\alpha}\left(E_{At}^{\gamma} - (2+r)\right)} \tag{9}$$

Hence, financial and ability thresholds expressed in Equations (8) and (9) determine the fraction of individuals that would invest in advanced education, in period t. This fraction is given as follows:

$$S_t = \int_{a^*}^{\bar{a}} \int_{x_t^*(a)}^{\bar{x}} f_t(x_t)\, g(a)\, dx\, da \qquad (10)$$

Thus, in the short run, the size of the skilled population is a function of the distribution of individuals' abilities, and of the initial distribution of wealth (i.e., in t=0), since the fraction of individuals that invests in advanced education is determined by the proportion of the population that has inherited more than $x_t^*(a)$ in period t, and is at the same time endowed with abilities more than a^*. We show below, that the initial distribution of wealth also determines the size of the skilled workers in the long run.

II- The dynamics of dynasties and intergenerational mobility

II-1 Evolution of dynasties

This sub-section derives the dynamics of wealth transmission, and determines the long-run proportion of skilled workers as well as the distribution of wealth across rich and poor dynasties. The bequest an individual gives to his offspring depends on that individual's inheritance and his labour income, with labour income depending on ability. Hence, the distributions of both inheritances and abilities in period t determine the distribution of bequests in period $t+1$. According to Equations (5b), (6b), and (7b), these dynamics can be presented as follows:

$$x_{t+1} = \begin{cases} B_{Bt}(x_t, a) = (1-\rho)\left[(1-\tau)(2+r)\ h_{Bt}(a) + x_t\ (1+r)^2\right] & \text{if } x_t < x_t^* \text{ or } a < a^* \\ B_{At}(x_t, a) = (1-\rho)\left[(1-\tau)h_{At}(a) + (1+i)\left[(1+r)x_t - \phi\right]\right] & \text{if } x_t^* \le x_t < (\phi/1+r) \ \&\ a \ge a^* \\ B_{At}(x_t, a) = (1-\rho)\left[(1-\tau)h_{At}(a) + (1+r)\left[(1+r)x_t - \phi\right]\right] & \text{if } (\phi/1+r) \le x_t \ \&\ a \ge a^* \end{cases} \quad (11)$$

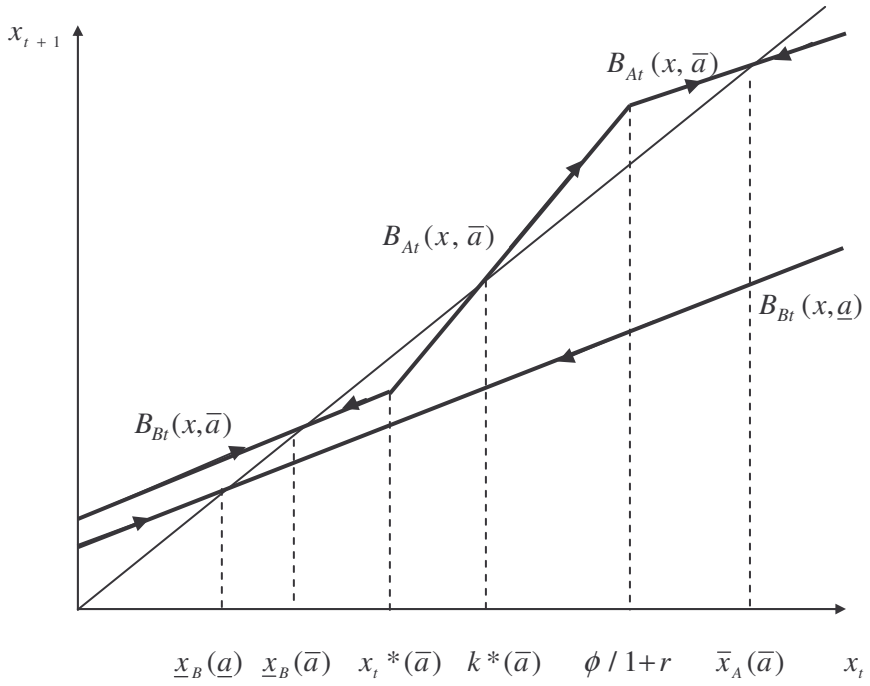
where x_0 is given.

Recall that B_{Bt} is the financial bequest of unskilled workers (those with only basic education), and B_{At} is that of skilled workers (both borrowers and lenders with advanced education). System (11) defines a Markov process where the size of a bequest, x_{t+1}, is conditional on the size of inheritance, x_t, and the level of abilities, a. The first equation of the system implies that individuals with either very low inheritance or low ability would transfer B_{Bt} to their children, as they are excluded from investing in advanced education. The last two equations point out that those having inherited more than $x_t^*(a)$ must also be endowed with abilities higher that a^*, in order to transfer to their children the amount of B_{At}.

Figure 1, below, illustrates the dynamical relationship between inheritances and bequests for both poor and rich dynasties, while considering the case of $a = \underline{a}$ for the group of individuals with abilities ranging between $\underline{a}$ and a^*, and the case of $a = \bar{a}$ for those with abilities between a^* and $\bar{a}$.

Notice that we impose the condition that $(1-\rho)(1+r)^2 < 1$, so that the size of a transfer does not grow indefinitely. An additional assumption, which is implicit in Figure 1, is that $(1-\rho)(1+i)(1+r) > 1$. That is, the cost of keeping track of borrowers is high, so that the spread between the lending and borrowing interest rates is high as well.

Figure 1: *The dynamics of intergenerational wealth transmission*



The dynamics of wealth transmission can be understood as following:

a- Independently of their initial wealth, all individuals with ability $a < a^*$ cannot go beyond basic education, and are therefore employed as unskilled workers. Their bequests are represented by the straight line, B_{Bt}. For this group, the example of $a = \underline{a}$ is considered for graphical representation. An increase in a shifts up the locus $B_{Bt}(x, \underline{a})$. Inheritances of these individuals converge in the steady-state to the lower long run values, $\underline{x}_B(a)_{a<a^*}$, given by:

$$\underline{x}_B(a)_{a<a^*} = \frac{(1-\rho)(1-\tau)(2+r)\, E_{Bt}^{\alpha}\, a}{1-(1-\rho)(1+r)^2} \tag{12}$$

Indeed, individuals in this range of abilities, who received a transfer of less than $\underline{x}_B(a)_{a<a^*}$, pass on to their children a transfer larger than the one they received. Those having received a transfer of more than $\underline{x}_B(a)_{a<a^*}$, pass on to their children a transfer that is less than the one they received.

b- Individuals with $a \geq a^*$, who inherited more than $x_t^*(a)_{a>a^*}$ invest in higher education, but not all of their descendants remain in the skilled labour sector. The critical wealth levels are $k^*(a)_{a \geq a^*}$, where:

$$k^*(a)_{a \geq a^*} = \frac{(1-\rho)\left[(1+i)\phi - (1-\tau)\, E_{Bt}^{\alpha}\, E_{At}^{\gamma}\, a\right]}{(1-\rho)(1+i)(1+r) - 1} \qquad (13)$$

For this range of abilities, Figure 1 considers the example of individuals endowed with ability of $a = \overline{a}$. The critical wealth level in this case is given by $k^*(\overline{a})$. In the case of these individuals, follow three configurations:

- Individuals with $a \geq a^*$, who inherited less than $k^*(a)_{a \geq a^*}$ in period t pass on to their children bequests which are less than the ones they received. Therefore, these individuals may work as skilled workers (since they inherited more than $x^*(a)$), but after some generations, their descendants become unskilled workers, and their inheritances converge to $\underline{x}_B(a)_{a \geq a^*}$. In Figure 1, this is represented by the point $\underline{x}_B(\overline{a})$, for the case of $a = \overline{a}$.

- However, individuals with $a \geq a^*$, who inherited more than $k^*(a)_{a \geq a^*}$ would bequeath values higher than the ones they received. In the long run, their bequests converge to the highest values, $\overline{x}_A(a)_{a \geq a^*}$ given by:

$$\overline{x}_A(a)_{a \geq a^*} = \frac{(1-\rho)\left[(1-\tau) E_{Bt}^{\alpha} E_{At}^{\gamma} a - (1+r)\,\phi\right]}{1-(1-\rho)(1+r)^2} \qquad (14)$$

Figure 1 considers the case of individuals that are endowed with $a = \overline{a}$, and shows that the wealth of those individuals converge, in the long-run, to the point $\overline{x}_A(\overline{a})$.

- Individuals with $a \geq a^*$, who inherit more than $\phi/(1+r)$, invest in higher education. They remain in the skilled labour sector, generation after generation, and their bequests converge to the highest long-run levels given by $\overline{x}_A(a)_{a \geq a^*}$.

To sum up, in the long run, the population in this economy is divided in two groups: skilled workers and unskilled workers. Skilled workers have a wealth of $\overline{x}_A(a)$, whereas unskilled workers have a wealth of $\underline{x}_B(a)$, with both wealth levels are increasing in the individuals' abilities. The relative size of these two groups depends unambiguously on the initial distribution of wealth, as well as on the distribution of abilities. Indeed, in the long-run, the proportion of the highly educated population, noted below by $\widetilde{S}$, is determined by the individuals who inherited more than $k^*(a)$ in period t and have, at the same time, more than a^*. That is:

$$\widetilde{S} = \int_{a^*}^{\overline{a}} \int_{k^*(a)}^{\overline{x}} f_t(x_t)\; g(a)\; dx\, da \qquad (15)$$

In what follows, we study the different possibilities of interclass mobility across generations, and confirm that the fraction of rich dynasties is given, in the long run, by the fraction of individuals with advanced education, $\widetilde{S}$.

II-2 Intergenerational economic mobility

We define economic mobility as the change in dynasties' adherence to income groups between generations. *Upward mobility* refers to a situation in which individuals although born to poor parents (i.e., with $x_t < \phi/(1+r)$), acquire advanced education and become rich. *Downward mobility* refers to a situation in which individuals born to rich parents (i.e., with $x_t \geq \phi/(1+r)$), do not invest in advanced education and become poor. Finally, the *no mobility* case is the situation in which children whose parents are rich also become rich, and children whose parents are poor remain poor.

Downward mobility arises in our model as some individuals born to rich parents do not acquire advanced education because of their low levels of ability (i.e., $a < a^*$). Upward mobility, however, concerns the fraction of individuals with inheritance of $x_t \in \left[k^*(a)_{a \geq a^*}, \phi/(1+r)\right]$. It occurs because individuals who inherit more than $k^*(a)_{a \geq a^*}$ would bequeath values higher than the ones they received, which allows to their offspring to be skilled workers, generation after generation. The possibility of upward mobility for these individuals is strengthened because individuals with high levels of abilities have lower levels of wealth thresholds above which they become highly educated. Finally, no mobility concerns all dynasties which are either rich and highly talented, or with wealth less than $k^*(a)$.

One possible way to measure economic mobility is by means of a transition conditional probability matrix. This matrix presents as follows:

Table 1: *The transition conditional probability matrix.*

		Child type	
		rich	***poor***
Parent type	***rich***	$\Pr(r/r)$	$\Pr(p/r)$
	poor	$\Pr(r/p)$	$\Pr(p/p)$

where:

- $\Pr(r/r)$ is the probability that children born to rich parents remain rich, (or equivalently, the fraction of rich individuals born to rich parents), which is given by:

$$\Pr(r/r) = \int_{a^*}^{\bar{a}} \int_{\phi/(1+r)}^{\bar{x}} f_t(x_t)\ g(a)\ dx\,da\ = \left[1 - F_t(\phi/(1+r))\right]\left[1 - G(a^*)\right]$$

- $\Pr(p/r)$ is the probability that children born to rich parents become poor, (or equivalently, the fraction of poor individuals born to rich parents), and is given by:

$$\Pr(p/r) = \int_{\underline{a}}^{a^*} \int_{\phi/(1+r)}^{\bar{x}} f_t(x_t)\ g(a)\ dx\,da\ = \left[1 - F_t(\phi/(1+r))\right] G(a^*)$$

- $\Pr(r/p)$ is the probability that children born to poor parents become rich, (or equivalently, the fraction of rich individuals born to poor parents), and writes as follows:

$$\Pr(r/p) = \int_{a^*}^{\bar{a}} \int_{k^*(a)}^{\phi/(1+r)} f_t(x_t)\ g(a)\ \ dx\,da$$

- $\Pr(p/p)$ is the probability that children born to poor parents remain poor, (or equivalently, the fraction of poor individuals born to poor parents), and is defined by:

$$\Pr(p/p) = \int_{\underline{a}}^{a^*} \int_{k^*(a)}^{\phi/(1+r)} f_t(x_t)\ g(a)\ \ dx\,da\ + \int_{\underline{a}}^{\bar{a}} \int_{\underline{x}}^{k^*(a)} f_t(x_t)\ g(a)\ \ dx\,da$$

Notice that $F_t(.)$ and $G(.)$ are respectively the distribution functions of $f_t(.)$ and $g(.)$, and that the sum of these probabilities is unity.

It follows from these probabilities that the proportions of upward and downward mobile-individuals write as below:

Table 2: *The fractions of upward and downward mobile-individuals*

Upward mobility	$\Pr(r/p)$
Downward mobility	$\Pr(p/r)$

By referring to the expression of each of these probabilities given above, one can unambiguously show that downward mobility increases in $G(a^*)$ which is the fraction of individuals that are endowed with ability less than a^*; and that upward mobility increases in the fraction of the population with more than both a^* and $k^*(a)$.

If we note the fraction of rich individuals in period t, as $R_t = 1 - F_t(\phi/(1+r))$, it follows that the fraction of rich individuals in $t+1, R_{t+1}$, is higher than R_t as long as upward mobility exceeds downward mobility, and vice versa. As the fractions of upward and downward mobile-individuals are equal (i.e., $\Pr(r/p) = \Pr(p/r)$), R_t reaches its long-run equilibrium value, noted by $\tilde{R}$, where:

$$\tilde{R} = \int_{a^*}^{\bar{a}} \int_{k^*(a)}^{\bar{x}} f_t(x)\ g(a)\ dx_t\, da = \tilde{S} \qquad (16)$$

$\tilde{S}$ is given in Equation (15), and denotes the long-run fraction of individuals that invests in advanced education, (or the skilled population). This fraction is a depending function of the initial distribution of wealth, and that of abilities.

As the long-run fractions of rich and poor dynasties as well as their corresponding levels of wealth are determined, the long-run aggregate (or average) wealth of the economy - noted below by $\tilde{X}$ - can be defined as follows:

$$\tilde{X} = \int_{a^*}^{\bar{a}} \int_{k^*(a)}^{\bar{x}} \bar{x}_A(a)\ f_t(x)\ g(a)\ dx_t\ da + \int_{\underline{a}}^{a^*} \int_{\underline{x}}^{\bar{x}} \underline{x}_B(a)\ f_t(x)\ g(a)\ dx_t\ da + \int_{a^*}^{\bar{a}} \int_{\underline{x}}^{k^*(a)} \underline{x}_B(a)\ f_t(x)\ g(a)\ dx_t\ da \tag{17}$$

The first term in the right-hand side of Equation (17) corresponds to the long-run share of wealth held by the rich population, while the second and third terms represent the long-run wealth of the poor population. Clearly, $\tilde{X}$ increases in the fraction of rich population, $\tilde{R}$, and is consequently positively correlated with the proportion of the population that is initially endowed with a wealth more than $k^*(a)$, and with abilities more than a^*.

To sum up the results established in this section, one can assess that economies with identical taste and technology parameters, but different initial wealth distributions, can end up in different steady-states of investment in advanced education, mobility, and average wealth. The country with a more equal initial wealth distribution will have higher steady-state levels of advanced education, mobility, and average wealth. That is, there are multiple long-run equilibriums and the specific one the economy converges to, depends on the initial distribution of wealth.

Proposition 1:

The economy's long-run levels of investment in advanced education, mobility, and aggregate (average) wealth, depend on the initial distribution of wealth.

III- The evolution of the economy along the growth process

This section analyses the changes in mobility and in the distribution of wealth along the growth process. The growth process can be emphasised in the model as an increase in aggregate (average) income, Y_{t-1}. As shown in Equations (3) and (4), an increase in aggregate income expands the supply of educational expenditures in both basic and advanced schooling levels, leading to an improvement in the quality of education at both levels.

In the short-run, such improvement has two positive reinforcing effects on the fraction of individuals with advanced education, S_t. On the one hand, liquidity constraints on the poor are relaxed as the human capital (or income) of those with basic education increases. On the other hand, incentives for investment in advanced education increase among the rich as their incomes increase too. Accordingly, the proportion of individuals who afford advanced education, S_t, rises as the economy's total income increases. In order to illustrate this result, one may easily check that both ability and wealth thresholds, a^* and $x_t^*(a)_{a \geq a^*}$ respectively, are monotonically decreasing in Y_{t-1}.

In the long-run, the growth process raises the fraction of rich individuals –or equivalently that of highly educated workers– because net mobility is increased. Indeed, since the thresholds of a^* and $k^*(a)_{a \geq a^*}$ are both monotonically decreasing in Y_{t-1}, upward mobility rises and downward mobility falls, as it is apparent from Table 2 of

section II. Hence, net economic mobility increases along the growth path. As a result, the fraction of rich individuals in the long run, $\tilde{R}$, goes up as it is illustrated by Equation (16).

Furthermore, as shown in Equations (12) and (14), the growth process also results in higher long-run values of wealth held by both poor and rich dynasties (i.e., $\underline{x}_B(a)_{a<a^*}$, $\underline{x}_B(a)_{a\geq a^*}$, and $\bar{x}_A(a)_{a\geq a^*}$ are increasing in Y_{t-1}). Therefore, the long-run aggregate (average) wealth, $\tilde{X}$, increases along the growth path. These results are summarised in the following proposition:

Proposition 2:

Along the growth process, both investment in advanced education and mobility are increased. In the long run, the fraction of rich individuals (or equivalently, of highly educated workers) as well as the levels of wealth held by both rich and poor dynasties are raised up.

IV- Educational expenditure policies

In this section, we explore the impacts of educational provision policies on investment in advanced education, economic mobility, and the distribution of wealth. Two educational funding policies are examined. The first is an increase in total public education expenditures which is financed by an increase in the tax rate, τ. The second policy is a reallocation of these resources across the two levels of education while holding the tax rate fixed. More specifically, this policy consists of varying the share of expenditures allocated to basic education, e_B. We show below that how public funds are allocated across the two levels has direct implications on investment in advanced

education and, consequently, on the aggregate economy. Throughout this analysis, policy implications are examined in both the short and the long-run.

IV-1 First policy : an increase in the total budget for education

Under this policy, it is assumed that the shares of expenditures allocated to basic and advanced education stages are fixed (i.e., e_B is given). The government may increase the total budget for education by increasing the tax rate, τ. This policy has both short and long-run effects.

IV-1-1 The short-run effects

There are two opposite effects in the short-run associated with the increase in the tax rate. First, as shown by Equations (3) and (4), this policy simultaneously improves the quality of education at both basic and advanced stages. As a result, the stock of human capital accumulated by students with basic education, h_{Bt}, increases, implying a relaxation in the liquidity constraints that face the poor. At the same time, the income of highly educated individuals, h_{At}, increases, implying higher incentives for the rich to acquire advanced education. Second, because the increase in the education budget is financed through distorsive income taxation, the higher the tax rate, the lower is the disposable income of both skilled and unskilled individuals. This distortion effect tends to reduce the incentives to acquire education.

Nevertheless, this negative effect is always outweighed by the positive effect of increasing incentives, so that, the fraction of individuals that invests in advanced education, S_t, monotonically increases with the income tax rate. To illustrate this result, one may see that both ability and wealth thresholds, a^* and $x_t^*(a)$ respectively, are

monotonically decreasing in the tax rate, τ (proofs are in the Appendix). This result is summarised in the proposition below:

Proposition 3:

In the short-run, the fraction of individuals that invests in advanced education increases in a monotonic way with respect to the tax rate, τ.

IV-1-2 The long-run effects

Varying the education budget through income taxation affects the fractions of upward and downward mobile-individuals as illustrated in Table 2. This, consequently, influences the long-run proportion of rich individuals, $\tilde{R}$ (or equivalently, the fraction of highly educated population, $\tilde{S}$).

- It is worthwhile to notice that, like the threshold of ability, a^*, the fraction of downward mobile-individuals is monotonically decreasing with the tax rate, τ .

- Upward mobility, however, depends on the thresholds of both ability, a^*, and wealth, $k^*(a)$. By using Equation (13), it is easy to show that, for any level of ability, the threshold $k^*(a)$ decreases (increases) in the tax rate, τ, if $\tau < \tau^*$ ($\tau > \tau^*$), where:

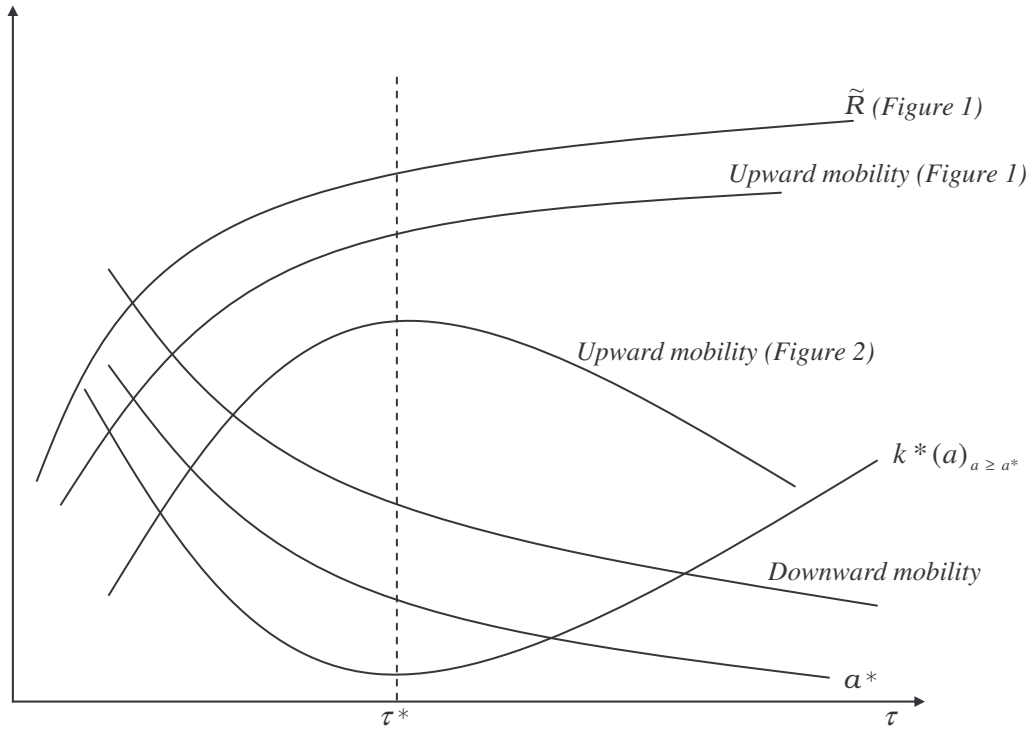
$$\tau^* = \frac{\alpha + \gamma}{1 + \alpha + \gamma} \tag{18}$$

Hence, as long as $\tau \leq \tau^*$, the fraction of upward mobile-individuals increases with τ because both a^* and $k^*(a)$ are decreasing in τ. Conversely, when $\tau > \tau^*$, a^* is decreasing in τ and $k^*(a)$ is increasing. Thus, upward mobility may increase or decrease depending on the magnitude of the impacts of the tax rate on these thresholds. Indeed, two figures are possible when $\tau > \tau^*$:

- *Figure 1*: if $\partial k^*/\partial \tau < \partial a^*/\partial \tau$, then upward mobility increases with the tax rate, τ.
- *Figure 2*: if $\partial k^*/\partial \tau > \partial a^*/\partial \tau$, then upward mobility decreases with the tax rate, τ.

The variations in upward and downward mobility affect the long-run proportion of rich individuals, $\widetilde{R}$. Specifically, $\widetilde{R}$ rises if upward mobility increases and downward mobility decreases; and vice versa. Figure 2, below, illustrates the effects of varying the income tax rate on upward and downward mobility, as well as on the resulting stationary proportion of rich individuals in the long-run.

Figure 2: *The effects of the tax rate on mobility and the long-run size of rich dynasties*



Proposition 4:

a- *As long as* $\tau \leq \tau^*$*, net mobility increases, and the long-run proportion of rich individuals,* $\tilde{R}$*, rises with* τ*.*

b- *If* $\tau > \tau^*$*, there are two configurations :*

- *if* $\partial k^*/\partial \tau < \partial a^*/\partial \tau$*, then* $\tilde{R}$ *increases with* τ*.*
- *if* $\partial k^*/\partial \tau > \partial a^*/\partial \tau$*, then the evolution of* $\tilde{R}$ *with respect to* τ *is indeterminate.*

Varying the level of the education budget affects not only the distribution of the population in the long-run, $\tilde{R}$, but also the levels of wealth held by each dynasty of the population. This effect is non-monotonic because of the distortion effects of taxation associated with this policy. Indeed, one can show the following:

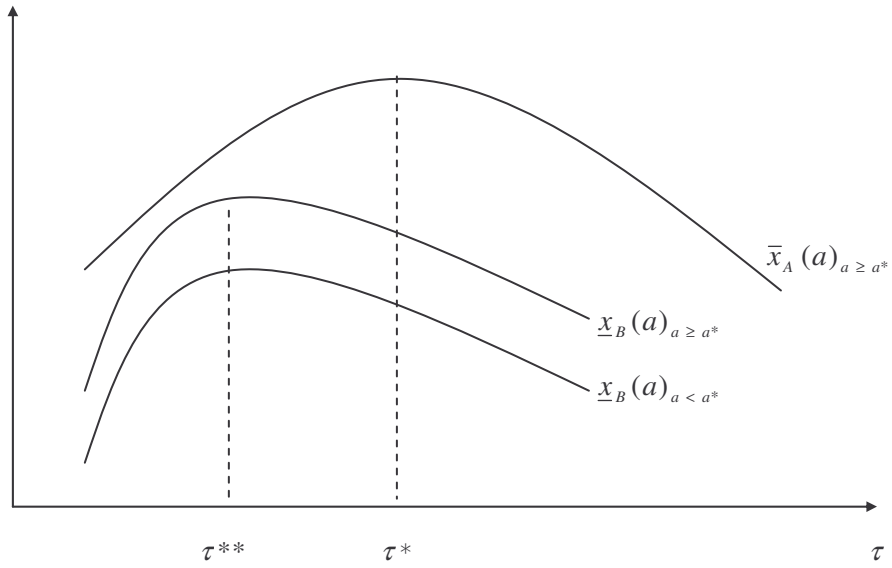
- The highest levels of wealth , $\bar{x}_A(a)_{a \geq a^*}$, are increasing (decreasing) in τ if $\tau \leq \tau^*$ ($\tau > \tau^*$), where τ^* is defined in Equation (18).

- Similarly, the lowest levels of wealth, $\underline{x}_B(a)_{a<a^*}$, and $\underline{x}_B(a)_{a \geq a^*}$, are increasing (decreasing) in τ if $\tau \leq \tau^{**}$ ($\tau > \tau^{**}$), where:

$$\tau^{**} = \frac{\alpha}{1+\gamma} < \tau^* \qquad (19)$$

These effects are illustrated graphically below.

Figure 3: *The effects of the tax rate on rich and poor dynasties' long-run levels of wealth*



To summarise, as long as the income tax rate that finances the education-budget increments is not too high (i.e., $\tau \leq \tau^*$), the increase in the budget of education is associated in the long-run with a higher mobility, a higher proportion of rich population, and a higher levels of wealth held by the rich and poor dynasties (the wealth of poor dynasties increase provided that τ is too low). However, if the increase in the education budget is financed through highly distorsive taxation (i.e., $\tau > \tau^*$), this policy decreases the long-run levels of wealth of both poor and rich dynasties, while its effect on the size of the rich population is ambiguous as it fosters both upward and downward mobility.

IV-2 Second policy : the reallocation of expenditures across the stages of education

Under this policy scheme, the tax rate is fixed so that the total budget for education (τY_{t-1}) is fixed as well. The government affects the allocation of these

resources across basic and advanced levels of education by varying the ratio of e_B. This policy affects the economy in both the short and the long-run.

IV-2-1 The short-run effects

How public expenditures are allocated across basic and advanced educational stages affects the number of students enrolled in the latter stage, S_t. Specifically, an increase in e_B improves the quality of basic education (i.e., E_{Bt} increases), but worsens the quality of advanced education (i.e., E_{At} decreases). Because of the hierarchical feature of educational investment, this policy implies two opposite effects on schooling decisions in the advanced stage. On one side, it increases the stock of human capital accumulated at the basic level which, in turn, relaxes the liquidity constraints that face the poor, and raises the fraction of students demonstrably able to continue investing in the advanced schooling level. On the other side, the reduction in the quality of education at the advanced level lowers the income of highly educated individuals, and therefore, reduces the incentives for those individuals to invest in advanced education. Hence, investment in this level is governed by the interplay between these two effects.

To clarify this result, one may check that the ability and wealth thresholds, a^* and $x_t^*(a)$, evolve in a non-monotonic way with respect to the share of expenditures allocated to basic education, e_B.

In order to provide an analytical solution for the effect of varying e_B, we consider here the case of $\alpha = \gamma = 1$. It follows that both thresholds decrease (increase) in e_B if $e_B < e_B^*$ ($e_B > e_B^*$), where:

$$e_B^* = \frac{\tau Y_{t-1} - (2+r)}{2\tau Y_{t-1}} \tag{20}$$

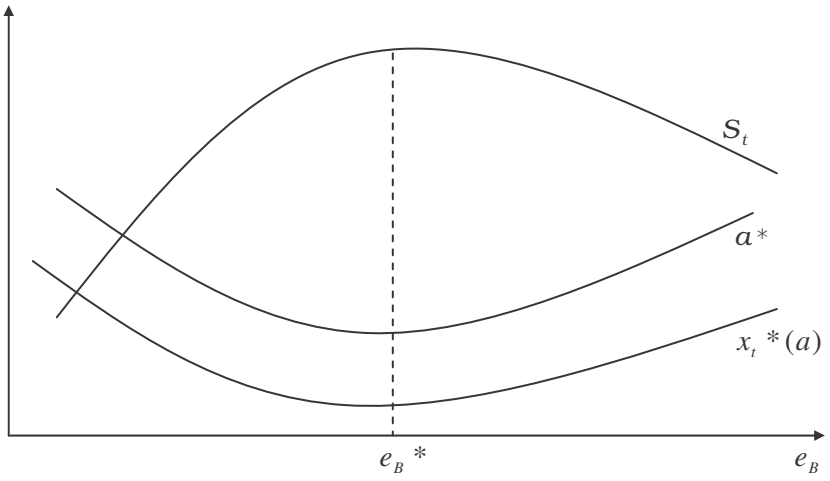
This result is summarised in the following proposition.

Proposition 5:

In the short-run, given a fixed size of public education funds, an increase in e_B *raises (decreases) the fraction of individuals that invests in advanced education if* $e_B < e_B^*$ ($e_B > e_B^*$).

This relationship is illustrated in Figure (4), below. It shows that the size of the skilled population, S_t, can be increased when the expenditure on the advanced education is decreased if the sums taken from the expenditure on this schooling level are transferred to basic education. Indeed, this transfer improves the quality of education at the basic level and raises the stock of human capital accumulated at this level. This in turn allows to some individuals -namely those with high abilities- to invest in the advanced level. Nevertheless, the transfer of public resources toward basic education may discourage investment in advanced education if this transfer becomes excessive (i.e., if $e_B > e_B^*$).

Figure 4: *The evolution of the skilled population with respect to the share of expenditures devoted to basic education*



IV-2-2 The long-run effects

We show in this paragraph that through its effect on individuals' mobility, the allocation of expenditures across the various stages of education affects the fraction of skilled individuals as well in the long run. This policy also alters the long-run levels of wealth held by the rich and the poor. The effects of the reallocation policy on upward and downward mobility are non-monotonic. Indeed,

- As has shown in the previous paragraph, the ability threshold, a^*, and thus, the fraction of downward mobile-individuals is decreasing (increasing) in e_B if $e_B < e_B^*$ ($e_B > e_B^*$), where e_B^* is given in Equation (20).

- The effects of varying e_B on both ability and wealth thresholds, a^* and $k^*(a)$ respectively, determine how upward mobility evolves with respect to e_B. It can be shown in the case of $\alpha = \gamma = 1$, that the wealth thresholds, $k^*(a)$, decrease (increase) in e_B if $e_B < e_B^{**}$ ($e_B > e_B^{**}$), where [6]:

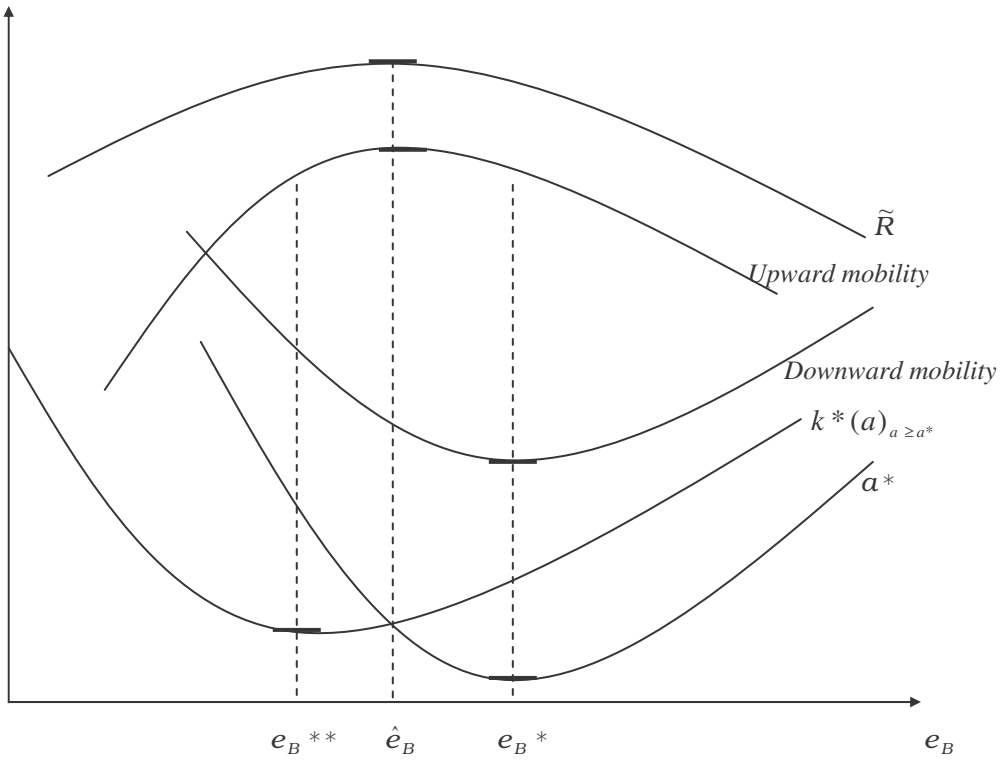
$$e_B^{**} = \frac{1}{2} < e_B^* \tag{21}$$

As a result, there exists an allocation of public expenditures -noted by $\hat{e}_B$- such that, $\hat{e}_B \in [e_B^{**}, e_B^*]$, below which, the number of upward mobile-individuals is increasing in e_B, and above which, this number is decreasing in e_B.

6: *For any other values of α and γ, we have* $e_B^* = \frac{\alpha}{\alpha + \gamma}$.

Figure (5), below, illustrates the effects of transferring public resources from advanced education to basic education (an increase in e_B) on both fractions of upward and downward mobile-individuals and the resulting stationary proportion of rich dynasties in the long-run, $\tilde{R}$. As apparent from the figure, this transfer raises the stationary fraction of rich individuals, $\tilde{R}$, if it is not too high. However, $\tilde{R}$ decreases in this transfer, if the latter intensifies.

Figure 5: *The effects of expenditure allocation on mobility and the long-run size of rich dynasties*



Proposition 6:

Given a fixed size of public education funds, an increase in e_B raises (decreases) the fraction of rich individuals in the long-run, $\tilde{R}$, if $e_B < \hat{e}_B$ ($e_B > \hat{e}_B$).

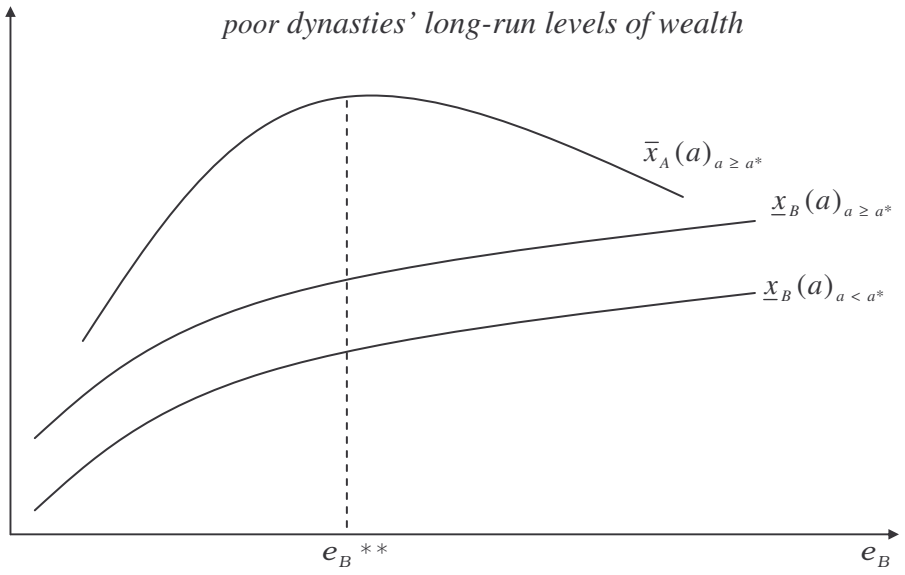
The effect of this transfer on $\tilde{R}$ reflects the interplay between two conflicting forces: the improvement in the quality of education at the basic level, and the disincentives to acquire education at the advanced level. If the former effect outweighs the latter, upward mobility exceeds downward mobility, so that the equilibrium fraction of rich individuals, $\tilde{R}$, is increasing in this transfer, and vice versa.

How expenditures on education are allocated across basic and advanced stages also has implications on the level of wealth held by each dynasty in the long-run.

- According to Equation (12), the lowest long-run levels of wealth, i.e., $\underline{x}_B(a)_{a<a^*}$ and $\underline{x}_B(a)_{a\geq a^*}$, are monotonically increasing in e_B.

- However, Equation (14) shows that the highest long-run levels of wealth, $\overline{x}_A(a)_{a\geq a^*}$, increase (decrease) in e_B as long as $e_B < e_B{}^{**}$ ($e_B > e_B{}^{**}$), where $e_B{}^{**}$ has been defined in Equation (21). We illustrate these relationships in Figure (6), below.

Figure 6: *The effects of expenditure allocation on rich and poor dynasties' long-run levels of wealth*



Proposition 7:

Given a fixed size of public education funds, an increase in e_B *raises the long-run levels of wealth held by poor dynasties. The increase in* e_B *also raises the long-run levels of wealth held by rich dynasties as long as* $e_B < e_B$ **, *and vice versa.*

Conclusion

In this first chapter, we developed an overlapping-generations model of education investment in which credit-markets are imperfect, individuals' abilities are heterogeneous, and education is modelled as a two-stage process. We showed that there is a possibility of multiple steady-state equilibriums with different levels of investment in advanced education, mobility, and average wealth, and the specific equilibrium the economy converges to, depends on the initial distribution of wealth. More specifically, the more unequal the economy's initial wealth distribution, the lower is that equilibrium.

In addition, we have found that investment in advanced education, interclass mobility, and average wealth are increased along the growth process. Indeed, by increasing public expenditures at all levels of education, the growth process relaxes the liquidity constraints on the poor and enhances the incentives to acquire advanced education for the rich. As a result, net mobility and average wealth are shifted up.

Using our model, we analysed the effects of two educational finance policies: an increase in the total budget of education through the increase in the income tax rate; and a reallocation of public resources across basic and advanced stages of education, while holding fixed the level of education budget. An important result from this analysis is that the effects of both policies differ too much. We find that provided that the income tax rate is not too distorsive, the increase in the education budget is associated in the long-

run with positive effects on the levels of investment in advanced education, net mobility, and the levels of wealth held by both rich and poor dynasties. However, the effect of reallocating educational resources from basic to advanced education on the incentives to acquire advanced education reflects a tension between two effects of opposite signs: a negative effect on the incomes of the poor, which strengthens their liquidity constraints; and a positive effect on the incomes of the rich, which enhances their incentives to acquire advanced education. Particularly, there is an optimal allocation of public resources in favour of advanced education, such that beyond this allocation, additional expenses in favour of this schooling level results, in the long-run, in a lower economic mobility, a lower fraction of skilled individuals, and lower levels of wealth that are held by both rich and poor dynasties.

Appendix

- The ability threshold level in Equation (9) can be written as follows:

$$a^* = \frac{\phi\,(1+r)}{(1-\tau)\,(\tau e_B Y_{t-1})^{\alpha}\left[\tau^{\gamma}(1-e_B)^{\gamma}Y_{t-1}^{\gamma} - (2+r)\right]}$$

Partial derivation with respect to τ gives:

$$\frac{\partial a^*}{\partial \tau} = -E_{Bt}^{\alpha}\,\tau^{-1}\left[\frac{\phi\,(1+r)}{(1-\tau)^2 D^2}\right]\left[E_{At}^{\gamma}\left((\alpha+\gamma)(1-\tau)-\tau\right) - C\left(\alpha(1-\tau)-\tau\right)\right] < 0$$

where: $E_{At}^{\gamma} = \tau^{\gamma}(1-e_B)^{\gamma}Y_{t-1}^{\gamma}$; $E_{Bt}^{\alpha} = (\tau e_B Y_{t-1})^{\alpha}$ $C = 2+r$; and $D = E_{Bt}^{\alpha}\left[E_{At}^{\gamma} - C\right]$.

Clearly, this derivative is always negative since we have: $\gamma(1-\tau)>0$.

- The wealth threshold level given in Equation (8) can be written as follows:

$$x_t^*(a) = \frac{\left[(1+i)\,\phi - (1-\tau)\,a(\tau e_B Y_{t-1})^{\alpha}\left[\tau^{\gamma}(1-e_B)^{\gamma}Y_{t-1}^{\gamma} - (2+r)\right]\right]}{(1+r)(i-r)}$$

The derivation of this expression with respect to τ yields:

$$\frac{\partial x_t^*(a)}{\partial \tau} = \frac{-a\,E_{Bt}^{\alpha}}{\tau(1+r)(i-r)}\left[E_{At}^{\gamma}\,\gamma(1-\tau)^2(1-\alpha) - (2+r)\left((1-\tau)\alpha - \tau\right)\right] < 0$$

This derivative is always negative since we have $\gamma(1-\tau)>0$.

Chapter II

An optimal dynamic program of human capital investment within a two-stage education model

Introduction

This chapter offers an extension to the analysis pursued in the previous chapter by focusing on the optimal distribution of the economy's stock of human capital across educational stages. Precisely, the analysis addressed here aims to determine the optimal distribution of human capital across basic and advanced levels of education and along the development process, and to characterize the mechanisms that allow for establishing the equilibrium.

The study of the effect of the distribution of human capital on economic growth is legitimate in light of the stylized facts which are raised in the micro-econometric literature regarding the effect of education on individuals' incomes. Psacharopoulos (1994) and Psacharopoulos and Patrinos (2004) provide a good overview of this empirical literature, which points out the supremacy of the social return to the primary school level, relative to those of the secondary and higher education levels. However, for several reasons, the analysis of rates of return is inappropriate for the determination of an optimal distribution of human capital across the various school levels.

First, in almost all countries, primary education is compulsory. Hence, as long as the rates of return associated with the post-primary levels are positive, it is always optimal for these countries to increase the proportion of the population investing in these

levels. Unfortunately, this result leaves the optimal proportionality between primary and post-primary stocks of education undetermined.

Second, as long as the micro-econometric empirical literature typically focuses on static rates of return, these rates cannot be a reliable policymaking tool in determining the optimal distribution of education along the economy's growth process, because of the dynamical interdependence that exists between the various types of human capital stocks. For instance, increases in the fraction of the labour force with a certain educational level should drive down the rate of return of this school level, and simultaneously raise those of the other levels. Unfortunately, the estimates of static rates of return do not take into account such dynamical interdependence.

Finally, beyond these two issues, the estimated structure of rates of return is likely to be biased. An excellent critical evaluation of the rates of return estimations is made by Weale (1993), who argued that there are many biases entering into these estimations [1].

1: In general, rates of return can be biased upwards because of a failure to take into account the influences on incomes of factors other than education (experience, ability, socio-cultural origins, the quality of education…), or they may be depressed because survey-based calculations inevitably fail to take account of most external effects of education (less unemployment among the better educated, technological progress driven by the high skilled workers…). Rates of return such those summarized by Psacharopoulos (1994) or Psacharopoulos & Patrinos (2004) are likely to be highly overestimated. In fact, in these studies, the private return to education in the developing regions are between 13 and 37% for the primary, 13 and 24% for the secondary, and 18 and 28% for the higher-education level, which are likely too high estimates.

Our study applies optimal control theory principles to human capital investment in order to explore the optimal distribution of human capital along the growth process. As in Chapter I of this thesis, we present an endogenous growth model with two successive education stages. The accumulation of education starts with the compulsory basic level, which has a uniform duration of studies for all individuals, and ends with the advanced level, where individuals choose their duration of studies. The remaining individuals' time is allocated to working. The individuals' stocks of human capital accumulated at each schooling stage depend principally on the duration of studies spent at this level, and on the relevant schooling quality given by public education expenditures. In addition to human capital, individuals accumulate physical capital, which is used as an input in production, like the two stocks of human capital. Individuals with basic education only choose the optimal path of consumption to maximize their present discounted value of utility, whereas individuals who decide to continue investing in advanced education choose both their optimal levels of consumption and duration of studies.

The model enables us to determine the optimal distribution of these human capital stocks in the long-run, and to study the transitional dynamics toward the equilibrium. We show that, in the symmetric equilibrium, individuals' optimal programs result in non-monotonicities in the transition path toward the long-run equilibrium distribution of human capital. In particular, starting from an initial situation with relative scarcity in advanced human capital, the duration of studies at this level should increase until the optimal distribution of human capital is reached. This equilibrium is found to be a saddle. The optimal growth path of consumption depends on the inter-temporal substitution elasticity parameter of consumption.

We also find that the long-run level of economic growth is increasing in the equilibrium duration of studies at the advanced education, which in turn is increasing in

the quality of education received at this stage. The comparative static exercise shows that increasing the quality of education at the advanced level raises the ratio of advanced to basic human capital stocks along the transition path, and in the long-run as well. In addition, this quality improvement not only raises the long-run growth rate of the economy, but also allows reaching this growth rate faster. However, increases in the quality of education at the basic education level drive down the ratio of advanced to basic human capital stocks, both in the transition phase and in the long-run. Raising the quality of education at this level does not affect the long-run economic growth rate, but it speeds the transition to the steady state equilibrium.

Studies employing optimal control theory techniques to determine a dynamical solution for the optimal distribution of human capital are rare. For instance, Driskill and Horowitz (2002) employ optimal control principles in a model with two hierarchical education stages to determine optimal educational investment from a planner perspective. Their main finding is that expenditures on education should be concentrated on the advanced schooling level along the transition phase. Once the optimal human capital distribution is reached, this concentration should switch. However, one important implicit assumption in this study is that human capital investment is exogenous. Thereby, the mechanisms that allow reaching the optimal distribution of human capital are not determined. In addition, while this study analyses optimal investment choices, the long-run economic growth determinants are left unexplored.

The study of Rajhi (1996) is another interesting example, and employs optimal investment program techniques to determine the optimal path of human capital investment. There is only one level of education in Rajhi's (1996) study that allows for the accumulation of human capital. As in our model, consumption and the fraction of time allocated to education are two control variables that permit reaching the equilibrium. However, whereas Rajhi (1996) aims to determine the transitional and long-

run proportionality between the stock of physical capital and that of human capital, our analysis focuses on the proportionality between two kinds of human capital stocks.

The remainder of this chapter is organized as follows. The first section provides a non-exhaustive critical review of the recent literature that treats the relationship between the distribution of human capital and economic growth. The second section presents the theoretical model, where individuals' behaviours and the evolution of the aggregate economy are presented. In the third section, we characterise the equilibrium of the economy and determine the transition dynamics toward this equilibrium. Finally, comparative static concerning the effects of varying the quality of education at both levels of schooling is discussed in the fourth section.

I- Optimal distribution of human capital and economic growth : a critical review of the literature

Recently, there has been an increase in the literature exploring the optimal distribution of human capital for economic growth, but studies in this research area are subject to several critics and insufficiencies. Theoretical works mainly include Galor and Tsiddon (1997), Lopez, Thomas, and Wang (2001), Berthélemy and Arestoff (2002), and Xuejuan Su (2003), while empirical studies include the estimations provided by Lopez, Thomas, and Wang (2001) for their theoretical framework, and the studies of Judson (1998), Thomas, Wang, and Fan (2000), and Castello and Domenech (2002).

Galor and Tsiddon (1997) demonstrate that an increase in the inequality of the distribution of human capital is essential in the early stages of development. As the human capital of the highly educated population increases and income inequality

widens, the accumulated knowledge trickles down to the less-educated segments of the society via a technological progress in production. This result stems from the interplay between two types of externalities: a local externality transmitted from parents to children, and a global externality transmitted from aggregate human capital to the technological process. In the early stages of development, the local externality dominates and both distributions of human capital and incomes become polarized, whereas in the advanced stages of development, these distributions become more equalized.

Although this paper highlights the role of the distribution of human capital in the development process, it does not determine the optimal distribution of human capital, which is crucial from a planner's point of view. In addition, the result of non-monotonicities is obtained on the basis of the interplay of two types of externalities, which are unobservable in the data.

Lopez, Thomas, and Wang (2001) explore the effect of the distribution of education on per-capita income by focusing on the optimal distribution of human capital. The individual's income is given by a concave function of this individual's stocks of human and physical capital, as well as his level of ability. As in Galor and Tsiddon (1997), Lopez, Thomas, and Wang (2001) show that the relation between educational inequality and growth has an inverted U-shape. In this study, the optimal concentration of education mirrors that of the individuals' abilities. As far as the concentration degree of education is below the optimal level, per-capita income can be increased by raising the concentration of education among the most able individuals. If, however, the distribution of education exceeds its optimal level, per-capita income can be increased by reducing the concentration of education.

Nevertheless, this analysis raises at least two issues. The first stems directly from the definition of what an optimal distribution of human capital is. The fact that the

optimal distribution of human capital is determined by the distribution of abilities among the population is problematic from the social planner's point of view. Individuals' potential abilities are, indeed, unobservable during the schooling period, and one can only observe test scores, which are only noisy signals of an individual's true abilities. Second, the model points out that in each period, there exists an optimal level of human capital concentration which is given by the distribution of abilities. The question of the optimal distribution of human capital across the educational levels is, however, left unexplored.

Berthélemy and Arestoff (2002) employ rates of return to education presented in Pscharopoulos (1994), and define a 'corrected' Mincerian function in which the parameter expressing the rate of return to education becomes a decreasing function of schooling years. This study finds that the earnings function is convex until the end of the first cycle of the secondary level, and concave above. Hence, Berthélemy and Arestoff (2002) conclude that it is always optimal to concentrate education on higher levels of schooling in countries with low levels of human capital since the earnings function is convex in these countries. This result contrasts with the one of Lopez, Thomas, and Wang (2001) whose finding points out the existence of an optimal degree of concentration of human capital. However, in developed countries, the earnings function is concave, and in this case only, the theoretical predictions of Lopez, Thomas, and Wang (2001) may hold.

Nevertheless, the result indicating that a more unequal distribution of education may be beneficial for the economy's aggregate productivity or income should be treated with caution, even under the convexity hypothesis of the earnings function. In fact, one should take into account the increments in both productivity and costs resulting from additional investments in each educational level. In many developing economies, the

distribution of education is highly unequal, but this inequality has clearly not benefited the aggregate productivity in these countries.

The study of Xuejuan Su (2003) focuses on the optimal allocation of public expenditures between a basic school level, which is compulsory, and an advanced level. The author shows that there exists a lower bound on funding basic education since this level is a prerequisite for enrolment in advanced education. It follows that allocation policies below this lower bound are strictly Pareto-dominated. Nevertheless, like the studies mentioned above, the one of Xuejuan Su (2003) does not offer any analysis of the transitional dynamics to explain how the long-run equilibrium can be reached. These studies also lack an analytical formalisation of the economy's long-run growth rate and the distribution of education it corresponds with.

In the macro-empirical literature, there is evidence that the distribution of education matters for per-capita income and growth. For instance, Lopez, Thomas, and Wang (2001) find that inequality in the distribution of human capital, as measured by the Gini index of education, has a negative impact on per-capita income in Latin America and Asia. The same result is found in Thomas, Wang, and Fan (2000), who make use of a larger sample of countries. Per-capita GDP increments are, indeed, negatively correlated with inequality in education.

Castello and Domenech (2002) use cross-country regressions to estimate the growth effects of the level of human capital stock and its distribution. The results show that countries with initially greater education inequality experiment lower physical and human capital investment rates than countries with more equal education distribution. As a consequent, these low investment rates produce lower income growth rates. Although the results presented in this study tend to confirm the negative effect of education inequality on per-capita incomes and growth rates, the estimation results are likely to be

biased because of the high correlation that exists between the level of human capital stock and its distribution.

Judson (1998) constructs a measure of efficiency in the allocation of educational resources, and finds that countries whose allocations are inefficient gain little from investments in education. That is, compared to countries whose allocations are more efficient, the elasticity of per-capita income to human capital is significantly lower and is insignificantly different from zero. Although interesting, this result faces one criticism concerning the measure of efficiency it is based on. Judson (1998) defines it as the ratio of the achieved to the optimal total rate of return to education. In turn, the optimal rate of return is determined by the optimal enrolment rate at the lower educational level that the policymaker should choose given the distribution of individuals' abilities and the educational costs. That is, allocation efficiency is defined by the optimal level of enrolments in primary education given the cost of each level of education and the distribution of individuals' abilities. Beyond the fact that abilities can only be measured with error, such definition cannot help the planner to determine either the optimal distribution of the population across school levels or the optimal allocation of expenditures.

This chapter aims to contribute to this literature by further examining the issue of the optimal distribution of human capital within an endogenous macro-dynamical model, through employing optimal control principles.

II- A two-stage education model

We consider a closed economy where the population has a fixed size of unity. There are two sectors. One production sector produces consumption goods, and one education sector forms human capital. As in the model developed in the first chapter, we

assume here that human capital investment is hierarchical, and this hierarchy is modelled as a two-stage process. All individuals firstly invest in the basic education level, which is compulsory and has a uniform duration of studies. Then, while some of these individuals choose to drop out with only a basic level of education, others decide to continue investing in the advanced level. Each individual has one period of time to allocate between education and labour.

II-1 Individuals

Individuals with different choices have different technologies of human capital accumulation and production. We distinguish two types of decisions:

a- A typical individual i who invests in basic education accumulates human capital according to the following technology:

$$\dot{H}^{i}_{Bt} = q_B \, l \, H_{At} \tag{1}$$

where subscript t indexes time and $0<l<1$.

There are three inputs in this technology: the compulsory duration of studies at this level, l; the relevant schooling quality, q_B (assumed exogenous and constant) [2], and the average advanced human capital stock, H_{At}. This formulation captures the positive externalities of the economy's average advanced human capital in individuals' accumulation of education at the basic level. In this sense, since the stock of advanced human capital is necessary in the formation of basic human capital, the higher this stock, the more important the individual's accumulation of human capital at the basic level.

2: As in the first chapter, the quality of education in this study can be measured by public expenditures allocated to this sector.

With only basic education, an individual becomes an unskilled worker and has an income (or production) function defined by:

$$Y_{Bt}^{i} = \xi (K_{Bt}^{i})^{\theta} \left[(1-l) H_{Bt}^{i}\right]^{1-\theta} \tag{2}$$

where $0 < \theta < 1$ and ξ is total factors productivity. K_{Bt}^{i} denotes the individual's stock of physical capital, H_{Bt}^{i} is his accumulated stock of human capital, and $1-l$ is his remaining time devoted to working. Output can be consumed or invested. If we note by C_{Bt}^{i} the consumption of this individual, we can write his investment in physical capital as follows:

$$\dot{K}_{Bt}^{i} = Y_{Bt}^{i} - C_{Bt}^{i} \tag{3}$$

This unskilled worker has an utility noted by $U(C_{Bt}^{i})$, which is specified by the following iso-elastic function:

$$U(C_{Bt}^{i}) = \frac{(C_{Bt}^{i})^{1-\sigma} - 1}{1-\sigma} \tag{4}$$

where σ is the inter-temporal substitution elasticity parameter of consumption.

b- A typical individual i who invests in both levels of education accumulates human capital according to this technology:

$$\dot{H}_{At}^{i} = q_{A} (l + n_{t}^{i}) H_{At} \tag{5}$$

where $0 < l + n_{t}^{i} < 1$.

Again, there are three inputs: the fraction of time necessary to be highly educated which is captured by the term $(l + n_{t}^{i})$, with n_{t}^{i} is the fraction of time invested in the

advanced school level; the quality of education devoted to this level, q_A - which is assumed exogenous and constant-; and the average stock of advanced human capital, H_{At}. Once again, the presence of H_{At} in this equation captures the advanced human capital spillovers in the individual's human capital accumulation technology.

This individual becomes a skilled worker and has an income (or production) function given by:

$$Y_{At}^{i} = \zeta (K_{At}^{i})^{\mu} \left[(1-l-n_t^{i}) H_{At}^{i}\right]^{1-\mu} \tag{6}$$

where $0<\mu<1$, and ζ is total factors productivity. K_{At}^{i} denotes the individual's stock of physical capital, H_{At}^{i} is his accumulated stock of human capital, and $1-l-n_t^{i}$ is his remaining time devoted to working.

This individual accumulates physical capital according to the following relation:

$$\dot{K}_{At}^{i} = Y_{At}^{i} - C_{At}^{i} \tag{7}$$

He derives utility from his consumption, $U(C_{At}^{i})$, given by the following function:

$$U(C_{At}^{i}) = \frac{(C_{At}^{i})^{1-\sigma}-1}{1-\sigma} \tag{8}$$

where σ is the inter-temporal substitution elasticity parameter of consumption.

II-2 Optimal individuals' behaviour

II-2-1 The unskilled individual's program

The program of an individual which decides to dropout from the education system just after the basic level consists in choosing the optimal path of consumption

that maximizes his present discounted value of utility. This program may be written as follows:

$$\begin{aligned} &\max_{C^i_{Bt}} \quad W^i_B = \int_0^{+\infty} U(C^i_{Bt})\ e^{-\rho t}\, dt \\ &s.t \quad \dot{K}^i_{Bt} = \xi (K^i_{Bt})^{\theta} \left[(1-l) H^i_{Bt}\right]^{1-\theta} - C^i_{Bt} \\ &\qquad \dot{H}^i_{Bt} = l\ q_B\ H_{At} \end{aligned} \tag{9}$$

where ρ denotes the discount rate.

To characterize the optimal solution, we use Pontryagin's maximum principle. The present-value Hamiltonian for this program is:

$$\boldsymbol{H_1} = U(C^i_{Bt}) + \lambda_{Kt}\left(\xi (K^i_{Bt})^{\theta} \left[(1-l) H^i_{Bt}\right]^{1-\theta} - C^i_{Bt}\right) + \lambda_{Bt}\ l\ q_B\ H_{At}$$

where λ_{Kt}, and λ_{Bt} are the co-state variables defined as the implicit prices associated with the stocks of physical and basic human capital.

First order conditions yield:

$$\begin{aligned} &(C^i_{Bt})^{-\sigma} = \lambda_{Kt} \\ &\dot{\lambda}_{Kt} / \lambda_{Kt} = \rho - (f^i_{Kt})_B \\ &\dot{\lambda}_{Bt} / \lambda_{Bt} = \rho - \left(\lambda_{Kt} / \lambda_{Bt}\right) f^i_{Bt} \end{aligned} \tag{10}$$

where $(f^i_{Kt})_B = \partial Y^i_{Bt} / \partial K^i_{Bt}$ and $f^i_{Bt} = \partial Y^i_{Bt} / \partial H^i_{Bt}$ denote respectively the marginal productivity of physical capital and basic human capital of the unskilled worker. By using the first and second equations of the system (10), we can write the consumption growth rate of the unskilled individual as follows:

$$g_{C^i_B} = \frac{\dot{C}^i_{Bt}}{C^i_{Bt}} = \sigma^{-1}\left((f^i_{Kt})_B - \rho\right) \tag{11}$$

This condition implies that consumption may rise or fall depending on whether the marginal productivity of physical capital exceeds or falls below the rate of time preference.

II-2-2 The skilled individual's program

The program of a representative individual who decides to invest in advanced education is to maximize the present discounted value of utility by choosing the optimal paths of consumption and time devoted to advanced education. That is,

$$\begin{aligned} &\max_{C^i_{At},\, n^i_t} \; W^i_A = \int_0^{+\infty} \mathrm{U}(\mathrm{C}^i_{At})\; \mathrm{e}^{-\rho t}\; \mathrm{d}t \\ &s.t \quad \dot{K}^i_{At} = \zeta (K^i_{At})^{\mu} \left[(1-l-n^i_t) H^i_{At}\right]^{1-\mu} - C^i_{At} \\ &\qquad \dot{H}^i_{At} = q_A (l+n^i_t) H_{At} \end{aligned} \tag{12}$$

where ρ denotes the discount rate.

The present-value Hamiltonian for this program is:

$$\boldsymbol{H_2} = U(C^i_{At}) + \upsilon_{Kt} \left(\zeta (K^i_{At})^{\mu} \left[(1-l-n^i_t) H^i_{At}\right]^{1-\mu} - C^i_{At}\right) + \upsilon_{At}\, q_A (l+n^i_t) H_{At}$$

where υ_{Kt}, and υ_{At} are the co-state variables associated with physical and advanced human capital stocks. First order conditions yield the following system:

$$\begin{aligned} &(C^i_{At})^{-\sigma} = \upsilon_{Kt} \\ &\upsilon_{Kt}\, f^i_{At} = \upsilon_{At} (1-l-n^i_t) q_A \\ &\dot{\upsilon}_{Kt} / \upsilon_{Kt} = \rho - (f^i_{Kt})_A \\ &\dot{\upsilon}_{At} / \upsilon_{At} = \rho - q_A (1-l-n^i_t) \end{aligned} \tag{13}$$

where $(f_{Kt}^{i})_{A} = \partial Y_{At}^{i} / \partial K_{At}^{i}$ and $f_{At}^{i} = \partial Y_{At}^{i} / \partial H_{At}^{i}$ denote respectively the marginal productivity of physical capital and advanced human capital of the skilled worker. By combining the first and third equations of the system (13), the growth rate of consumption of a skilled worker may be written as follows:

$$g_{C_{A}^{i}} = \frac{\dot{C}_{At}^{i}}{C_{At}^{i}} = \sigma^{-1}\left((f_{Kt}^{i})_{A} - \rho\right) \tag{14}$$

II-3 The aggregate economy

In this section, we use the individuals' behaviours to determine the growth rates of the main variables of the model at the aggregate level along the balanced growth path. In order to have symmetric equilibrium at all times one needs to assume identical individuals inside each group of workers; and equality between the marginal productivity of physical capital of skilled and unskilled workers, i.e., $(f_{Kt}^{i})_{B} = (f_{Kt}^{i})_{A} = f_{Kt}$.

Hence, in symmetric equilibrium, Equations (11) and (14) yield the following average growth rate of consumption:

$$g_{C_{A}^{i}} = g_{C_{B}^{i}} = g_{C} = \sigma^{-1}\left(f_{Kt} - \rho\right) \tag{15}$$

Let's Y_{t} note the average production (or income) of the population. We assume that it depends on the average stocks of physical and human capital according to the following Cobb-Douglas technology:

$$Y_{t} = \gamma K_{t}^{1-\alpha-\beta}\left[(1-l-n_{t})H_{At}\right]^{\alpha}\left[(1-l)H_{Bt}\right]^{\beta} \tag{16}$$

where γ is total factor productivity, K_t, H_{At} and H_{Bt} denote respectively the average stocks of physical capital, advanced human capital and basic human capital. $1-l$ represents the average fraction of time that unskilled workers devote to working, $1-l-n_t$ is the average fraction of time supplied by the skilled workers on the labour market, and $(\alpha,\beta) \in]0\ ,\ 1[\times]0\ ,\ 1[$. The average physical capital evolves as follows:

$$\dot{K}_t = Y_t - C_t \tag{17}$$

where C_t denotes average consumption.

If we note by $x_t = C_t / K_t$, the ratio of average consumption to average physical capital, and by $z_t = H_{At} / H_{Bt}$, the ratio of advanced to basic average human capital stocks, we can define from equations (1), (5), (16) and (17) the following growth rates:

$$g_{H_B} = \frac{\dot{H}_{Bt}}{H_{Bt}} = l\, q_B\, z_t \tag{18.a}$$

$$g_{H_A} = \frac{\dot{H}_{At}}{H_{At}} = q_A\,(l+n_t) \tag{18.b}$$

$$g_K = \frac{\dot{K}_t}{K_t} = f_{Kt} / (1-\alpha-\beta) - x_t \tag{18.c}$$

$$g_Y = \frac{\dot{Y}_t}{Y_t} = (1-\alpha-\beta)\, g_K + \alpha\, g_{H_A} + \beta\, g_{H_B} - \left(\alpha\, n_t /(1-l-n_t)\right) g_n \tag{18.d}$$

where g_{H_B}, g_{H_A}, g_K, g_n, and g_Y denote respectively the growth rates of the average basic human capital, the average advanced human capital, the average stock of physical capital, the average duration of advanced education, and the average income.

The balanced growth path is characterized by the constancy of the marginal productivity of the physical capital, f_{Kt}, the constancy of the ratios x_t and z_t, and the constancy of the fraction of time, n_t. Indeed, the constancy of f_{Kt} is necessary to obtain from equation (15) a constant consumption growth rate. Similarly, the constancy of z_t is necessary to get from equation (18.a) a constant growth rate of basic human capital stock. Finally, Equations (18.b) and (18.c) show that f_{Kt}, x_t and n_t must be constant so that the average stocks of physical capital and advanced human capital grow at a constant rate.

The constancy of z_t implies that $g_{H_A} = g_{H_B}$. Similarly, the constancy of x_t implies that $g_C = g_K$. Furthermore, by using the definition of f_{Kt} , it can be deduced from the constancy of n_t and the fact that $g_{H_A} = g_{H_B}$, that $g_K = g_{H_A}$. By using (18.d), it is interesting to show that all the key variables of the model grow in the stationary equilibrium at a same rate given by:

$$g_Y = g_K = g_{H_A} = g_{H_B} = g_C = \sigma^{-1}(f_K^* - \rho) \tag{19}$$

where f_K^* will be next determined.

III - Transition dynamics

We show in this section how the proper mechanisms of the model allow to re-establish the long-run proportionality between basic and advanced human capital stocks during the transition dynamics, when the initial condition of such proportionality is violated in terms of relative scarcity or abundance of the advanced human capital.

To characterize transition dynamics from an initial condition until the optimal distribution of human capital, $z^* = (H_A / H_B)^*$, is reached, we re-write the dynamical system (18.a)-(18.d) as a function of the variables x_t, z_t, f_{Kt} and n_t, which are constant in the stationary equilibrium, i.e.,:

$$g_x = g_C - g_K = x_t + \left(\frac{\delta - \sigma}{\delta \sigma}\right) f_{Kt} - \frac{\rho}{\sigma} \tag{20.a}$$

$$g_z = g_{H_A} - g_{H_B} = q_A (l + n_t) - l\, q_B\, z_t \tag{20.b}$$

$$g_n = \left(\frac{1 - l - n_t}{\alpha\, n_t}\right)\left(f_{Kt} - \delta\, x - (1-\alpha)\, q_A (l + n_t) + \alpha\, l\, q_B\, z_t\right) \tag{20.c}$$

$$g_{f_K} = g_{H_A} - g_K = q_A (l + n_t) + x_t - f_{Kt} / \delta \tag{20.d}$$

where $\delta = 1 - \alpha - \beta$. The expression of g_n is obtained by using the fact that $g_Y = g_{H_A}$ in the stationary equilibrium. By using the definition of the physical capital marginal productivity as well as equation (20.c), it is easy to show that the growth rate of this productivity, g_{f_K}, can be written as in (20.d).

According to the equations (20.a) and (20.d), the constancy of x_t and f_{Kt} implies that:

$$f_{Kt} = \rho + \sigma\, q_A (l + n_t) \tag{21}$$

Since we are focussing on the optimal distribution of two types of human capital, we substitute equation (21) in the system (20.a)-(20.c), and we use first-order conditions in (13) in order to re-write the dynamical model as a function of x_t, z_t, and n_t only. We obtain:

$$g_z = \frac{\rho}{\delta-\sigma} - \frac{\delta}{\delta-\sigma} x_t - l\, q_B\, z_t \tag{22.a}$$

$$g_x = \frac{\delta}{\sigma} x_t + \frac{\delta-\sigma}{\sigma} q_A (l+n_t) - \frac{\rho}{\sigma} \tag{22.b}$$

$$g_n = \frac{1-l-n_t}{\alpha n_t}\left(-\delta x + q_A - (l+n_t)\, q_A (1+\delta)\right) \tag{22.c}$$

As pointed out above, along the balanced growth path, x_t, z_t and n_t are constant, i.e., $g_x = g_z = g_n = 0$. This implies the following steady state equilibrium values:

$$\begin{aligned} z^* &= \frac{(q_A-\rho)}{l\, q_B (1+\sigma)} \\ x^* &= \frac{\rho(1+\delta)+(\sigma-\delta) q_A}{\delta(1+\sigma)} \\ (l+n^*) &= \frac{q_A-\rho}{q_A(1+\sigma)} \end{aligned} \tag{23}$$

Notice that an implicit assumption of the model stemming from the system (23) is that $q_A > \rho$. By using the equilibrium values in (23), the relation (21) yields:

$$\begin{aligned} f_K{}^* &= \rho + \sigma\, q_A (l+n^*) \\ &= \frac{\rho+\sigma q_A}{1+\sigma} \end{aligned} \tag{24}$$

Substituting (24) in (19) allows re-writing the long-run growth rate as follows:

$$g_Y = g_K = g_{H_A} = g_{H_B} = g_C = \left(\frac{q_A - \rho}{1+\sigma}\right) \tag{25}$$

To determine the stability of this steady state equilibrium, we study the linear differential equation system that approximates (22.a), (22.b) and (22.c) at z^*, x^* and n^*. This linearization yields the following system [3].

$$\begin{bmatrix} \dot{z} \\ \dot{x} \\ \dot{n} \end{bmatrix} = \begin{bmatrix} \phi_z & \phi_x & \phi_n \\ \psi_z & \psi_x & \psi_n \\ \Omega_z & \Omega_x & \Omega_n \end{bmatrix} \begin{bmatrix} z - z^* \\ x - x^* \\ n - n^* \end{bmatrix} \tag{26}$$

where the elements of the Jacobian matrix evaluated at the steady state are:

$$\phi_z = \frac{\partial \dot{z}}{\partial z} = \frac{\rho - q_A}{1+\sigma} < 0, \qquad \phi_x = \frac{\partial \dot{z}}{\partial x} = \frac{\delta}{\sigma - \delta} z^* > ?< 0, \qquad \phi_n = \frac{\partial \dot{z}}{\partial n} = 0,$$

$$\psi_z = \frac{\partial \dot{x}}{\partial z} = 0, \qquad \psi_x = \frac{\partial \dot{x}}{\partial x} = \frac{\delta}{\sigma} x^* > 0, \qquad \psi_n = \frac{\partial \dot{x}}{\partial n} = \frac{\delta - \sigma}{\sigma} q_A > ?< 0,$$

$$\Omega_z = \frac{\partial \dot{n}}{\partial z} = 0, \qquad \Omega_x = \frac{\partial \dot{n}}{\partial x} = -\frac{\delta(\rho + \sigma q_A)}{\alpha(1+\sigma) q_A} < 0, \qquad \Omega_n = \frac{\partial \dot{n}}{\partial n} = -\frac{(1+\delta)(\rho + \sigma q_A)}{\alpha(1+\sigma)} < 0.$$

The notation "$>?<0$" associated with ϕ_x and ψ_n means that the sign of these two elements is either positive or negative depending on the sign of $(\delta - \sigma)$.

The eigenvalues of the Jacobian matrix determine the local stability properties of the economy. These eigenvalues are defined as the roots of the characteristic equation generated by the Jacobian matrix. This characteristic equation is given by: $\det(\kappa I - J)$, with κ is an eigenvalue, J is the Jacobian matrix, and 'det' is the determinant of the matrix $(\kappa I - J)$. We present in the Appendix (A) the different stability patterns of a given equilibrium.

3: Linearizing around the steady state permits to study the dynamic and stability of a non-linear system of equations by transforming it to a linear one. This consists on calculating the Jacobian matrix of the system and evaluating it at the steady state equilibrium.

At the steady state, the characteristic equation writes:

$$\kappa^3 - \kappa^2 (\phi_z + \psi_x + \Omega_n) + \kappa[\phi_z \psi_x + \Omega_n (\phi_z + \psi_x) - \psi_n \Omega_x] + \phi_z (\psi_n \Omega_x - \psi_x \Omega_n),$$

which has the following roots:

$$\kappa_1 = \frac{\psi_x + \Omega_n}{2} + \frac{\Delta^{1/2}}{2},$$
$$\kappa_2 = \frac{\psi_x + \Omega_n}{2} - \frac{\Delta^{1/2}}{2},$$
$$\kappa_3 = \phi_z$$

where $\Delta = (\psi_x - \Omega_n)^2 + 4\psi_n \Omega_x$

The sign of κ_3 is negative, while the signs of κ_1 and κ_2 depend on σ and δ. It is worthwhile to distinguish three cases, which after some calculations give the following signs:

If $\underline{\sigma > \delta}$, we have $\psi_n < 0$ and $\Delta > 0$. It follows that $\kappa_1 > 0$ and $\kappa_2 < 0$.

If $\underline{\sigma < \delta}$, we have $\psi_n > 0$ and $\Delta > 0$. It follows that $\kappa_1 > 0$ and $\kappa_2 < 0$.

If $\underline{\sigma = \delta}$, we have $\psi_n = 0$ and $\Delta > 0$. It follows that $\kappa_1 > 0$ and $\kappa_2 < 0$.

Hence, in all the cases we have $\kappa_1 > 0$, $\kappa_2 < 0$, and $\kappa_3 < 0$, which imply that the stationary equilibrium is a stable saddle-point.

Figures 1-a, 1-b, and 1-c, shown below, present a graphical solution of the transitional dynamics of the model, using phase diagrams for $\sigma < \delta$, $\sigma > \delta$ and $\sigma = \delta$, respectively.

In all of the figures, the system (22.a)-(22.c) is represented by the three corresponding curves in phases (I) and (II). In phase (III), we represent a 45° line in the (n_t, n_t) plane in order to relate phase (II) with phase (IV). Finally, phase (IV) represents,

once again, the equation $g_z = 0$ in order to display z_t as a function of n_t [4]. This phase relates phase (III) with the other phases of the diagram.

We begin the discussion of the diagrams by assuming that at the initial period, say at $t=0$, the economy is characterised by scarcity in advanced human capital relative to basic human capital, so that the ratio z_0 is under-adjusted relative to its long-run level, z^*. Therefore, z_0 should increase until z^* is reached.

The convergence of z_0 to its long-run level is determined by the transition paths of the consumption ratio, x_t, and of the fraction of time allocated to advanced human capital investment, n_t. Whether the initial levels of x_0 and n_0 are under-adjusted or over-adjusted relative to their respective stationary levels, x^* and n^*, respectively, depends on the inter-temporal substitution elasticity parameter of consumption, σ.
In all of the cases, the diagrams show a unique path that allows reaching the stationary long-run equilibrium.

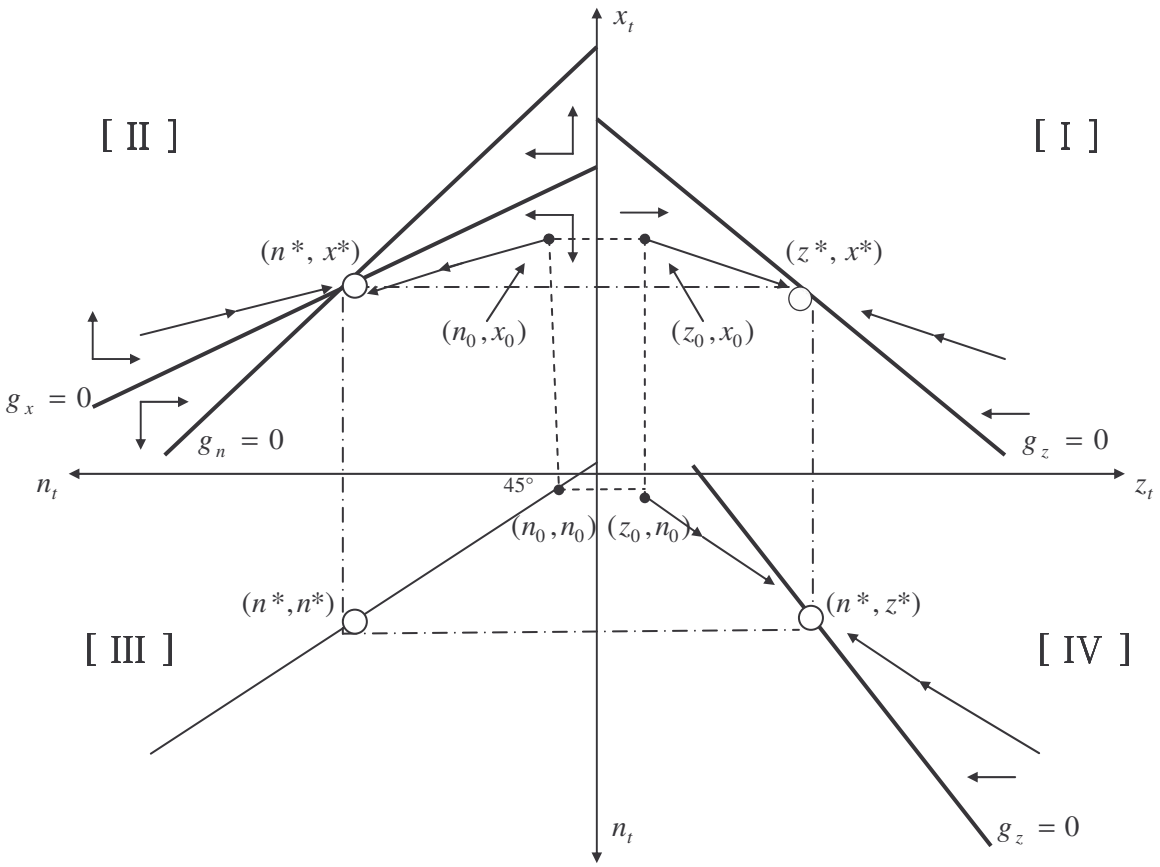
Case 1: $\sigma < \delta$

This is a situation where consumers permute easily present and future consumption (σ is low). In this case, each of the locus $g_z = 0$, $g_x = 0$ and $g_n = 0$ are represented in phases (I) and (II) by a downward sloping curve.

4 : By using the relation (20.b), it's easy to show that z_t is monotonically increasing in n_t along the transition path. i.e., $z_t = (l + n_t)\, q_A \,/\, l\, q_B$.

It follows that when z_0 is under-adjusted, the initial ratio of consumption, x_0, is over-adjusted relative to its equilibrium level, x^*, while the initial fraction of time allocated to advanced education, n_0, is under-adjusted relative to its long-run level, n^*. Therefore, the steady state will be approached monotonically, with x_t falling and n_t growing. This adjustment increases the ratio of relative human capital stocks, z_t, until it reaches the equilibrium value z^*. Indeed, the increase in n_t favours the accumulation of human capital at the advanced level and raises the ratio of z_t as shown in phase (IV).

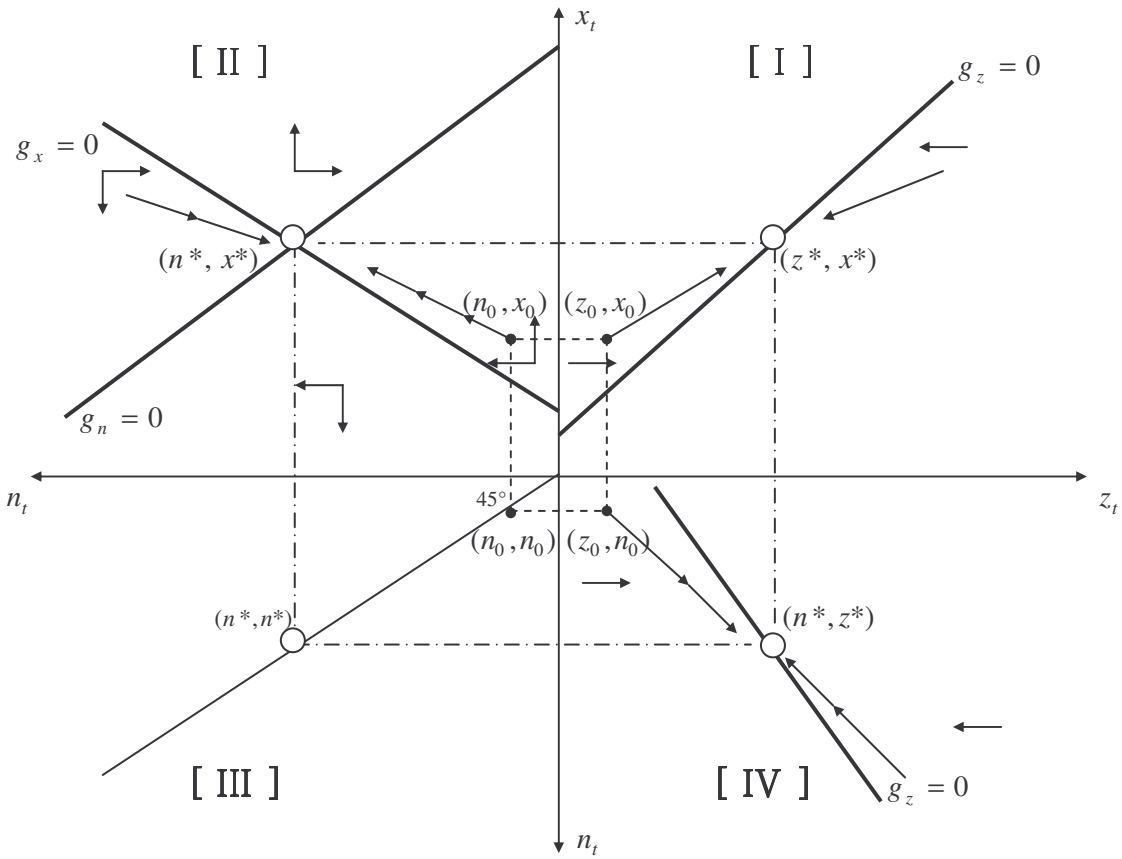
Figure 1-a: *Transition phase diagram and optimal human capital distribution: case of* $\sigma < \delta$



Case 2: $\sigma > \delta$

This is the case of a low degree of substitution between present and future consumption. The locus $g_z = 0$ and $g_x = 0$ are now represented in phases (I) and (II) by two upward sloping curves, while the locus $g_n = 0$ is still represented by the downward sloping curve, as in the previous case. In this situation, for any $z_0 < z^*$, both x_0 and n_0 must increase to reach their stationary values. This adjustment allows increasing the average stock of advanced human capital, and thereby re-establishing proportionality between advanced and basic human capital stocks.

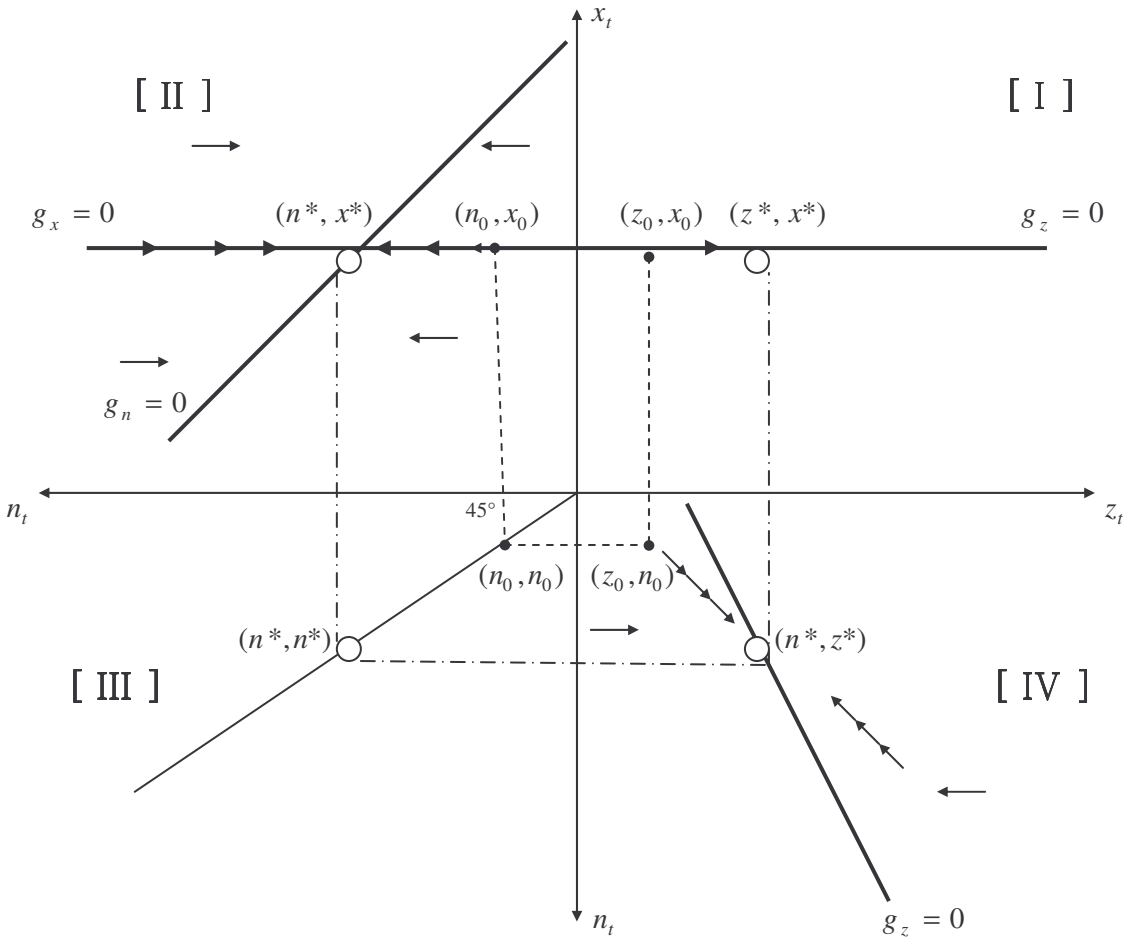
Figure 1-b: *Transition phase diagram and optimal human capital distribution: case of* $\sigma > \delta$



Case 3: $\sigma = \delta$

This case illustrates a situation where σ is moderate. The locus $g_z = 0$ and $g_x = 0$ are illustrated in phases (I) and (II) respectively by two horizontal curves. The ratio of x_0 is well-adjusted relative to its long-run equilibrium level, $x^* = \rho/\sigma$. By contrast, as long as n_t is decreasing in x_t, it follows from the $g_n = 0$ locus that the initial ratio of n_0 is under-adjusted relative to its equilibrium level. Under this condition, the dynamic consists simply of increasing the ratio of n_0 along the curve $g_x = 0$ until n^* is reached.

Figure 1-c: *Transition phase diagram and optimal human capital distribution: case of* $\sigma = \delta$



This shift speeds the average growth rate of advanced human capital stock, and brings the ratio of z_0 to its long-run level, z^*, as illustrated in phase (IV) of the figure.

In the following proposition, the optimal transition dynamics of the model are summarized:

Proposition 1:

Starting from an initial position with relative scarcity in advanced human capital (z_0 is low), the optimal transition path involves an increase in the duration of advanced education, n_t, to reach its long-run level. The ratio of consumption, x_t, decreases, increases, or remains constant along the transition depending on the level of σ, the inter-temporal substitution elasticity parameter of consumption. The steady state equilibrium is found to be a saddle.

IV- Comparative static analysis

Comparative static analysis of the steady state can be made. We focus on the effects of varying the quality of education at the advanced and basic schooling levels, q_A and q_B, respectively, at a given period t of transition. According to the dynamical system (22.a)-(22.c) and the stationary levels given in (23), such a variation has both transitional and long-run effects.

IV-1 The impact of improving the quality of education at the advanced level

An increase in the quality of education at the advanced schooling level, q_A, shifts the stationary equilibrium curves $g_x = 0$ and $g_n = 0$, and thereby involves new long-run equilibrium values. These effects differ with respect to the cases considered above.

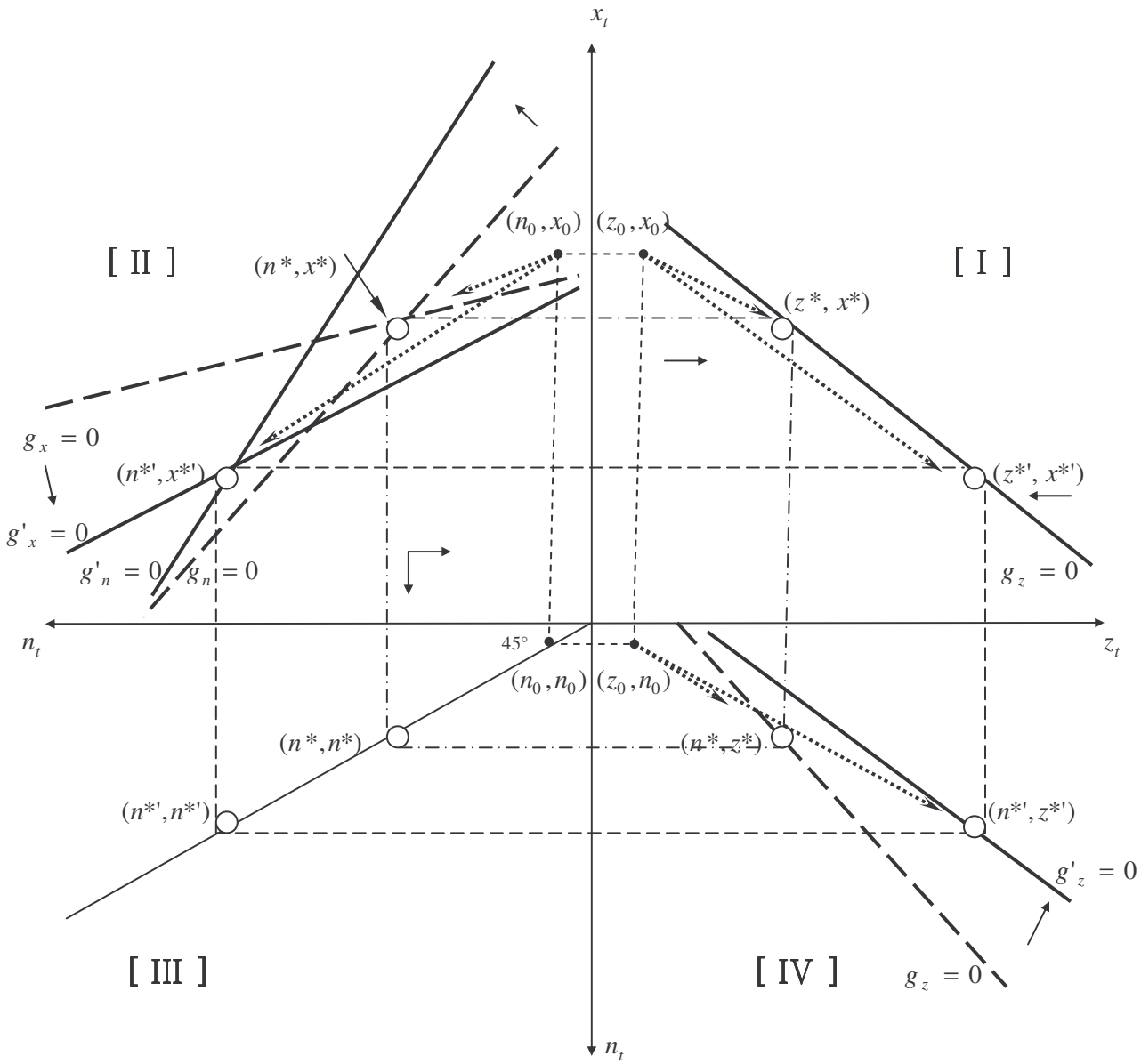
Case 1: $\sigma < \delta$

This case is illustrated in Figure 2-a. An improvement in q_A lowers the $g_x = 0$ locus and raises the $g_n = 0$ locus. The new curves are represented in the figure by $g'_x = 0$ and $g'_n = 0$, respectively. The shift in the equilibrium curves involves new long-run stationary values of n^* and x^*. Specifically, the equilibrium ratio of consumption decreases, while the duration of studies in advanced education increases. The new combination is now $(x^{*'}, n^{*'})$ in the figure.

The upward shift in n^* results in an upward shift in the locus $g_z = 0$, as illustrated in phase (IV) of the figure. This, in turn, raises the equilibrium ratio of relative human capital stocks from z^* to $z^{*'}$. The two optimal transition paths before and after varying the quality of advanced education, q_A, are shown in the figure by the dotted arrows.

It is worthwhile to point out that one can evaluate the effects of varying q_A on the long-run equilibrium ratios by referring to the relations given in (23). Clearly, it can be found that: $\partial n^*/\partial q_A > 0$, $\partial z^*/\partial q_A > 0$, and $\partial x^*/\partial q_A < 0$ if $\sigma < \delta$, and $\partial x^*/\partial q_A > 0$ if $\sigma > \delta$.

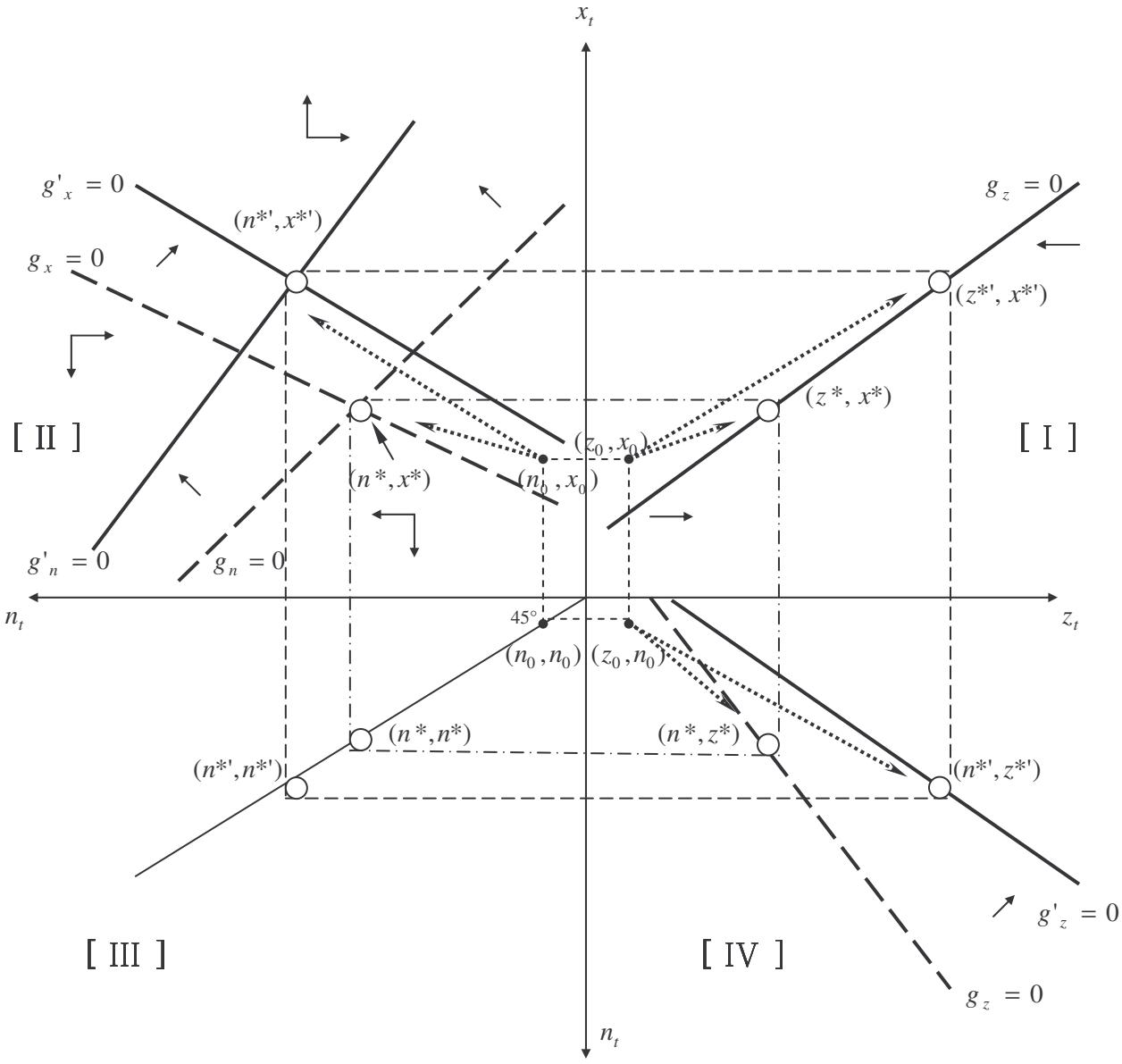
Figure 2-a: *The impact of improving* q_A *: case of* $\sigma < \delta$



Case 2: $\sigma > \delta$

The effects of improving the quality of advanced education, q_A, are depicted, in this case, in Figure 2-b below. Because the equilibrium locus $g_x = 0$ and $g_n = 0$ are now increasing, an increase in q_A shifts up both locus. The new intersection involves a new optimal transition path, which yields a higher equilibrium ratio of consumption, and a longer duration of advanced education.

Figure 2-b: The impact of improving q_A : case of $\sigma > \delta$

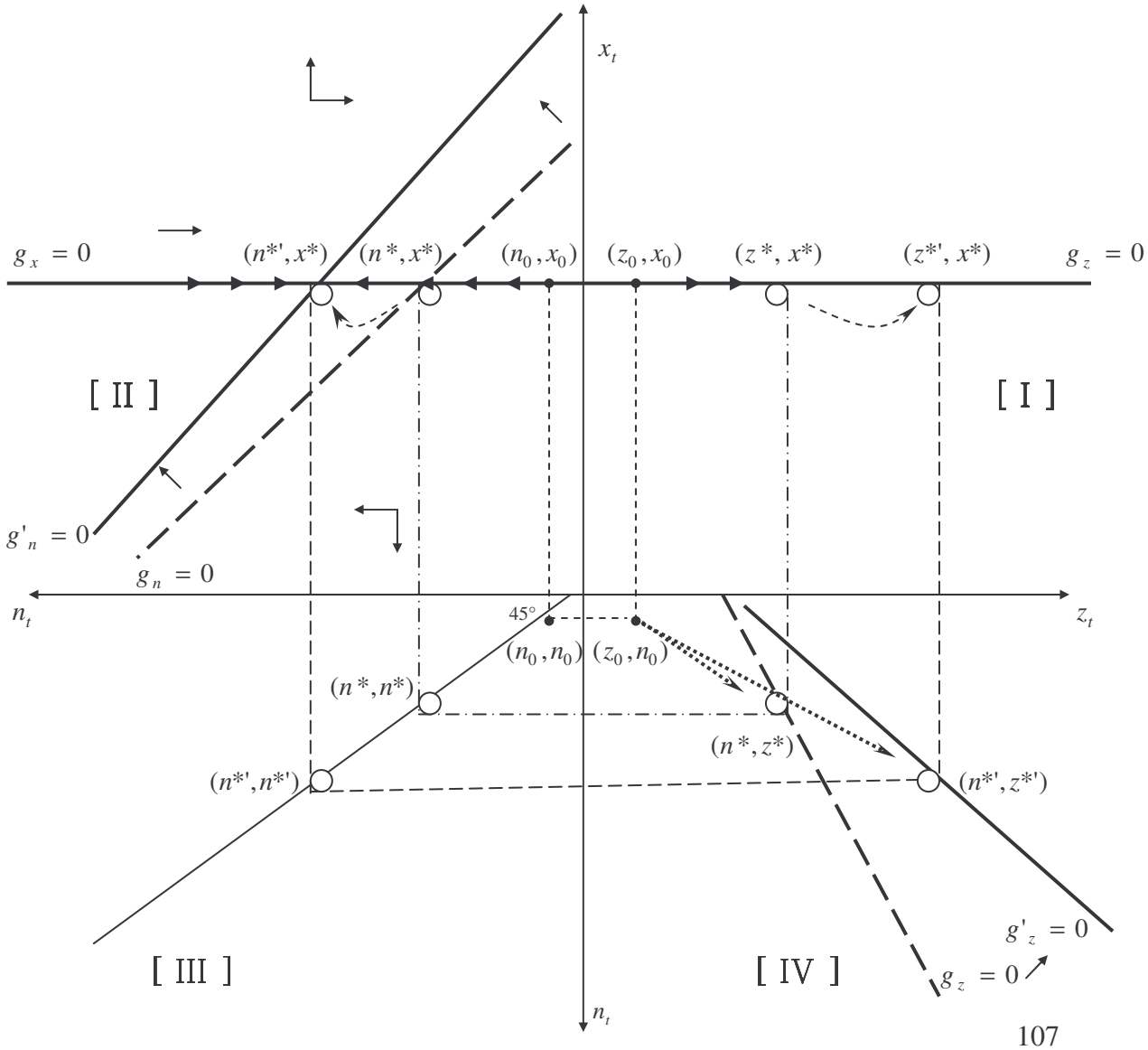


Phase (IV) of the diagram shows that the upward shift in n_t is associated with an upward shift in the ratio of relative human capital stocks, z_t. This adjustment yields a higher equilibrium ratio of z^*, which is noted in the figure by $z^{*\prime}$.

Case 3: $\sigma = \delta$

Under this condition, an improvement in q_A results in an upward shift in the equilibrium locus $g_n = 0$. The $g_x = 0$ locus is still represented in Figure 2-c by a horizontal curve, so that the long-run equilibrium ratio of consumption, x^*, remains unaffected by the variation in q_A.

Figure 2-c: *The impact of improving* q_A*: case of* $\sigma = \delta$



It follows that the average duration of advanced education n_t increases along the curve $g_x = 0$ until reaching the new equilibrium combination, $(n*', x*)$. The adjustment in n_t is associated with an upward shift in the transition path of the ratio z_t towards its equilibrium value. The latter rises from $z*$ to $z*'$ in the figure.

Finally, it is crucial to underline that, independently of σ, Equations (18.b) and (18.d) show that an increase in q_A accelerates the growth rate of g_{H_A}, which, in turn, results in a higher growth rate of the economy along the transition path. This implies a faster convergence toward the long-run equilibrium. In the long-run, the increase in q_A also leads to an increase in the equilibrium growth rate of the economy, as can be deduced from Equation (25), i.e., $\partial g_Y / \partial q_A > 0$.

Notice that the growth effect of the improvement in the quality of advanced education may also stem from the increase in the stationary duration of advanced education, $n*$, that accompanies such improvement, as shown in Equation (23).

IV- 1 The impact of improving the quality of education at the basic level

This section briefly discusses the impacts of improving the educational quality at the basic schooling level on the optimal transition paths and the long-run equilibrium. An increase in q_B fosters the growth rate of basic human capital, g_{H_B}, and leaves unaffected the growth rate of advanced human capital, g_{H_A}, as can be seen from Equations (18.a) and (18.b). Therefore, following Equations (22.a)-(22.c), this policy

scheme implies a new transition path along which only the equilibrium locus $g_z = 0$ shifts, while the $g_x = 0$ and $g_n = 0$ curves are left unchanged.

Figures 3-a, 3-b, and 3-c in the Appendix (B) depict the new transition paths and long-run equilibrium combinations associated with this policy for different cases of σ. It is crucial to underline that, although the improvement in q_B has no effect on the long-run growth rate, g_Y, as it comes out from Equation (25), it fosters this growth rate during the transition - as can be deduced from Equations (18.a) and (18.d). That is, the increase in q_B leads to reaching the long-run equilibrium growth rate more rapidly.

Case 1: $\sigma < \delta$

In this case, and according to Equation (22.a), an increase in q_B shifts down the stationary equilibrium curve $g_z = 0$ as illustrated in phase (I) of the diagram. This policy does not affect the equilibrium curves in phase (II), so that the long-run combination of (n^*, x^*) is unchanged. Thereby, the optimal transition path involves an increase in the equilibrium ratio of basic to advanced human capital stocks, or equivalently, a decrease in the ratio of z^* towards $z^{*\prime}$, as illustrated in Figure 3-a.

Case 2: $\sigma > \delta$

The same mechanism of adjustment toward the new steady state equilibrium is involved here. Improving the quality of basic education, q_B, fosters the accumulation rate of basic human capital, and thereby lowers the ratio of z_t. In the long run, this ratio converges to a lower value, $z^{*\prime}$. The long-run values of consumption and duration of advanced education are unaffected by the change in q_B. The adjustment of z_t is represented in Figure 3-b by the upward shift in the $g_z = 0$ locus.

Case 3: $\sigma = \delta$

As in the previous cases, the equilibrium value of z^* is decreased as a result of increasing q_B. This is illustrated in Figure 3-c by the downward shift in the locus $g_z = 0$ in phase (IV) until the new equilibrium of $z^{*'}$ is reached. Once again, both optimal long-run ratios of consumption and duration of advanced education are left unchanged.

The proposition below sums up the results established in the comparative static analysis:

Proposition 2:

a- *An improvement in the quality of advanced education, q_A, has both transitional and long-run effects:*

- In the short-run, it results in an upward shift in the optimal transition path of the duration of advanced education, n_t, which in turn is associated with an upward shift in the optimal transition path of advanced to basic human capital ratio, z_t. The increase in q_A also accelerates the growth rate of the economy, g_Y, during the transition.

- In the long-run, the equilibrium values of n^* and z^* are increased, and the economy grows at a faster rate.

b- *An improvement in the quality of basic education, q_B, has the following effects:*

- In the short-run, it promotes the accumulation rate of basic education, and thereby, it shifts down the optimal transition path of the ratio of z_t. It also increases the growth rate of the economy, g_Y, during the transition path.

- In the long-run, the equilibrium value of z^* is decreased while the long-run growth rate of the economy is left unaffected.

Conclusion

The model considered here is an attempt to contribute to the recent macroeconomic literature on the optimal distribution of human capital. It addresses the issue of how to determine the optimal distribution of human capital across basic and advanced stages of education. Its main novelty is its explicit formalization of the economy's transitional dynamics and long-run equilibrium within an endogenous growth framework that employs optimal control principles. As long as basic education is compulsory, the shift in the distribution of human capital toward its equilibrium level is determined by the evolution of the duration of studies at the advanced level, and that of consumption level.

The analysis shows that, with initial situation of scarcity in the advanced human capital, the duration of studies should increase until reaching the equilibrium level, while the evolution of consumption during the transition depends on the inter-temporal substitution elasticity parameter of consumption. We also show that, along the transition and in the long-run as well, the ratio of advanced to basic human capital stocks increases with the quality of education allocated to the advanced level, whereas it decreases in the quality of the basic educational level. Furthermore, we find that the economy's growth rate increases in both the transition phase and the long-run as the quality of advanced education improves. However, an improvement in the quality of education at the basic level does not affect the long-run growth rate, but speeds the transition toward the steady state equilibrium.

Appendix (A)

- The solution to an *arbitrary pair* of linear differential equations may exhibit the following patterns:

a- *The eigenvalues are real and of opposite signs*: the stationary point is a stable saddlepoint.

b- *The eigenvalues are real and both positive*: the path of the differential equations cannot converge to the steady state. It will move away from it. The stationary point is thus unstable.

c- *The eigenvalues are real and both negative*: the equilibrium would be completely stable with all paths converging to it.

d- *The eigenvalues are complex with negative real part*: the paths would show transitory oscillations until they reach the steady state, which is stable.

e- *The eigenvalues are complex with positive real part*: the paths move away the steady state with transitory oscillations.

- In a more general case of n linear differential equations, the solution may exhibit the following patterns:

a- *all the eigenvalues have negative real parts*: the equilibrium is completely stable.

b- *all the eigenvalues have positive real parts*: the equilibrium is unstable.

c- *both eigenvalues with positive and negative real parts are non-zero*: the equilibrium is a saddle point.

Appendix (B): *Phase diagrams associated with the improvement in* q_B.

Figure 3-a: *The impact of improving* q_B*: case of* $\sigma < \delta$

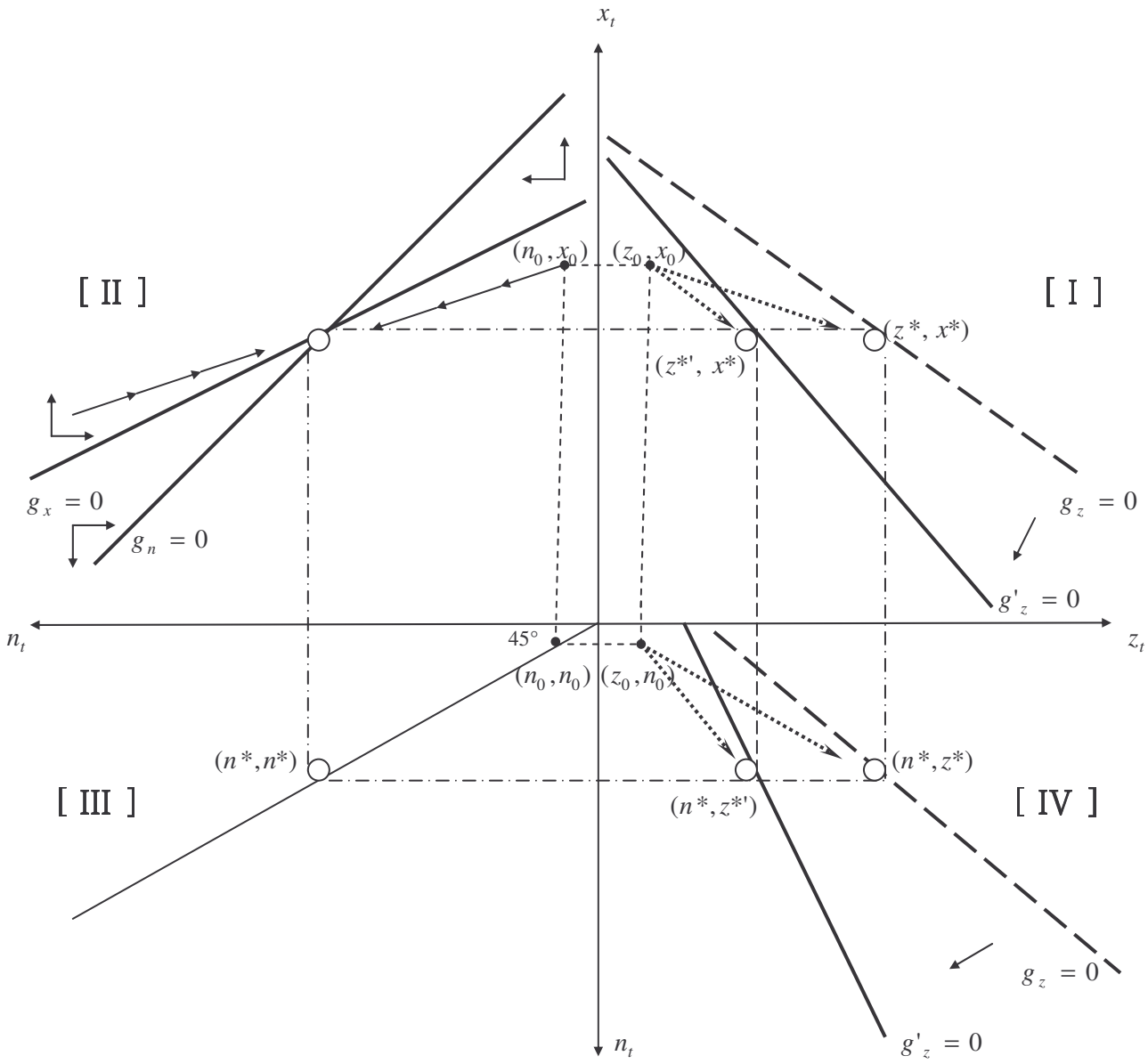


Figure 3-b: *The impact of improving* q_B*: case of* $\sigma > \delta$

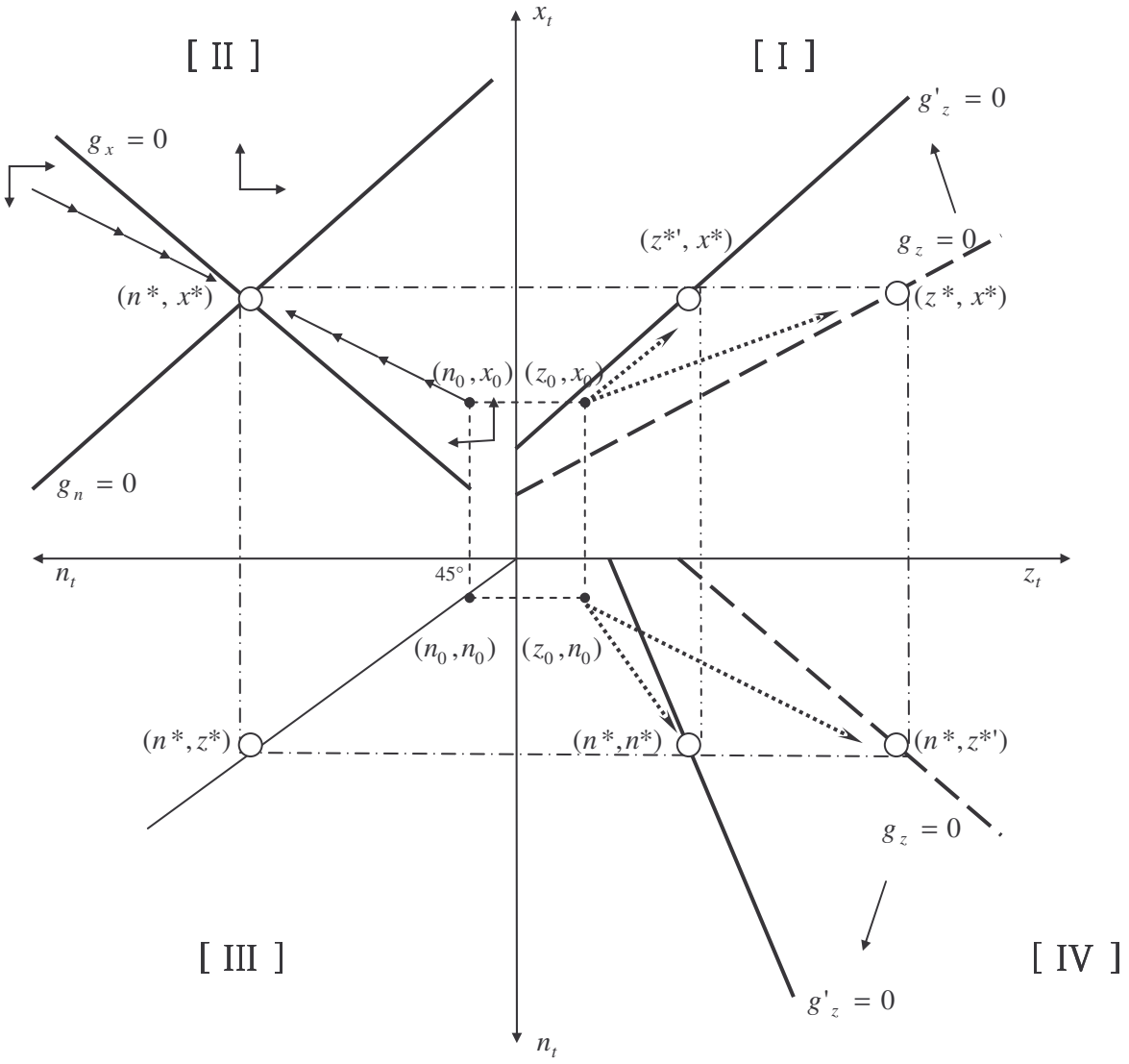
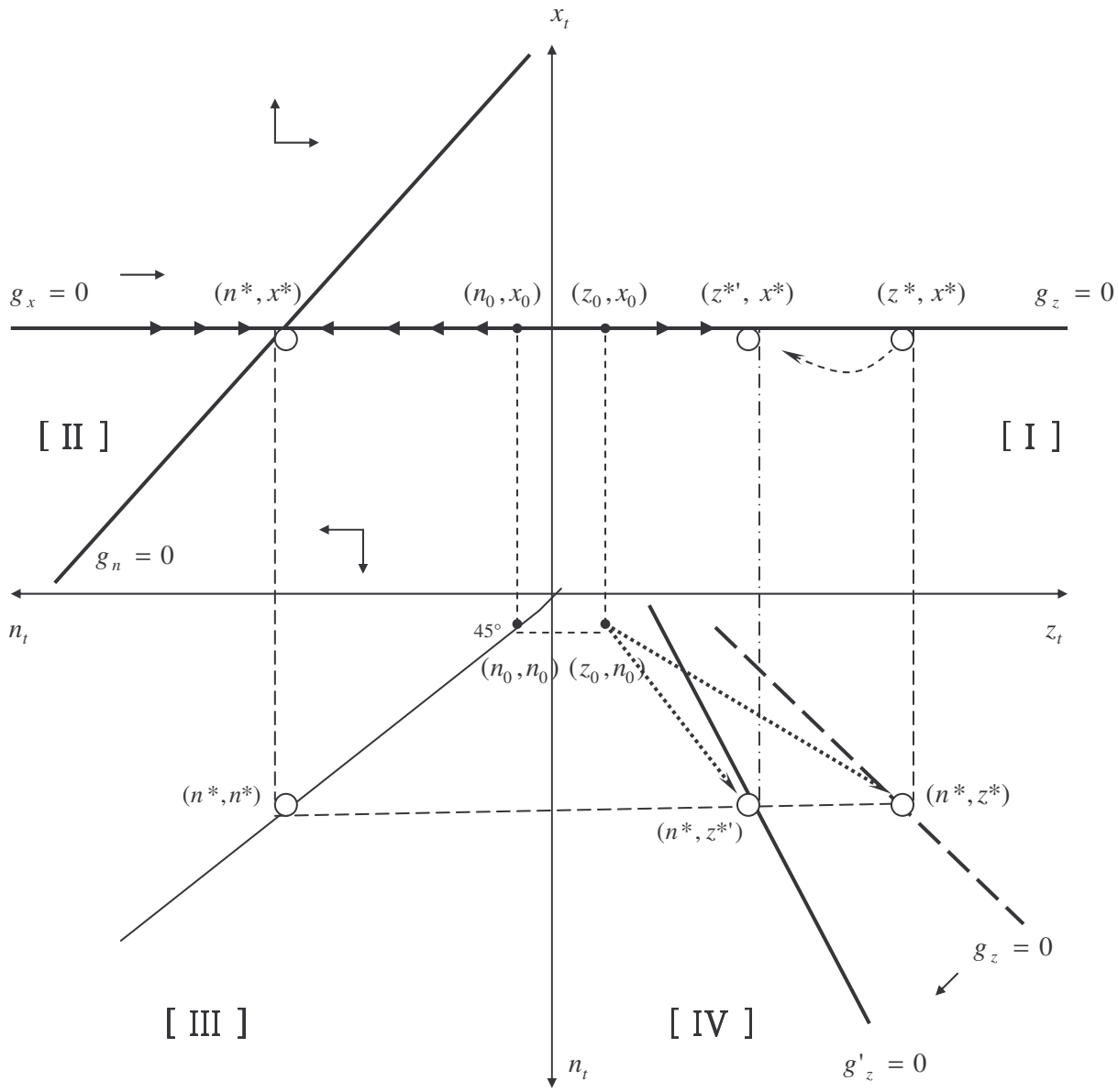


Figure 3-c: *The impact of improving* q_B*: case of* $\sigma = \delta$



Chapter III

Redistribution through education and tax policies under capital-market imperfections and uncertainty: a welfare analysis *

Introduction

The aim of this chapter is to compare the impacts of public education provisions and those of fiscal redistribution policies on the distribution of skills and incomes, and on economic efficiency and social welfare. In the first part of the chapter, we confront the implications of the education subsidy program with those of two tax policies: a negative income tax, where all individuals receive a lump-sum income transfer, and an unskilled wage subsidy financed through an income tax levied on skilled wage labour.

We embed our study of the general-equilibrium implications of the considered policies within a two-period model. In addition, we consider the hypotheses that capital markets are imperfect; skilled and unskilled labour are complements in the production function; and the education process involves failure risk. This risk is associated with the uncertainty feature of investment in education, and it arises in our study because of the heterogeneity in individuals' abilities to successfully complete education.

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*: *This chapter is a detailed version of a published paper in "LABOUR: Review of Labour Economics and Industrial Relations", vol 19 (2), 191-236, (2005).*

This feature has at least one major implication, which makes our conclusions different from those addressed in previous works in this line of research. In fact, with higher subsidies to education, more people can invest and, because of the risk associated with this investment, more people are likely to fail in completing their education. This implies that a higher tax rate that finances education subsidies finances a higher marginal failure rate as well. It follows that the efficiency impact of the education subsidy policy is decreasing in the tax rate.

To evaluate social welfare, we consider an isoelastic function, which is based on individuals' utilities and which allows for parametric variation of inequality aversion. In comparing the policies' outcomes, we make a distinction between the *ex-ante* and *ex-post* evaluations. Indeed, whether outcomes are evaluated in *ex-ante* or *ex-post* sense, they differ too much, and the policies may even change place in the orderings. *By the 'ex-ante evaluation', we mean the evaluation of outcomes before the adjustments in labour remunerations—which accompany the individuals' educational decisions—are known. The 'ex-post evaluation', however, is based on outcomes observed after these adjustments have been realized.* Both analytical and numerical simulation techniques are employed in this study in order to perform such comparisons.

We find that relative to the no-government case, the three policies provide more equality in the *ex-ante* point of view, and this equality is the highest under the unskilled wage subsidy policy. In *ex-post* sense, however, inequality increases under the unskilled wage subsidy and the negative income tax policies, while it decreases under the education subsidy regime. Therefore, on the contrary to some studies that have pointed out the reverse redistribution feature of the education subsidies policy (see Fernandez and Rogerson (1995) and Penalosa and Wälde (2000)), our study shows that this feature may not be a problem in an *ex-post* point of view, as unskilled workers benefit from the

tax-subsidy system because of the complementarities in the production technology between the two types of labour.

In terms of social welfare, we show that *ex-post*, the education subsidy policy is optimal, provided that the degree of inequality aversion is quite high and the tax rate is not too distortive. In fact, while education subsidies have positive effects on equality, they are also a source of efficiency losses because of the extra-schooling failure rate that this policy generates. Hence, this policy regime raises the issue of the efficiency/equality trade-off.

Beyond this issue, this policy can neither completely remove liquidity constraints that bind the poor nor reduce the risk associated with the educational investment. In light of these issues, a natural question is whether there is a 'better mechanism' to finance education. The second part of this chapter aims to answer this question.

Numerous studies evoke public education loans as a solution to overcome credit-constraints that stem from capital-market imperfections. We show that the general equilibrium effects of the loan policy depend on the way the loan is implemented. This is illustrated by studying three public loan schemes: i) a scheme of pure public loan, under which all individuals may borrow from the government the amount needed to finance education and pay it back once they start working, irrespective of whether they have completed their education, ii) a combination of pure public loan and education subsidies, where subsidies are fully financed through skilled labour wage taxation, and iii) a conditional loan reimbursement, where only those who successfully complete their education will pay back the loan they have borrowed. Several interesting results emerge from the comparison among these three alternatives.

First, relative to the no-government-intervention situation, the pure public loan removes completely the borrowing constraints and leads to more equality with zero efficiency cost. Hence, this policy eliminates the efficiency/equality trade-off issue.

Under-investment, however, is still high because the risk associated with this investment is important—a risk that is even more important than under the education subsidy policy. Therefore, investment in human capital is lower under the pure public loan policy than the education subsidy program.

Second, combining the pure public loan and the education subsidies reduces this risk and leads to more investment in human capital than does the pure public loan alone. This combination raises equality but at the cost of some distortion effects. Therefore, this policy is optimal only when the degree of inequality aversion is relatively high; otherwise, the pure public loan policy is optimal.

Finally, under the conditional loan policy all individuals decide to invest in education, as the risk associated with failure is completely eradicated. This 'over-education' harms efficiency, however, as it dramatically depresses the skill premium. Therefore, although this policy considerably reduces inequality, it is not optimal.

The analysis pursued in this chapter should be considered as complementary to the recently increasing literature on the impact of public education provisions on welfare. Yet the literature has recognized that fiscal redistribution harms efficiency because taxation distorts labour supply and discourages incentives to accumulate human capital. This view is essentially shared in numerous studies based on the theory of political economy, as more inequality implies a higher level of voted tax, which in turn distorts labour supply and saving [1].

1: Persson and Tabellini (1994), Alesina and Rodrik (1994), Nielson and Sorensen (1997), and Milanovic (2000) show that greater inequality leads—via the political mechanism—to greater redistribution and thus more distortionary taxation which, in turn, reduces growth. Orazem and Lesfatsion (1997) demonstrate that in the case where children base their educational decisions on their parents' after-tax returns to schooling, income redistribution can result in sub-optimal effort choices that offset the beneficial effects of parental transfers and lower welfare.

Some other papers, however, show that the distortion effects of redistribution can be offset, if taxes are used to finance education subsidies. For instance, S. Paul and Verdier (1993) show that public education provisions financed through income tax increase aggregate human capital, and tend to make a more equal income distribution. In Bénabou (1996, 2000, 2002), the decline in labour supply and savings due to taxation is shown to be fully offset by the education subsidies that restore the investment rate. Bovenberg and Jacobs (2001) demonstrate that education subsidies may alleviate the inefficiency caused by taxes, because they reduce the impact of the tax system on learning decisions.

Like these studies, our analysis shows that education subsidies may offset the distortion effects of taxation and lead to higher efficiency. Nevertheless, in contrast to these works, we show that this result holds provided that outcomes are evaluated in *ex-ante* terms and that the tax rate is not too high. Indeed, in *ex-post* terms, efficiency decreases as a result of increasing the subsidy rate because the labour wage of skilled workers decreases, while that of unskilled workers increases. In addition, the tax rate must not be too high in order to limit the cost associated with the extra-failure rate that stems from the risk aspect of the educational investment.

Janeba (2000) finds a result similar to the one predicted by our model. He compares the negative income tax policy to the education subsidies regime in an economy that faces a widening wage gap between skilled and unskilled workers, as a result of a more intensified foreign competition. The study shows that education subsidies are a useful tool for increasing welfare, provided that the inequality aversion is quite high and financing the subsidy is not too distortive. Some implicit assumptions in this paper, however, are that capital markets are perfect and there is no risk associated with educational investment.

Under the same assumptions, Barthélémy (2000) explores the optimal schedule of taxation when the individuals' decisions with regard to education depend on the personal training effort and the productivity of the public education system. The author shows that education is subsidized unless the effect of intergenerational transfer externality on the schooling effort is relatively low. Otherwise, education is taxed. This study, however, considers a utilitarian welfare function, such that no consideration is given to inequality. Contrary to this paper, we demonstrate that taxing skills reduces incentives to acquire education, which consequently raises inequality in *ex-post* terms. Such a policy, therefore, cannot be optimal if the society is averse to inequality. Hanushek, Leung and Yilmaz (2001) find—as in our study—that the education subsidy regime is associated with more equality than are the negative income tax and unskilled wage subsidy. Because capital markets are assumed to be perfect, this analysis does not offer any alternative (such as public education loans), which treats the equality/efficiency trade-off stemming from the education subsidy policy. The paper of Penalosa and Wälde (2000) is one rare and interesting case that explores the implications of public loans when individuals are borrowing-constrained. Contrary to our study, however, this paper focuses only on the *ex-ante* evaluation of the outcomes and does not study these implications for the distribution of skills and social welfare.

The remainder of this chapter is organized as follows: Section I presents the model in the benchmark case of no government intervention, and briefly determines schooling attendance and success rates under the regimes of education subsidy, the negative income tax, and the unskilled wage subsidy. Section II uses both analytical and numerical solutions to compare these policies in terms of their effects on efficiency and equality in both *ex-ante* and *ex-post* points of view. Finally, Section III introduces the public loan system under several schemes and compares the effects of each scheme with the competitive economy and the education subsidy policy.

I - The model

The model focuses on the role of public schooling and transfers in an economy where the social planner cares about both economic efficiency and inequality. In the context of capital-market imperfections, the government intervenes through multiple redistributive mechanisms. These mechanisms consist in education subsidy, unskilled wage subsidy, a negative income tax, and a system of public loans.

I-1 Description of the economy

The model we consider here is very similar to the one developed in Chapter I. There is a continuum of individuals who differ in their financial inheritances noted by x, and innate abilities noted by a. Inheritances are distributed in the interval $[0\,,\,\bar{x}]$ according to the density function of $f(x)$, while abilities evolve in the interval $[0\,,\,1]$, and have a density function of $g(a)$. The two distributions are assumed to be independent, and the size of the population is normalized to one.

Individuals live within two periods. In the first period, they must choose whether or not they invest in education. The cost of the education, noted by ϕ, is the same for all individuals and is endogenously determined. In the second period of life, individuals consume and work. Individuals face liquidity constraints that arise from credits-market imperfections. As in Chapter I, the same form of imperfections is assumed here. The world rate of interest is equal to $r > 0$ and is assumed to be constant over time. There are costs stemming from borrowers, which may evade debt reimbursement, and from lenders, which must keep track of borrowers in order to avoid such defaults. These costs create capital-market imperfections, where individuals can borrow only at an interest rate i higher than r, the lender's interest rate (i.e., $i > r$). Such imperfections make

borrowing costly and may prevent some individuals—although with high abilities—from borrowing.

The schooling decisions involve uncertainty because individuals with different abilities have different probabilities of successfully completing their schooling. Hence, to be a skilled worker, an individual must not only invest in education, but also must succeed in completing this investment. Each individual faces the known probability of success, given by his level of ability, i.e., $P_a = a$. The probability of failing is therefore, $1 - a$. It follows that unskilled workers comprise all those who do not invest at all in education and those who invest but fail to complete their studies.

I-1-1 The case of no government intervention

With no government intervention, all agents maximize a utility function given by [2]:

$$U_j(c_j, \ l_j) = c_j - \delta l_j^{\eta} \tag{1}$$

where c and l are, respectively, consumption and labour supply, δ and η are parameters related to the disutility of labour (where $\delta > 0$ and $\eta > 1$), and $j = (u, s)$ for, respectively, unskilled and skilled workers.

Individuals consume the totality of their labour incomes and their inheritance net of education cost. The gross wage rate of skilled labour is noted by w_s, while that of the unskilled labour is w_u.

2: The assumption that preferences are quasi-linear is common in the literature of optimal redistribution. We refer readers to the works of Bourguignon and Spadaro (2000), Janeba (2000) and Hanushek, Leung and Yilmaz (2001) for similar use.

According to the distribution of the initial financial inheritances and that of abilities, one can distinguish the following individuals' educational decisions:

a- Individuals who inherit in the first period of life an amount $x < \phi$, and do not invest in education are unskilled workers in the second period of life. Their lifetime utility is given by:

$$U_u = w_u l_u + x(1+r) - \delta l_u^{\eta} \tag{2}$$

b- Individuals with inheritance $x < \phi$, and who invest in education are borrowers with utility:

$$\begin{cases} U_s^b = w_s l_s + (x-\phi)(1+i) - \delta l_s^{\eta} & \text{if they successfully complete education,} \\ \text{and} & \\ U_f^b = w_u l_u + (x-\phi)(1+i) - \delta l_u^{\eta} & \text{if they fail in completing education.} \end{cases} \tag{3}$$

These individuals have an expected utility from education, given by the appropriately weighted average of these two utilities:

$$EU^b = a U_s^b + (1-a) U_f^b \tag{4}$$

c- Individuals with inheritance $x \geq \phi$, and who invest in education are lenders with utility:

$$\begin{cases} U_s^l = w_s l_s + (x-\phi)(1+r) - \delta l_s^{\eta} & \text{if they successfully complete education,} \\ \text{and} & \\ U_f^l = w_u l_u + (x-\phi)(1+r) - \delta l_u^{\eta} & \text{if they fail to complete education.} \end{cases} \tag{5}$$

These individuals have an expected utility from attending education given by:

$$EU^{l} = a\, U_{s}^{l} + (1 - a)\, U_{f}^{l} \tag{6}$$

It can be deduced from Equations (2) and (4) that borrowers invest in education as long as $EU^{b} > U_{u}$. This condition provides the following critical level of financial inheritance, under which these individuals cannot acquire education:

$$x^{*}(a) = \frac{\left[\phi\,(1+i) - a\left(w_{s}\, l_{s} - w_{u}\, l_{u} - \delta(l_{s}^{\eta} - l_{u}^{\eta})\right)\right]}{(i - r)} \tag{7}$$

This threshold level is increasing in the cost of education, ϕ, and decreasing in the level of abilities. Equations (2) and (6) show that lenders acquire an education as far as their abilities exceed a certain critical level, given by:

$$a^{*} = \frac{\phi(1+r)}{(w_{s}\, l_{s} - w_{u}\, l_{u}) - \delta(l_{s}^{\eta} - l_{u}^{\eta})} \tag{8}$$

Hence, Equations (7) and (8) define the proportion of individuals that may undertake investment in education.

To summarise, investment in education is limited to individuals that are endowed with both sufficient ability, $a \geq a^{*}$, and financial inheritance, $x \geq x^{*}(a)$.
The following relation gives the fraction of individuals that invests in education:

$$N_{e} = \int_{a^{*}}^{1} \int_{x^{*}(a)}^{\bar{x}} f(x)\; g(a)\; dx\, da \tag{9}$$

The fraction of individuals that successfully completes education is thus:

$$N_s = \int_{a^*}^{1} \int_{x^*(a)}^{\bar{x}} a \; f(x) \; g(a) \; dx\, da \tag{10}$$

Consequently, the percentage of schooling failure is given by:

$$N_f = N_e - N_s = \int_{a^*}^{1} \int_{x^*(a)}^{\bar{x}} (1-a) \; f(x) \; g(a) \; dx\, da \tag{11}$$

Individuals who cannot invest at all in education are those with either insufficient initial wealth or insufficient ability. That is,

$$N_d = 1 - N_e = \int_{0}^{1} \int_{0}^{x^*(a)} f(x)\, g(a) \; dx\, da + \int_{0}^{a^*} \int_{x^*(a)}^{\bar{x}} f(x)\, g(a) \; dx\, da \tag{12}$$

Hence, the fraction of the unskilled population, noted by N_u, is given by the individuals who do not invest in education at all, and those who invest but fail (i.e., $N_u = N_d + N_f$). Individuals determine their optimal labour supply choice, l_j, in order to maximize their utility function, given in equation (1). We obtain:

$$l_j = \left(w_j / \eta \delta\right)^{\frac{1}{\eta - 1}} \tag{13}$$

where $j = (s, u)$.

I-1-2 Determination of labour wages and the cost of education

The economy produces a unique consumption good, Y, whose production technology requires both skilled and unskilled workers. The following Cobb-Douglas technology is assumed [3]:

$$Y = \gamma \left(L_s\right)^{\alpha} \left(L_u\right)^{1-\alpha} \tag{14}$$

where $L_s = N_{sp}\ l_s$ is the effective unit of educated labour, N_{sp} is the proportion of successfully educated individuals who participate in goods production. We assume that successful students (i.e., skilled workers), N_s, are divided between goods production activity with a proportion of N_{sp}, and teaching activity with a proportion of N_t (i.e., $N_s = N_{sp} + N_t$). The number of educated individuals needed to teach, N_t, will be explicitly determined below. The variable L_u in the production function, where $L_u = N_u l_u$, measures the effective units of unskilled labour, where N_u is defined above.

With perfect competition in the labour market, gross wage rates are given by the labour marginal productivities. i.e.:

$$\begin{cases} w_s = \alpha \gamma \left(L_u / L_s\right)^{1-\alpha} \\ w_u = (1-\alpha)\, \gamma \left(L_s / L_u\right)^{\alpha} \end{cases} \tag{15}$$

3: The Cobb-Douglas production function implies an elasticity of substitution of 1 between skilled and unskilled workers. Choosing another function (a CES one, for example) with higher elasticity of substitution may reduce the general equilibrium effects of wages, but these effects are still important.For instance, Hanushek, Leung and Yilmaz (2001) employ a CES function with an elasticity of 1.3 (a value

close to the estimates of Katz and Autor (1999)), and show that the general equilibrium effects are important.

As the skilled wage is decreasing in the educated population and the unskilled wage is increasing, one can easily show that the ratio of skilled to unskilled gross wage, (w_s / w_u), is always decreasing in the fraction of educated individuals, N_e. Such a wage effect stems from the relative scarcity of the two types of labour.

We now turn to the determination of the cost of education, ϕ. We assume below that it simply equals the total wage bill of teachers per student. This seems quite realistic, as in many countries, the wage bill of teachers represents a large component of governmental education expenditures. In equilibrium, skilled workers receive the same utility from teaching or from goods production. Thus, teachers supply the same quantity of working time, l_s, as other skilled workers. Each enrolled student requires h hours of teaching to achieve education and each teacher can only teach ε students simultaneously. Thus, we must get $N_t l_s \varepsilon = N_e h$, (i.e., the total number of possible teaching hours must equal the total number of required hours of training). Hence, the number of teachers required is $N_t = N_e h / \varepsilon l_s$, which is endogenous, as N_e and l_s are endogenous. Hence, the cost of acquiring education, ϕ, is measured by the total wage bill of teachers divided by the total number of enrolled students; that is,

$$\phi = \frac{N_t \; l_s \; w_s}{N_e} = \left(\frac{h}{\varepsilon}\right) w_s \tag{16}$$

I-2 Public redistribution policies

In this section, the education subsidy regime is compared to the negative income tax and the unskilled wage subsidy policies. Each of these policies provides very

different outcomes in terms of the schooling attendance and success rates, the wage ratio, efficiency, and social welfare. Although in real terms, many elements of all these policies can be found, these policies are analyzed here in isolation from each other. This is motivated by two reasons: first, outcomes may be easily compared among these policies; and second, the general equilibrium effects are somewhat complicated, especially in the *ex-post* evaluation case.

I-2-1 The education subsidy policy

It is assumed under this policy regime that the government taxes the labour income of all workers at a rate of τ and offers education at a subsidized tuition rate of v, so that total public expenditures on education are equal to total tax payments; that is,

$$v\phi N_e = \tau \left[w_s \; N_s \; l_s + w_u \; N_u \; l_u \right] \tag{17}$$

Under this policy, the critical levels of ability and financial inheritance (a^* and $x^*(a)$, respectively) defined in Equations (7) and (8) are written now as follows:

$$a^* = \frac{\phi(1-v)\,(1+r)}{(1-\tau)(w_s\, l_s - w_u\, l_u) - \delta(l_s^{\eta} - l_u^{\eta})} \tag{18a}$$

and

$$x^*(a) = \frac{\left[\phi(1-v)(1+i) - a\left((1-\tau)\,(w_s\, l_s - w_u\, l_u) - \delta(l_s^{\eta} - l_u^{\eta}) \right) \right]}{(i - r)} \tag{18b}$$

where labour supply of educated and uneducated workers are written, respectively, as follows:

$$l_s = \left(w_s (1-\tau) / \eta \delta\right)^{\frac{1}{\eta - 1}} \tag{19a}$$

and

$$l_u = \left(w_u (1-\tau) / \eta \delta\right)^{\frac{1}{\eta - 1}} \tag{19b}$$

Notice that with education subsidies all individuals pay a tax, but, only those endowed with more than a^* and $x^*(a)$ can afford education.

I-2-2 The negative income tax

Under this regime, all individuals receive a lump-sum transfer, noted by g, which is financed by levying a linear tax τ on labour incomes. The negative income tax tends thus to be progressive because of the uniform transfer. Education is privately financed ($v = 0$). Because the population in the economy is normalized to 1, the government budget constraint is written as follows:

$$g = \tau \left[w_s N_s l_s + w_u N_u l_u \right] \tag{20}$$

The following critical levels of ability and parental transfers determine the fraction of individuals that can afford education under this policy:

$$a^* = \frac{\phi(1+r)}{(1-\tau)(w_s l_s - w_u l_u) - \delta(l_s^\eta - l_u^\eta)} \tag{21a}$$

and

$$x^*(a) = \frac{\left[\phi(1+i) - a\left((1-\tau)(w_s l_s - w_u l_u) - \delta(l_s^\eta - l_u^\eta)\right)\right]}{(i-r)} \tag{21b}$$

where labour supply of both types of workers is given in Equations (19a) and (19b).

I-2-3 The unskilled wage subsidy

In this context, a tax rate τ^e is levied on the wage of skilled workers (i.e., those who successfully complete education), and the resources so collected are, in turn, transferred to the unskilled workers in the form of a wage subsidy at a rate of τ^u. Clearly, the transfers benefit those who fail in completing their education, and those who do not enrol at all. Notice that the cost of education, ϕ, is once again entirely privately financed. The governmental budget equilibrium implies, in this case, equality between total taxes and total transfers, so that:

$$\tau^e \, w_s \, N_s \, l_s = \tau^u \, w_u \, N_u \, l_u \tag{22}$$

Labour supply of educated and uneducated workers is written, respectively, as follows:

$$l_s = \left(w_s \, (1 - \tau^e) / \eta \, \delta\right)^{\frac{1}{\eta - 1}} \tag{23a}$$

and

$$l_u = \left(w_u \, (1 + \tau^u) / \eta \, \delta\right)^{\frac{1}{\eta - 1}} \tag{23b}$$

The critical levels of ability and wealth become:

$$a^* = \frac{\phi(1 + r)}{(1 - \tau^e) \, w_s \, l_s - (1 + \tau^u) \, w_u \, l_u - \delta(l_s^\eta - l_u^\eta)} \tag{24a}$$

and

$$x^*(a) = \frac{\left[\phi(1 + i) - a\left(w_s \, l_s \, (1 - \tau^e) - w_u \, l_u \, (1 + \tau^u) - \delta(l_s^\eta - l_u^\eta)\right)\right]}{(i - r)} \tag{24b}$$

II- Evaluation of the policies

This section evaluates the policies presented in the previous section by looking at their implications in terms of economic efficiency, equality, and social welfare.

II-1 Efficiency, inequality, and welfare measurement

We refer to aggregate utility - noted below by V - to measure economic efficiency:

$$
\begin{aligned}
V(\tau^e, \tau^u, v, g) &= \int_0^1 \int_0^{\bar{x}} U_m \; f(x) \; g(a) \; dx\,da \\
&= \int_0^1 \int_0^{x^*(a)} U_u \; f(x)\, g(a) \; dx\,da + \int_0^{a^*} \int_{x^*(a)}^{\bar{x}} U_u \; f(x)\, g(a) \; dx\,da + \\
&\int_{a^*}^1 \int_{x^*(a)}^{\phi} \left[a\, U_s^b + (1-a) U_f^b\right] f(x) \; g(a) \; dx\,da + \\
&\int_{a^*}^1 \int_{\phi}^{\bar{x}} \left[a\, U_s^l + (1-a)\, U_f^l\right] f(x)\, g(a) \; dx\,da
\end{aligned}
\tag{25}
$$

According to Equation (25), there are five groups of individuals: those who do not invest at all, (i.e., N_d, the two first terms), both borrowers who invest and succeed and who invest but fail, (i.e., N_s^b and N_f^b respectively, the third term), and both lenders who invest and succeed and who invest but fail, (i.e., N_s^l and N_f^l respectively, the last term).

On the other side, our measurement of the inequality is based on the *GINI* coefficient of utilities after taxes and transfers, rather than on labour incomes. The importance of computations based on utilities is that they capture the utility derived from

parental inheritances as well as the disutility related to labour. The evaluation of this coefficient is based on the relation below:

$$GINI(\tau^e, \tau^u, v, g) = \frac{1}{\overline{U}} \sum_{m>n} \sum_{n} N_m N_n \left| \overline{U}_m - \overline{U}_n \right| \tag{26}$$

where m and n denote the different groups of individuals, $\overline{U}$ is the aggregate utility, $\overline{U}_m$ and $\overline{U}_n$ are mean utilities of groups m and n, respectively, and N_m and N_n are the fractions of individuals of type m and n, respectively.

To evaluate social welfare we consider an iso-elastic function, which is based on individuals' utilities, and which allows for parametric variation of inequality aversion (see Atkinson and Stiglitz, 1980). For $\rho \neq 1$, social welfare is defined as follows:

$$\Omega(\tau^e, \tau^u, v, g) = \frac{1}{1-\rho} \int_0^1 \int_0^{\bar{x}} (U_m)^{1-\rho} f(x)\, g(a)\, dx\, da \tag{27}$$

$$= \frac{1}{1-\rho} \left\{ \int_0^1 \int_0^{x^*(a)} (U_u)^{1-\rho} f(x) g(a)\, dx\, da + \int_0^{a^*} \int_{x^*(a)}^{\bar{x}} (U_u)^{1-\rho} f(x) g(a)\, dx\, da \right.$$

$$+ \int_{a^*}^1 \int_{x^*(a)}^{\phi} \left[a\,(U_s^b)^{1-\rho} + (1-a)(U_f^b)^{1-\rho} \right] f(x) g(a)\, dx\, da$$

$$\left. + \int_{a^*}^1 \int_{\phi}^{\bar{x}} \left[a (U_s^l)^{1-\rho} + (1-a)(U_f^l)^{1-\rho} \right] f(x) g(a)\, dx\, da \right\}$$

The parameter ρ indicates the degree of inequality aversion. Higher values of ρ reflect increasing concern for inequality. When $\rho = 0$, Ω is utilitarian so that, only the aggregate utility is relevant.

The evaluation of the socioeconomic outcomes associated with the different policy regimes is performed in both *ex-ante* and *ex-post* terms. In *ex-ante* point of view, the government observes the initial distribution of skills, the labour supply of each type of workers, and the corresponding gross wages. It then implements the parameters of its policies that balance its budget. This choice of parameters affects the distribution of skills by influencing the thresholds of both ability and initial wealth that determine educational investment. Efficiency and inequality are then evaluated with regard to this distribution of skills and the initial gross wages. In *ex-post* point of view, however, the evaluation must also take into account *the impacts of the realised distribution of skills on gross labour wages,* according to Equation (15). Thus, *ex-post*, the general equilibrium effects of the public policies are necessarily different from those obtained in the *ex-ante* sense.

II-1-1 The ex-ante evaluation

The proposition below summarizes the effects of a tax rate increase under the different policy regimes in *ex-ante* point of view. Analytical proofs are shown in the appendix.

Proposition 1:

a- *Increasing the income tax rate,* τ or τ^e, *raises the percentage of skilled individuals,* N_s , *under the education subsidy policy, while it decreases it under both the negative income tax and the unskilled wage subsidy regimes. This decrease is more important under the unskilled wage subsidy scheme.*

b- *Economic efficiency is higher under the education subsidy regime than under the negative income tax, which in turn is higher than that under the wage subsidy policy.*

c- *The distribution of utilities is more equal under the unskilled wage subsidy program than under the negative income tax, which in turn is more equal than under the education subsidy regime.*

The result in part (a) of this proposition may easily be checked by computing the derivatives of the expressions of ability and wealth thresholds with respect to the tax rate, τ or τ^e, under each of the three considered regimes. The computations are shown in the Appendix. A reduction in these thresholds implies unambiguously a higher proportion of individuals that enrol in education, N_e, and consequently, a higher success rate, N_s.

Under the negative income tax, both thresholds increase in the tax rate, implying lower schooling enrolments. This is due to the distortion effect of taxation, which lowers the utility of the skilled population (and raises that of the unskilled population). Such a disincentive effect towards investment is more important when government directly subsidizes unskilled workers. That's why investment rate and, therefore, the percentage of skilled workers are at their lowest levels under this policy.

Under tuition subsidies, however, the two thresholds decline, which implies that more individuals can afford education. This arises because the negative distortion effect of the tax is offset by the enhancing effect of education subsidies.

The results in part (b) are driven from the ones established in part (a). With education subsidies, the percentage of skilled workers grows. These workers, moreover, are better off under this policy than under any other program. Under the two other policies, the proportion of the unskilled workers and their utility increase, whereas the proportion of skilled workers and their utility drop. As these effects are more important under the unskilled wage subsidy than under the negative income tax, efficiency is

higher under the latter regime. By following the definition of efficiency given in Equation (25), one can easily check the orders given in (b).

The results in part (c) indicate that the most important equalizing effect arises under the unskilled wage subsidy policy, since the utility of unskilled workers (those without education and those who fail to complete their education) is increased at the expense of the utility of skilled workers. This redistributive effect is somewhat lower under the negative income tax. Under the tuition subsidies policy, however, unskilled workers are found to be worse off than under any other regime, because they are taxed on their incomes but do not receive education. They thus contribute to finance the subsidy of the skilled individuals, who are initially rich and sufficiently talented. This effect is called "*reverse redistribution*".

Notice that one cannot directly evaluate social welfare generated by the different programs, as the one that provides higher efficiency yields, at the same time, less equality, and vice versa. Therefore, to compare the programs on a social welfare ground, the degree of inequality aversion, ρ, must be fixed. Nevertheless, one can expect the following result: when the degree of inequality aversion is low, the education subsidies policy comes out optimal. With higher degrees of inequality aversion, however, the unskilled wage subsidy policy is optimal.

II-1-2 The ex-post evaluation

The evaluation of the outcomes in an *ex-post* sense cannot be easily characterized analytically, as we must now incorporate the effect of the realised labour wages that result from the change in the distribution of skills. However, one can expect some outcomes.

According to part (a) of proposition (1), the ratio of skilled to unskilled wages declines under the education subsidies regime, whereas it grows up under both the negative income tax and the unskilled wage subsidy schemes. This increase is more important under the unskilled subsidy regime. Unambiguously, this wage effect raises equality under the education subsidy policy and lowers it under the two other programs. Moreover, it alters efficiency, as unskilled individuals now become better off, and skilled individuals become worse off under the education subsidy policy than the other regimes. Hence, contrary to the *ex-ante* evaluation, the ordering of the policies in terms of inequality, efficiency, and welfare will change in *ex-post* calculations. In what follows, we use numerical techniques to gain more insight on the general-equilibrium policy effects in both *ex-ante* and *ex-post* terms.

II-2 Numerical techniques : procedure and parameter setting

The principle of this exercise is simple. We first start defining a benchmark situation without government intervention ($\tau = 0$). In this situation, the distribution of education is given by the distributions of individuals' abilities and inheritances, $g(a)$ and $f(x)$ respectively, as well as by the critical levels of a^* and $x^*(a)$. Inequality, efficiency, and welfare which correspond to this benchmark situation are then calculated.

The next step of the exercise consists of determining the effects of varying the tax rate, τ, on the threshold levels of a^* and $x^*(a)$, and in turn, on the distribution of education, as well as on efficiency and inequality, under the different policy regimes.

A number of key parameters must be fixed in order to determine the two critical levels in the benchmark situation. The decision of parameter values begins with the elasticity of labour supply with respect to the wage rate which is given by the parameters of η and δ

(see Equation (13)). There exists a wide range of estimates for labour supply elasticity established by considerable empirical analyses that employ experimental and econometric approaches (Pencavel (1986), Killingsworth and Heckman (1986), Blundell and MaCurdy (1999)). We use an elasticity of 1/2 (i.e., $\eta = 3$ and $\delta = 1/3$), which falls between the estimates of these studies. This value also falls between those employed in the theoretical studies of Hanushek, Leung and Yilmaz (2001) and Janeba (2000), which considered the values of 1/3 and 1, respectively. On the production side, we assume that the gross wage ratio of skilled to unskilled workers is equal to 2 in the benchmark situation (i.e., $w_s / w_u = 2$). By using Equation (15), this gives a productivity factor of $\gamma \approx 3$ and a share of skilled labour in production of $\alpha \approx 0.64$. The cost of education is assumed to represent 20% of the skilled wage (i.e., $\phi = 0.4$), (See Equation (16)).

On the credits-market side, lenders' and borrowers' rates of interest (r and i, respectively) are fixed at 5% and 15%, respectively. Finally, we assume that individuals' abilities are uniformly distributed in the interval of $[0,1]$, while inheritances are normally distributed in the interval of $[0,1]$ with a mean of 0.5 and a standard variation of 0.15. Notice that while it is common to find estimates of IQ or other proxies for ability as normally distributed, we know of no analysis that addresses the functional form for stochastic ability -the ability to complete schooling- as used here. The set of parameters and assumptions considered above yields the following distribution of skills:

Table 1: *The distribution of skills (in %) in the benchmark case* ($\tau = 0$).

$N_e = 62$				
$N_s = 42$		$N_f = 20$		N_d
N_s^l	N_s^b	N_f^l	N_f^b	38
33	9	16	4	

Only 62% of the population invest in education, while the remaining (38%) are without education. Forty-two percent of the population succeed in completing education and become skilled workers; among them, 33% are lenders and 9% are borrowers. Twenty percent of the population fail to complete their education and become unskilled and thus, join those without any education. Among the failing students, 16% are lenders and 4% are borrowers.

It is important to underline that making any other set of parameters implies two different threshold levels of abilities and wealth. This, in turn, affects the distribution of education in the benchmark situation. Nevertheless, outcomes under the various policies are qualitatively unaffected, since they are based on the same benchmark situation. To say it differently, the results we present below are robust with regard to parameter changes. In what follows, we evaluate the effects of varying the tax rate τ on the distribution of education, efficiency, and on inequality under the different programs from both *ex-ante* and *ex-post* points of view.

II -3 The results

II-3-1 The ex-ante evaluation

We begin presenting our results by Table 2, below, which shows the corresponding equilibrium subsidy and transfer rates for each level of taxation and by policy regime. The level of the tax rate simply indicates the size of each redistributive program. A higher tax rate implies either a higher subsidy rate of education, v, or a higher lump-sum transfer, g, or a higher subsidy rate of the unskilled wage, τ^u.

Table 2: *Tax and equilibrium subsidy and transfer rates*

	Education subsidy	***Negative income tax***	***Unskilled wage subsidy***
Tax rate (τ)	v	g	τ^u
0.00	*0.000*	*0.000*	*0.000*
0.02	*0.143*	*0.035*	*0.041*
0.04	*0.246*	*0.069*	*0.083*
0.06	*0.430*	*0.102*	*0.124*
0.08	*0.573*	*0.133*	*0.166*
0.10	*0.641*	*0.165*	*0.207*
0.12	*0.861*	*0.192*	*0.249*

Table 3 shows how the different policy schemes affect the patterns of attendance and success in education. With greater education subsidies, the cost of education falls. This, in turn, decreases both critical levels (see Equations 18a and 18b) and consequently raises the educational investment rate, N_e . Hence, both success and failure rates (N_s and N_f) increase, while the share of the population with no education, N_d , decreases. The more important impact of this policy, however, is on the marginal failure rate, N_f .

Table 3*: Distribution of school attendance and success by redistributive program and tax rate*

Tax rate (τ)	***Education subsidy***			***Negative income tax***			***Unskilled wage subsidy***		
	N_s	N_f	N_d	N_s	N_f	N_d	N_s	N_f	N_d
0.00	*0.42*	*0.20*	*0.38*	*0.42*	*0.20*	*0.38*	*0.42*	*0.20*	*0.38*
0.02	*0.44*	*0.23*	*0.33*	*0.42*	*0.19*	*0.39*	*0.41*	*0.18*	*0.41*
0.04	*0.46*	*0.27*	*0.27*	*0.41*	*0.18*	*0.41*	*0.39*	*0.15*	*0.46*
0.06	*0.47*	*0.31*	*0.22*	*0.40*	*0.17*	*0.43*	*0.37*	*0.13*	*0.50*
0.08	*0.48*	*0.35*	*0.17*	*0.40*	*0.16*	*0.44*	*0.34*	*0.10*	*0.56*
0.10	*0.49*	*0.39*	*0.12*	*0.39*	*0.16*	*0.45*	*0.29*	*0.08*	*0.63*
0.12	*0.50*	*0.44*	*0.06*	*0.39*	*0.15*	*0.46*	*0.23*	*0.05*	*0.72*

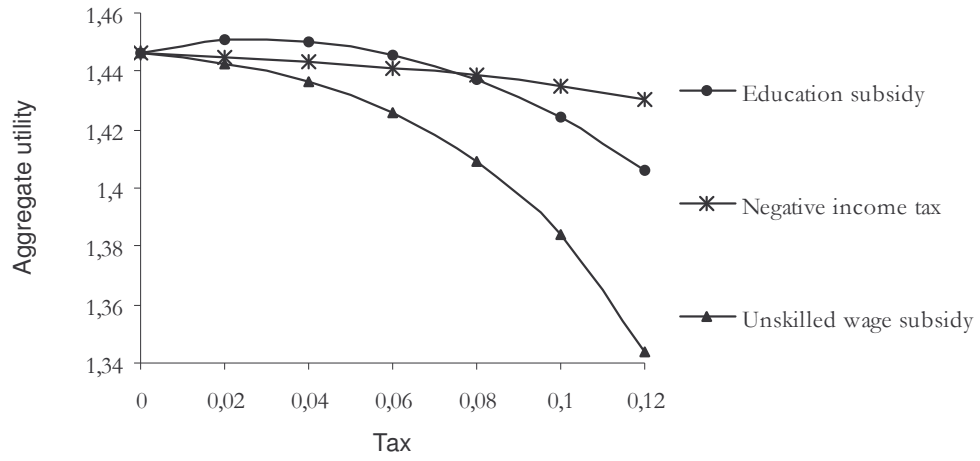
Note: N_s , N_f and N_d are respectively the proportions of success, failure, and non-attendance.

Indeed, while the percentage of students who successfully complete education goes from 42% of the population in the no-intervention case to 50% in the case of a tax rate of 12%, the percentage of those who attend but fail to complete their education raises from 20% to 44%. This disproportion in the growth of success and failure rates reflects the high levels of education subsidies. In fact, at a 2% tax rate, the education subsidy represents only 14.3% of the education cost, while at a 12% tax rate, this subsidy rate is 86.1% (Table 2), and the corresponding schooling attendance rate is now 94% (Table 3). As a result, many more individuals are likely to fail in completing their education. This implies that the marginal effect of the subsidy on the fraction of skilled workers declines as the tax rate increases.

The evolution of the educational patterns, however, is very different under the two other redistributive programs. Indeed, the increase in the level of the lump-sum transfer or in the rate of the wage subsidy results in a decline in schooling attendance, with the decline being more important in the case of the unskilled wage subsidy program. Under this policy regime, a higher unskilled wage subsidy, τ^u, is associated with a higher tax rate of the skilled wage, τ^e, which is detrimental to investment in education. For instance, under the unskilled wage subsidy policy, the proportion of individuals that enrols in education falls from 62% in the case of no tax, to 28% only in the case of 12% tax rate. At this tax level, the rate of success falls to 23%, compared to 39% in the case of no government intervention.

These results provide support to part (a) in proposition 1, which assesses the supremacy of the education tuition program in enhancing skills. Figure 1 below provides a direct comparison of the effects of the redistributive schemes on economic efficiency from an *ex-ante* point of view for tax rates ranging between zero and 12%.

Figure 1: Efficiency and tax rate (Ex-ante evaluation)



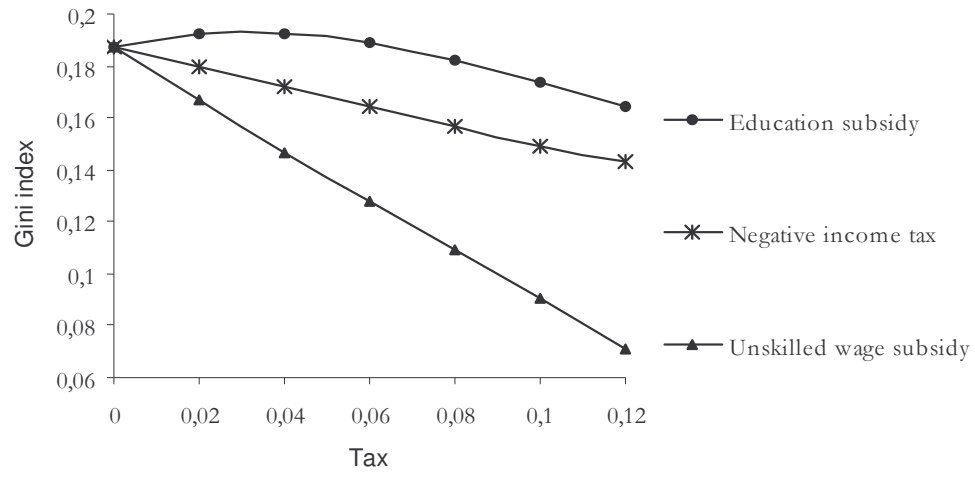
It is generally asserted that fiscal redistribution harms economic efficiency because it distorts labour supply and incentives to be skilled. This is the case under the unskilled wage subsidy and the negative income tax policies, since the aggregate utility decreases monotonically in the tax rate as illustrated in Figure 1.

Figure 1 also shows that for small-tax values, the education subsidy regime provides higher levels of efficiency than in the case of no government intervention. Nevertheless, efficiency decreases with higher levels of tax rate. In fact, an increase in the education subsidy has two opposite effects on efficiency. First, by reducing the cost of education, it lowers the sums that borrowers need to finance their education and increases the wealth of lenders net of education cost. This, in turn, results in additional gains in terms of interest rates for both lenders and borrowers (see Equations 3 and 5). Second, an increase in the education subsidy increases labour supply distortions and raises the marginal failure rate (see Table 3), so that the marginal efficiency of the subsidy is decreased.

Therefore, for small tax rates, the gains associated with the education subsidy policy outweigh its losses, and consequently, economic efficiency increases in the tax rate. For higher levels of tax rate, however, gains are smaller than losses, and the efficiency decreases. It is crucial to point out that this result contrasts with the widely held belief along which, efficiency monotonically increases with education subsidies (see Bénabou (2000 and 2002) and Bovenberg and Jacobs (2001)).

Figure 2 below compares the three programs on the basis of their impact on inequality measured by the *GINI* index of utilities, as in Equation (26). In *ex-ante* sense, subsidizing the wage of unskilled workers by taxing the wage of skilled workers is found to be as the most equalising tool of utilities distribution.

Figure 2: Inequality and tax rate (Ex-ante evaluation)



It is also of interest to underline that under the education subsidy policy, inequality evolves along an inverted U-shape with respect to the income tax rate. This result reflects the interaction between the 'composition' and the 'level' effects associated with increments in the fraction of educated individuals. Indeed, on one hand, as this

fraction increases, the composition of the population is such that a larger fraction of the population has a high level of utility, which favours inequality. On the other hand, the increase in this fraction raises the level of mean utility of the population, and reduces inequality. For low tax rates, the composition effect dominates, while for high tax rates, the level effect dominates.

Figures 3a, 3b, and 3c in the Appendix show how mean utilities of the different groups of individuals evolve with respect to the tax rate and under the various programs in an *ex-ante* sense. Recall that there are five groups: individuals who do not invest at all in education, with a utility of U_u; borrowing individuals who invest but fail, with a utility of U_f^b; borrowing individuals who invest and succeed, with a utility of U_s^b; lenders who invest but fail, with an utility of U_f^l; and lenders who invest and succeed in completing education, with a utility of U_s^l. Groups of individuals with utilities of U_u, U_f^b, or U_f^l are unskilled workers, whereas those with U_s^b or U_s^l are skilled.

Under the three programs, unskilled individuals' utilities tend to converge toward those of skilled ones as the tax rate increases, with the more rapid convergence being achieved under the unskilled wage subsidy regime. The supremacy of the unskilled wage subsidy policy in reducing inequality in the *ex-ante* sense may also be assessed when we compare the distribution of utilities under the different policy regimes with a same tax rate. This is depicted in Figure 4 in the Appendix, which takes a tax rate of 6% as an example. This figure shows that utilities are more concentrated on their mean level under the unskilled wage subsidy than under any other regime. Overall, the results presented above confirm the statements in parts b and c of the proposition 1.

To compare the programs on the social welfare basis, we consider two scenarios: a scenario of low inequality aversion with $\rho = 0.2$, and a scenario of high inequality aversion with $\rho = 0.8$. Figures 5a and 5b below, use Equation (27) to evaluate welfare under the three policy regimes in *ex-ante* sense for the two scenarios.

Figure 5 a: Social welfare and tax rate : ρ = 0.2
(Ex-ante evaluation)

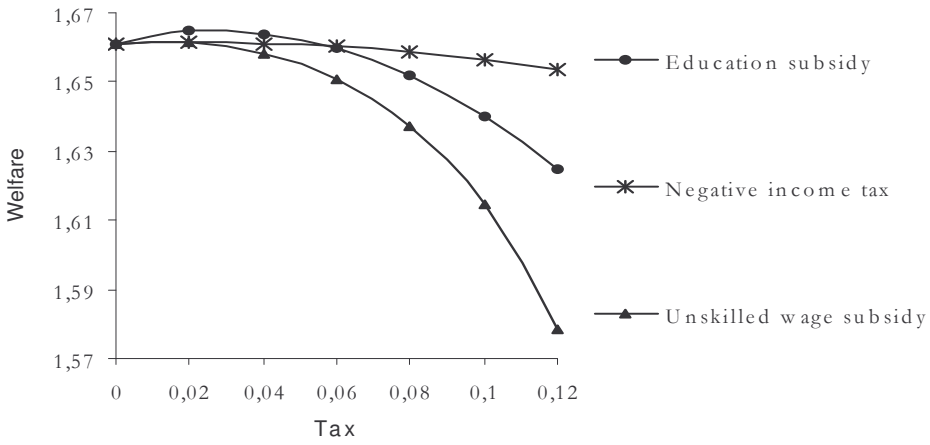
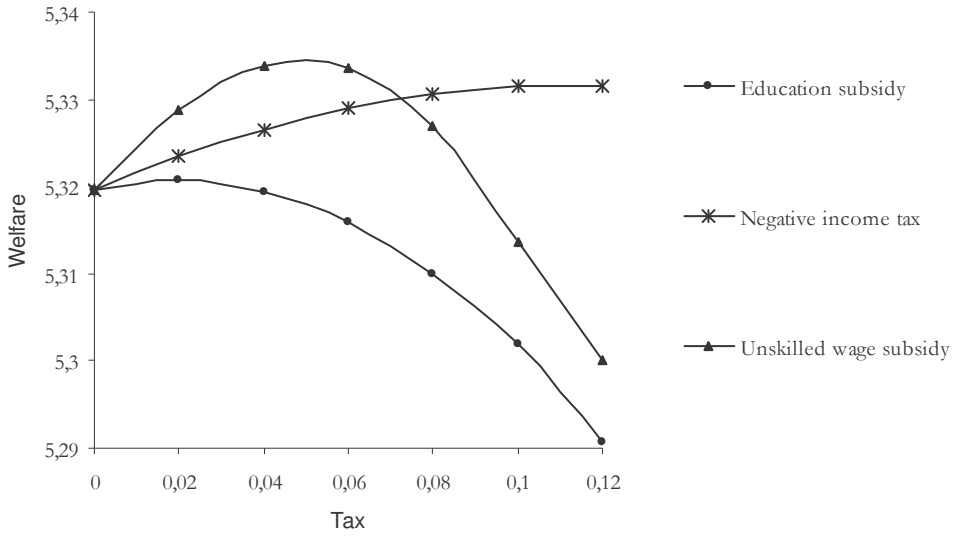


Figure 5 b: Social welfare and tax rate : ρ = 0.8
(Ex-ante evaluation)



These figures show a crucial fact, which we summarize in the proposition below:

Proposition 2:

In ex-ante sense, the education subsidy policy is optimal, provided that the degree of inequality aversion is low and the tax rate is not too high. When inequality aversion is high, the unskilled wage subsidy regime is optimal, provided that the tax rate is not too high.

The relevant question to ask now is how these policies perform from an *ex-post* point of view.

II-3-2 The ex-post evaluation

By contrast to the *ex-ante* evaluation, the *ex-post* evaluation should take into consideration the adjustments in wages that stem from the change in the distribution of skills that accompanies individuals' schooling decisions. Table 4, below, illustrates the evolution of the ratio of skilled to unskilled gross wage, (w_s / w_u), with respect to the tax rate under the various policy programs.

Table 4*: The ratio of skilled to unskilled gross wage by redistributive program and tax rate*

Tax rate (τ)	*Education subsidy*	*Negative income Tax*	*Unskilled wage Subsidy*
0.00	*2.00*	*2.00*	*2.00*
0.02	*1.93*	*2.04*	*2.18*
0.04	*1.89*	*2.09*	*2.43*
0.06	*1.63*	*2.14*	*2.77*
0.08	*1.56*	*2.20*	*3.29*
0.10	*1.52*	*2.26*	*4.15*
0.12	*1.49*	*2.34*	*4.95*

As has been indicated in the parameters-setting paragraph, the gross wage of skilled workers is assumed to be twice that of the unskilled workers in the competitive market case with no government (i.e., $w_s / w_u = 2$ for $\tau = 0$).

Table 3 has shown that education subsidies induce more people to invest in education and to be skilled. Because of the complementarities between skilled and unskilled labour in the production technology, the increased proportion of skilled workers drives down their relative wage (see Equation 15). For instance, the ratio of relative wages, (w_s / w_u), falls to 1.49 under this policy regime in the case of a 12% tax rate. The two other redistributive channels, however, induce the opposite effect, as they perform worse in terms of education participation and success. Subsidizing the unskilled wage by taxing the skilled wage yields the highest ratio of labour wages. Indeed, this ratio grows to 4.95 with a tax rate of 12%.

Figures 6 and 7, below, show that the effects on efficiency and inequality of the income tax are different from those that have been established in the *ex-ante* evaluation. The following proposition points out two important results that emerge in *ex-post* terms:

Proposition 3:

In ex-post point of view, it is found that:

a- *Under all policy regimes, efficiency decreases as the tax rate increases.*

b- *Inequality falls under the education subsidy policy, whereas it increases under the unskilled wage subsidy and the negative income tax policies.*

The first result of the proposition 3 stipulates that all policies result in less efficiency. Thus, contrary to the *ex-ante* evaluation, even the education subsidy policy results in lower efficiency in an *ex-post* sense as the tax rate increases. This result is due

to the decline in the wage ratio associated with this policy, which in turn translates into less utility for skilled workers and hence, less aggregate utility.

Figure 6: Efficiency and tax rate (Ex-post evaluation)

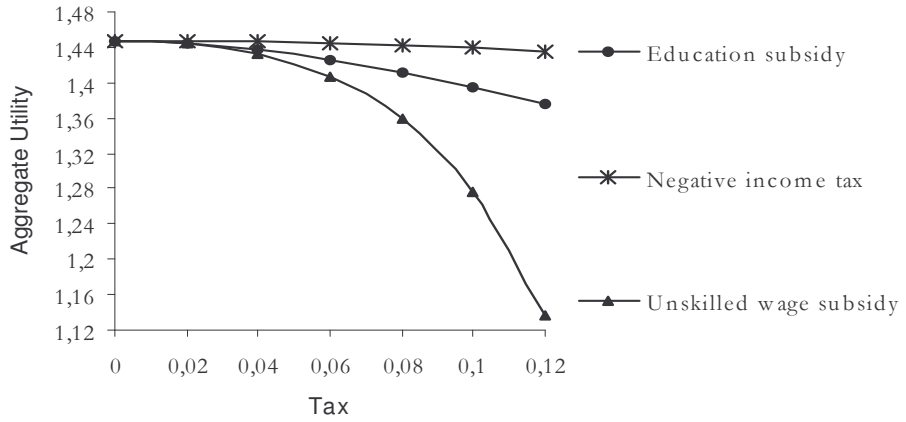
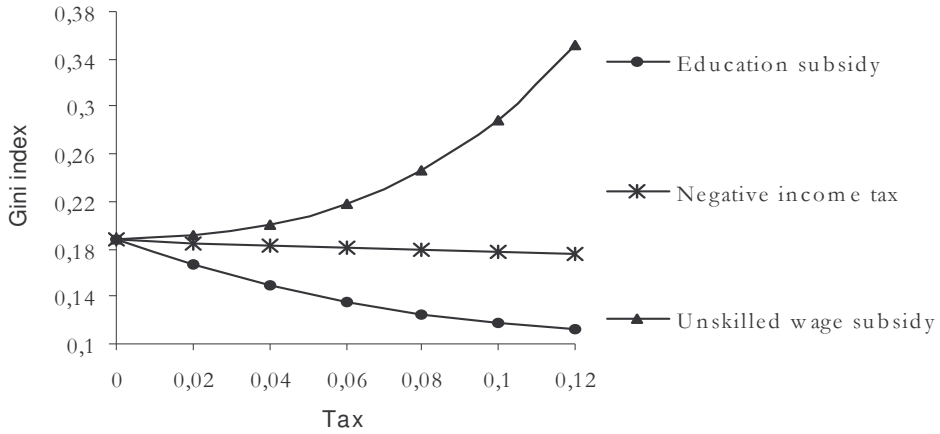


Figure 7: Inequality and tax rate (Ex-post evaluation)



The second result of this proposition stipulates that the unskilled wage subsidy and the negative income tax policies are now regressive, as it is illustrated by the increasing levels of the *GINI* index. This result stems from the widening in the wage gap between skilled and unskilled workers that is observed under these two policies (see Table 4). However, since the education subsidy regime compresses this wage gap, it also

reduces inequality in the distribution of utilities. Hence, contrary to several studies that point out the importance of the reverse redistribution effect associated with the education subsidy policy, we find that this effect matters only if inequality is evaluated in an *ex-ante* sense. In an ex-post sense, however, reverse redistribution completely disappears, as unskilled workers benefit from the tax-subsidy system due to the presence of complementarities in the production function between skilled and unskilled labour. It is worthwhile to underline that the education subsidy regime still raises the efficiency/equality trade-off, with efficiency decreasing in the tax rate and equality increasing.

Figures 8a, 8b, 8c, and 9 in the Appendix illustrate the distribution of utilities by program in *ex-post* terms. All the figures confirm the supremacy of the education subsidy policy in reducing inequality. Indeed, it can be seen that mean utilities of the different groups of individuals converge under this program, whereas they diverge under the two other programs. The more important divergence occurs under the unskilled wage subsidy regime. Once again, this result contrasts diametrically with the one established in the *ex-ante* evaluation.

In *ex-post* evaluation, both the bottom and the middle groups (those who fail and those without education, respectively) are now better off under the education subsidy policy than any other regime. This arises because this policy does not only subsidise school failures, but it also brings up the unskilled wage. By contrast, the top group (skilled workers) are worse off under this policy, as tuition subsidies lower their labour wage. Therefore, the reverse redistribution effect emerging in *ex-ante* evaluation disappears in *ex-post* terms, as the unskilled workers benefit from the tax-subsidies system.

Figures 10a and 10b, below, depict the evolution of social welfare with respect to the tax rate under the three policy regimes and for low and high values of inequality

aversion, respectively. The following proposition summarises the most important results shown in these figures:

Proposition 4

Ex-post, the education subsidy policy is optimal, provided that inequality aversion is high and financing the subsidy is not too high. For low levels of inequality aversion or high tax rates, however, the negative income tax is optimal.

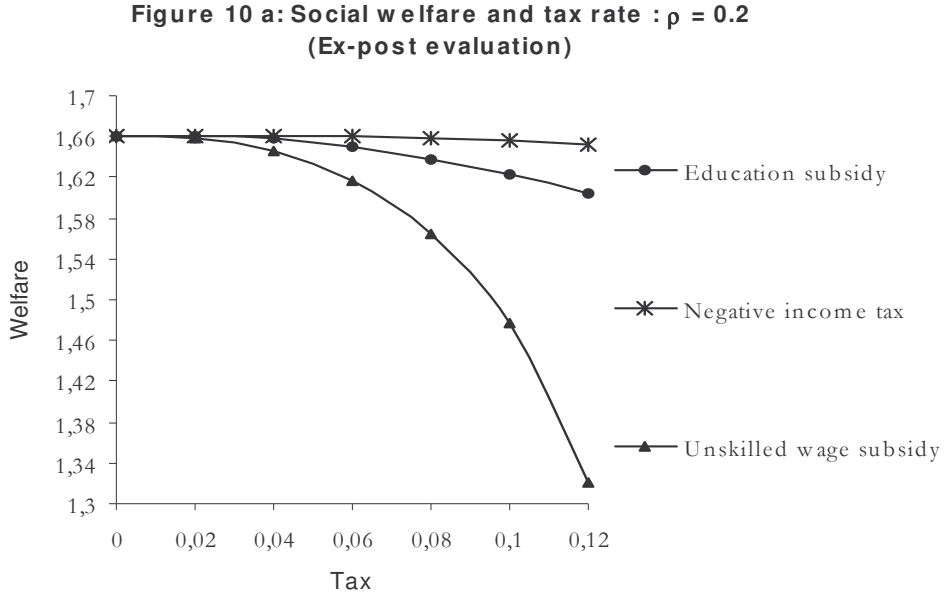
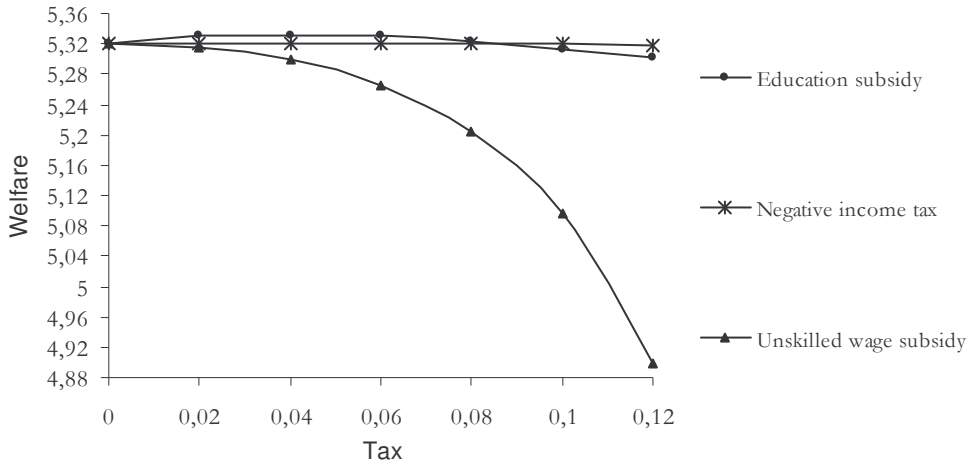


Figure 10 b: Social welfare and tax : ρ = 0.8
(Ex-post evaluation)



III- Avoiding the equality/efficiency trade-off ?

As the previous discussion has shown, subsidising education is a powerful tool for reducing inequality in *ex-post* point of view. This equalizing effect, however, is achieved at the cost of an efficiency loss. Moreover, this policy does not eliminate under-investment in education because it does not provide insurance against the failure risk. This raises the question of whether there is a better mechanism to finance education. A straightforward solution, which avoids inefficiency losses, is to abolish all subsidies to education and introduce a public loan scheme. At the same time, this policy removes liquidity constraints stemming from the capital-market imperfections. Education would be entirely privately financed, and capital-market imperfections would be overcome by public loans.

Individuals who enrol in education can take out a loan and repay it once they start working. Contrary to the previous redistributive policies, all individuals may invest in education when a loan system is implemented. Three alternative ways of

implementing the loan program are considered in this section: a pure loan scheme; a mixture of public loan and education subsidy; and a conditional loan reimbursement scheme. The evaluation of outcomes is performed in *ex-post* sense only.

III-1 A pure public loan policy

It's assumed under this regime that all individuals can obtain a loan that totally covers the cost of education, ϕ. This loan has to be fully reimbursed, irrespective of whether or not the individual succeeds in completing his education. The government budget is thus balanced, as total loans are paid back. This policy removes the liquidity constraint that binds the poor, so that the decision of schooling investment only depends on the individuals' potential abilities. However, for an individual, the cost of schooling failure is higher under this policy than under the education subsidy regime.

Individuals with low levels of ability cannot invest in education. Their utility is given by:

$$U_u = w_u l_u + x(1+r) - \delta l_u^{\eta} \tag{28}$$

Those with higher levels of ability invest in education, but some of them fail to achieve this investment. This group of individuals has a utility of:

$$U_f = w_u l_u + x(1+r) - \delta l_u^{\eta} - \phi \tag{29}$$

The remaining individuals succeed in completing their education and become skilled workers. They have a utility of:

$$U_s = w_s l_s + x(1+r) - \delta l_s^{\eta} - \phi \tag{30}$$

The comparison between the expected utility from investing and not investing in education yields the following threshold of ability, under which individuals do not invest in education:

$$a^* = \frac{\phi}{(w_s l_s - w_u l_u) - \delta(l_s^{\eta} - l_u^{\eta})} \tag{31}$$

Hence, the fraction of individuals that invests in education is now given by:

$$N_e = \int_{a^*}^{1} g(a)\, da \tag{32}$$

The fraction of successful individuals is:

$$N_s = \int_{a^*}^{1} a\, g(a)\, da \tag{33}$$

Hence, the fraction of individuals that fails to complete education is:

$$N_f = N_e - N_s = \int_{a^*}^{1} (1-a)\, g(a)\, da \tag{34}$$

Finally, the population that cannot invest at all in education is defined by:

$$N_d = 1 - N_e = \int_{0}^{a^*} g(a)\, da \tag{35}$$

It follows that the unskilled population, N_u, comprises individuals who do not acquire any education and those who fail to complete their education (i.e., $N_u = N_d + N_f$).

III-2 A mixture of public loan and education subsidy

This policy regime has two components. First, as under the pure public loan, individuals can obtain a loan that has to be fully paid back, irrespective of whether or not they become skilled workers. Second, education is subsidized at a rate of v. Education subsidies are financed by taxing those who have successfully completed their education. Unsuccessful students do not have to pay this tax. Hence, successful students have to reimburse their own cost of education (the public loan net of the subsidy) and the subsidy received by unsuccessful students. Thus, under this policy regime, the balanced government budget is written as below:

$$v\phi N_e = \tau w_s N_s l_s \tag{36}$$

Individuals who cannot acquire education at all (because of their low levels of ability) have a utility of:

$$U_u = w_u l_u + x(1+r) - \delta l_u^{\eta} \tag{37}$$

Those who invest but fail in completing education have the following utility:

$$U_f = w_u l_u + x(1+r) - \delta l_u^{\eta} - \phi(1-v) \tag{38}$$

Those who succeed in completing their education become skilled and enjoy the following utility:

$$U_s = (1-\tau) w_s l_s + x(1+r) - \delta l_s^{\eta} - \phi(1-v) \tag{39}$$

The comparison between the expected utility from investing and not investing in education provides the following critical level of ability under which individuals cannot be educated:

$$a^* = \frac{\phi(1-v)}{(1-\tau)w_s l_s - w_u l_u - \delta(l_s^\eta - l_u^\eta)} \tag{40}$$

III-3 Repaying public loan under the condition of success

Contrary to the pure loan regime, this program consists of a loan that the student receives from the government, such that repayment takes place only in the event that he successfully completes his education (i.e., when he becomes a skilled worker). Thus, the unskilled workers do not have to pay back the loan they received. All individuals, however, are taxed on their labour incomes in order to raise the revenues needed to cover the education cost of unsuccessful students. The government balances its budget by choosing the labour income tax rate that allows it to cover the loans allocated to failing students. Thus, the equilibrium tax rate must satisfy the condition below:

$$\tau^* = \phi N_f \; / \; (w_s N_s l_s + w_u N_u l_u) \tag{41}$$

The expected utility from investing in education is given by:

$$EU = x(1+r) + a\left[(1-\tau)w_s l_s - \delta l_s^\eta - \phi\right] + (1-a)\left[(1-\tau)w_u l_u - \delta l_u^\eta\right] \tag{42}$$

The utility from not investing is:

$$U_u = x(1+r) + (1-\tau)w_u l_u - \delta l_u^\eta \tag{43}$$

Performing the difference between these two levels of utility, and assuming that additional benefits from schooling exceed its additional costs (i.e., $(1-\tau)\left(w_s\, l_s - w_u\, l_u\right) > \phi + \delta\left(l_s^{\eta} - l_u^{\eta}\right)$), one may see that $EU > U_u$. Hence, under this policy regime, all individuals are incited to enrol in education, irrespective of their levels of ability. The size of the population that invests in education is therefore $N_e = 1$ (i.e., the fraction of individuals that does not enrol at all, $N_d = 0$). Accordingly, given the risk associated with the schooling investment, the proportions of individuals that respectively succeed and fail in completing education are as follows:

$$N_s = \int_0^1 a\; g(a)\; da \tag{44a}$$

and

$$N_f = \int_0^1 (1-a)\, g(a)\; da \tag{44b}$$

III-4 Efficiency and equality measurement

With a loan system, parental inheritances play no role in determining schooling decisions. Recall that under the first and the second regimes considered above (when loans have to be paid back, irrespective of whether the individual succeeds or fails in completing his education), there are three groups of individuals: those who do not invest at all, with utility of U_u; those who invest but fail, with utility of U_f; and those who invest and succeed, with utility of U_s. In this case, efficiency can be written as follows:

$$V = \int_0^{a^*}\int_0^{\bar{x}} U_u\; f(x)\, g(a)\; d\,x\, d\,a + \int_{a^*}^1\int_0^{\bar{x}} \left[a\, U_s + (1-a)\, U_f\right] f(x)\, g(x)\; d\,x\, da \tag{45}$$

Under the last regime, however -when reimbursement is made conditional to the eventual success so that all individuals enrol in education- there are only two groups of individuals: those who succeed, with utility of U_s; and those who fail, with utility of U_f. Hence, efficiency writes as follows:

$$V = \int_0^1 \int_0^{\bar{x}} \left[a\, U_s^l + (1-a)\, U_f^l \right] f(x)\; g(x)\; d\,x\,da \tag{46}$$

As in the previous section, we use the *GINI* index of utilities to measure inequality. i.e.,

$$GINI = \frac{1}{\overline{U}} \sum_{m>n} \sum_{n} N_m\, N_n \left| \overline{U}_m - \overline{U}_n \right| \tag{47}$$

where m and n denote the groups of individuals, $\overline{U}$ is aggregate utility, $\overline{U}_m$ and $\overline{U}_n$ are mean utilities of groups m and n, respectively, and N_m and N_n are the fractions of individuals of type m and n, respectively.

Again, social welfare is evaluated on the basis of individuals' utilities. Under the first two regimes, it can be defined as follows:

$$\begin{aligned} \Omega = \frac{1}{1-\rho} \Bigg\{ & \int_0^{a^*} \int_0^{\bar{x}} (U_u)^{1-\rho}\, f(x)\, g(a)\; dxda \\ & + \int_{a^*}^1 \int_0^{\bar{x}} \left[a (U_s)^{1-\rho} + (1-a)(U_f)^{1-\rho} \right] f(x)\, g(a)\; dxda \Bigg\} \end{aligned} \tag{48}$$

Under the last regime, welfare is given by:

$$\Omega = \frac{1}{1-\rho}\left\{\int_0^1\int_0^{\bar{x}} \left[a\,(U_s)^{1-\rho} + (1-a)(U_f)^{1-\rho}\right] f(x)\,g(a)\,dx\,da\right\} \qquad (49)$$

III-5 The comparison results

III-5-1 The analytical results

The comparison of outcomes associated with the three considered loan programs yields the results which we summarize in the following proposition:

Proposition 5:

a- *Schooling attendance and success rates (N_e and N_s, respectively) are higher under the program of conditional loan reimbursement than the combination policy of public loan and education subsidies, which in turn are higher under the pure public loan program. All these policies produce higher school participation and success rates than those observed in the case of no government intervention.*

b- *Efficiency is higher under the pure public loan regime than the combination policy, which in turn is higher under the conditional loan reimbursement program.*

c- *Equality is higher under the conditional reimbursement loan policy than the combination policy, which in turn is higher under the pure loan policy. All these policies result in more equality than that achieved under the competitive economy.*

The result in part (a) of this proposition assesses the supremacy of the conditional loan policy in fostering the rates of schooling participation and success. Indeed, exonerating unsuccessful individuals from paying back their loans provides

insurance against the failure risk, which incites all individuals to enrol in education. Therefore, the most important rate of success is achieved under this policy regime.

The pure public loan results in a higher schooling attendance rate compared to that associated with the competitive economy because credit-constraints are overcome. The risk against failure, however, is still binding. The cost of failure is even higher than that observed under the education subsidy policy. In fact, while individuals who fail have to reimburse the total cost of education under the pure loan, this cost is subsidised under the education tuition policy. Hence, setting a pure loan still discourages some individuals with a low level of ability from investing in education, although credit-constraints are fully eliminated. Therefore, human capital investment is lower under this policy than the education subsidy regime. Combining the pure loan with the education subsidy reduces the disincentives to invest in education for individuals with low levels of ability, which consequently implies higher investment and success rates under this combination than the pure loan policy.

Part (b) of the proposition points out that the pure public loan yields the highest level of efficiency among all the programs considered in this study. This result is due to the absence of any distortion tax effect under this policy. This policy also outperforms the no-government-intervention situation, because it generates a higher proportion of skilled workers (with the highest utility level). Under the combination policy, however, efficiency decreases as the tax rate (or education subsidy) goes up.

With the conditional loan program, all workers are taxed on their labour incomes in order to finance the loans that unsuccessful workers have obtained. In this context, efficiency dramatically decreases for two reasons. First, the resulting proportion of skilled workers associated with this policy dramatically shifts down the gross wage of this population. Second, this wage is taxed.

The result in part (c) of this proposition arises both from the composition and the wage effects associated with the different policies. Indeed, the degree of inequality is the lowest under the conditional loan program, since the fraction of skilled workers is the highest and its relative gross wage is the lowest under this policy regime. The combination policy and the pure public loan regime, however, exert lower equalizing effects, respectively.

The evaluation of the policies in terms of social welfare is sometimes easy to perform. For instance, relative to the no-government-intervention case, the pure public loan scheme results always in higher levels of welfare (i.e., whatever is the degree of inequality aversion) because both efficiency and equality are higher.

For the two other policies, however, where the equality/efficiency trade-off still holds, one should set the degree of inequality aversion parameter, ρ. For instance, while the combination policy provides more equality than the pure public loan, efficiency is higher under the pure loan than under the combination policy. Moreover, while the conditional loan reimbursement regime is the most equalizing policy, it exerts the most harmful effect on efficiency. In what follows, we provide numerical solutions to perform the ordering of the alternative policies in terms of social welfare.

III-5-2 The numerical results

Table 5 below summarises the simulation results for the rates of schooling attendance and success under each of the three programs considered above. It also evaluates the aggregate expected utility (AEU), the *GINI* index, and the level of social welfare by policy regime, and for both low and high parameters of inequality aversion.

This table shows that relative to the case of no-government intervention, the pure loan scheme induces 5% extra-schooling investment. This reflects the fact that with a

loan program, wealth ceases to be determinant in schooling decisions. This schooling increment is, however, of low magnitude, as this policy regime does not provide insurance against school failure. Nevertheless, relative to the no-government-intervention situation, efficiency is improved under the pure public loan since schooling investment increases without labour distortion tax ($\tau = 0$).

Table 5*: Summarized (ex-post) outcomes under the different public loan schemes*

			N_s	N_f	N_d	AEU	*GINI*	Welfare $\rho=0.2$	Welfare $\rho=0.8$
No government intervention			0.42	0.20	0.38	1.446	0.187	1.661	5.319
Pure public loan			0.45	0.22	0.33	1.459	0.161	1.671	5.324
	$\tau=0.00$	$v=0.00$	0.45	0.22	0.33	1.459	0.161	1.671	5.324
Pure	$\tau=0.02$	$v=0.09$	0.45	0.24	0.31	1.488	0.149	1.672	5.331
public loan	$\tau=0.04$	$v=0.19$	0.46	0.26	0.28	1.454	0.137	1.671	5.335
and	$\tau=0.06$	$v=0.28$	0.46	0.27	0.27	1.452	0.127	1.670	5.338
education	$\tau=0.08$	$v=0.37$	0.47	0.29	0.24	1.445	0.114	1.665	5.339
subsidy	$\tau=0.10$	$v=0.47$	0.48	0.32	0.20	1.439	0.103	1.661	5.339
	$\tau=0.12$	$v=0.56$	0.49	0.34	0.17	1.431	0.092	1.655	5.337
Public loan under conditional reimbursement ($\tau = 0.104$)			0.5	0.5	0.0	1.363	0.038	1.594	5.295

The table also indicates that compared to the no-government-intervention situation, the economy achieves more equality by implementing the pure public loan, as shown by the lower level of the *GINI* index. Indeed, the increase in the fraction of skilled workers drives down the wage ratio of skilled to unskilled workers, and the distribution of utilities becomes more equal. Since both efficiency and equality improve under the pure loan policy, welfare is higher under this policy than the no-government case, regardless of the degree of inequality aversion.

Some other interesting results emerge when the pure public loan is combined with the education subsidy regime. First, the combination policy yields lower levels of inequality than the pure loan policy does, but it does so at the cost of efficiency losses stemming from the tax distortion effects. Therefore, this policy outperforms the pure loan scheme on social welfare ground, provided that the degree of inequality aversion is relatively high. For low levels of inequality aversion, however, the pure loan regime comes out as the optimal policy.

Second, the combination policy is superior to the education subsidy policy in terms of both efficiency and equality, and thus, in terms of social welfare. Indeed, under the combination policy, efficiency is higher because the tax is paid only by successful students. So, the labour distortions are diminished, and the marginal failure rate is reduced because the subsidy rate, in this case, is lower (see Table 2). In addition, more equality may be achieved under the combination policy because unskilled workers do not have to pay the income tax, contrary to the case of the education subsidy regime. Hence, since both efficiency and equality are higher under the combination policy than the education subsidy program, welfare is also higher, regardless of the degree of inequality aversion.

With the regime of conditional public loan reimbursement, loans are paid back only in the event of success. This provides total insurance against failure, and all individuals borrow the loan and invest in education. It results in over-education, which lowers drastically the gross wage of skilled labour. Consequently, this policy yields the lowest level of efficiency, as compared to all the policies considered in this study. At the same time, this policy regime is associated with the lowest level of inequality (*GINI* index = 0.038) because the skilled-to-unskilled wage ratio is dramatically decreased. Hence, in spite of its significant positive effect on equality, the conditional loan policy provides less welfare, as compared to the all other policies.

Figures 11a and 11b below compare the levels of social welfare under the loan programs, the education subsidy regime, and the negative income tax program for low and high degrees of inequality aversion, respectively.

Figure 11a: Social welfare and tax: ρ = 0.2
(Ex-post evaluation)

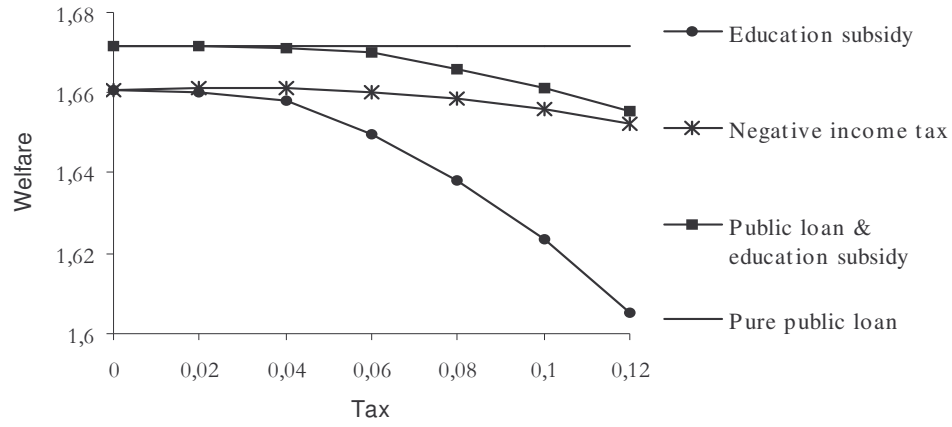
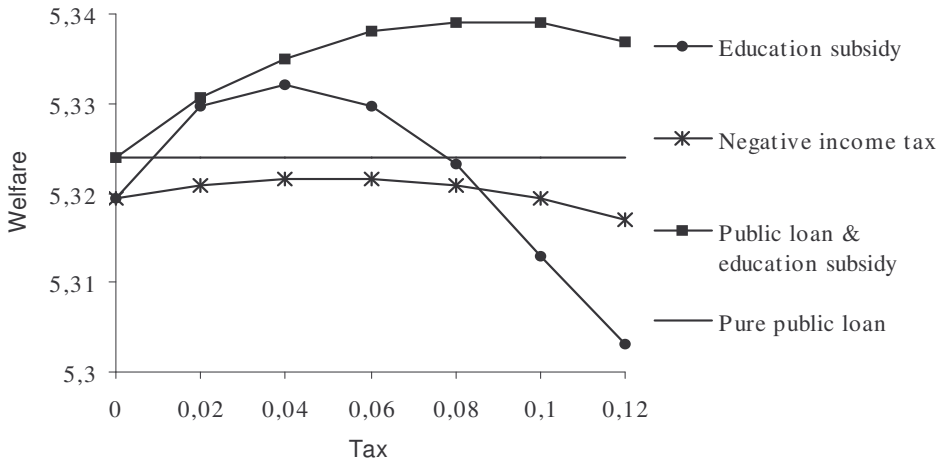


Figure 11b: Social welfare and tax: ρ = 0.8
(Ex-post evaluation)



The proposition below summarises the main results emerging from this comparison.

Proposition 6:

- When the degree of inequality aversion is low, welfare is higher under the pure public loan policy than the combination policy, which in turn is higher under the negative income tax and the education subsidy policies.

- When the degree of inequality aversion is relatively high, a combination of the pure public loan and the education subsidy is optimal. It performs better than these two policies when separated.

Conclusion

The main purpose of this chapter was to compare the public education provision policy to fiscal redistributive policies on the basis of social welfare in an economy where capital markets are imperfect and investment in education involves uncertainty. The redistributive policies include a negative income tax and an unskilled wage subsidy. Welfare is evaluated both on the grounds of efficiency and equality. The important insight from this analysis is that these policies have quite different effects on human capital investment, efficiency, equality, and consequently, social welfare. In particular, we find that when outcomes are evaluated in *ex-post* sense, inequality is higher under the direct subsidy of unskilled wage and the negative income tax policies than the education subsidy program. Furthermore, while education subsidies raise equality in *ex-post* sense, they reduce efficiency, because they are associated with tax distortions and high marginal failure rates. Therefore, this policy is optimal, provided that the degree of inequality aversion is relatively high and the income tax is not too distorsive.

A pure public loan eliminates such equality/efficiency trade-off, since more equality can be achieved without distortion effects. In addition, the society achieves more equality when the pure loan is combined with the education subsidy policy. This, however, is realized at the cost of a distortion tax. Therefore, this combination provides higher levels of welfare than all the other policies addressed in this study, provided that the degree of inequality aversion is relatively high. For low degrees of inequality aversion, however, the pure public loan is optimal.

Appendix

Proofs of proposition 1

In order to analytically evaluate the impact of a tax increase on the distribution of education, we determine the partial derivatives of the two thresholds with respect to the tax rate under the three policies. Recall that in ex-ante terms, gross wages are given, i.e., they are unaffected by the change in the distribution of skills that stems from the tax increase.

- By using Equations (17), (18a), (18b), (19a) and (19b), we can write -after some simplifications- the two derivatives under the education subsidy policy as follows:

$$\frac{\partial\, a^*}{\partial\, \tau} = -\frac{\phi(1+r)(1-v)}{A^2}\left[\frac{v}{\tau(1-v)A} - \left(\frac{\eta A}{(\eta-1)(1-\tau)}\right)\right] < 0$$

where $A = (1-\tau)(w_s\, l_s - w_u\, l_u) - \delta(l_s^{\eta} - l_u^{\eta}) > 0$,

and

$$\frac{\partial x^*(a)}{\partial \tau} = -\frac{1}{(i-r)}\left[\frac{v\phi(1+i)}{\tau} - a\left(\frac{\eta A}{(\eta-1)(1-\tau)}\right)\right] < 0$$

Indeed, since $x^*(a) > 0$, Equation (18b) implies that: $\phi(1-v)((1+i) > a\,A, \quad \forall a$.
Hence these two derivatives are negative as far as: $v/\tau(1-v) > \eta(\eta-1)(1-\tau)$, which is likely to be always true for reasonable parameter values.

- By using Equations (19a), (19b), (21a) and (21b), these derivatives write under the negative income tax as follows:

$$\frac{\partial a^*}{\partial \tau} = \frac{\eta\phi\,(1+r)}{(\eta-1)\,(1-\tau)A} > 0,$$

and

$$\frac{\partial\, x^*(a)}{\partial \tau} = \frac{\eta a}{(\eta-1)(i-r)(1-\tau)} > 0$$

- Under the unskilled wage subsidy policy, we obtain after using Equations (22), (23a), (23b), (24a) and (24b) the following derivatives:

$$\frac{\partial a^*}{\partial \tau} = \frac{\eta \phi (1+r)}{(\eta - 1) B^2} \left[\left(\frac{1}{1-\tau^e} \right) ((1-\tau^e) w_s l_s - \delta l_s^\eta) + \left(\frac{\tau^u}{\tau^e} \right) \left(\frac{1}{1+\tau^u} \right) ((1+\tau^u)\, w_u l_u - \delta l_u^\eta) \right] > 0$$

, and

$$\frac{\partial x^*(a)}{\partial \tau} = \frac{\eta a}{(\eta - 1)(i - r)} \left[\left(\frac{1}{1-\tau^e} \right) ((1-\tau^e) w_s l_s - \delta l_s^\eta) + \left(\frac{\tau^u}{\tau^e} \right) \left(\frac{1}{1+\tau^u} \right) ((1+\tau^u) w_u l_u - \delta l_u^\eta) \right] > 0$$

where: $B = (1-\tau^e) w_s\ l_s - (1+\tau^u) w_u\ l_u - \delta (l_s^\eta - l_u^\eta) > 0$

One can easily check that both derivatives are higher under the unskilled wage subsidy than the negative income tax which are, in turn, higher than under the education subsidy policy.

Figures

Figure 3a: Evolution of mean utilities under tuition subsidies regime (Ex-ante evaluation)

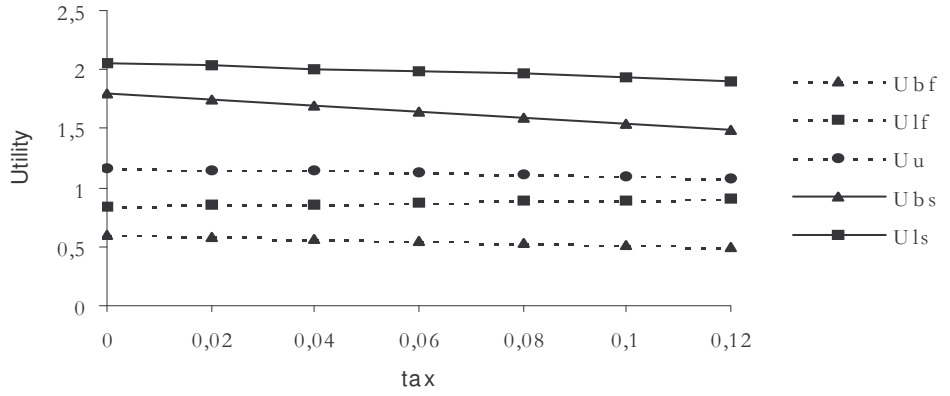


Figure 3b: Evolution of mean utilities under the negative income tax regime (Ex-ante evaluation)

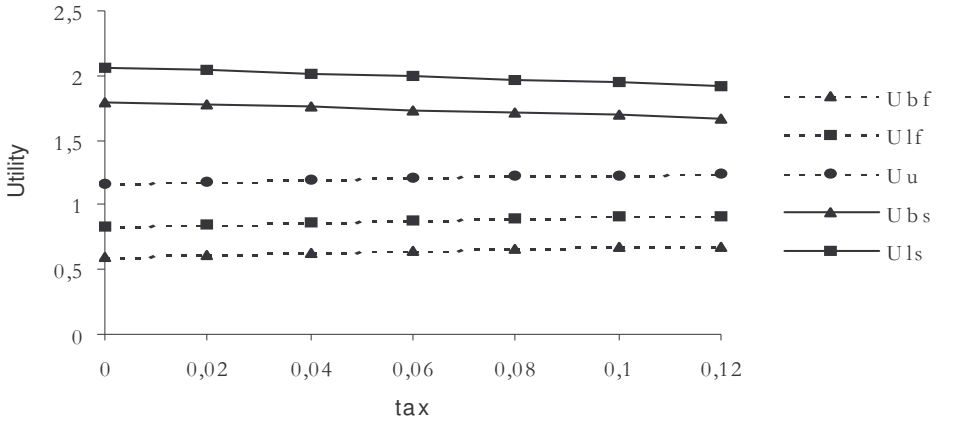


Figure 3c: Evolution of mean utilities under the unskilled wage subsidy regime (Ex-ante evaluation)

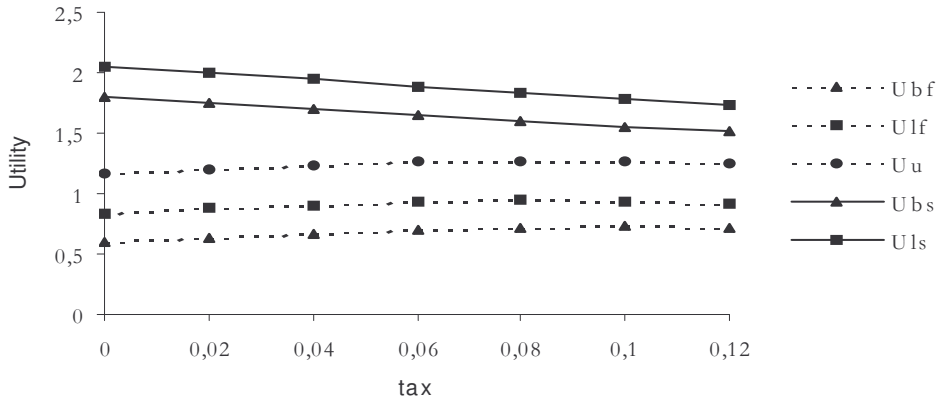


Figure 4: Ex-ante distribution of utilities (τ = 6 %)

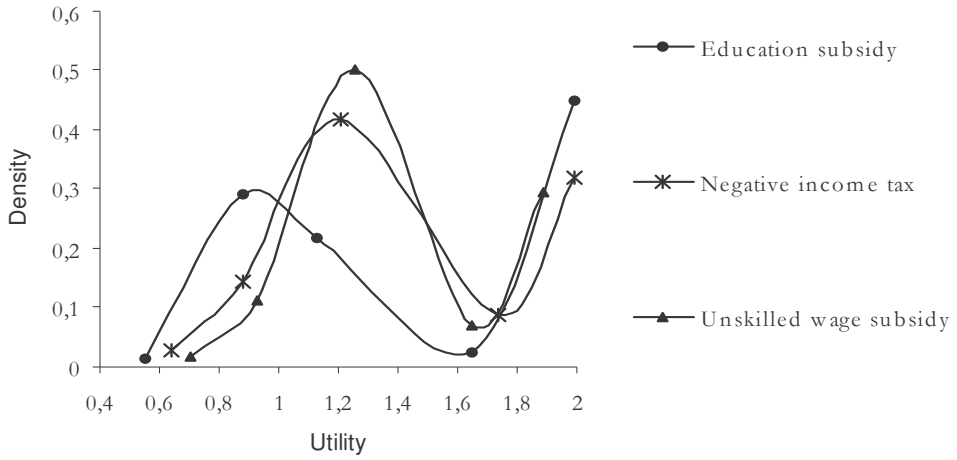


Figure 8a: Evolution of mean utilities under tuition subsidies regime (Ex-post evaluation)

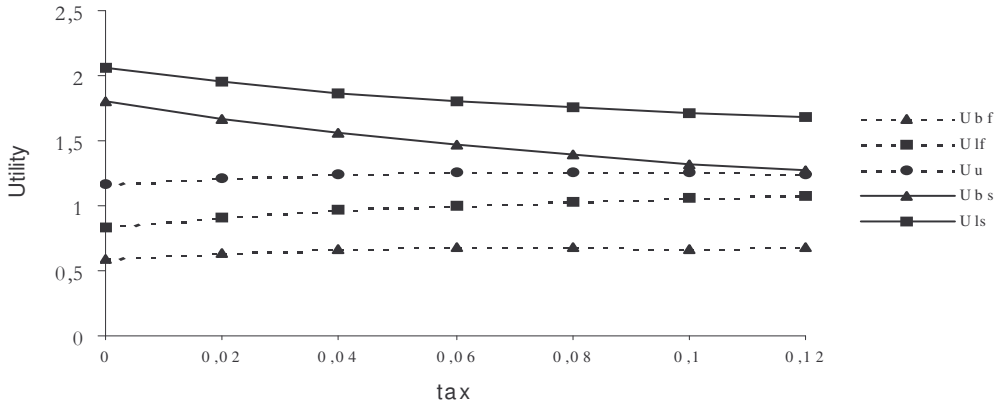


Figure 8b: Evolution of mean utilities under the negative income tax regime (Ex-post evaluation)

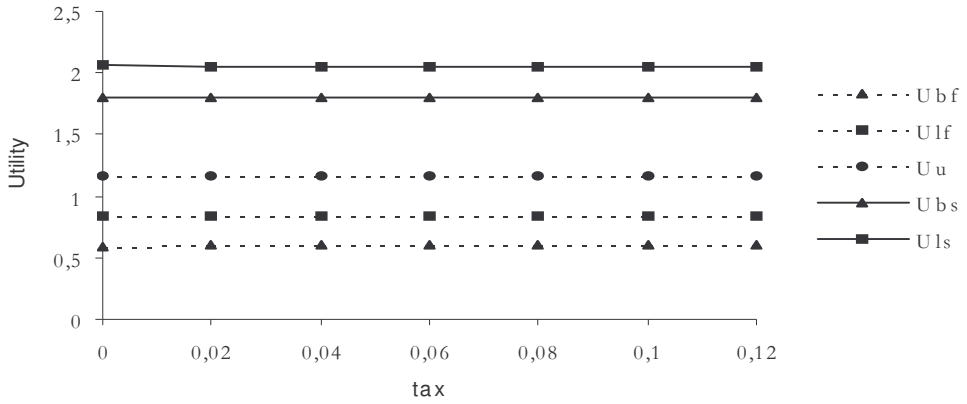


Figure 8c: Evolution of mean utilities under the unskilled wage subsidy regime (Ex-post evaluation)

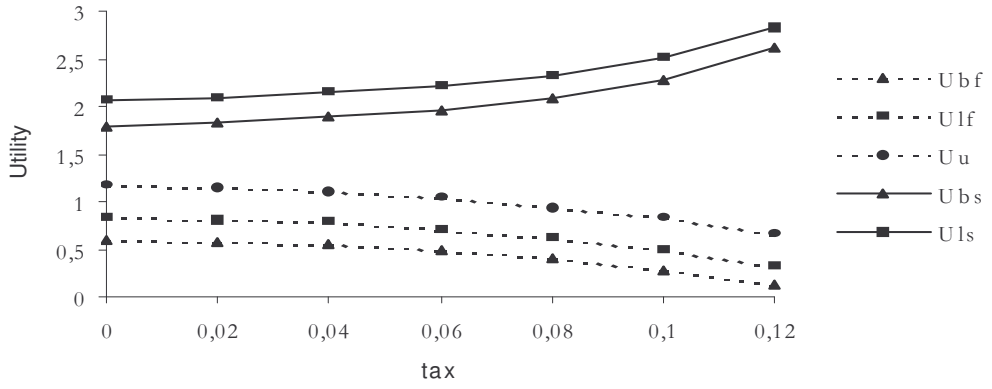
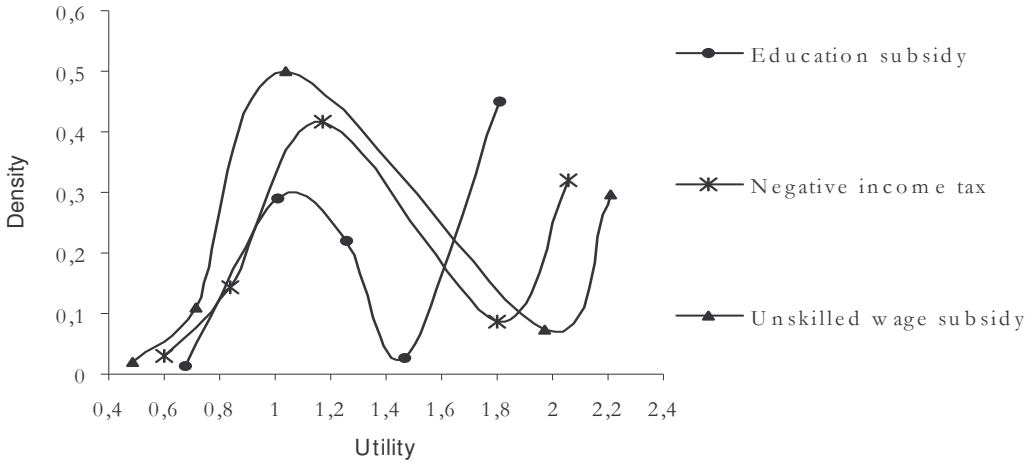


Figure 9: Ex-post distribution of utilities (τ = 6 %)



Chapter IV

Post-primary schooling: the impacts of credit-constraints and public education expenditures *

Introduction

The current chapter tests empirically the robustness of the credit-constraints hypothesis used throughout the first and third chapters of the thesis, and provides an evaluation of the contribution of public education expenditures to the cross-country post-primary schooling gaps. Testing the credit-constraints hypothesis is crucial because of the debate raised while interpreting the effect of parents' incomes on children's educational attainment [1]. Indeed, there are, in theory, two—not necessarily mutually exclusive—interpretations of such intergenerational correlation.

The first interpretation focuses on the credit-constraints argument, in which students from poor families may be prevented from investing in higher levels of education, as they are borrowing-constrained.

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*: *This chapter is a detailed version of a published paper in the "Journal of Applied Economics", forthcoming, (2007).*

1: *Recent micro-economic literature established that children from rich families invest more in education than children from poor ones. For instance, based on 35 developing countries, Filmer and Pritchett (1998) found that the bulk of the deficit from universal enrolment up to primary comes from the poor. Using American data, Ellwood and Kane (2000) find that students in the richest quarter of the income distribution were 26 percent more likely to enrol in post-secondary schooling than students in the poorest quarter.*

The second interpretation emphasizes the role of the family social background—namely, parents' education—as it is associated with higher family incomes. Because parents' higher incomes are generally associated with parents' higher education levels, children of wealthy parents also are better able to access higher educational levels. In fact, children of better-educated parents may inherit the abilities, personalities, and preferences that led to the higher educational achievement of their parents [2].

On the micro-empirical level, the issue of the relative importance of the two arguments is still unresolved. Indeed, one set of studies finds that the effect of parents' income on children's schooling attendance is insignificant, compared to that of parents' education, and it concludes for the lack of importance of the borrowing-constraint argument vis-à-vis the social-factors argument [3].

For instance, Ellwood and Kane (2000) find that the enrolment gap between the poorest and richest quartile in the U.S. declined from 26 percent to 9 percent, once controlling for the student's cognitive test scores and parents' education. Cameron and Heckman (1999, 2001) and Carneiro and Heckman (2002 and 2003) show that after controlling for ability, the family income/college enrolment relationship is small and statistically insignificant in the U.S., and that responses to tuition are uniform across income groups. Ability and parents' education, however, are found to be more important, even though a group of people (at most, 8 percent of the population) is seen to be facing credit-constraints that affect their post-secondary schooling. Moreover, Keane and Wolpin (2001) stress that liquidity constraints are tight but have little effect on school attendance decisions in the U.S.

2: We refer the reader to the studies of Becker. G (1964), Boudon (1973), Bourdieu & Passeron (1970), Glomm.G (1997), Birdsall (1999) and Oreopoulos, Page and Stevens (2003) for a more extensive literature on the intergenerational transmission of education.

3: Notice that some recent empirical studies pointed out that the positive relationship between parents' education and children's schooling is found to be not robust to controls for unmeasured, intergenerationally-correlated endowments. These studies include Behrman, Jere R. and Mark R Rosenzweig, (2002 & 2005); Black, Sandra E., Paul J. Devereux, and Kjell G. Salvanes (2005).

Credit-constraints are found to have their primary effects on other choices made by youths; that is, the relaxation of borrowing-constraints induces students to work less—while studying—and consume more, but does little to affect attendance decisions. Controlling for parents' background variables and children's ability, Shea (2000) finds a significant effect of parents' income on children's schooling. Using instrumental variables, however, this effect comes out insignificant.

Another set of studies establishes a positive correlation between public expenditures and schooling attainment and greater tuition sensitivity of enrolments for the poor, which provides support for the financial-constraints assessment. For example, Dynarski (1999) finds a significantly large impact of government financial aid on the college attendance of middle- and upper-income youth in the state of Georgia. Furthermore, Kane (1994) argues that the sensitivity of college enrolment to tuition fees is greater for students from poorer families. Finally, Ellwood and Kane (2000) find that differences in state tuition and grant programs result in differences in terms of children's enrolments in the U.S.

We use, throughout this chapter, cross-country data on schooling enrolments to test the relevance of the borrowing-constraints argument, while controlling for the effects of social factors and public expenditures on education. Studying this issue from an international point of view may help understand whether the result of the lack of importance of the role of borrowing constraints in educational investment is specific to the U.S. (or more generally, to developed countries), or may be extended to developing countries.

On the macro-level side, previous empirical works, including De Gregorio (1996), Li, Squire and Zou (1998), Flug, Spilimbergo and Wachtenheim (1998), Checchi (2000) and Clarke, Xu and Zou (2003) have emphasised the role of credit-constraints but are subject to some insufficiencies.

The first insufficiency stems from the fact that these studies usually interpret the negative estimated coefficient upon the income-inequality variable in the regression of human-capital investment as evidence that supports the borrowing-constraint theory. These studies, however, do not control for the effect of the differences in social factors. Omitting this effect would bias upward the effect of income inequality and would weaken the robustness of the credit-constraint hypothesis.

Second, these studies do not test for the robustness of the borrowing-constraint argument to the composition of the sample of countries. The study of Flug et al. (1998) is an exception, because it shows the importance of this argument in both poor and industrialised countries. However, as this work does not control for the effect of the distribution of social factors on schooling enrolments, the robustness of this argument should be re-examined.

Finally, these studies use an aggregate proxy for public education expenditures in the regression of schooling enrolment rates which is the ratio of total expenditures on education to GDP. Most of these works find insignificant correlation between these two variables [4]. This may arise simply because this proxy is inappropriate in determining the impact of expenditures on schooling investments.

In this analysis, we disaggregate public education expenditures into expenditures allocated to the primary, the secondary, and the tertiary schooling levels.

4: For instance, De Gregorio (1996) finds that the ratio of public education expenditures over GDP has positive but non-significant effect on tertiary schooling enrolment ratio. Flug et al (1998) find that this effect is insignificant in the case of the secondary schooling enrolment ratio. Checchi (2000) shows that this effect is significantly positive in the tertiary enrolment case, and significantly negative in the secondary case. The low association of the total public expenditures on education and schooling attainments is also documented in Gupta, et al.(1997) and Gupta, et al.(2002) for the case of African countries, and Benedict (1997) and Birdsall (1999) for the case of Latin American countries.

This disaggregation allows us to better understand the mechanisms through which the impact of expenditures transmits to schooling enrolments, and to offer policy guidance in terms of the allocation of expenditures across the various schooling levels.

The analysis pursued in this chapter should be seen as complementary to the studies stressed above, as it attempts to shed more lights on the question of the relevance of the credit-constraints hypothesis, its robustness, and the contribution of education provision policy in closing cross-country schooling gaps. The remainder of the chapter is organized as follows. Section I presents the data and estimation methodology used in this analysis. Section II presents the basic estimation results and tests for the robustness of the credit-constraints thesis. Section III examines the impacts of public education expenditures in their disaggregated form on schooling enrolments, and confirms the robustness of the results by using proxies for the allocation of expenditures across the educational levels. Finally, section IV evaluates the relative contributions of the variables used throughout this analysis in explaining the enrolment gaps observed between the Sub-Saharan African region and Latin American countries on one hand, and the OECD countries on the other hand.

I- Data and estimation methodology

Throughout this study, we use both gross secondary and tertiary enrolment ratios from 1970 to 2000 as our measures of investment in human capital [5]. These data are extracted from the UNESCO database (2003). In order to test for the liquidity-constraint thesis, we experiment with two explanatory variables.

5: Gross secondary (tertiary) enrolment ratio is defined as the total enrolment of students of all ages in secondary (tertiary) school as a proportion of the total population of the pertinent age group. These ratios may exceed 100 percent because some students are older than the corresponding age group.

i) The first variable is the *Gini index of incomes*, which should proxy for the degree of the collaterable asset inequality [6]. This index is obtained from Deininger and Squire data set (1996). This data-set promises to be of higher quality and broader coverage than any other available data set on income distribution. Notice that the definition of what is being measured by the Gini index varies in this database across countries: inequality can be measured in terms of gross or net income or in terms of expenditures, and it can be per-capita or per-household. Because variation in definitions can affect the international comparability of the data, we include in our regressions controls for different definitions of inequality.

ii) Our second variable is a proxy of the *extent of credit accessibility*. Beck and Levine (1999) constructed data on total credits to households from the banking system over GDP for a large number of countries. This measure can be used as a proxy for the development of the banking system, and, at the same time, for the ability of households to obtain credit. This variable is denoted later by *CR*. The higher *CR,* the less severe is the borrowing constraint. One may argue that this proxy is not informative with regard to the real extent of borrowing constraints; namely, in the developed countries where households have the possibility to borrow from other financial and non-financial institutions.

6: As far as data on distribution are concerned, ideally we need data on the distribution of wealth, which are hard to find. Some data compiled by Alesina and Rodrik (1994) on the distribution of land ownership in 1960 for some countries are available, which is the closest we can get to the distribution of wealth.

However, one also can claim that the existence of such a possibility does not imply that households in the developed countries are not credit-constrained, as some financial guarantees are generally necessary in order to borrow from these institutions. Therefore, it is likely that poor individuals who are constrained in the banking system are also those who are prevented from borrowing outside this system. This conjecture justifies the use of our proxy of the borrowing-constraint in both developing and developed countries. Furthermore, our proxy provides the magnitude of borrowing-constraints with more precision than monetary aggregate ratios, like M2/GDP or M3/GDP which are often employed in the literature [7].

For the test of the family social-background factors, we use the *Gini index of education* over the period 1970-2000 as a proxy for the inequality in the distribution of parents' education. We compute this index using the Barro and Lee database (2000) on the distribution of the population with more than 25 years across the various stages of education. Details of the computations are presented in the Appendix.

Based on these considerations, we begin our tests by estimating the baseline equation given below:

$$S = \beta_1 + \beta_2 \, Log(y)_{70} + \beta_3 \, GiniEduc + \beta_4 Gini + \beta_5 \, C\,R + \beta_6 \, D_j \qquad (I)$$

7: See Li, Squire and Zou (1998) and Flug et al.(1998) for examples.

where:- S is the secondary (or tertiary) gross enrolment ratio in (%),

- $Log\ (y)_{70}$ is the logarithm of per-capita income in 1970 expressed in PPPs at constant prices. This variable is extracted from the Penn World Tables (6.1) (2002).
- *GiniEduc* is the Gini index of education in (%),
- *Gini* denotes the Gini coefficient of incomes in (%),
- CR is the ratio of credits to households from the banking system to GDP in (%),
- $D_j\ (j=1,2,3)$ denote dummies associated with the definitions of the *Gini* index of incomes, with D_1 = incomes versus expenditures, D_2 = individual versus household, and D_3 = gross versus net.

Sign expectations are as follows. Enrolment rates are likely to be higher in rich countries ($\beta_2 > 0$). Including this variable in the regression of schooling enrolment ratios is crucial to distinguishing the wealth effect from the banking-sector development effect. The higher the inequality in the distribution of parents' education, the lower is the fraction of children who are demonstrably able to achieve the primary school level and to attain the secondary and the tertiary levels ($\beta_3 < 0$). Income inequality may limit the access to education when financial markets are imperfect ($\beta_4 < 0$). The more developed a banking system, the less binding are the borrowing-constraints and the higher is the participation rate in the higher stages of education ($\beta_5 > 0$).

Our sample consists of unbalanced data from 19 OECD countries and 67 developing countries (hereafter, DCs). Tables (A) and (B) in the Appendix show the individual data on the variables used in this analysis by country, with averages for OECD and DCs, and for the years 1970 and 2000, respectively. The statistics show that the secondary and the higher-education enrolment ratios are at least twice as high in OECD countries as in DCs in 1970 and 2000. OECD countries also have much lower *Gini*

indexes of both income and education than DCs do. The ratio of credits to GDP is, on the contrary, by far higher in OECD countries than in DCs, with respectively ratios of 62 percent and 26 percent in 2000 in these sub-samples.

The regression of the baseline equation is run using both cross-section and panel data procedures. The latter procedure allows to controlling for the country-specific effects. In the case of cross-section estimation, we use the data averaged over the period 1970-2000. In the panel estimation case, data are averaged over five-year periods for two reasons: first, data on *Gini* coefficients of income are limited in time. By using five-year averages, we achieve a more balanced panel data-set. Second, the data on *Gini* coefficients of education are available only over quinquennial periods.

In the case of cross-section regressions, equation (I) can be estimated by ordinary least squares technique (OLS), unless the variance of the error term is heteroscedastic. We test for the potential presence of heteroscedasticity by using the *Breusch-Pagan/Cook-Weisberg* test. If heteroscedasticity is detected, standard errors are estimated using the *White's procedure* (in order to obtain robust standard errors). The *Breusch-Pagan/Cook-Weisberg* test is based on the null hypothesis that the variance is constant. Therefore, when the probability is large (> 5 %), we accept the null hypothesis of constant variance.

In the case of panel-data regressions, the generalised least squares (GLS) estimator is the most efficient, provided that the *Hausman test* accepts the null hypothesis of no correlation between the specific effects and the regressors. This test compares the estimation results of fixed and random effects models. *Hausman (1978)* shows that when the regressors are exogenous, both the Within and the GLS estimators are consistent. Nevertheless, under the endogeneity hypothesis, the Within estimator is consistent, but not the GLS. Hence, with the null hypothesis of exogeneity, the two estimators provide similar results and the differential statistic is low (and the probability is large (> 5 %)).

We provide the results of the tests for the homoscedasticity and exogeneity hypotheses at the bottom of each table that contains the estimation results.

II- The estimation results

The estimation results of equation (I) are presented in Table 1, below, for both the secondary and the higher-education enrolment rates. Overall, the variables on which we focus in this section account for more than 80 and 55 percent of the cross-country differences, respectively, in the secondary and tertiary enrolment rates. Two major results emerge from these estimates.

First, controlling for the countries' economic-development levels and educational inequality, we find that both income inequality and the development of the credit-markets are highly significant in explaining the international variance in schooling enrolment ratios. This result is evident in both cases of secondary and higher-education levels, and tends to contrast with the conclusion of Cameron and Heckman (1999, 2001) and Carneiro and Heckman (2002 and 2003), which points to the insignificant effects of financial factors on the children's schooling attendance.

Second, both cross-section and panel-data estimations show *deceasing marginal effects* of social and financial factors with respect to the schooling level. To provide a quantitative appreciation, let's consider the cross-section results. On average, a one standard deviation increase in the *Gini index of education* reduces the secondary enrolment rate by about 17 percent and the higher-education enrolment rate by only 7 percent. On the other hand, a one standard deviation increase in the *Gini index of incomes* translates into a reduction of 6 percent in the secondary enrolment ratio and a reduction of about 3.5 percent in the tertiary enrolment ratio. With regard to the effect of the borrowing constraint, we find that a one standard deviation increase in the degree of

accessibility to credits (*CR*) is associated with an increase of about 4 percent in the secondary enrolment ratio and of 1.2 percent in the tertiary enrolment ratio.

These results may be understood as follows: first, the decreasing marginal effect of educational inequality is directly due to the decreasing marginal impact of the parents' education on children's schooling attendance. Indeed, one may argue that social background factors that are present from birth through adolescence mainly produce the ability needed to participate in secondary education. Their marginal effect is, however, diminished during the higher stages of education.

Second, the marginal decrease in the effects associated with both income inequality and the extent of credit accessibility is due to the degree of heterogeneity in students' income-classes that declines with respect to the schooling level. In this sense, students who have succeeded in enrolling in the secondary level are more likely to be those of relatively wealthy parents. Therefore, additional financial facilities (through redistributing income or relaxing the borrowing-constraints) to those students would have only a low-marginal impact on enrolments at the tertiary education level. By contrast, the marginal effect of such facilities should be higher in the case of the secondary schooling, as enrolled students (coming from the primary level) are from more heterogeneous income classes.

Notice that this result is consistent with the study of Checchi (2000), in which the marginal effect of income inequality on enrolments is higher in the secondary than in the tertiary level. In addition, De Gregorio (1996) points out that the secondary schooling enrolment ratios are the most affected by the degree of borrowing-constraints. Nevertheless, these results are left unexplained in these studies.

Table 1: *The determinants of Secondary and Higher-education enrolment rates: 1970-2000*

Dependent variables*: Gross Secondary and Higher-education enrolment rates (%)*

	Secondary education		**Higher education**	
Variables	**Cross-section**	**Panel-data**	**Cross-section**	**Panel-data**
Constant	93.02 (13.9)	5.241 (0.44)	15.23 (1.13)	7.490 (5.51)
Log (y)$_{70}$	3.150 (2.44)	11.06* (9.35)	4.115 (2.35)	7.231* (6.25)
GiniEdu (%)	- 0.903 (- 9.53)	- 0.521 (- 4.66)	- 0.381 (- 3.63)	- 0.422 (- 5.12)
Gini (%)	- 0.661 (- 3.50)	- 0.562 (- 4.62)	- 0.398 (- 1.94)	- 0.313 (- 2.13)
CR (%)	0.218 (2.63)	0.121 (2.33)	0.128 (1.35)	0.272 (6.02)
D1 : Inc/exp	3.704 (0.70)	1.015 (0.37)	5.218 (1.33)	0.825 (0.24)
D2 : Ind/hous	- 8.391 (- 2.33)	- 0.054 (- 0.03)	- 5.404 (- 1.13)	0.103 (0.04)
D3 : Gross/net	- 4.748 (- 1.10)	1.435 (0.62)	4.253 (0.87)	3.732 (1.13)
N.countries[obs]	72	[287]	71	[284]
R^2	0.869	0.831	0.621	0.515
B-Pagan χ^2(.)	0.02	----	12.39	----
Pr > χ^2	0.892 [a]	----	0.000 [b]	----
Hausman χ^2(.)	----	16.22	----	11.26
Pr > χ^2	----	0.012 [c]	----	0081 [d]

Note: t-statistics are in brackets.

**: In the case of panel-data estimates, Log (y) is used instead of Log (y)$_{70}$.*

a: Estimations are run using OLS technique.

b: Estimations are run using White's procedure.

c: Estimations with fixed effects.

d: Estimations with random effects.

Inequalities in incomes and education, as well as the extent of the financial-market access, could have different effects on enrolments, depending on the level of income in an economy. In order to check this, we split our sample into high- and low-income countries by considering the per-capita income of US$8000 (Purchasing Power Parity terms) in 2000 as the divisor income [8].

The regression results for each subgroup of countries are given in Table 2, below. They confirm that the key variables of the model remain highly significant in most of specifications, and have quite different effect magnitudes across the two sub-samples. The surprising result is that our key variables have greater impacts in wealthy countries than in poor ones. This implies that policies that aim to alleviate inequalities in income and/or to facilitate the access of households to the credit-market are likely to be more effective in fostering schooling enrolments in wealthy countries. This result seems surprising in light of the widely held conventional wisdom along which these policies should be especially effective in poor countries, where income and education inequalities are high and the financial market is less developed. How can we thus explain this result?

8: In 1999, the World Bank defines high-income countries as countries whose GNP per-capita was $9266 or more in 1999. This group includes both developed countries and high-income developing countries.

Table 2: *The determinants of Secondary and Higher-education enrolment rates, by economic development : 1970-2000*

Dependent variables*: Gross Secondary and Higher-education enrolment rates (%)*

	Per-capita income < US$ 8000 (PPP)		**Per-capita income > US$ 8000 (PPP)**	
Variables	**Secondary**	**Tertiary**	**Secondary**	**Tertiary**
Constant	106.5 (9.83)	25.57 (3.66)	123.2 (11.2)	91.63 (3.13)
GiniEdu (%)	- 0.813 (- 6.84)	- 0.212 (- 2.77)	- 1.140 (- 9.10)	- 0.773 (- 2.31)
Gini (%)	- 0.629 (- 3.28)	- 0.242 (- 1.97)	- 0.876 (- 3.43)	- 1.514 (- 2.22)
CR (%)	0.137 (1.93)	0.113 (1.45)	0.212 (2.11)	0.143 (1.55)
D1 : Inc/exp	- 6.458 (- 0.99)	- 0.585 (- 0.14)	18.30 (2.82)	4.881 (0.28)
D2 : Ind/hous	- 0.754 (- 0.15)	- 0.843 (- 0.27)	- 3.923 (- 1.18)	2.314 (0.26)
D3 : Gross/net	5.957 (1.02)	7.732 (2.06)	- 7.344 (- 2.38)	10.43 (1.27)
N.countries[obs]	54	53	18	18
R^2	0.790	0.590	0.957	0.704
B-Pagan χ^2(.)	0.91	0.20	1.30	3.59
Pr > χ^2	0.339 [a]	0.656 [a]	0.253 [a]	0.058 [a]

Note: t-statistics are in brackets.

a: Estimations are run using OLS technique

A higher degree of income inequality is generally associated with a larger fraction of the population which is prevented from borrowing to invest in education. In a poor economy, income inequality tends to be high, and therefore, increases in the amount of credits to households should benefit only a small fraction of the population. This fraction should be larger in a wealthy country, where income inequality is relatively low (i.e.,

where the fraction of the population which is able to borrow is relatively high). Similarly, because inequalities in incomes and education are higher in low-income countries than in wealthy countries, their marginal impact on enrolments appear lower in the first group of countries.

III- The effects of public education expenditures

The previous section has established the robustness of both financial and social-factors arguments to the specific-country effects and to the composition of the considered samples of countries. In this section, we test the robustness of these arguments to the inclusion of the supply-side variables; namely, public education expenditures. Education expenditures may positively affect human capital investment by lowering the cost of education that parents have to pay for their children (the liquidity effect), or by improving the quality of education received by the students (the quality effect). These two effects raise the probability of children's participation in higher levels of education or in achieving these levels.

Notice that unlike theoretical studies that have assumed that more financial education resources translate into a better educational quality, the empirical tests of such a relationship are not conclusive. For instance, Ehrenberg and Brewer (1995) show that measurable school input has little impact on student achievement, and Hoxby (1998) finds no evidence that smaller classes have a positive effect on test scores. Furthermore, Hanushek and Somers (1999) find no significant association between education spending and students' performance in the U.S as measured by their test scores.

On the other hand, Betts (1995), Goldhaber and Brewer (1997), and Eide and Showalter (1998) argue that teacher qualifications, smaller classes, and spending funds on computers have a positive impact on students' achievement. In addition, Card and

Abigail (2002) point out that, changes in spending inequality in the U.S. can affect the gap in test scores among different social-background groups. Barro and Lee (1997) show that family input and school resources are closely related to students' performance, as measured by internationally comparable test scores, repetition rates, and dropout rates. Lorraine and Costas (2000) show that the pupil-teacher ratio has, in the UK, a positive impact on women's wages. Finally, Kelly and William (2000) find that teaching expenditures and classroom resources (versus administrative resources) have a positive and significant effect on students' test scores in California.

Testing the strength of the relationship between educational expenditures and the quality of education goes beyond the scope of this analysis. Nevertheless, by studying the effects of public expenditures in their disaggregated form, we are able to provide evidence that shows that this relationship is strong. As has been stressed in the introduction of this chapter, macroeconomic studies often tend to focus on the ratio of total expenditures on education to GDP to display the impact of government expenses on schooling enrolments. But in most of cases, the effect is found to be insignificant.

There are at least two major drawbacks in using education expenditures in their aggregated form. The first one is that this form is unable to provide any policy recommendation regarding the allocation of expenditures across the levels of schooling. The second one is that it offers no information on the channels through which expenditures affect schooling decisions. More precisely, the ratio of public education expenditures over GDP cannot distinguish the liquidity and the quality effects associated with education expenditures. This distinction is crucial in light of the result established in Chapter I of this thesis, which stresses the role of these two effects in the decision to acquire advanced education. Indeed, as investment in education is hierarchic, enrolments in advanced education not only depend on the resources devoted to this level, but on those allocated toward the previous schooling levels as well. One should therefore

analyse the effects of public education expenditures in a more disaggregated way in order to better understand the relative importance of the mechanisms through which educational expenditures affect schooling enrolments.

III-1 International comparison of public education expenditures by schooling level

Internationally comparable data on public expenditures by educational stage are not available. Our study remedies this deficiency by constructing data on annual per-student public education expenditures at the primary, secondary, and tertiary levels, expressed in PPP (Purchasing Power Parity) terms. We use data on national public expenditures and total enrolments by schooling level from the UNESCO database (2003), and data on the PPPs of GDP from the Penn World Tables (6.1) (2002) in order to convert the national measures of per-student expenditures into a real one that is internationally comparable.

Figures 1 and 2 in the Appendix show the levels of per-student public expenditures by schooling level and by geographical region for the years 1970 and 2000, respectively, whereas Table 3, below, provides the ratios of these expenditures in a way that gives an idea on the magnitude of the gap in education funding across educational levels. It is clear from the two figures that higher stages of education tend to receive higher levels of public expenditures, and that per-student expenditures have been increased in the period 1970-2000. However, the evolution in the gaps in education funding across the educational stages differ widely across regions. Indeed, while some regions have dramatically reduced these gaps between 1970 and 2000, other ones still have gaps of a great magnitude. For instance, the ratio of tertiary-to-primary per-student expenditures declined from 2.7 in OECD countries in 1970 to 2.4 in 2000; and from 3.3

to 2.5 in East Europe between these same years. The most spectacular evolution toward equalization of public educational expenditures is achieved in East Asia, as the ratio of tertiary-to-primary per-student expenditures declined from 14.8 to only 2.8 between the years 1970 and 2000, and that of tertiary-to-secondary per-student expenditures has fallen from 6.5 to 1.9 in this same period.

***Table 3**: The distribution of public expenditures across educational levels, by region:*

Region		*OECD*	*Sub-Sahar. Africa*	*Mle.East & Nth.Afr*	*South Asia*	*East Asia*	*Latin America*	*East Europe*
Ratio: Exp_{High} / Exp_{Prim} (*)	*1970*	*2,7*	*40*	*9,8*	*11,9*	*14,8*	*12,2*	*3,3*
	2000	*2,4*	*15,6*	*7,6*	*5,4*	*2,8*	*7,6*	*2,5*
Ratio: Exp_{High} / Exp_{sec} (**)	*1970*	*1,8*	*5,2*	*4,8*	*7,5*	*6,5*	*6,1*	*1,4*
	2000	*1,8*	*5*	*4,1*	*2,2*	*1,9*	*5,4*	*2,1*

***Source**: Author's calculations*

(*) Exp_{High} / Exp_{Prim} denotes the ratio of tertiary to primary per-student public expenditures.

(**) Exp_{High} / Exp_{sec} is the ratio of tertiary to secondary per-student public expenditures.

Unlike these regions, the other ones still remain highly unequal in terms of their educational funding policy, with a ratio of tertiary-to-primary per-student expenditures going from 40 to 15 in Sub-Sahara African region between 1970 and 2000, from 12 to 7.6 in Latin America, from 12 to 5.4 in South Asia, and from 9.8 to 7.6 in the Middle-East and North Africa region.

To sum up, except for East Asian countries, the concentration of public expenditures on the higher stages of education, especially on the tertiary education, appears as one structural feature that characterizes the education funding policy in most

of DCs. OECD countries, however, have been much more egalitarian in their allocation of education expenditures during the last three decades. In the section below, we show that the allocation policy matters in explaining cross-country enrolment gaps.

III-2 Public education expenditures and post-primary schooling enrolments : the regression analysis

The partial correlations in Table 4, below, show a low association between schooling enrolment ratios and public education expenditures, as measured by the ratio of total public education expenses over GDP (τ): a correlation of 0.06 and 0.09, respectively, for the secondary and the tertiary levels. This result suggests that such a ratio may not be appropriate in estimating the effects of expenditures on schooling enrolments. There is evidence, however, of a higher correlation between schooling enrolments, and per-student public expenditures allocated to these levels and to the previous ones. For instance, there is a positive correlation between the secondary enrolment ratio and per-student expenditures devoted to both secondary and primary levels. Furthermore, high enrolment ratios at the tertiary level tend to be associated with higher per-student public expenditures allocated to this level and toward the primary and the secondary levels as well.

Finally, we notice that partial correlations across per-student expenditures at the different levels are fairly high suggesting that including more than one level of expenditure in the regression of schooling enrolments can introduce bias into the estimations. We therefore re-estimate equation (I) by firstly including the per-student expenditures at the different educational levels, separately.

***Table* 4**: *Public education expenditures and schooling enrolment rates:*

(Partial correlations)

Nbre.obser (287)	*Sec.enrol*	τ	*Log (Exp)$_{Prim}$*	*Log (Exp)$_{Sec}$*
Sec.enrol	1.000			
τ	0.063	1.000		
Log (Exp)$_{Prim}$	0.182	0.543	1.000	
Log (Exp)$_{Sec}$	0.288	0.611	0.811	1.0000

Nbre.obser (284)	*High.enrol*	τ	*Log (Exp)$_{Prim}$*	*Log (Exp)$_{Sec}$*	*Log (Exp)$_{High}$*
High.enrol	1.000				
τ	0.091	1.000			
Log (Exp)$_{Prim}$	0.202	0.631	1.000		
Log (Exp)$_{Sec}$	0.177	0.729	0.807	1.000	
Log (Exp)$_{High}$	0.195	0.625	0.566	0.775	1.000

Notes: *- Sec.enrol = Secondary enrolment rate*

- High.enrol = Higher-education enrolment rate

- τ = ratio of total public expenditures on education over GDP.

- (Exp)$_{Prim}$ = per-student public expenditures at the primary level.

- (Exp)$_{Sec}$ = per-student public expenditures at the secondary level.

- (Exp)$_{High}$ = per-student public expenditures at the higher-education level.

- Log = the Logarithm form.

This specification may, however, suffer from an endogeneity problem that arises from possible simultaneity effects between enrolment ratios and the expenditure variables. For this reason, we re-run the same regressions using, in the case of cross-section estimations, average enrolment ratios on the period 1985-2000 as the dependent variables, and lagged values of expenditures averaged over the 1970-1985 period as instruments for the expenditure variables. In the case of panel-data estimations with fixed effects, lagged values of expenditures are used as instruments for the expenditure variables.

The estimation results are reported in Tables 5 and 6 for the secondary and the higher-education levels, respectively. We shall, first of all, underline that cross-country and panel-data specifications show the same qualitative result; namely, the robustness of the impact associated with the social and financial factors, to the inclusion of the expenditure variables. Two other interesting results shown in these tables concern the magnitude of the effects of education expenditures. First, the estimations show a positive coefficient upon the effect of the ratio of total public expenditures over GDP in all the specifications and for the two levels of education. But as expected, this effect is statistically insignificant in all the cases. Second, the estimations show more significant coefficients on per-student expenditures allocated across the various schooling levels ($Log\ (Exp_i)$). This is especially evident when estimations are run using *2SLS* technique.

Table 5: *The determinants of Secondary enrolment rates using education-expenditure variables: 1970-2000*
Dependent variable*: Gross Secondary enrolment rates (%)*

	OLS			2SLS					
Variables	**Cross-section (a)**			**Cross-section (b)**			**Panel-data with fixed effects (c)**		
Constant	95.58 (7.87)	95.81 (6.97)	96.77 (7.21)	114.1 (6.07)	101.4 (7.82)	110.9 (8.43)	29.05 (2.24)	32.07 (5.28)	38.60 (2.80)
$Log(y)_{70}$	2.668 (1.87)	2.335 (1.26)	1.527 (0.82)	1.335 (0.69)	1.299 (0.70)	1.012 (0.78)	9.933* (7.08)	8.971* (8.06)	7.591* (3.91)
GiniEdu (%)	- 0.904 (- 10.96)	- 0.908 (- 9.58)	- 0.913 (- 10.2)	- 0.945 (- 7.99)	- 0.896 (- 9.80)	- 0.920 (- 10.4)	- 0.722 (- 9.78)	- 0.672 (- 10.4)	- 0.670 (- 6.04)
Gini (%)	- 0.614 (- 3.70)	- 0.599 (- 2.96)	- 0.591 (- 3.10)	- 0.740 (- 3.17)	- 0.695 (- 3.61)	- 0.626 (- 3.47)	- 0.515 (- 4.73)	- 0.757 (- 8.32)	- 0.764 (- 4.77)
CR (%)	0.223 (3.10)	0.212 (2.44)	0.214 (2.50)	0.220 (2.09)	0.179 (2.18)	0.270 (2.73)	0.185 (3.70)	0.136 (2.24)	0.197 (2.63)
τ (%)	0.042 (0.04)	----	----	0.698 (0.43)	----	----	0.132 (0.18)	----	----
$Log\ (Exp)_{Sec}$	----	0.802 (1.16)	----	----	2.343 (1.90)	----	----	2.501 (1.97)	----
$Log\ (Exp)_{Prim}$	----	----	1.090 (0.72)	----	----	1.843 (1.85)	----	----	1.633 (1.86)
D1 : Inc/exp	3.906 (0.85)	4.410 (0.88)	4.227 (0.86)	7.069 (1.07)	4.197 (0.85)	2.718 (0.57)	0.671 (0.19)	- 12.80 (- 1.40)	6.854 (1.52)
D2 : Ind/hous	- 9.768 (- 2.78)	- 10.64 (- 2.79)	- 10.06 (- 2.76)	- 5.507 (- 1.21)	- 8.546 (- 2.43)	- 5.441 (- 1.28)	- 3.913 (- 1.90)	10.97 (2.54)	- 2.195 (- 5.02)
D3 : Gross/net	- 4.305 (- 1.15)	- 4.318 (- 0.94)	- 3.728 (- 0.83)	- 3.491 (- 0.72)	- 1.235 (- 0.31)	- 0.163 (- 0.04)	- 4.826 (- 1.82)	18.99 (2.26)	- 0.602 (- 1.16)
N.countries[obs]	72	72	72	72	72	72	[215]	[215]	[215]
R^2	0.900	0.891	0.893	0.829	0.910	0.921	0.878	0.971	0.981
B-Pagan $\chi^2(.)$	8.33	6.55	4.45	----	----	----	----	----	----
$Pr > \chi^2$	0.00	0.01	0.03	----	----	----	----	----	----

Notes: - t-statistics are in brackets. (a): Average secondary enrolment ratios are computed over 1970-2000 period. Regressions are run using Robust estimations. (b): Enrolment ratios are those over 1985-2000 period, and expenditure variables are instrumented using their mean values over 1970-1985 period. Exogeneity test cannot be run in the case of 2SLS estimations. (c): Instruments for education expenditures are lagged values of these variables. Only fixed-effects estimations can be run in the case of 2SLS, and Hausman test cannot therefore be performed. Fixed country-effects are not reported.
*: *Log (y)* is used instead of $Log\ (y)_{70}$.

Table 6: *The determinants of Higher-education enrolment rates using education-expenditure variables: 1970-2000*
Dependent variable*: Gross Higher- education enrolment rates (%)*

	OLS				2SLS							
Variables	**Cross-section (a)**				**Cross-section (b)**				**Panel-data with fixed effects (c)**			
Constant	15.31	- 2.185	14.29	19.61	12.03	- 5.15	15.45	18.75	9.423	10.24	10.67	9.575
	(1.19)	(- 0.14)	(1.38)	(1.74)	(0.63)	(- 0.16)	(1.30)	(1.72)	(1.91)	(2.25)	(1.69)	(1.93)
$Log(y)_{70}$	2.555	2.921	0.569	0.958	3.092	1.479	1.952	2.100	6.908*	6.241*	5.275*	4.227*
	(1.30)	(1.77)	(0.28)	(0.50)	(1.59)	(1.57)	(2.12)	(2.22)	(5.29)	(3.58)	(4.23)	(4.02)
GiniEdu (%)	- 0.369	- 0.314	- 0.282	- 0.334	- 0.372	- 0.406	- 0.277	- 0.335	- 0.184	- 0.128	- 0.233	- 0.385
	(- 3.22)	(- 3.11)	(- 3.05)	(- 3.34)	(- 3.12)	(- 2.00)	(- 2.38)	(- 3.52)	(- 2.10)	(- 1.52)	(- 3.70)	(- 2.08)
Gini (%)	- 0.359	- 0.595	- 0.372	- 0.271	- 0.501	- 0.837	- 0.401	- 0.285	- 0.247	- 0.396	- 0.314	- 0.251
	(- 1.90)	(- 2.30)	(- 2.30)	(- 1.67)	(- 2.13)	(- 2.37)	(- 2.07)	(- 1.45)	(- 2.08)	(- 2.37)	(- 1.75)	(- 1.74)
CR (%)	0.120	0.155	0.113	0.105	0.145	0. 139	0.123	0.147	0.124	0.109	0.126	0.145
	(1.25)	(1.49)	(1.18)	(1.08)	(1.93)	(1.83)	(1.73)	(1.94)	(1.65)	(1.90)	(1.95)	(2.02)
τ (%)	1.784	----	----	----	1.740	----	----	----	1.114	----	----	----
	(1.20)				(1.06)				(1.32)			
$Log\ (Exp)_{High}$	----	3.700	----	----	----	3.645	----	----	----	1.309	----	----
		(1.87)				(2.20)				(1.73)		
$Log\ (Exp)_{Sec}$	----	----	3.221	----	----	----	3.802	----	----	----	1.346	----
			(1.58)				(2.80)				(2.02)	
$Log\ (Exp)_{Prim}$	----	----	----	2.043	----	----	----	2.252	----	----	----	1.419
				(1.43)				(1.96)				(2.26)
D1 : Inc/exp	5.405	8.855	7.961	6.391	7.849	7.541	12.33	12.49	- 1.196	4.200	2.377	- 0.990
	(1.31)	(2.62)	(1.94)	(1.48)	(1.18)	(0.79)	(2.07)	(1.80)	(- 0.32)	(1.01)	(0.39)	(- 0.15)
D2 : Ind/hous	- 2.817	- 4.046	- 7.415	- 8.162	0.566	3.613	- 7.268	- 6.142	0.521	5.127	- 4.939	- 5.062
	(- 0.47)	(- 0.69)	(- 1.99)	(- 2.21)	(0.12)	(0.52)	(- 1.94)	(- 1.03)	(0.21)	(1.09)	(- 1.09)	(- 1.02)
D3 : Gross/net	4.774	7.358	4.541	3.905	7.015	12.79	5.498	2.616	3.877	2.906	4.140	4.387
	(0.96)	(1.27)	(0.97)	(0.89)	(1.44)	(1.62)	(1.41)	(0.46)	(1.45)	(1.46)	(0.80)	(4.32)
N.countries[obs]	71	71	71	71	71	71	71	71	[203]	[203]	[203]	[203]
R^2	0.641	0.549	0.683	0.672	0.546	0.600	0.604	0.588	0.702	0.767	0.711	0.773
B-Pagan $\chi^2(.)$	6.83	5.55	5.45	6.65	----	----	----	----	----	----	----	----
$Pr > \chi^2$	0.02	0.01	0.01	0.02	----	----	----	----	----	----	----	----

Notes:- t-statistics are in brackets. (a): Average tertiary enrolment ratios are computed over 1970-2000 period. Regressions are run using Robust estimations. (b): Enrolment ratios are those over the 1985-2000 period, and expenditure variables are instrumented using their mean values over 1970-1985 period. Exogeneity test cannot be run in the case of 2SLS estimations. (c): Instruments for education expenditures are lagged values of these variables. Only fixed-effects estimations can be run in the case of 2SLS, and Hausman test cannot therefore be performed. Fixed country-effects are not reported. *: *Log (y)* is used instead of $Log\ (y)_{70}$.

Table 7 below summarises the effects associated with the increase in the various types of public education expenditures on post-primary schooling rates.

Table 7: *The (partial) impacts on enrolment ratios (in %) of a one standard deviation increase in per-student expenditures at the various schooling levels*

	Cross-section estimates		**Panel-data estimates**	
	Secondary	***Higher***	***Secondary***	***Higher***
$Log\ (Exp)_{Prim}$	2.39	2.92	2.25	1.95
$Log\ (Exp)_{Sec}$	2.45	3.98	2.83	1.52
$Log\ (Exp)_{High}$	-----	3.17	-----	1.17

Source: *Author's calculations from the 2SLS estimations in Tables 5 and 6.*

The results in this table are unequivocal. First, as long as the coefficients on the expenditure variables are statistically significant, our argument of the 'liquidity' and 'quality' channels associated with the effects of public expenditures seems to be well supported by the data. In fact, the liquidity effect is expressed by the positive correlation between the enrolment ratio at the secondary level and the expenditures allocated to this schooling level, and also by the positive impact of the expenditures received at the tertiary level on the enrolment ratio at this same level. The quality improvement effect is associated with the positive impact of expenditures allocated to the primary level on the secondary enrolment ratios. This effect is also apparent from the positive impact of expenditures devoted toward both primary and secondary educational levels on the higher-education enrolments ratios.

Second, the estimations reveal the effectiveness of financing the lower levels of schooling in fostering enrolment rates at the higher stages of education. Indeed,

according to Table 7, expenditures at the primary schooling level are at least as important as those devoted to the secondary level in affecting enrolment rates at the secondary level. Similarly, through their quality effect, per-student expenditures allocated to the primary and the secondary levels also exert a significant effect on enrolment rates at the tertiary level. Both cross-section and panel-data estimations provide evidence that tertiary-education enrolment ratios are more affected by additional expenditures that are allocated to both primary and secondary levels than by expenditures devoted to the tertiary level. Therefore, the importance of the quality effect associated with the financing of the basic schooling levels should depress the general belief that expenditures should be biased in favour of the higher levels of education in the context of credit-market imperfections. In fact, the estimations presented above show that countries with low levels of per-student expenditures at the basic schooling stages also experience lower enrolment ratios at the higher levels of education. Overall, the results reported in Tables 5 and 6 contrast with the conjecture that public education provisions are not effective in improving schooling participation.

Notice, however, that one can argue that in order to test the robustness of our claims concerning the relative importance of the different levels of expenditures, we would probably need evidence based on including these expenditures simultaneously in the equation of enrolment rates. Given that it is not possible to control for the different kinds of expenditures simultaneously without getting imprecise estimates -because of multicollinearity problems we pointed out above-, we use below only one variable that captures the allocation of expenditures across the educational levels. This is shown in Table 8 below, in which expenditures by schooling level are replaced by the Gini index of the distribution of these expenditures across the primary and the secondary levels (*Gini_S*); and across the primary, the secondary, and the tertiary levels (*Gini_T*),

respectively for the secondary and the tertiary regressions. The higher these indexes, the more concentrated are educational expenditures on the higher levels of schooling at the expense of the lower levels. We provide in the Appendix details on the computation of these indexes, as well as individual data of these variables for the years of 1970 and 2000. These data show unambiguously that, on average, DCs have by far larger values of these indexes than OECD countries do in both years of 1970 and 2000. For instance, the mean level of the *Gini_T* evolves from 49.6% to 38.5% in the DCs between these two years, and from 31.1% to 25.8% in the OECD countries. The *Gini_S* exhibits the same kind of evolution, i.e., a tendency toward decreasing values for both samples of countries, with Gini indexes being higher in the Dcs. One other salient fact shown in these tables is that the levels of *Gini_T* tend to be higher than those of *Gini_S*, especially in the DCs, which points toward a higher concentration of public funds on the tertiary schooling level than on the secondary level.

The estimation results in Table 8 show clearly that these indexes are negatively signed and statistically different from zero in the regressions of both secondary and tertiary enrolment rates. Unambiguously, this is evidence that supports our claims made above along which countries whose allocations of resources are biased against the lower schooling levels, also experiment low enrolment ratios at the higher stages of education.

Table 8: *The determinants of Secondary and Higher-education enrolment rates using Gini indexes for the distribution of exenditures:1970-2000*

Dependent variables*: Gross Secondary and Higher-education enrolment rates (%)*

	Secondary education		**Higher education**	
Variables	**Cross-section**	**Panel-data**	**Cross-section**	**Panel-data**
Constant	51.27 (2.15)	45.20 (2.12)	10.13 (1.30)	8.013 (0.25)
Log (y)$_{70}$	8.640 (3.01)	8.830* (4.44)	5.877 (2.63)	4.128* (2.38)
GiniEdu (%)	- 0.680 (- 6.09)	- 0.557 (- 4.08)	- 0.355 (- 3.13)	- 0.280 (- 4.22)
Gini (%)	- 0.730 (- 4.21)	- 0.890 (- 4.16)	- 0.400 (- 1.96)	- 0.241 (- 2.33)
CR (%)	0.192 (2.49)	0.147 (1.72)	0.148 (1.65)	0.174 (4.04)
Gini_S (%)	- 0.396 (- 1.98)	- 0.428 (- 1.90)	---- ----	---- ----
Gini_T (%)	---- ----	---- ----	- 0.280 (- 1.95)	- 0.215 (- 1.88)
D1 : Inc/exp	- 1.825 (- 0.32)	5.620 (1.11)	- 2.938 (- 0.44)	- 5.141 (- 0.90)
D2 : Ind/hous	- 4.309 (- 1.14)	- 2.423 (- 2.42)	- 2.517 (- 0.53)	- 7.184 (- 1.96)
D3 : Gross/net	0.205 (0.05)	- 4.205 (- 1.00)	8.653 (2.00)	- 4.141 (- 0.83)
N.countries[obs]	72	[287]	71	[284]
R^2	0.930	0.862	0.724	0.561
B-Pagan χ^2(.)	0.20	----	9.59	----
Pr > χ^2	0.652 [a]	----	0.002 [b]	----
Hausman χ^2(.)	----	25.82	----	12.22
Pr > χ^2	----	0.001 [c]	----	0.141 [d]

Note: t-statistics are in brackets.

**: In the case of panel-data estimates, Log (y) is used instead of Log (y)$_{70}$.*

a: Estimations are run using OLS technique. b: Estimations are run using White's procedure.

c: Estimations with fixed effects. d: Estimations with random effects.

- Gini_S and Gini_T are the Gini indexes of the distribution of public expenditures across the primary and the secondary levels; and across the primary, the secondary, and the tertiary levels, respectively.

IV- Inter-regional comparison of the sources of enrolment gaps

As a final point of our analysis, it is interesting to illustrate the contribution of the variables used in our regressions to the observed inter-regional variance in schooling enrolment ratios. To do that, we compare the regional averages of secondary and higher-education enrolment ratios between the Sub-Saharan African countries and Latin America on one hand, and the OECD countries on the other hand.

Sub-Saharan African and Latin American countries are known to have high income and education inequalities and an inefficient financial system. They are also known for their inefficient educational systems, even though they absorb high levels of public resources. The ratio of public expenditures on education to GDP over the period 1970-2000 was, indeed, 4.41 percent in the Sub-Saharan African countries and 3.98 percent in the Latin American countries, against 4.85 percent in the OECD countries.

Over the period 1970-2000, the gaps in the average schooling enrolment rates between the Sub-Saharan African region and the OECD countries are 64 percent at the secondary level, and 30.6 percent at the higher-education level. These gaps are, respectively, of 40.1 percent and 20.5 percent between the Latin American countries and the OECD countries. These differences are broken down in Table 9, according to the contribution of each of the variables used in this analysis. To explain our approach, let's take the panel-data estimations presented in Table 8. Enrolment rates can be expressed as follows:

$$S_{it} = \alpha + X_{it}\beta + v_i + \varepsilon_{it}$$

where X_{it} is a matrix of the explanatory variables used in the analysis, v_i is the country-specific residual, and ε_{it} is the "usual" residual with the usual properties.

If we define a region j as a group of countries, it must be true that average enrolment rate in this region is given by:

$$\overline{S}_j = \alpha + \overline{X}_j\beta + \overline{v}_j + \overline{\varepsilon}_j$$

where:

$$\overline{S}_j = \frac{1}{n_j T_j}\sum_i^{n_j}\sum_t^{T_j} S_{it} \; ; \quad \overline{X}_j = \frac{1}{n_j T_j}\sum_i^{n_j}\sum_t^{T_j} X_{it} \; ; \quad \overline{v}_j = \frac{1}{n_j}\sum_i^{n_j} v_i \; ; \quad \overline{\varepsilon}_j = \frac{1}{n_j T_j}\sum_i^{n_j}\sum_t^{T_j} \varepsilon_{it}$$

and n_j and T_j are respectively the size and time period of the region j.

Thus, the observed difference in the average enrolment rates between two regions, say A and B, can be decomposed as follows:

$$\overline{S}_A - \overline{S}_B = \left(\overline{X}_A - \overline{X}_B\right)\beta + \left(\overline{v}_A - \overline{v}_B\right) + \left(\overline{\varepsilon}_A - \overline{\varepsilon}_B\right)$$

The first term in the right-side of this equality expresses the contribution of the observed variables in explaining the enrolment difference, while the second and third terms refer to the contribution of the unobserved factors in the enrolment gap.

The results in Table 9 point out the importance of both social and material factors in explaining the observed gaps in schooling enrolments across the three considered regions. Indeed, controlling for the initial degree of economic development, we find that inequality in education explains around 26 percent of the secondary and tertiary schooling gaps between Sub-Saharan African and OECD countries, and around 32 percent of these gaps between Latin American and OECD countries. Income inequality and the extent of borrowing-constraints, together, account for around 25

percent of the secondary and tertiary schooling gaps across Sub-Saharan and OECD countries, and for around 42 percent of these gaps between Latin American and OECD countries.

The results in Table 9 also show that educational-fund allocation policies have an important role to play in explaining the observed interregional gaps in both the secondary and the higher-education enrolment ratios. Indeed, the Gini indexes of the distribution of expenditures can explain around 4 and 9 percent of the secondary and tertiary schooling gaps in the Sub-Saharan African countries/OECD comparison, and around 6 percent of these gaps in the Latin American countries/OECD comparison. This finding supports allocation policies that favour the financing of the lower-schooling levels. In this sense, post-primary schooling enrolment gaps that are observed in Sub-Saharan African and Latin American countries vis-à-vis the OECD countries would be lower if the allocations of public expenditures in these two regions were more equal.

Notice finally that the explanatory variables used in this study capture most of the observed inter-regional enrolment gaps. These gaps, indeed, are seen as more than 87 percent. The reminder of these gaps shown in the line ‘difference unexplained’ is attributed to the unobservable residuals; namely, the specific-country effects; and to the definitional dummies associated with income inequality.

***Table 9**: Sources of inter-regional differences in average enrolment rates: 1970-2000.*

Differences in Secondary enrolment ratios					*Differences in Higher-education enrolment ratios*				
	Sub-Saharan.Afr / OECD		*Latin America / OECD*			*Sub-Saharan.Afr / OECD*		*Latin America / OECD*	
Variables	*Point difference*	*Percent difference*	*Point difference*	*Percent difference*	*Variables*	*Point difference*	*Percent difference*	*Point difference*	*Percent difference*
- *Per-capita GDP_70*	- 16.68	26.03	- 9.81	24.43	- *Per-capita GDP_70*	- 7.80	25.44	- 4.58	22.34
- *GiniEduc*	- 20.53	32.03	- 10.40	25.90	- *GiniEduc*	- 10.32	33.67	- 5.39	26.29
- *Gini*	- 11.93	18.61	- 13.20	32.88	- *Gini*	- 3.23	10.53	- 4.12	20.09
- *CR*	- 4.08	6.36	- 3.62	9.01	- *CR*	- 4.82	15.72	- 4.33	21.12
- *Gini_S*	- 2.95	4.60	- 2.55	6.35	- *Gini_T*	- 2.70	8.81	- 1.29	6.29
- *Difference estimated*	- 56.22	87.7	- 39.58	98.57	- *Total estimated*	- 28.87	94.19	- 19.71	96.14
- *Difference observed*	- 64.08	100	- 40.14	100	- *Difference observed*	- 30.65	100	- 20.5	100
- *Difference unexplained*	- 7.86	12.3	- 0.56	1.43	-*Difference unexplained*	- 1.78	5.81	- 0.79	3.86

***Notes**:* - The results in this table rely on the estimated coefficients using panel-data regressions presented in Table 8.

Conclusion

We tested in this chapter the strength of the credit-constraints thesis in post-primary schooling using international data. We confront our regression results with other empirical studies that use American data and find no significant role of the credit-constraints in explaining American schooling-attendance gaps. Our regression results present several pieces of evidence that support the importance of the credit-constraints in producing cross-country schooling gaps.

First, controlling for the effects of per-capita income and education inequality, we find that enrolment ratios in both secondary and higher-education levels are negatively correlated with the Gini index of income and positively correlated with the degree of financial development. Second, these correlations are robust to the specific-country effects, the sample composition, and the inclusion of public education expenditures. Finally, public education expenditures are an important determinant of the variance of schooling enrolments in both the secondary and the tertiary levels.

Distinguishing poor from wealthy countries can show a crucial fact: the marginal effects of both social and material factors are higher in wealthy countries than in poor ones. This result implies that more equal income distribution and greater accessibility to the credit market are likely to be more effective in fostering enrolment ratios in the developed countries than in the developing ones.

Finally, we find that schooling enrolment ratios are affected not only by the expenditures directly allocated to the relevant educational levels but also by those allocated to the previous ones. Therefore, countries whose allocations of expenditures are biased against the lower-schooling stages also experience a drop in schooling enrolment rates at the higher stages.

The inter-regional comparison exercise shows that inequalities in incomes and education, as well as the extent of the credit-constraints and the allocation of public

education expenditures, together capture at least 94 percent of the tertiary-education enrolment gap between the Sub-Saharan African region and the OECD countries, and 96 percent of this gap between the Latin American countries and the OECD. At the secondary level, these variables account for 87 to 98 percent of the observed gaps in the schooling enrolment ratios across these regions, respectively.

Appendix:

- *Computation of the Gini index of education*:

This index is computed using data on the distribution of the population aged more than 25 years across the school levels, from Barro and Lee's (2000) data-set. The following relation is then employed:

$$GiniEdu = \frac{1}{2H} \sum_{i}^{n} \sum_{j}^{n} p_i \, p_j \left| x_i - x_j \right|$$

where: H is mean years of education of the population; p_i and p_j are the proportions of individuals with respectively the levels i and j of education; n is the number of educational levels (7 levels in Barro and Lee's (2000) dataset: no education, incomplete primary, complete primary, incomplete secondary, complete secondary, incomplete tertiary, and complete tertiary). x_i and x_j are the duration of studies at the levels i and j. For simplicity of computations, we have assumed that 5 years are necessary to complete one stage of education, and that incomplete education accounts for 2.5 years.

- *Computation of the Gini indexes of expenditures*:

The Gini index of the distribution of expenditures across primary and secondary schooling levels, *Gini_S*, is computed as follows:

$$Gini\_S = \frac{1}{D} \left(l_p \, l_s \left| D_p - D_s \right| \right)$$

where, D is total education expenditures; D_p and D_s are expenditures devoted respectively to the primary and the secondary levels; l_p and l_s are the proportions of enrolled students at the primary and the secondary levels, respectively.

The Gini index of the distribution of expenditures across primary, secondary, and tertiary schooling levels, *Gini_T*, is computed as follows:

$$Gini\_T = \frac{1}{D}\left(l_p\, l_s\, \left|D_p - D_s\right| + l_p\, l_t\, \left|D_p - D_t\right| + l_s\, l_t\, \left|D_s - D_t\right|\right)$$

where l_t and D_t are respectively the proportion of students enrolled in the tertiary education, and education expenditures at this educational level, respectively.

Table (A): *Individual data, by country, for the year 1970.*

Country	***GDP/capi***	***Sec.Enrol***	***High.Enrol***	***Gini* (%)***	***GiniEd (%)***	***CR (%)***	***τ (%)***	***Exp_{prim}***	***Exp_{sec}***	***Exp_{high}***	***Gini_S***	***Gini_T***
<u>Average DC s</u>	***1020***	***20.7***	***4.1***	***41.8***	***58.3***	***13.9***	***3.28***	***63***	***161***	***706***	***0.370***	***0.496***
Algeria	*562*	*7*	*1*	*54.1*	*85.4*	*51*						
Bahamas				*29*		*46.4*						
Bangladesh	*260*	*13*	*1*		*91.3*	*11.6*	*0.5*	*132*	*126*	*1929*	*0.05*	*0.546*
Barbados	*1599*	*52*	*15*		*25.3*	*31.7*		*115*	*124*	*1505*	*0.08*	*0.534*
Belarus				*46.8*								
Bolivia	*566*	*18*	*5*		*51.9*	*4.4*						
Botswana	*222*	*2*	*0.4*	*62*	*72.6*	*7.7*	*3.0*	*10*	*84*	*345*	*0.384*	*0.436*
Brazil	*653*	*16*	*2*	*27*	*60*	*8.9*	*2.2*	*50*	*80*	*3245*	*0.303*	*0.634*
Bulgaria	*1320*	*55*	*17*	*23*	*32*	*4.8*	*3.4*	*157*	*409*	*466*	*0.444*	*0.484*
Chile	*988*	*34*	*6*	*33*	*36.5*	*10.8*	*3.7*	*102*	*230*	*1597*	*0.317*	*0.499*
China	*160*	*23*	*0.1*	*51*			*1.4*	*12*	*90*	*400*	*0.543*	*0.521*
Colombia	*628*	*17*	*3*	*47*	*53*	*12.7*	*5.7*	*21*	*73*	*270*	*0.451*	*0.488*
Costa Rica	*841*	*24*	*6*	*51*	*40*	*16.4*	*4.6*	*37*	*78*	*270*	*0.416*	*0.399*
Cote d'Ivoire	*513*	*6*	*0.1*	*44*	*48*	*27.3*	*5.1*	*18*	*162*	*993*	*0.630*	*0.576*
Dominican, rep.	*455*	*12*	*2*		*49*	*7.2*	*2.6*	*13*	*34*	*206*	*0.355*	*0.554*
Ecuador	*523*	*17*	*3*		*51*	*16.8*	*3.5*	*10*	*41*	*256*	*0.381*	*0.446*
Egypt, Arab rep.	*428*	*26*	*7*			*23.2*	*4.4*	*65*	*110*	*146*	*0.371*	*0.324*
El Salvador	*840*	*17*	*2*			*22.8*		*30*	*72*	*780*	*0.343*	*0.545*
Gabon	*964*	*11*				*15.9*						
Ghana	*402*	*13*	*1*	*59*		*8.2*	*3.8*					
Guatemala	*652*	*8*	*2*	*54*	*75*	*13*		*23*	*107*	*816*	*0.515*	*0.533*
Honduras	*408*	*10*	*1*	*22*	*67*	*20.2*	*2.7*	*20*	*46*	*168*	*0.397*	*0.441*
Hungary	*1670*	*34*	*13*	*31.8*	*22.5*	*29.8*	*3.4*	*32*	*43*	*205*	*0.261*	*0.399*
India	*221*	*27*	*5*	*33.1*	*79.1*	*12.7*	*2.2*	*12*	*30*	*150*	*0.376*	*0.45*
Indonesia	*174*	*20*	*2.7*	*38*	*75.3*	*22.9*		*65*	*98*	*930*	*0.312*	*0.546*
Jamaica	*616*	*51*	*3*	*40.8*	*35.3*	*19.3*	*2.5*	*32*	*83*	*350*	*0.431*	*0.476*
Jordan	*524*	*38*	*2*		*75.6*	*35.3*			*100*			
Kazakhstan				*57*						*370*		
Kenya	*215*	*4*	*0.1*	*39*	*77*	*17.9*	*3.68*	*11*	*78*	*578*	*0.564*	*0.665*

Korea, rep.	*385*	*35*	*6*		*54*	*31.7*	*2.7*	*117*	*127*	*431*	*0.152*	*0.343*
Latvia						*13.1*		*272*	*239*		*0.060*	
Lesotho	*184*	*4*	*0.1*		*44.2*	*7.4*		*5*	*36*	*495*	*0.584*	*0.566*
Lithuania								*112*	*946*		*0.454*	
Madagascar	*347*	*8*	*1*	*53*		*18.4*		*45*	*183*	*1777*	*0.523*	*0.755*
Malaysia	*564*	*42*			*65*	*20.7*		*39*	*93*	*361*	*0.403*	*0.555*
Mauritania	*258*	*1*	*0.1*	*40*					*608*			
Mauritius	*1005*	*26*	*3*	*58*	*57.8*	*19.5*	*2.7*	*9*	*90*	*603*	*0.613*	*0.601*
Mexico	*1065*	*17*	*4*		*56*	*8.4*	*1.2*	*165*	*464*	*1484*	*0.374*	*0.429*
Morocco	*430*			*53*		*12*			*70*	*312*		
Nepal	*185*	*5*	*1*			*4.8*	*1.4*	*17*	*18*	*167*	*0.04*	*0.398*
Nicaragua	*876*	*14*	*2*		*70*	*2.6*		*213*	*390*		*0.254*	
Niger	*382*	*1*		*42*		*10.1*						
Nigeria	*215*	*5*	*0.1*	*31*		*6.3*			*122*	*644*		
Pakistan	*216*	*12*	*2*		*88.2*	*21.5*	*1.7*	*41*	*92*	*595*	*0.349*	*0.432*
Panama	*677*	*34*	*7*		*43.7*	*51.1*		*65*	*129*	*540*	*0.312*	*0.498*
Peru	*906*	*25*	*8*	*46*	*56.7*	*12.3*	*3.2*	*131*	*276*	*1042*	*0.334*	*0.487*
Philippines	*503*	*41*	*19*	*25*	*47*	*28*		*65*	*105*	*623*	*0.29*	*0.440*
Poland	*1010*	*69*	*18*		*27*	*4.3*	*2.2*	*97*	*169*	*333*	*0.310*	*0.387*
Rwanda	*183*	*2*	*0.1*		*95*	*5.5*	*2.2*	*5*	*17*	*212*	*0.390*	*0.632*
Senegal	*478*	*7*	*1*		*73*	*31.1*	*4*	*33*	*285*	*697*	*0.669*	*0.656*
Sierra Leone	*307*	*5*	*0.1*	*42*		*5.3*		*20*	*59*	*372*	*0.36*	*0.434*
Singapore	*806*	*45*	*10*		*58*	*80*	*2.7*	*53*	*98*	*463*	*0.296*	*0.47*
Slovak, rep.								*208*	*335*	*1402*	*0.269*	*0.398*
Slovenia												
South Africa	*1198*	*15*	*4*	*46*	*53*							
Sri Lanka	*336*	*35*	*2*		*43.8*	*17.7*		*158*	*143*	*967*	*0.05*	*0.323*
Sudan		*4*	*1*	*27.9*	*88.7*	*8.3*				*1105*		
Taiwan	*664*	*45*	*14*			*49.2*		*10*	*92*	*267*	*0.554*	*0.490*
Thailand	*332*	*14*	*2*	*46.1*	*47.1*	*46*	*2.6*	*10*	*66*	*140*	*0.416*	*0.39*
Trinidad & Tobago	*1084*	*36*	*2*	*44*	*35.7*	*17.7*		*120*	*131*	*811*	*0.194*	*0.365*
Tunisia	*619*	*16*	*2*		*93*	*50*	*4.2*	*32*	*116*	*975*	*0.449*	*0.491*
Uganda	*133*	*4*	*0.1*	*45*		*2.7*						
Venezuela	*1088*	*27*	*7*	*31.8*	*58.2*	*26.1*	*3.5*	*77*	*172*	*897*	*0.398*	*0.487*
Yugoslavia		*65*	*13*	*44*	*46.6*	*29*		*171*	*448*		*0.365*	

Zambia	*548*	*7*			*64.9*	*6.3*	*3.2*	*29*	*51*	*831*	*0.311*	*0.470*
Zimbabwe	*496*	*6*	*0.1*			*10.1*	*2.3*	*21*	*226*	*567*	*0.754*	*0.69*
Average OECD	***3398***	***59.8***	***14.7***	***33.7***	***28.5***	***34.2***	***4.7***	***988***	***1456***	***2629***	***0.246***	***0.311***
Australia	*3837*	*62*	*16*	*32.1*	*18.1*	*23.5*	*6.4*	*904*	*1762*	*3075*	*0.315*	*0.293*
Belgium	*3157*	*75*	*15*		*26.3*	*18.2*	*5.5*	*879*	*1320*	*2742*	*0.294*	*0.28*
Canada	*3677*	*56*	*26*	*27.5*	*21.5*	*44.2*				*2803*		
Denmark	*3993*	*83*	*14*	*33*	*28.2*	*50.2*	*4.5*	*1788*	*1556*	*2947*	*0.054*	*0.196*
Finland	*3095*	*76*	*11*	*31*	*24.1*	*43.6*	*5.2*	*1411*	*1431*	*2725*	*0.063*	*0.186*
France	*3191*	*56*	*18*	*34*	*23.9*	*79.4*	*3.3*	*1214*	*1364*	*2772*	*0.132*	*0.278*
Greece	*3126*	*49*	*10*	*38.3*	*37.9*	*15.1*	*1.5*	*1369*	*1670*	*2221*	*0.211*	*0.223*
Ireland	*2977*	*51*	*12*	*39*		*30.3*		*650*	*1624*	*1959*	*0.410*	*0.32*
Italy	*2963*	*47*	*11*	*29*		*57.4*	*4.4*	*720*	*1269*	*2345*	*0.330*	*0.342*
Japan	*2983*	*82*	*13*	*33*	*28.6*	*117.8*	*2.5*	*680*	*1720*	*2820*	*0.390*	*0.360*
Luxembourg	*3956*	*33*				*62.2*	*2.1*	*790*	*1496*	*2856*	*0.412*	*0.334*
Netherlands	*2411*	*61*	*17*	*29*	*23.7*	*64.4*		*880*	*990*	*2381*	*0.15*	*0.310*
New Zealand	*3087*	*75*	*15*	*30*	*21.2*	*13.1*	*4.3*	*980*	*1140*	*2890*	*0.131*	*0.298*
Norway	*3440*	*64*	*11*	*36*		*35.2*	*5.1*	*796*	*1500*	*2573*	*0.346*	*0.331*
Portugal	*2748*	*42*	*5*	*37*	*58.2*	*45.3*	*3.3*	*395*	*790*	*1750*	*0.418*	*0.372*
Spain	*2975*	*38*	*6*	*28*	*37.9*	*33.4*	*1.6*	*650*	*1205*	*1806*	*0.350*	*0.342*
Sweden	*3878*	*62*	*13*	*33*		*46.3*	*6.2*	*1447*	*664*	*2142*	*0.05*	*0.215*
United kingdom	*3481*	*66*	*12*	*30*		*111.7*	*4.4*	*880*	*1342*	*2499*	*0.268*	*0.31*
United States	*4530*	*88*	*40*	*37*	*21.8*	*63.1*	*7.4*	*1338*	*1709*	*4641*	*0.236*	*0.373*

***Notes**: * Data refer to those observed in 1970 or in the closest year to 1970. GDP/capita refers to per-capita GDP ($ PPP), Sec.Enrol and High.Enrol refer to the Secondary and Higher-education enrolment ratios respectively, Gini and GiniEdu are the Gini indexes of incomes and education respectively, CR is the Credits to GDP ratio, τ is the ratio of public education expenditures to GDP, Exp_{prim}, Exp_{sec}, and Exp_{high} are respectively Primary, Secondary, and Tertiary per-student expenditures ($ PPP). Gini_S and Gini_T are the Gini indexes of public expenditures across the primary and the secondary schooling levels, and across the primary, the secondary and the tertiary levels, respectively.*

Table (B): *Individual data, by country, for the year 2000.*

Country	***GDP/capita***	***Sec.Enrol***	***High.Enrol***	***Gini** (%)***	***GiniEd (%)***	***CR***(%)***	***τ (%)***	***Exp_{prim}***	***Exp_{sec}***	***Exp_{high}***	***Gini_S***	***Gini_T***
Average DC s	***4770***	***53.9***	***15***	***41.4***	***45.8***	***26.1***	***4.2***	***761***	***1203***	***3768***	***0.217***	***0.385***
Algeria	*4325*	*61.5*	*11.3*		*59.9*	*42.1*						
Bahamas		*91.4*	*24.2*	*48.4*		*31.2*						
Bangladesh	*1289*	*21*	*5.5*	*39*	*73.3*	*5.4*	*1.5*	*286*	*845*	*1323*	*0.414*	*0.361*
Barbados	*12680*	*86*	*28.6*		*30*	*38*		*546*	*678*	*6454*	*0.19*	*0.434*
Belarus	*6256*	*91.6*	*42.6*									
Bolivia	*2357*	*37.8*	*23.2*		*53.6*	*5.2*						
Botswana	*5489*	*55*	*4.9*		*52.3*	*19.5*	*3.3*	*420*	*880*	*3898*	*0.323*	*0.511*
Brazil	*6039*	*42.8*	*11.2*	*58*	*39.2*	*18*	*4.6*	*955*	*1105*	*11565*	*0.203*	*0.655*
Bulgaria	*6421*	*73.3*	*33.9*	*21.5*	*21.2*	*5.8*	*3.5*	*2210*	*1990*	*2980*	*0.08*	*0.243*
Chile	*7040*	*69.2*	*25.5*	*46*	*31.3*	*7.9*	*2.8*	*1700*	*1940*	*6930*	*0.197*	*0.469*
China	*2260*	*58.8*	*3.9*	*37.8*	*42.2*	*86.1*	*1.9*	*375*	*835*	*5465*	*0.313*	*0.554*
Colombia	*4830*	*57.1*	*16.4*	*52*	*48.6*	*11.4*	*2.4*	*610*	*806*	*5232*	*0.199*	*0.442*
Costa Rica	*4916*	*45.5*	*30.8*	*44*	*42.5*	*17.6*	*5.8*	*1340*	*1308*	*5775*	*0.08*	*0.291*
Cote d'Ivoire	*1857*	*22.9*	*4*	*38*		*17.7*	*4.6*	*151*	*556*	*2151*	*0.350*	*0.372*
Dominican, rep.	*3217*	*38.6*	*21.4*	*43.3*		*13.4*	*1.8*	*456*	*590*	*3560*	*0.185*	*0.349*
Ecuador	*3538*	*52.3*	*21.2*		*44.8*	*13.7*	*2.8*	*352*	*691*	*2330*	*0.281*	*0.426*
Egypt, Arab rep.	*3330*	*75.7*	*17.7*		*62.1*	*17.8*	*4.9*	*320*	*960*	*2350*	*0.331*	*0.363*
El Salvador	*3560*	*29.6*	*15.8*			*24.2*		*286*	*326*	*3248*	*0.153*	*0.455*
Estonia	*6661*	*97.5*	*27.3*									
Gabon	*7796*					*9.7*						
Ghana	*1181*	*36.4*	*1.4*			*1.6*	*2.7*					
Guatemala	*3468*	*24.8*	*7.9*		*62.5*	*11.1*		*260*	*1255*	*1629*	*0.425*	*0.332*
Honduras	*1968*	*32.6*	*9.6*	*59*	*46.8*	*18.3*	*3.5*	*238*	*283*	*1098*	*0.117*	*0.354*
Hungary	*7985*	*90.4*	*18.4*	*24*	*21.1*	*17.5*	*4.6*	*2100*	*2370*	*5865*	*0.10*	*0.229*
India	*1709*	*48.2*	*5.9*	*29.7*	*68.6*	*25.8*	*2.9*	*884*	*1193*	*3932*	*0.161*	*0.272*
Indonesia	*3116*			*31.7*	*40.7*	*19.3*		*95*	*180*	*1450*	*0.23*	*0.466*
Jamaica	*3411*	*65*	*6.6*	*43*	*32.9*	*23.7*	*4.6*	*254*	*450*	*2608*	*0.276*	*0.469*
Jordan	*3547*	*38*	*2*	*40.8*	*75.6*				*1007*			
Kazakhstan	*5757*	*90.8*	*35.6*									
Kenya	*1143*	*26*	*1.5*	*55*	*51.5*	*19.5*	*4.1*	*35*	*120*	*1230*	*0.37*	*0.65*

Korea, rep.	*11514*	*94.8*	*45.6*	*33*	*21.8*	*31.2*	*3.4*	*3514*	*4725*	*4374*	*0.112*	*0.1*
Latvia	*6498*	*87*	*23.5*					*1062*	*1871*		*0.180*	
Lesotho	*1180*	*27.4*	*2.1*		*64.1*	*12.9*	*11.3*	*38*	*149*	*2238*	*0.341*	*0.595*
Lithuania	*6341*	*83.6*	*27.9*									
Madagascar	*778*	*16*	*2.7*			*18.5*						
Malaysia	*7012*				*42.1*	*9.9*	*3.6*	*234*	*556*	*3993*	*0.293*	*0.365*
Mauritania	*1272*	*14.9*	*3.6*			*29.8*			*942*	*2519*		
Mauritius	*9853*	*58.5*	*5.5*	*46*	*43.8*	*22.2*	*3.5*	*245*	*546*	*3540*	*0.28*	*0.415*
Mexico	*7128*	*56.4*	*14.2*	*50*	*38.3*	*8.1*	*4.4*	*1130*	*1480*	*5320*	*0.176*	*0.298*
Morocco	*3338*					*14.9*		*149*	*331*	*3546*		
Nepal	*1109*	*36.6*	*5.2*	*31*		*14.1*	*3.3*	*560*	*1560*	*2400*	*0.31*	*0.333*
Nicaragua	*1746*	*41.5*	*10.2*		*58.7*	*19*			*1198*	*4410*		
Niger	*809*	*6.5*	*0.7*			*17.1*		*181*	*214*		*0.15*	
Nigeria	*786*	*29.8*	*4.1*	*37*		*16.3*						
Pakistan	*1714*	*26*	*3.2*	*32*	*64.4*	*20.5*	*3.6*	*156*	*942*	*2492*	*0.395*	*0.421*
Panama	*5198*	*65.2*	*26.6*		*33.9*	*45.2*		*107*	*239*	*3879*	*0.214*	*0.488*
Peru	*3723*	*67.4*	*31.4*	*43*	*43.1*	*3.8*	*2.8*	*485*	*580*	*2001*	*0.144*	*0.32*
Philippines	*2752*	*76.8*	*27.3*	*51.3*	*32.8*	*15.7*	*2.6*	*475*	*405*	*1230*	*0.09*	*0.161*
Poland	*6202*	*92.8*	*24.6*	*26*	*14.1*	*2.5*	*4.9*	*276*	*292*	*1530*	*0.10*	*0.379*
Rwanda	*817*	*10.7*	*0.5*		*66.1*	*5.7*	*2.1*	*55*	*230*	*2995*	*0.372*	*0.554*
Senegal	*1330*	*16.2*	*3.4*		*69.7*	*29.1*	*3.9*					
Sierra Leone	*945*	*18*	*1.4*			*5.4*						
Singapore	*19415*	*67*	*26.7*	*40.7*	*44*	*58.3*	*2.3*	*3640*	*5800*	*9300*	*0.195*	*0.25*
Slovak, rep.	*9010*	*90.1*	*17.7*					*1427*	*2130*	*5555*	*0.213*	*0.385*
Slovenia	*10959*	*90.8*	*29.8*			*20.7*						
South Africa	*6903*	*86.1*	*14.9*			*46.9*			*4009*	*3080*		
Sri Lanka	*2633*	*74.6*	*4.7*		*28.8*	*6.9*						
Sudan		*19.3*	*4*		*75.2*	*10.9*				*2512*		
Taiwan	*12457*		*17.9*	*31.2*		*35.5*		*3540*	*5472*	*6355*	*0.187*	*0.192*
Thailand	*5539*	*42.8*	*18.9*	*48*	*39.1*		*3.2*	*730*	*1260*	*3230*	*0.155*	*0.283*
Trinidad & Tobago	*9010*	*76*	*7.4*	*51*	*31.2*	*13.9*		*550*	*778*	*2995*	*0.146*	*0.33*
Tunisia	*4959*	*53*	*11.4*	*40*	*61.6*	*51.3*	*5.6*	*950*	*1290*	*5010*	*0.196*	*0.323*
Uganda	*677*	*11.8*	*1.5*									
Venezuela	*6507*	*34.9*	*27.2*	*44*	*47.2*	*16.6*	*4.2*	*530*	*790*	*9890*	*0.163*	*0.412*
Yugoslavia												

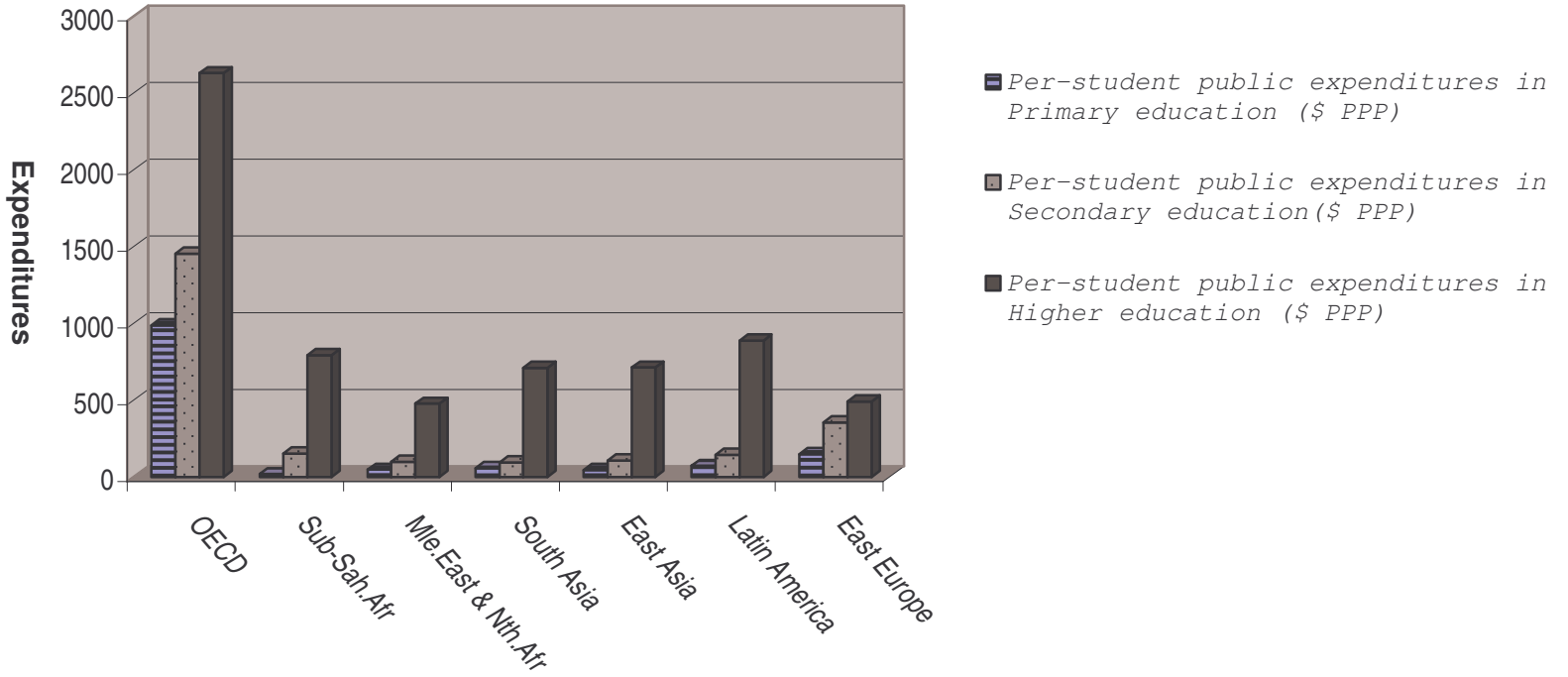
Zambia	*878*	*26.3*	*2.4*		*46.8*		*1.9*	*45*	*110*	*1226*	*0.30*	*0.430*
Zimbabwe	*2558*	*47*	*5.9*			*15.9*	*6.5*	*303*	*641*	*2688*	*0.314*	*0.44*
Average OECD [a]	***17660***	***110.4***	***49.6***	***32.1***	***29.9***	***62.6***	***5.87***	***4360***	***5665***	***10230***	***0.192***	***0.258***
Australia	*19689*	*114.5*	*57.6*	*41.7*	*20.6*	*46.1*	*4.1*	*4858*	*6860*	*11750*	*0.238*	*0.298*
Belgium	*19362*	*134*	*49.8*		*29.2*	*15.3*	*6.4*	*3952*	*6444*	*9725*	*0.282*	*0.261*
Canada	*20601*	*103.9*	*91.8*	*31.6*	*10.1*	*27.3*		*4343*	*5764*	*14980*	*0.217*	*0.35*
Denmark	*21125*	*115.4*	*43.1*	*27.5*	*26.2*	*42.9*	*4.1*	*6720*	*7630*	*10660*	*0.157*	*0.266*
Finland	*17075*	*117.8*	*62.4*	*26*	*27.5*	*70.9*	*6.9*	*4100*	*5886*	*8089*	*0.193*	*0.260*
France	*18759*	*107.1*	*48*	*44*	*35.3*	*29.3*	*5.5*	*4100*	*7150*	*7860*	*0.29*	*0.263*
Greece	*11402*	*94.6*	*36.8*	*37*	*27.1*	*26.5*	*4.9*	*3304*	*3900*	*4305*	*0.116*	*0.189*
Ireland	*14714*	*111.7*	*35.7*	*39*	*26*	*4.9*		*3020*	*4385*	*9675*	*0.186*	*0.303*
Italy	*18647*	*89.8*	*37.8*	*39*			*4.1*	*5231*	*6520*	*7551*	*0.190*	*0.212*
Japan	*21874*	*98.8*	*38.6*	*33*	*24.5*	*82.4*	*3.6*	*5210*	*6040*	*10300*	*0.180*	*0.310*
Luxembourg	*29391*					*58.1*	*3.9*					
Netherlands	*19166*	*132.1*	*46.5*	*29*	*25.2*	*87*	*5*	*4800*	*5674*	*12256*	*0.187*	*0.281*
New Zealand	*15251*	*101.5*	*54.6*	*36*	*24.5*	*77.2*	*5.3*	*3867*	*4130*	*9368*	*0.141*	*0.245*
Norway	*20943*	*114.9*	*52.8*	*38*		*35.5*	*7.3*	*5920*	*7630*	*12050*	*0.216*	*0.277*
Portugal	*12144*	*95.1*	*32.5*	*41*	*43.1*	*56.6*	*4.8*	*3480*	*5230*	*4810*	*0.211*	*0.20*
Spain	*14172*	*115*	*43.8*	*25.9*	*36.4*	*63.3*	*4.4*	*3650*	*4870*	*5770*	*0.176*	*0.233*
Sweden	*18987*	*121.6*	*40.1*			*39.5*	*7.8*	*5730*	*5920*	*14220*	*0.15*	*0.25*
United kingdom	*17618*	*122.6*	*42.9*	*24.3*		*18.3*	*5.3*	*4676*	*5610*	*9760*	*0.177*	*0.219*
United States	*25596*	*97*	*81*	*34*	*14.3*	*51.1*	*5.2*	*7590*	*8160*	*19220*	*0.16*	*0.231*

Notes: ** *Data refer to those observed in the closest year to 2000.*

*** *Data refer to those observed in 1999.*

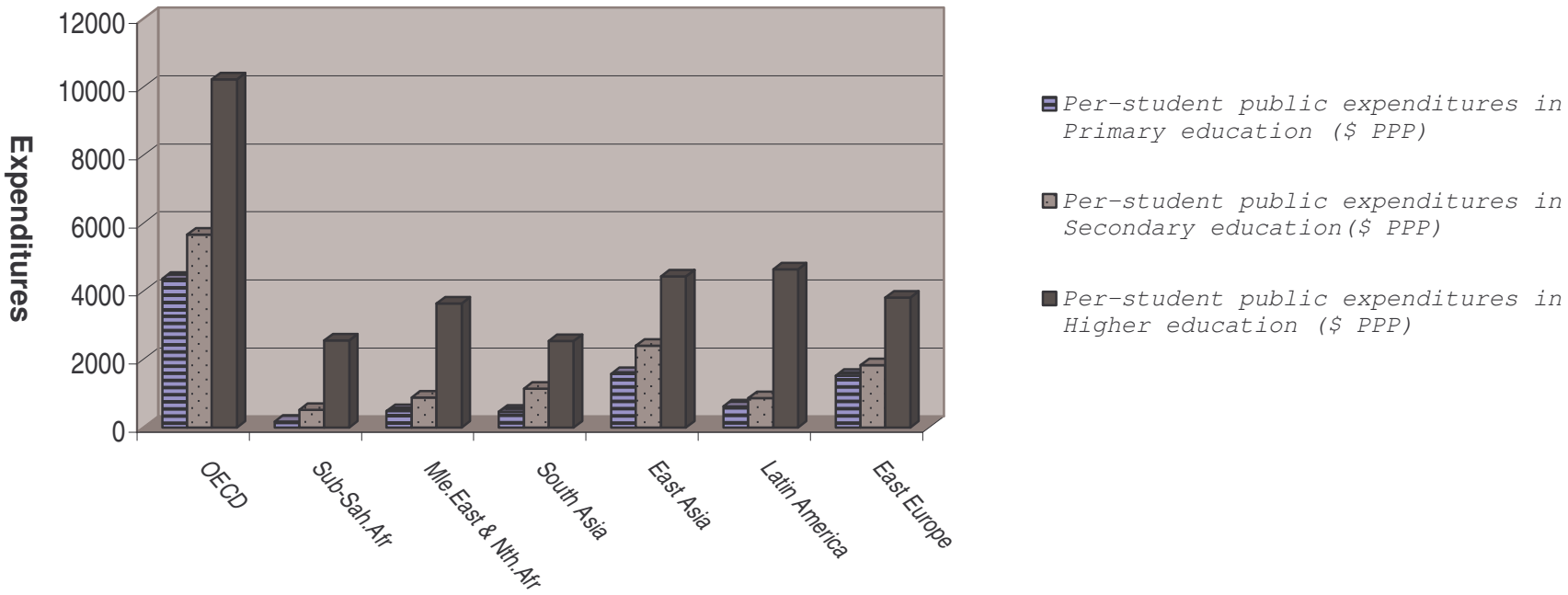
a : As in 1970, Mexico, Korea. rep, Hungary, and Slovak. rep. are not considered in the OECD group in 2000.

Figure1: Per-student public expenditures by educational level (in $ PPP)-1970



Source: *Author's calculations from the UNESCO data base*

Figure2: Per-student public expenditures by educational level (in $ PPP)-2000



***Source**: Author's calculations from the UNESCO database*

Chapter V

The impacts of human capital and public education expenditures on economic growth: a disaggregated empirical analysis

Introduction

The analysis pursued in the previous chapter has shown the relative contributions of the financial and socio-cultural factors with regard to human capital investment. In this last chapter, we extend this analysis by studying empirically the role of human capital and public education expenditures in economic growth. The study of such a role is a major subject of interest in both the augmented Solow neo-classical approach that emerged after the work of Mankiw, Romer and Weil (1992), and the endogenous growth theories developed with the premonitory works of Lucas (1988) and Romer (1990). However, the estimation of a macroeconomic production function, including education as a regressor, presents a host of still-unresolved issues.

We focus here on two of these major issues. The first one is the discouraging estimation results with regard to the contribution of human capital accumulation to economic growth. Educational variables frequently turn out to be insignificant or to have the wrong sign in growth regressions, particularly when these are estimated using first-differenced or panel specifications. Several studies showed, in fact, that the positive estimates obtained in some studies using cross-section data get considerably worse when the relation 'human capital-growth' is re-estimated on the basis of first-

differenced or panel specifications, which rely more heavily on the time-series variation of the data. These studies include Benhabib and Spiegel (1994), Islam (1995), Barro and Sala-i-Martin (1995), Pritchett (1996), Wolff. E (2000) and De la Fuente and Doménech (2006). Such results have consequently raised skepticism on the role of human capital accumulation in the growth process, which in turn has led some researchers to seriously consider possible reasons why the contribution of educational investments to productivity growth may be negative.

Several reasons have been evoked: [a] the role of trade openness and rent-seeking activities (Berthélemy, Dessus and Varoudakis (1997)), [b] the role of the distribution of education in the population (Lopez, Thomas and Wang (1999) and Castello and Domenech (2002)), [c] the fact that the indicators of human capital often miss cross-country differences in educational quality (Hanushek and Kim (1995), Hanushek and Kimko (2000), Barro and Lee (1997), Barro (2001), Dessus. S (2000), and finally, [d] the deficiencies in data on human capital or the inadequacies of the econometric specification (A.B.Krueger and M.Lindahl (2000), Cohen and Soto (2001), and De la Fuente and Doménech (2006).

The second issue raised in this empirical literature goes beyond the 'right' estimates of the contribution of human capital accumulation to economic growth. Frequently, the 'human capital-growth' regressions tend to use aggregate indicators of human capital, with mean education of the population as the most-used indicator. These aggregated measures, however, do not provide the education policy-maker information with regard to the efficient allocation of education expenditures across the various schooling levels. For this reason, looking at the growth effects of education at the different educational stages would overcome this insufficiency.

Studies that aim to estimate the growth impact of human capital accumulated at the various stages of education are scarce. The study of Gemmell (1996) is one notable

contribution to this literature. It uses cross-section data to estimate the economic growth impact of both stocks and accumulation rates of education at the various schooling levels (primary, secondary, and tertiary). The author's main conclusion is that human capital effects on growth are most evident at the primary and secondary levels in lower- and higher-income developing countries, respectively, but are more evident at the tertiary level in the case of developed countries.

This result, however, should be taken with some cautions, as i) the author does not provide any direct comparison of the effects of different flows and stocks across developed and developing countries; ii) the growth effects of both the stock and the accumulation of education at the secondary level are found to be negative in the case of developed countries, which is a result difficult to interpret, and iii) this study does not explain how primary human capital stock and accumulation may foster income growth; namely, in the case of developing countries. Thereby, this work still raises some other issues. Is investment in tertiary education not rewarded in the developing countries? Economic growth in the developed countries is more affected by investments in the tertiary education; does this imply that governments in these countries should allocate fewer resources to the basic school levels?

Beyond these unanswered questions, previous empirical works do not explicitly estimate the magnitude of the impact of public expenditures at the successive schooling levels, which is a crucial issue from a governments' point of view in the context of education provisions. Our study aims to fill the gaps discussed above by proceeding in two steps. We first estimate the growth impacts of human capital in its disaggregated form, and compare these impacts between developing countries (DCs) and OECD countries. We then estimate the growth effects of public education expenditures at the different stages of education for these two groups.

We find -contrary to Gemmell (1996)- that the accumulation and initial stocks of secondary and tertiary education have positive effects on economic growth in both groups of countries, with the higher marginal impacts in DCs. This evidence suggests a close association between human capital produced at the higher levels of education and technological progress, which is a source of growth. Human capital accumulated at the primary schooling level, however, is excluded from the sources of growth enhancing. This type of human capital is only a prerequisite for attending advanced-education levels but does not, in itself, promote growth.

In addition, our estimations point out clearly *decreasing* marginal returns of the per-student public expenditures, with respect to the schooling level in DCs. This result indicates that education public funds are misallocated in DCs, which supports, *ceteris paribus,* a reallocation policy of public resources in favour of the lower stages of education. Indeed, despite the fact that growth is more likely affected by the accumulation of higher levels of human capital, DCs should reinforce their funding of education at the lower levels; namely, at the primary education. By improving the quality of education at these levels, this policy should contribute to raising the participation rate at the higher stages of education in the DCs, and thereby to fostering their economic growth.

These conclusions are confirmed once proxies for inequality in the distribution of expenditures across the educational stages, and of initial human capital stocks are included in the growth equation. Indeed, we find that economic growth decreases as inequality in the allocation of public education funds rises, and as initial distribution of human capital stocks is being more unequal.

The remainder of this chapter is structured as follows. Section I firstly presents cross-section estimates of the effect of human-capital accumulation on economic growth. We show that the counterintuitive results with regard to the elasticity of per-

capita income with respect to education can be due to an omitted variable bias. In the second step, we re-estimate the growth equation by using the disaggregated form of human capital. In section II, the flows of per-student expenditures are used as regressors in the 'growth equation' instead of the rates of human-capital accumulation. We show that DCs should allocate differently their expenditures across educational levels. Finally, in section III, we tackle the multicollinearity issue that arises with the disaggregated forms of educational expenditures and human capital stocks.

I- Human capital accumulation and growth: the baseline estimates

I-1 The aggregated form of human capital

We focus in this sub-section on the effect of human-capital accumulation—in its aggregated form—on economic growth. Starting with Pritchett (1996), researchers have noted the implications of traditional earning functions for analyses at the cross-country level. If an individual's education contributes directly to his productivity, in the manner envisaged by labour economists, we should expect to observe a correlation between the change in income per-worker and the change in average educational attainment, at least after controlling for other variables. This argument has shifted the focus of researchers towards regressions that relate per-capita income growth to the change in educational attainment, rather than its level. Several well-known studies have found the correlation to be surprisingly weak and even negative.

We show in what follows that this counterintuitive result may be due to a missing variable problem. Specifically, the inclusion of the initial stock of human capital in the 'standard' growth equation produces satisfactory estimates of the impact of human-capital accumulation.

I-1-1 Data and estimation methodology

In order to measure the growth effect of human capital accumulation, we estimate the following 'standard' equation:

$$GR(y) = a_0 + a_1 \, Log(y)_{60} + a_2 \, Log(S_k) + a_3 \, GR(H) \qquad (I)$$

where: - $GR(y)$ = Growth of per-capita GDP at constant prices (over 1960-2000), available in the Penn World Table (version 6.1).

- $GR(H)$ = Growth of education attainment of the population (over 1960-2000), calculated from the revisited Barro and Lee (2000) database on both the distribution and mean years of education.
- y_{60} = real GDP per-capita in 1960 at constant prices, from the PWT (6.1).
- S_k = the ratio of capital investment over GDP (average, 1960-2000), available from the PWT (6.1).
- "Log" indicates the log form.

We use mean education as a proxy for the stock of human capital because other proxies, like school enrolment ratios, do not distinguish between the 'stock' and the 'accumulation' growth effects associated with human capital. Sign predictions are: $a_1 < 0$ if conditional convergence occurs, $a_2 > 0$, and $a_3 > 0$. The sample consists of a cross-section of countries: 85 developing countries (DCs), and 22 OECD countries. The sample period is 1960–2000. Notice that most of countries that are used in this study are those which are employed in the previous chapter. Table (A) in the Appendix provides summary statistics of the variables used in this analysis. These statistics show that, on average, the OECD countries had, over the 1960–2000 period, a growth rate of

per-capita income of 2.8 percent (with a standard variation of 0.78 percent) against a growth rate of 1.9 percent (with a standard deviation of 2.2 percent) for the DCs. The capital investment ratios are also higher (and with lower standard deviation) in the OECD countries than in the DCs. The growth rate of educational attainment was, on the contrary, higher (and with higher standard deviation) in the DCs than in the OECD countries, with respectively growth rates of 14 percent and 5 percent in these sub-samples.

The above growth equation can be estimated by ordinary least squares (OLS) unless the variance of the error term is heteroscedastic. In order to test for the potential presence of heteroscedasticity, we use the *Breusch-Pagan/Cook-Weisberg* test. If heteroscedasticity is detected, standard errors are estimated using the *White's procedure* (in order to obtain robust standard errors). The *Breusch-Pagan/Cook-Weisberg* test is based on the null hypothesis that the variance is constant. Therefore, when the probability is large (> 5 %), we accept the null hypothesis of the constant variance. In addition, the specification above may raise an endogeneity issue because of the possible simultaneity in the effects of growth of per-capita income and growth of human capital. It indeed may be argued that faster growth economies experience faster human-capital accumulation, as they are able to devote more resources to the education sector.

In the context of endogeneity, OLS estimations are inconsistent, and one shall, in this case, use instrumental variables to estimate the equation above. In order to test for the exogeneity of the regressors (here, $GR(H)$), we perform the *Hausman test*. This test consists of adding the residual from a regression of the suspected endogenous variable on its instruments to the original regression and testing the null hypothesis that the residual is null. Low probability values (< 5 %) indicate the presence of endogeneity, while higher values indicate that the regressions may be run using the OLS technique.

I-1-2 The estimation results

The estimation results are reported in Table 1 below for the full sample, the DCs, and the OECD countries, separately. Statistics related to the homoscedaciticy and exogeneity tests are shown at the bottom of this table. For the exogeneity test, we use initial per capita income, $Log\,(y)_{60}$; education attainment of the population in 1960, $Log\,(H)_{60}$; and the percentage of urban population in 1960, $urban_{60,}$ as instruments of $GR(H)$. The regression—not reported here—shows that $GR(H)$ is positively and significantly influenced by $Log\,(y)_{60}$ and $urban_{60}$, and negatively and significantly affected by $Log\,(H)_{60}$. These instruments, -together with the constant term- explain more than 80 percent of the variation in $GR(H)$.

***Table 1*: Growth regression results.**

Dependent variable: *Growth of GDP per-capita ((%), average 1960-2000)*

	Full sample			*Developing Countries*			*OECD*		
Variables	*Eq (1a)*	*Eq (2a)*	*Eq (3a)*	*Eq (1b)*	*Eq (2b)*	*Eq (3b)*	*Eq (1c)*	*Eq (2c)*	*Eq (3c)*
Constant	- 3.66 (- 4.16)	3.30 (1.87)	3.49 (2.31)	- 3.72 (- 3.74)	5.44 (2.12)	5.11 (2.14)	1.68 (0.48)	5.44 (2.14)	7.33 (3.20)
Log (S_k)	1.97 (7.13)	2.14 (6.62)	1.44 (4.23)	2.02 (6.15)	2.03 (5.41)	1.24 (3.16)	1.20 (1.55)	1.51 (1.52)	1.36 (1.68)
$GR(H)$ (%)	0.032 (1.78)	- 0.055 (- 1.94)	0.086 (2.99)	0.03 (1.41)	- 0.053 (- 1.63)	0.095 (2.94)	0.14 (2.48)	- 0.026 (- 0.65)	0.067 (1.93)
Log (y)$_{60}$	----	- 0.98 (- 3.98)	- 1.15 (- 5.04)	----	- 1.32 (- 3.46)	- 1.38 (- 4.20)	----	- 1.87 (- 6.54)	- 2.23 (- 4.01)
Log (H)$_{60}$	----	----	1.42 (4.34)	----	----	1.53 (4.12)	----	----	1.08 (1.66)
N. obs	86	86	86	64	64	64	22	22	22
$\bar{R}^2$	0.328	0.371	0.494	0.306	0.359	0.496	0.380	0.742	0.768
B-Pagan χ^2(.)	0.74	0.55	0.48	0.04	0.45	1.58	1.20	2.66	6.17
Pr > χ^2 (*)	0.38	0.42	0.49	0.83	0.45	0.21	0.20	0.10	0.01 [e]
Hausman F	0.35	10.4	2.26	0.52	7.95	1.19	7.29	0.09	1.46
Pr > *F* (**)	0.55	0.001 [f]	0.13	0.47	0.00 [f]	0.25	0.01 [f]	0.76	0.24

Notes: t-statistics are in brackets.

(*): The Breush-Pagan test for homoscedasticity. e: Homoscedasticity hypothesis is rejected, and estimations are run using White's procedure.

(**): -The Hausman test for endogeneity: we use Log (y_{60}), Log (H)$_{60}$, and the percentage of urban population in 1960 as instruments for $GR(H)$.

- f: the Hausman test rejects the exogeneity hypothesis, and estimations in this case are run using 2SLS technique.

As may be seen in Table 1, the *Hausman test* shows evidence of endogeneity of $GR(H)$ in some regressions. In this case, the growth equation is re-estimated using *2SLS* techniques. The estimations report highly significant growth effects of initial income and capital investment ratio. Conditional income convergence is thus evident, not only in the case of the full sample of countries, but within the groups of OECD and DCs as well.

The estimations also indicate that for the various samples, the effect of human-capital accumulation comes out significantly positive, but surprisingly, appears not robust to the addition of the initial income. In fact, this effect turns out negative. Such a result tends to confirm the counterintuitive finding in the empirical works regarding the contribution of human-capital accumulation to economic growth. When the initial stock of human capital, $Log\ (H)_{60}$, is included in the regression, the coefficient upon the growth of human capital becomes significantly positive for all the samples of countries, and has a higher magnitude than in the former specifications. This result points towards omitted variable bias that stems from the correlation that exists between the rate of human-capital accumulation and the initial human-capital stock. That is, the omission of the initial stock of human capital in the growth equation –whereas this variable influences the accumulation rate of human capital–, yields counterintuitive estimation results with regard to the growth effect of human-capital accumulation. Figures 1-a, 1-b, and 1-c in the Appendix show the negative correlation between the growth rate of human capital and the initial human-capital stock for the three samples of countries.

Notice that the estimations in Table 1 produce an elasticity of per-capita income with respect to years of schooling of 9.5 percent in the DCs, and 6.7 percent in the OECD countries. These estimates of human-capital returns appear too close to the macro-estimations of Cohen and Soto (2001), which have reported an elasticity of 8 percent for the entire sample of countries (versus 8.6 percent in our regressions).

Furthermore, the coefficient upon the initial stock of education, $Log\ (H)_{60}$, comes out significantly positive in the cases of the full sample and the DCs, which has been widely interpreted as a result that reflects externalities of the stock of human capital. These externalities may take the form of facilitating adoption of technologies from abroad, as stressed by Nelson and Phelps (1966), or creating appropriate domestic technologies, as suggested by Romer (1990). This result is also similar to the one established by Barro (1991) which argues that given a country's initial per-capita income level, larger initial levels of human capital should be associated with faster growth of per-capita income.

Summing up, our estimations show that the accumulation rate and the initial stock of human capital as well, have positive effects on the growth of per-capita income. In the paragraph below, human capital is decomposed into primary, secondary, and higher human-capital in order to determine the relative contribution of each stage of education to economic growth, and to provide policy guidance in terms of public-educational investments.

I-2 The disaggregated form of human capital

We aim here to identify the effects of human capital in its disaggregated form on growth, which is an issue that previous studies in this research area have not sufficiently treated. As far as we have considered average educational attainment of the population as a proxy of human capital, one may disaggregate this stock by considering the distribution of the population across the educational levels, as illustrated in the Barro and Lee's (2000) database. We thus obtain the stock of primary, secondary, and higher-education, defined by the fractions of individuals that have attained the primary, the secondary, and the higher-education stages, respectively. Analysing the contribution of education in its disaggregated form to economic growth is an interesting task, because

different types of human capital are expected to have different effects on growth and across the groups of countries. In what follows, we estimate the impacts of both the accumulation rate of the three forms of human capital and their corresponding initial stocks, on the growth of per-capita income. In the right-hand side of Equation (II) below, the initial stock and the accumulation rate of human capital are expressed in their disaggregated form.

$$GR(y) = a_0 + a_1 \, Log(y)_{60} + a_2 \, Log\,(S_k) + \sum_i a_{3i} \, Log(H_i)_{60} + \sum_i a_{4i} \, GR\,(H_i) \quad \text{(II)}$$

where: $(H_i)_{60}$ and $GR(H_i)$ are respectively the initial stock and average growth rate of human capital of type i, where $i=$ (Primary, Secondary, and Higher-education levels). Average growth rates of human-capital stocks are calculated over the period 1960–2000. Initial stocks of primary, secondary, and tertiary human capital are shown in the summary statistics in the Appendix as fractions of total labor force [1]. They indicate, on average, that in 1960, 60 percent of the population in the OECD had only primary education, 28 percent had secondary education, and 6 percent had tertiary education. In DCs, these proportions were 36 percent, 7.5 percent, and 1.5 percent, respectively, for the same year.

Over the period 1960–2000, the growth rates of the three 'types' of human capital were by far greater in DCs than in OECD countries, reflecting faster growth in relevant enrolment rates (especially in the secondary).

1: In the summary statistics, the sum of the initial stocks is in general less than 1, because of the fraction of the population without any education which is, here, not taken into account.

Table 2: Growth regression results with disaggregated human capital

Dependent variable: *Growth of GDP per-capita ((%), average 1960-2000)*

	Full sample			*Developing Countries*			*OECD*		
Variables	*Eq (1a)*	*Eq (2a)*	*Eq (3a)*	*Eq (1b)*	*Eq (2b)*	*Eq (3b)*	*Eq (1c)*	*Eq (2c)*	*Eq (3c)*
Constant	3.65	2.29	1.00	8.11	3.48	1.94	11.16	8.45	7.35
	(1.83)	(1.71)	(0.58)	(2.96)	(1.74)	(0.73)	(5.42)	(4.73)	(4.40)
Log (S_k)	2.02	1.99	2.12	1.57	1.86	2.03	1.80	1.74	1.98
	(6.27)	(6.68)	(5.99)	(2.37)	(5.41)	(4.74)	(1.95)	(1.95)	(1.99)
Log (y)$_{60}$	- 0.94	- 1.08	- 0.75	- 1.05	- 1.25	- 0.88	- 2.24	- 2.23	- 2.04
	(- 3.94)	(- 4.44)	(- 2.84)	(- 1.85)	(- 3.59)	(- 2.20)	(-7.11)	(- 8.48)	(- 6.80)
HC. Accumulation									
$GR(H_P)$ (%)	- 0.005	----	----	- 0.005	----	----	- 0.005	----	----
	(- 0.80)			(- 0.57)			(- 1.26)		
$GR(H_S)$ (%)	----	0.013	----	----	0.014	----	----	0.012	----
		(1.98)			(1.96)			(2.02)	
$GR(H_H)$ (%)	----	----	0.018	----	----	0.019	----	----	0.015
			(1.96)			(2.03)			(1.95)
HC .Stocks									
Log (H_P)$_{60}$	0.21	----	----	0.26	----	----	0.13	----	----
	(0.56)			(0.52)			(0.63)		
Log (H_S)$_{60}$	----	0.73	----	----	0.83	----	----	0.68	----
		(3.97)			(3.86)			(2.81)	
Log (H_H)$_{60}$	----	----	0.36	----	----	0.38	----	----	0.32
			(1.85)			(1.92)			(178)
N.obs	88	90	88	67	69	67	21	21	21
$\overline{R}^2$	0.421	0.523	0.450	0.393	0.514	0.419	0.856	0.816	0.799
B-Pagan χ^2(.)	0.59	0.82	1.9	0.10	0.03	0.57	8.34	2.70	4.45
Pr > χ^2	0.40	0.36	0.2	0.65	0.85	0.44	0.00 [e]	0.10	0.03 [e]
Hausman F (*)	4.77	0.28	1.68	6.42	0.36	1.66	0.90	0.42	1.17
Pr > *F*	0.03 [f]	0.59	0.2	0.01 [f]	0.54	0.20	0.35	0.52	0.29

Notes: *t-statistics are in brackets. e: Homoscedasticity hypothesis is rejected, and estimations are run using White's procedure.*

f: *the Hausman test rejects the exogeneity hypothesis, and estimations in this case are run using 2SLS technique.*

(*): we use Log (y_{60}),, the percentage of urban population in 1960, and Log (H)$_{60}$ as instruments for respectively $GR(H_P)$, $GR(H_S)$ *and* $GR(H_H)$.

Because of the high correlation[2] across the initial human-capital stocks (H_P , H_S , H_H), they are included separately in the growth equation as shown in Table 2. Notice first of all that using the different forms of human capital variables instead of their aggregated form neither alters the sign nor the significance of the effect of initial income, $Log\ (y)_{60}$, and that of the capital investment rate, $Log\ (S_k)$. Furthermore, the regressions explain between 40 and 80 percent of the variation in per-capita GDP growth for the sub-samples of DCs and OECD countries, respectively. One can point out two major results from these estimations.

The first result concerns the effects of *initial human-capital stocks*. As can be seen from Table 2, the form of initial human-capital (hereafter, HC) stock that affects income growth differs across sub-samples, with secondary and higher initial HC stocks more relevant in DCs than in OECD countries. In fact, while a one standard deviation increase in the initial secondary HC stock translates into a 0.93 point increase in per-capita GDP growth in the case of DCs, this magnitude is of 0.58 point in the case of OECD countries. Similarly, while a one standard deviation increase in the initial tertiary HC stock is associated with 0.42 point increase in the growth of per-capita GDP of DCs, it raises the growth rate by 0.27 point only in the case of OECD countries. The growth effect of the primary initial HC stock, however, comes out positive, but statistically insignificant in both OECD and DCs.

2: The coefficients of correlation across these stocks are: $r\ (Log\ (H_P)_{60},\ Log\ (H_S)_{60}) = 0.59$, $r\ (Log\ (H_P)_{60},\ Log\ (H_H)_{60}) = 0.51$, *and* $r\ (Log\ (H_S)_{60},\ Log\ (H_H)_{60}) = 0.76$.

This result is crucial for at least two reasons. First, it identifies the sources of growth among the different forms of HC stocks. Unambiguously, primary HC is excluded from the enhancing growth factors. This finding implies that initially accumulated secondary and tertiary HC stocks, only, can contribute to fostering economic growth. By facilitating adoption or creation of new technologies, these forms of HC are considered as engines of technological progress in both groups of countries, and are, thereby, sources of economic growth. In this sense, initial stock of knowledge accumulated by workers with only primary education is unlikely able to contribute to the technological progress, and can thus promote economic growth neither in DCs nor in OECD countries. Nevertheless, although primary education has no direct effect on growth, it is essential for the growth process, as it is a prerequisite for acquiring advanced educational levels. We study in the next section the implication of such a role in terms of the allocation of public resources across the various schooling levels.

Second, it supports our theoretical result established in Chapter II of the thesis which stresses that, in the growth process, the stock of advanced education should increase relatively to that of basic education. Hence, the larger the fraction of the population with tertiary human-capital stock, the more rapid is the rate of economic growth in DCs. In more advanced stages of development, higher-education levels become more generalized in the population, which leads to a reduction in the marginal effect of tertiary HC stock on economic growth. This conjecture can explain why secondary and higher initial HC stocks have greater marginal effects in DCs than in OECD countries, as reported in Table 2.

Our result regarding the impacts of different initial HC stocks across countries is original in light of the scarcity of empirical works in this direction. As stressed in the introduction of this chapter, the Gemmell's (1996) paper is, to our knowledge, one exceptional study that has tackled this issue. Unfortunately, this study does not allow a

comparison of the effects of HC stocks in OECD and DCs, since the regressions do not employ all the forms of HC in both sub-samples of countries. For example, the author argues that initial primary and secondary HC stocks are important in DCs, whereas initial higher HC stock effects are stronger in OECD countries. We, however, have no idea about the effect of higher initial HC in the case of DCs, or that of primary HC in the OECD countries. Furthermore, this study does not provide any explanation of the mechanism through which initial primary HC stock may influence economic growth in the DCs.

The second important fact -shown in Table 2- concerns the impacts of *the growth rates* of the various types of human capital on the growth rate of per-capita income. The estimation results show that these impacts are *increasing* with the educational stage. Indeed, Equations 1a, 2a, and 3a of this table show that while a one standard deviation increase in the growth rate of secondary HC translates into a 0.243 increase in GDP per-capita growth, this impact is of 0.357 in the case of the tertiary HC. The effect of primary HC accumulation is, however, insignificantly negative.

This tendency toward increasing marginal returns of human capital accumulation is also evident in both sub-samples of countries. Indeed, in both groups, rapid accumulation of tertiary HC has greater effect on the growth of per-capita income than the accumulation of secondary or primary HC do. This result confirms the idea that technological progress and, thus, economic growth are driven by HC accumulated at the higher educational levels, which are associated with know-how and creativity. Furthermore, as for the effects of the initial stocks of HC, the estimation results show that the growth impacts of the accumulation rates of human capital are higher in the case of DCs than in OECD countries.

These results are novel as they clearly identify which type of HC accumulation can foster more rapidly economic growth. It follows that the more rapid the

accumulation rates of HC at the higher stages of education, the faster is the economic growth rate. Once again, this result contrasts diametrically with the one established by Gemmell (1996) with regard to DCs. Indeed, while this study -although it has run partial estimations- points out the importance of the primary human-capital accumulation rate in fostering income growth in this group of countries, we have shown that tertiary and secondary accumulation rates are more likely to enhance rapid income growth in these countries. Policy implication of such a result is obvious. Both OECD and DCs should foster the accumulation rates of human capital at the secondary and tertiary educational levels. This may be ensured by fostering enrolments at these schooling levels, which unambiguously involves the allocation policy of public funds across the successive stages of education.

The section below includes in the growth equation public-education expenditures in their disaggregated form in order to appreciate the contribution of the public educational provision policy in explaining economic growth.

II- Public education expenditures and growth

Public educational provisions may affect economic growth through at least two mechanisms: by increasing the accumulation rate of human capital via increasing enrolment rates, or through improving the quality of education for a given ratio of enrolments. Several studies have established that years of schooling as well as schooling quality are crucial factors in explaining economic growth (Hanushek and Kim (1995), Hanushek and Kimko (2000), Barro (1997, 2001), Sylwester. K (2000) and Bosworth and Collins (2003)).

To evaluate the growth impacts of the allocation funds policy, we use in this study our data-set on per-student public-education expenditures per-year and by educational level [4]. Chapter IV of this thesis has shown the importance of the 'liquidity' and 'quality' effects of public-education expenditures in influencing post-primary schooling enrolments. The main result of that analysis is that resources devoted to the lower-schooling levels are at least as important as those allocated to the higher levels in fostering enrolment ratios at the higher educational stages. Therefore, countries whose resource allocations are biased against the lower stages of education also tend to have low enrolment ratios at the higher stages. This is especially the case of most of DCs.

In light of this result, we examine hereafter whether the actual allocations of expenditures are growth-enhancing. Precisely, one should examine whether the increasing marginal effect of human capital accumulation on growth with respect to the schooling level can justify the bias in the allocation of educational expenditures in favour of the higher educational stages that is observed in DCs. Similarly, we ask whether equalizing the distribution of expenditures across the educational levels is an efficient policy in the OECD countries. Clearly, the answer upon the efficient allocations should take into account three important facts:

i) The elasticity of per-capita income with respect to human capital is increasing with the schooling level in both OECD and DCs. This tends to provide a more important role for the financing of the higher educational stages.

3: more details on this database are provided in Chapter IV.

ii) Compared to the OECD countries, primary and secondary education coverage is still low in many DCs (either because of no schooling at all or because of high dropout rates). Because primary education is a prerequisite for attending higher educational levels, this result suggests that DCs should concentrate their expenditures on the lower levels of education in order to generalize these levels to all the population, which in turn, increases the participation ratios in the higher stages of education.

iii) As has been stressed in Chapter IV, the observed allocations in the two groups of countries are such that the quality of education received at the prerequisite primary-schooling level is likely to be higher in OECD countries than in DCs. This result reinforces the argument above—that DCs should increase the expenditures allocated toward the lower schooling levels. This, in turn, should translate into higher participation rates in the higher stages of education.

The growth impacts of the educational expenditures are estimated using the model (II) of the sub-section I-2, with the only difference consisting of including the 'flows' of per-student expenditures as explanatory variables in the growth equation, rather than the accumulation rates of the various forms of human capital. By proceeding so, the estimated coefficients upon the expenditure variables can be interpreted as representing the 'marginal returns' of public investment in education. These returns would show how public expenditures should evolve, given the actual allocations. The equation we estimate is the following:

$$GR(y) = a_0 + a_1\, Log(y)_{70} + a_2\, Log\,(S_k) + \sum a_{3i}\, Log(H_i)_{70} + \sum a_{4i}\, Log\,(Exp_i) \quad \text{(III)}$$

where: $(H_i)_{70}$ and Exp_i are respectively the initial stock of human capital of type i, and the average per-student public expenditures at the i^{th} school level, where

i= (primary, secondary, and higher). Because data on expenditures and enrolments are only available from 1970 in the UNESCO database, average expenditures are computed on the period 1970–2000, initial income and initial human-capital stocks are those observed in 1970, and average per-capita income growth rate is calculated on the period 1970–2000. As in Chapter IV, expenditures are here included separately in the growth equation because of problems of multicollinearity. Estimation results are reported in Table 3, below. To perform the *Hausman test*, we use $Log\ (y)_{70}$ and the gross enrolment ratios at the various schooling levels in 1970 as instruments of the corresponding expenditure variables. In most of cases, the *Hausman test* accepts the null hypothesis of exogeneity of the educational expenditures.

Once again, the estimation results shown in Table 3 confirm the conditional convergence in per-capita incomes in the full sample and even among the OECD and DCs groups taken separately. Indeed, in all the specifications, initial per-capita income is negatively and significantly correlated with the per-capita income growth rate. Furthermore, the capital investment ratio comes out significantly positive in all the specifications. The results in Table 3 also corroborate the conclusions emerging from Table 2 with regard to the growth impacts of initial human capital stocks, namely, i) initial secondary and tertiary HC stocks have supremacy over the one of the primary HC, and ii) the marginal effects of these stocks are higher in DCs than in OECD countries.

The most important result shown in Table 3 has to do with the impacts of public expenditures on economic growth. It is important to point out that the estimated coefficients upon the expenditure variables are positive in the three samples of countries, but significantly different from zero in the full sample and the DCs sample only. This result provides support that educational expenditures have a role to play in fostering economic growth, namely in the DCs.

Another interesting finding emerging from these estimations consists in the *decreasing* marginal impact of the expenditures with respect to the schooling level when we consider the full sample and the DCs sample. This suggests that educational expenditures are misallocated, especially in the DCs. Indeed, the estimation results show that differences in the effects of educational expenditures in DCs are so high that they suggest high-growth benefits as a result of increasing resources in favour of the lower-schooling levels in these countries.

One should notice that this result does not contrast with the one established in the sub-section I-2 along which, the elasticity of per-capita income with respect to human capital is *increasing* in the schooling level. That is, the accumulation of human capital at the higher-educational levels in DCs is only possible through generalizing primary education, which in turn, requires increased resources toward this schooling level. In itself, human capital accumulated at the primary level does not benefit growth. But, because this education is a prerequisite for accumulating advanced human capital, the higher the coverage of this level, the more rapid is the accumulation rate at the higher stages of education, and the faster is economic growth.

In the OECD countries, however, primary -and even secondary education- are almost universal, and students at these stages receive relatively 'high' quality, so that enrolment ratios at the tertiary level are much higher than in the DCs. Consequently, the allocation of additional resources to any schooling level would only have low marginal impacts on economic growth.

Finally, when the full sample of countries is considered, the estimation results reveal that public expenditures devoted to the lower-schooling levels have higher growth effects, which reflects, on average, relatively low enrolment rates and low quality of education at these educational stages.

Table 3: *Growth regression results with disaggregated public education expenditures*

Dependent variable*: Growth of GDP per capita ((%), average 1970-2000)*

	Full sample			*Developing Countries*			*OECD*		
Variables	*Eq (1a)*	*Eq (2a)*	*Eq (3a)*	*Eq (1b)*	*Eq (2b)*	*Eq (3b)*	*Eq (1c)*	*Eq (2c)*	*Eq (3c)*
Constant	3.00	5.63	3.28	3.40	5.14	4.31	8.11	8.55	6.14
	(2.03)	(2.43)	(1.67)	(1.49)	(3.03)	(1.48)	(4.28)	(4.73)	(3.25)
Log (S_k)	1.44	1.38	1.97	1.22	1.78	1.92	1.95	1.91	1.97
	(3.25)	(2.57)	(5.18)	(2.27)	(4.96)	(4.19)	(1.97)	(1.96)	(2.00)
Log (y)$_{70}$	- 1.53	- 3.53	- 1.18	- 1.77	- 1.94	- 1.37	- 2.11	- 3.10	- 3.31
	(- 4.18)	(- 3.40)	(- 3.29)	(- 3.47)	(- 5.18)	(- 2.77)	(- 3.26)	(- 3.99)	(- 4.29)
P-stud.expenditures									
Log (*Exp*($_{Prim}$))	0.96	----	----	1.36	----	----	0.28	----	----
	(3.18)			(2.99)			(1.15)		
Log (*Exp*($_{Sec}$))	----	0.62	----	----	0.64	----	----	0.44	----
		(2.51)			(2.09)			(1.04)	
Log (*Exp*($_{High}$))	----	----	0.36	----	----	0.32	----	----	0.42
			(0.93)			(1.26)			(1.08)
HC .Stocks									
Log (H_P)$_{70}$	0.21	----	----	0.22	----	----	0.06	----	----
	(1.08)			(0.96)			(0.15)		
Log (H_S)$_{70}$	----	1.05	----	----	0.85	----	----	0.35	----
		(3.35)			(3.95)			(1.79)	
Log (H_H)$_{70}$	----	----	0.48	----	----	0.52	----	----	0.31
			(2.58)			(2.37)			(1.86)
N.obs	86	86	86	67	67	67	19	19	19
$\bar{R}^2$	0.394	0.419	0.352	0.369	0.422	0.361	0.434	0.511	0.638
B-Pagan χ^2(.)	0.98	0.78	0.00	0.03	0.58	0.01	1.36	0.00	0.63
Pr > χ^2	0.32	0.37	0.97	0.85	0.44	0.94	0.24	0.97	0.42
Hausman F (*)	1.99	6.02	1.05	1.82	3.54	0.60	1.05	0.03	0.43
Pr > *F*	0.08	0.01[f]	0.30	0.18	0.07	0.44	0.32	0.86	0.52

Notes**:** *- t-statistics are in brackets. (*) We use Log (y)$_{70}$ and enrolment ratios in 1970 as instruments of the corresponding expenditure variables. f: the Hausman test rejects the exogeneity hypothesis, and estimations in this case are run using 2SLS regression.*

III- Overcoming multicollinearity

The results emerging from both Tables 2 and 3 are based on regressions that employ the different initial stocks of HC and levels of expenditures, separately, because of the multicollinearity issue associated with these variables. In this paragraph, we show that our results are robust to including other variables that capture the growth impacts associated with the distributions of initial HC and expenditures across the schooling levels. These variables consist of the Gini index of education in 1970, noted by *GiniEdu_70*, and the Gini index associated with the distribution of public expenditures across primary, secondary, and tertiary schooling levels, noted by $Gini\_T$. The first index should proxy for the degree of inequality in the initial distribution of education in the working population, while the second index would indicate the extend of in(equality) in the public fund allocations across the three educational stages. More statistical details on these indexes are provided in Chapter IV. Notice that unlike the analysis conducted above in which the impacts of different kinds of initial HC and expenditures are evaluated, the estimated coefficient upon the indexes $Gini\_T$ and *GiniEdu_70* would indicate whether inequality in education helps fostering growth, and whether countries' resource allocations across the schooling levels are efficient.

Table 4, below, illustrates the growth impacts of inequality in the initial distribution of HC and of inequality in the allocation of public funds in the three considered samples of countries. The ratios of total expenditures to GDP, noted by τ, are included in the regressions in order to control for the cross-country differences in education budgets. We also introduce regional dummies to control for the specific regional-effects.

Table 4: *Growth regression results with Gini indexes for public education expenditures*

Dependent variable*: Growth of GDP per capita ((%), average 1970-2000)*

Variables	***Full sample***	***Developing Countries***	***OECD***
Constant	0.800 (0.20)	0.225 (0.03)	11.97 (2.72)
Log (S_k)	1.991 (2.19)	2.253 (1.92)	1.476 (1.90)
Log $(y)_{70}$	- 1.986 (- 3.33)	- 1.893 (- 2.56)	- 2.476 (- 2.63)
τ (%)	0.020 (0.10)	0.331 (0.62)	0.195 (1.62)
Gini_T (%)	- 2.426 (- 1.97)	- 3.918 (- 2.19)	0.333 (0.05)
GiniEdu_70 (%)	- 1.096 (- 1.99)	- 2.496 (- 2.31)	- 1.255 (- 1.87)
Sub-Sahara. Afr	- 1.170 (- 1.87)	- 1.071 (- 1.48)	----
Latin America	- 1.074 (- 2.26)	- 1.022 (- 1.52)	----
East Asia	0.741 (1.28)	1.372 (1.62)	----
N.countries	86	67	19
R^2	0.461	0.513	0.675
B-Pagan $\chi^2(.)$	0.01	0.10	3.35
$Pr > \chi^2$	0.941 [a]	0.757 [a]	0.553 [a]
Hausman F $Pr > F$	2.51 0.121 [b]	1.47 0.24 [b]	3.00 0.113 [b]

Note: t-statistics are in brackets.

a: Homoscedasticity hypothesis is accepted, and estimations are run using OLS technique.

b: For the Hausman test, we use the ratio of total educational expenditures over GDP (τ) in 1970, as instrument for this average ratio. In all the specifications, this test accepts the exogeneity of τ , and the estimations are run using OLS technique.

- GiniEduc_70 and Gini_T are respectively the Gini index of the distribution of education in 1970, and the Gini index of public expenditures across the primary, the secondary, and the tertiary levels over the period 1970-2000.

The estimation results are unequivocal. Indeed, they provide supplement evidence that public education expenditures are, on average, misallocated. This is especially more evident in the sample of DCs since the coefficient upon the variable of *Gini_T,* comes out significantly negative. In this sense, developing countries would gain much in term of economic growth rate if they allocate more equally their public funds across the educational stages. This result confirms the conjecture we pointed out in the previous section, namely, that the growth impacts of educational expenditures are decreasing with the level of schooling in the DCs.

Another important finding shown in Table 4 is that economic growth in the three samples of countries decreases as the degree of initial educational inequality rises. This is more salient in DCs than in OCDE countries as indicated by the higher estimated impact of the variable *GiniEdu_70* in the DCs sample (-2.49 versus -1.25). This result seems to corroborate the conclusion established in Section I-2 of this chapter along which, initial secondary and tertiary HC stocks have supremacy over the one of the primary HC in fostering economic growth; and the marginal effects of these stocks are higher in DCs than in OECD countries. Indeed, a higher value of the Gini index of education would imply that advanced human capital stocks (the secondary and the tertiary) are held by only a few of the population. It follows that the higher the fraction of the population endowed with advanced human capital stocks, the more equal is the distribution of education, and the lower is the Gini index associated with this distribution. Contrary to OECD countries, DCs had low stocks of advanced HC in 1970 and, consequently, higher levels of *GiniEdu_70*. Therefore, although initial educational inequality has a detrimental effect on the economic growth of both OECD and DCs, its marginal effect is higher in the second group of countries.

This result tends to confirm the empirical findings of Lopez, Thomas, and Wang (2001); Thomas, Wang, and Fan (2000); and Castello and Domenech (2002) with regard to the detrimental impact of educational inequality on economic growth [(4)].

Finally, one can notice that the ratio of expenditures over GDP, τ, has a positive, but, insignificant effect on the growth rate of per-capita income in both the full and the DCs samples. However, this effect comes out statistically significant at 10% in the case of the OECD countries, which seems to indicate that for educational budgets to have significant impact on economic growth rates, the allocation of these budgets across the schooling levels have not to be biased against the lower levels.

4: The reader can refer to Chapter II of this thesis for a more extensive literature on the growth effects of the distribution of human-capital.

Conclusion

Some recent empirical analyses of the effect of human-capital accumulation on the growth rate of per-capita GDP have surprisingly found this effect to be weak and even negative. Several explanations have been evoked in order to highlight the reasons for this counterintuitive result. In the analysis pursued in this chapter, we find –once controlling for the initial stock of human capital–, an elasticity of per-capita income with respect to human capital of 9.5 percent in DCs and of 6.7 percent in OECD countries.

Our study also identifies the contribution to growth of human capital accumulated at the successive educational levels. We find that whereas the initial stocks and accumulation of human capital at the secondary and the tertiary education have significant positive effects on per-capita income growth in both the OECD and DCs, those associated with the primary school level exert insignificant effects on these two samples of countries. This result suggests a close association between investment in the higher-educational levels and technological progress as a source of growth.

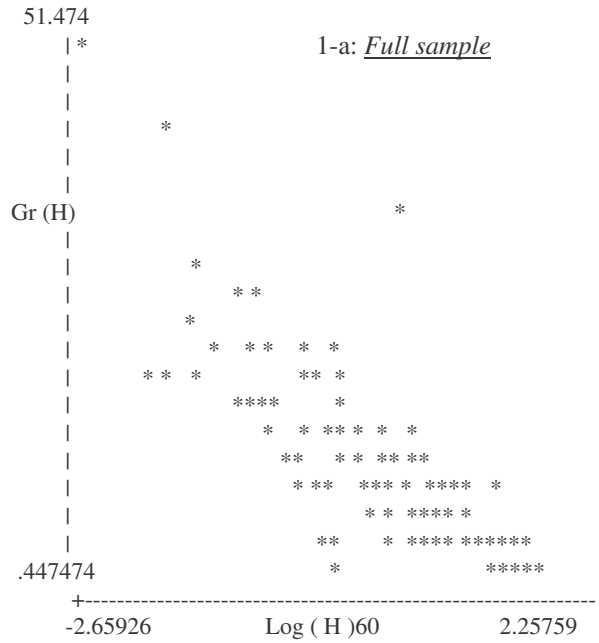
In light of this result, we have asked, in section II of this chapter, how public expenditures should be allocated across the educational levels. By using in the 'growth equation' the flows of per-student public expenditures at the different school levels, the estimations results point out *decreasing marginal returns* associated with public expenditures, with respect to the educational level in DCs, which suggests additional resources to be allocated in favour of the lower-schooling stages in this group of countries. Indeed, despite that primary human capital does not -in itself- benefit growth, more resources should be allocated in favour of this schooling level in the DCs, simply because it is a prerequisite for attaining higher educational levels. Educational investment is hierarchic, and such hierarchy creates interdependence between the stocks

of human capital accumulated at the successive schooling levels. In DCs, additional resources devoted to the primary level should aim to generalise education at this schooling level among the population and improve its quality, which in turn, should be associated with more investment in higher levels of education and faster growth. Unlike the DCs, economic growth rates in the OECD countries seem to benefit from two factors associated with education: low inequality in the initial distribution of education (i.e., advanced human capital stocks were high); and high levels of equality in the allocation of public expenditures across the schooling levels which translate into higher accumulation rates in advanced stages of education.

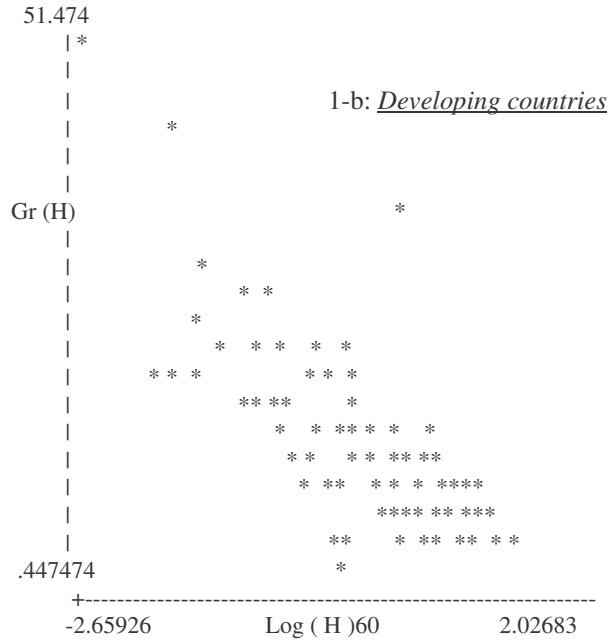
Appendix: ***Table (A):*** *Summary descriptive statistics: 1960-2000.*

	Full sample					*Developing Countries*					*OECD*				
	Obs	*Mean*	*S.D*	*Min*	*Max*	*Obs*	*Mean*	*S.D*	*Min*	*Max*	*Obs*	*Mean*	*S.D*	*Min*	*Max*
y_{60}	107	789	736	111	3414	85	491	319	111	1733	22	2007	707	778	3414
S_k	107	15.5	7.84	2.19	45.5	85	13.8	6.97	2.19	45.5	22	26.0	3.62	19.1	33.0
$GR(y)$	107	2.05	2.15	-6.94	8.06	85	1.91	2.28	-6.94	8.06	22	2.86	0.78	1.58	4.58
Initial human capital stocks (% of Labour force aged more than 25 years) (1960)															
H_{60}	86	3.4	2.5	0.1	9.5	64	2.5	1.8	0.1	7.6	22	6.65	1.94	1.94	9.56
$(H_P)_{60}$	88	41.1	25.1	0.3	90.3	67	36.2	24.4	0.3	69.3	21	59.9	17.9	31.4	90.3
$(H_S)_{60}$	90	11.6	12.8	0.2	61	69	7.5	7.04	0.2	27.9	21	27.6	17.6	3.5	61
$(H_H)_{60}$	88	2.3	3.3	0.1	20	67	1.5	1.74	0.1	9.9	21	5.85	5.60	1.1	20
Human capital growth (in %) (1960-2000)															
$GR(H)$	105	12.3	9.8	0.37	51.4	83	14.0	10.0	0.37	51.4	22	5.05	2.82	1.43	12.3
$GR(H_P)$	95	3.6	14.7	-20.8	68.0	73	6.30	15.0	-12.4	68.0	22	-7.74	5.41	-20.8	1.98
$GR(H_S)$	95	18.7	18.7	-9.41	154.7	73	21.2	19.4	-7.37	154.7	22	8.61	10.6	-9.41	29.4
$GR(H_H)$	95	28.4	19.8	-4.19	156.3	73	29.6	21.3	-4.19	156.3	22	23.6	10.4	3.58	42.4
Education expenditures (Average 1970-2000)															
$Exp(prim)$	86	930	1293	5	7590	67	460	586	5	3640	19	2971	1542	395	7590
Exp (sec)	86	1403	1187	17	8160	67	759	676	17	5800	19	3040	1086	664	8160
$Exp(high)$	86	3703	2531	146	19220	67	2212	2455	146	11565	19	6453	1997	1750	19220
Gini_T (%)	86	39.8	11.8	8.83	78.5	67	43.9	14.9	8.96	78.5	19	28.6	6.56	8.83	42.0

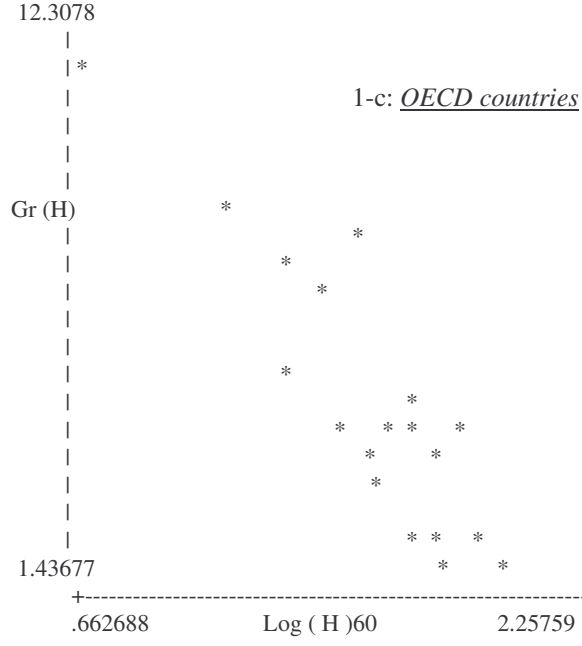
***Figure 1**: The relationship between the growth of human capital and its initial stock*



1-a: *Full sample*



1-b: *Developing countries*



1-c: *OECD countries*

General Conclusions

This Ph.D. thesis is principally motivated by the existence of drastic disparities across countries in terms of public efforts to finance education and the allocation of educational budgets across school stages. In this context, the study of the impacts of education provision policies on socio-economic performances is of major interest. Theoretical and empirical approaches have made it possible for the five chapters of this study to be conducted.

By developing a model of education where public expenditures are disaggregated into expenditures that are allocated respectively to basic and advanced educational levels, C*hapter I* has shown the role of initial wealth distribution in determining the economy's mobility, its long-run levels of aggregate wealth, and investment in advanced education. Indeed, we have found that, under credit-market imperfections, there is a possibility of multiple long-run equilibriums, and the one toward which the economy converges will depend upon the degree of (in)equality of its initial wealth distribution. Public educational fund policies allow the economy to converge along the transition path toward one of these equilibriums by influencing the minimum threshold levels of both wealth and abilities above which enrolment in the higher educational stage is possible. In particular, an increase in the education budget which is financed through additional income taxation has, -unless this tax is too high- positive effects on the long-run levels of investment in advanced education, mobility, and the wealth held by both poor and rich dynasties. We have also found that an allocation policy excessively favouring the financing of advanced education inhibits the quality of education at the basic level, and is therefore associated in the long-run with a

low economic mobility, a low fraction of skilled workers, and low levels of wealth of both the rich and the poor.

In C*hapter II,* we aimed to determine the optimal distribution of human capital stocks across educational levels along the economic transition process. The novelty of this study is its explicit formalisation of the transitional dynamics and the long-run equilibrium of the economy within an endogenous framework which employs optimal control principles. The economy considered has two stages of education: a compulsory one (basic education), and an advanced one (higher education). Parting from the individuals' behaviours, we have shown that in symmetric equilibrium, the transition path toward the long-run equilibrium of human capital distribution between basic and advanced education levels is non-monotonic. Specifically, assuming relative scarcity in the stock of advanced education, the duration of studies at this educational stage should increase until reaching its equilibrium level, which corresponds to the optimal distribution of human capital. At this equilibrium, the economy's balanced growth rate is increasing in the duration of studies at the advanced education, which is in turn, increasing in the level of public expenditures allocated to this stage. This second chapter also suggests that increases in public education funds in favour of advanced education stimulate economic growth in the long-run as well as in the transition phase. However, increases in the resources allocated to basic education do not affect the long-run growth rate, but rather speed the transition toward the steady-state equilibrium.

As long as the effects of public expenditure policies on schooling investment and growth are analysed, it is interesting to compare them with the ones generated under income tax redistribution policies. Such comparison was the subject of C*hapter III,* where the impacts of the education subsidy policy are compared to the ones associated with the negative income tax policy, the unskilled wage subsidy policy, and the public loan regimes, respectively. This exercise has particularly shown that when

outcomes are evaluated in *ex-post* sense, inequality in incomes is higher under the unskilled wage subsidy and the negative income tax policies than it is under the education subsidy program. Nevertheless, while the education subsidy policy raises equality in *ex-post* term, it reduces efficiency as it is associated with distortion effects and a high rate of schooling failure. Thereby, this policy is optimal provided that the degree of inequality aversion is relatively high and the subsidy is not excessive.

A pure public loan avoids such a trade-off between equality and efficiency because additional gains in terms of equality may be achieved with zero distortion effects. Combining education subsidies and the pure loan allows for further increase of these gains, but at the cost of some distortion effects. For this reason, compared to all the policies considered in this chapter, this combination is ultimately optimal, provided that the degree of inequality aversion is relatively high. For low degrees of inequality aversion, however, the pure public loan is optimal.

Chapter IV of this thesis empirically tests the robustness of the credit-constraints hypothesis used throughout Chapter I and III, and provides an evaluation of the contribution of public education expenditures in explaining cross-country post-primary schooling gaps. Performing this test is crucial in light of the debate that emerges while interpreting the positive correlation that exists between parents' incomes and children's education. Indeed, while one group of studies interprets such a correlation as a reflection of principally the positive contribution of the socio-cultural background factors of children, which themselves are correlated with parents' incomes, another group insists on the important contribution of material factors, such as access to credit-markets and public education expenditures, in explaining this correlation.

Both cross-section and panel-data estimation results are unequivocal: the credit-constraints thesis is relevant and robust in explaining cross-country variations in post-primary schooling enrolments. In addition, the estimation results of the impact of public

education expenditures suggest that countries that allocate low levels of expenditures to the lower-schooling stages also experience a drop in schooling enrolment rates at the higher stages. Hence, excessive efforts in several countries of Latin America and Sub-Saharan Africa in favour of higher education and at the cost of primary and secondary education have incontestably contributed to further hindering investment in post-primary education. Therefore, this policy as well, can contribute to the explanation of why these countries experience low enrolment rates in advanced educational levels compared to those achieved by OECD countries or even the East-Asian countries, where the financing of education is organised on the grounds of much more egalitarian principles.

This conjecture confirms the theoretical analysis conducted in C*hapter I* and is also reinforced by the econometric study developed in C*hapter V*. This last chapter of the thesis aimed to evaluate the impact of public education expenditures in their disaggregated form on countries' economic growth rates. This study has been conducted in three steps. First, we estimated the cross-country impact of human capital growth on the growth of GDP per-capita. This step has the merit to provide an explanation for the counterintuitive results of the recent empirical literature that concerned the insignificant contribution of human capital accumulation to the growth of GDP per-capita.

By controlling for the effect of initial human capital stock in the growth equation, our estimation results show, on average, an elasticity of GDP per-capita with respect to human capital of 9.5% in developing countries, and of 6.7% in OECD countries. This finding leads to the conclusion that one possible explanation for these paradoxical results is the problem of omission of the human capital stock in the growth equation. In the second step of this analysis, human capital stock is disaggregated into primary, secondary, and tertiary human capital stocks in order to evaluate the

contribution of each educational stage to economic growth. We found that in both groups of countries, economic growth is likely to be driven by human capital that was accumulated at the secondary and tertiary levels of education only. This result is crucial as it suggests that, in both groups of countries, technological progress is driven by the R&D activities that are incorporated in the human capital accumulated at the advanced educational levels. The last step of this study aimed thus to offer policy guidance in terms of the optimal allocation of public resources across the stages of education. By including successively in the growth equation the annual per-student public expenditures allocated at the successive schooling stages, and the Gini index of the allocation of these expenditures, the estimation results support that additional resources should be allocated toward basic education in the developing countries. Indeed, since basic education is a prerequisite for attending advanced education, it is vital for these countries to concentrate more financial efforts on the basic educational levels in order to ensure continuity in human capital investment and stimulate growth.

The current Ph.D. thesis has examined both theoretically and empirically the influence of public education expenditures on the socio-economic performances of countries by tackling issues which are not sufficiently treated in the literature of the field. The novel feature of each of the studied subjects needs to be extended further. One possible channel of investigation which is particularly promising is to study the endogenous determination of public budget allocation across educational stages. For instance, Xuejuan Su (2006) explained the observed cross-country differences in the budget allocation policies by the political mechanism. This study shows theoretically that in less developed economies, the top class has dominant political power to implement its most preferred policy, which is characterized by exclusive participation and high quality schooling at the level of higher education at the expense of basic

education. However, in developed economies, the budget allocation is more balanced because even the middle-class participates in the political process of drawing up the policies. Hence, it would be interesting to further investigate and develop this kind of explanation, and empirically test its relevance.

Our thesis has pointed out the contribution of higher-education to socioeconomic performances. It is possible to further expand this analysis by studying policy mechanisms which are necessary to concretizing this contribution. Indeed, in the actual context of rapid world's changes, one important challenge facing the higher-education system is the employability of its qualified students. Therefore, it is vital for a modern economy to implement policies which allow to take-up this challenge by particularly focussing on the continual adjustment of higher-education training with respect to the labour-market requirements.

References

Aghion. P and P. Bolton, (1997), "A Trickle-Down Theory of Growth and Development with Debt-Overhang", *Review of Economic Studies, 64, 151-172.*

Aghion. P et E. Cohen (2004), "Education et Croissance", *Rapport du Conseil d'Analyse Economique 46.*

Alan Heston, Robert Summers and Bettina Aten, Penn World Table Version 6.1, *Center for International Comparisons at the University of Pennsylvania (CICUP), October 2002.*

Alesina. A and D. Rodrik (1994), "Distributive Politics and Economic Growth", *Quarterly Journal of Economics, 109 (2).*

Alesina. A and R. Perotti (1996), "Income Distribution, Political Instability and Investment", *European Economic Review, vol 40, N° 6.*

Atkinson. A.B. and J.E. Stiglitz (1980), "Lectures on Public Economics", *McGraw-Hill, London, NY.*

Azariadis. C and A. Drazen, (1990), "Threshold Externalities in Economic Development", *The Quarterly Journal of Economics. Vol 105(4): 501-526.*

Banerjee. A and A. Newman (1993), "Occupational Choice and the Process of Development", *Journal of Political Economy, 101 (2).*

Barro. R.J (1991), "Economic Growth in A Cross-section of Countries", *Quarterly Journal of Economics, vol 106: 407-43.*

Barro. R.J (2001), "Human Capital and Growth", American Economic Review, 91(2): 12-17.

Barro. R.J and Lee. J.W (1997), "Schooling Quality in a Cross Section of Countries", *NBER WP 6198.*

Barro. R.J and Lee. J.W (2000), "International Data on Educational Attainment: Updates and Implications", *NBER WP N° 7911.*

Barro. R.J and X. Sala-i-Martin (1995), "Economic Growth", *New York: McGraw-Hill.*

Barthelemy. V (2000), "Système éducatif et bien-être social: faut-il subventionner l'éducation?", *L'actualité économique, Revue d'analyse économique. Vol 76 (4).*

Beck. T and R. Levine (1999), "A New Data Base of Financial Development and Structure", *The World Bank.*

Becker. G (1964), "Human Capital: A Theoretical and Empirical Analysis, With Special Reference to Education", *University of Chicago Press.*

Becker. G and N. Tomes (1979), "An Equilibrium Theory of the Distribution of Income and Intergenerational Mobility", *Journal of Political Economy, 87, 1153-1189.*

Behrman, Jere R. and Mark R. Rosenzweig (2002), "Does Increasing Women's Schooling Raise the Schooling of the Next Generation?", *American Economic Review* 92:1(March), 323-334.

Behrman, Jere R.and, Mark R. Rosenzweig (2005),"Does Increasing Women's Schooling Raise the Schooling of the Next Generation? – Reply" *American Economic Review* 95:5 (December), 1745-1751.

Ben Mimoun Mohamed (2005), "Redistribution through Education and Other Mechanisms under Capital-Market Imperfections and Uncertainty: A Welfare Effect Analysis", *LABOUR: Review of Labour Economics and Industrial Relations, vol 19 (2), 191-236.*

Ben Mimoun Mohamed (2007), "The Evidence of Credit-Constraints: New Results from International Data", *Journal of Applied Economics* (*forthcoming*).

Bénabou. R (1993), "Workings of a City: Location, Education, Production", *Quarterly Journal of Economics, 108.*

Bénabou. R (1996a), "Heterogeneity, Stratification and Growth: Macroeconomic Implications of the Community Structure and School Finance", *American Economic Review, 86 (3).*

Bénabou. R (1996b), "Equity and Efficiency in Human Capital Investment: The Local Connection", *Review of Economic Studies, (63).*

Bénabou. R (2000), "Unequal Societies: Income Distribution and the Social Contract", *American Economic Review, 90.*

Bénabou. R (2002), "Tax and education Policy in a Heterogeneous Agent Economy: What Levels of Redistribution Maximize growth and Efficiency?", *Econometrica. (March).*

Benedict. C (1997), "Income Distribution and Social Expenditure in Brazil", *IMF Working Paper/97/120.*

Benhabib. J and Spiegel. M (1994), "The Roles of Human Capital in Economic Development: Evidence from Aggregate Cross-country Data", *Journal of Monetary Economics, 34: 143-173.*

Berthélemy J.C, Dessus. S and Varoudakis. A (1997), "Capital humain et croissance: le rôle du régime commercial", *Revue Economique, vol 48: 419-28.*

Berthélemy. J.C and F. Arestoff (2002), " Les Stratégies d'éducation et le développement en Afrique", *mimeo. Communication au colloque de l'Institut de France sur "l'Education, Fondement du développement durable en Afrique", 7 Novembre 2002, Fondation Singer-Polignac.*

Betts. J (1995), "Which Types of Public School Spending are Most Effective? New Evidence on the School Quality Debate". *UCSD Mimeo*.

Birdsall. N (1999), "Education: The People's Asset", *Centre of Social and Economic Dynamics, WP N° 5.*

Birdsall. N and Londoño. J.L (1997), "Asset Inequality Does Matter: Lessons from Latin America", *Inter-American Development Bank. OCE WP, March 1997*

Black, Sandra E., Paul J. Devereux, and Kjell G. Salvanes (2005), "Why the Apple Doesn't Fall Far: Understanding Intergenerational Transmission of Human Capital", *American Economic Review* 95:1 (March), 437-449.

Blundell. R and MaCurdy. T (1999), "Labor Supply: A Review of Alternative Approaches" in *Ashenfelter, Orley and Layard, Richard ed., Handbook of Labor Economics, North Holland, Amsterdam.*

Boskin, Michael (1975), "Notes on The Tax Treatment of Human capital", *NBER WP 116.*

Bosworth. B and Collins. S.M (2003), "The Empirics of Growth: An Update", *Brookings Institution, September 22.*

Boudon.R (1973), "L'inégalité des chances", *Paris, Armand Colin.*

Bourdieu.P and Passeron. C, (1970), "La reproduction : éléments pour une théorie du système d'enseignement", *Les éditions de Minuit.*

Bourguignon. F and A. Spadaro (2000), "Redistribution et incitations au travail: une application à la fiscalité optimale", *Revue économique, vol.51, (3).*

Bovenberg. A.L and B. Jacobs (2001), "Redistribution and Education Subsidies are Siamese Twins", *CEPR Discussion Paper N°.3309.*

Cameron. S and J. Heckman (1999), "Can Tuition Policy Combat Rising Wage Inequality?", *In M. Kosters, ed., Financing College Tuition: Government Policies and Educational Priorities. Washington: American Enterprise Institute Press.*

Cameron. S and J. Heckman (2001), "The Dynamics of Educational Attainment for Black, Hispanic, and White Males", *Journal of Political Economy, 109. 455-99.*

Card. D and A. Krueger (1996), "School Resources and Student Outcomes: An Overview of the Literature and New Evidence from North and South Carolina*", NBER. WP 5708.*

Carneiro. P and J. Heckman (2002), "The Evidence on Credit Constraints in Post Secondary Schooling", *IZA Discussion Paper N°. 518.*

Carneiro. P and J. Heckman (2003), "Human capital policy", *NBER WP 9495.*

Castello. D and R. Doménech (2002), "Human Capital Inequality and Economic Growth: Some New Evidence", *The Economic Journal, 112 : 187-200.*

Checchi. D (2000), "Inequality in Income and access to Education: A Cross-country Analysis (1960-1995)" *World Institute for Development Economic Research, Research paper.*

Chiu. W (1998), "Income Inequality Human Capital Accumulation and Economic Performance", *Economic Journal 108.*

Clarke. G, L.C. Xu and H. Zou (2003), "Finance and Income Inequality: Test of Alternative Theories", *World Bank, Policy Research Working Paper N°.2984.*

Cohen. D (1996), "Tests of the Convergence Hypothesis: Some Further Results", *Journal of Economic Growth. Vol 1 (3), pp351-361.*

Cohen. D and Soto. M (2001), "Growth and Human Capital: Good Data, Good Results" *CEPR Discussion Paper N° 3025.*

David. C and A.A. Payne (2002), "School Finance Reform, The Distribution of School Spending, and the Distribution of Student Test Scores", *Journal of Public Economics, (83), 49-82.*

De Gregorio. J (1996), "Borrowing Constraint, Human Capital Accumulation, and Growth", *Journal of Monetary Economics, 37, 49-71.*

De la Fuente. A and Rafael Domenech (2001), "Schooling Data, Technical Diffusion, and the Neoclassical Model", *American Economic Review Papers and Proceedings, May 2001, 90(5), pp. 323-327.*

De la Fuente. A and Rafael Domenech (2006), "Human Capital in Growth Regressions: How Much Difference Does Data Quality Make?", *Journal of the European Economic Association. Vol 4 (1), pp.1-36.*

Deininger. K and L. Squire, (1996), "A New Data Set Measuring Income Inequality", *World Bank Economic Review 10(3).*

Dessus. S (2000), "Capital humain et croissance: le rôle retrouvé du système éducatif", *Economie Publique 2000/2: 95-115.*

Driskill. R.A and A.W. Horwitz (2002), "Investment In Hierarchical Human Capital", *Review of Development Economics, 6(1).*

Dynarski. S (1999), "Hope For Whom? Financial Aid for the Middle Class and its Impact on College Attendance", *NBER Working Paper.*

Ehrenberg R.G and Brewer D.J (1995), "Did Teachers Verbal-Ability and Race Matter in the 1960s-Coleman Revisited", *Economics of Education Review, 14 (1): 1-21.*

Eide. E and M.H. Showalter (1998), "The Effect of School Quality on Student Performance: A Quantile Regression Approach", *Economics Letters, 58(3): 345-350.*

Ellwood. D and Kane. T (2000), "Who is Getting a College Education?": Family Background and The Growing Gaps in Enrolment", *in S. Danziger and J. Waldfogel, eds., Securing the Future. New York: Russel Sage.*

Fender. J and P. Wang (2003), "Educational Policy in a Credit Constrained Economy with Skill Heterogeneity", *International Economic Review, vol 44, (3).*

Fernandez. R and R. Rogerson (1995), "On the Political Economy of Education Subsidies", *Review of Economic Studies, 62.*

Fernandez. R and R. Rogerson (1997), "Keeping People Out: Income Distribution, Zoning, and the Quality of Public Education", *International Economic Review, Vol 38 (1), 23-42.*

Fernandez. R and R. Rogerson (1999), "Equity and Resources: An Analysis of Education Finance Systems", *NBER WP 7111.*

Filmer. D and L. Pritchett (1998), "The Effect of Household Wealth on Educational Attainment", *Policy Research Working Paper N°. 1980.*

Flug. K, A. Spilimbergo and E. Wachtenheim (1998), "Investment in Education: Do Economic Volatility and Credit Constraints Matter ?", *Journal of Development Economics, Vol (55).*

Galor. O and D. Tsiddon (1997), "Technological Process, Mobility, and Growth", *American Economic review, 87, 363-82.*

Galor. O and D. Tsiddon (1997), "The Distribution of Human Capital and Economic Growth", *Journal of Economic Growth, vol 2 (1): 93-124.*

Galor. O and J. Zeira (1993), "Income Distribution and Macroeconomics", *Review of Economic Studies, 60.*

Galor. O and O. Moav (2004), "From Physical to Human Capital Accumulation: Inequality and the Process of Development", *Review of Economic Studies, 71, 1001-1026.*

Gemmell. N (1996), "Evaluating the Impacts of Human Capital Stocks and Accumulation on Economic Growth: Some New Evidence", *Oxford Bulletin of economics and statistics, 58(1), 9-28.*

Glomm. G (1997), "Parental Choice of Human Capital Investment", *Journal of Development Economics, 53.*

Glomm. G and B. Ravikumar (1992), "Public versus Private Investment in Human Capital: Endogenous Growth and Income Inequality", *Journal of Political Economy, vol 100, n° 4.*

Glomm. G and M. Kaganovich (2003), "Distributional Effects of Public Education In an Economy with Public Pensions", *International Economic Review, vol 44, n° 3.*

Goldhaber. D.D and Brewer D.J (1997), "Why Don't Schools and Teachers Seem To Matter? Assessing the Impact of Unobservables on Educational Productivity". *Journal of Human Resources, 32(3): 505-523.*

Gupta. S, K. Honjo and M. Verhoeven (1997), "The Efficiency of Government Expenditure: Experiences from Africa", *IMF WP 153.*

Gupta. S, M. Verhoeven, and E. Tiongson (2002), "The Effectiveness of Government Spending on Education and Health Care in Developing and Transition Economies", *European Journal of Political Economy, Vol 16 (4), 615-805.*

Hanusheck.E (1998), "Conclusions and Controversies About the Effectiveness of School Resources", *Economic Policy Review.*

Hanushek. E, C.K.Y. Leung and K. Yilmaz (2001), "Redistribution through Education and Other Transfer Mechanisms", *NBER Working Paper N°: 8588*

Hanushek. E. A and D. Kim (1995), "Schooling, Labor Force Quality, and Economic Growth", *NBER WP N° 5399.*

Hanushek. E. A and D. Kimko (2000), "Schooling, Labor-Force quality and the Growth of Nations", *American Economic review, 90(5): 1184-1208.*

Hanushek. E.A and Somers. J (1999), "Schooling, Inequality, and the Impact of Government"*, NBER Working Paper; 7450.*

Hausman (1978), "Specification Tests in Econometrics", *Econometrica 46(6).*

Hoxby. C.M (1998), "The Effects of Class Size and Composition on Student Achievement: New Evidence from Natural Population Variation", *NBER Working Paper 6869.*

Islam N (1995), "Growth Empirics: A Panel Data Approach", *Quarterly Journal of Economics, 110:* 1127-1170.

Iyigun. M. F (1999), "Public Education and Intergenerational Economic Mobility", *International Economic Review, Vol 40, (3), 697-710.*

Jacoby. H and E. Skoufias (1997), "Risk, Financial Markets and Human Capital in A Developing Country", *Review of Economic Studies, 64.*

Janeba. E (2000), "Trade, Income Inequality, and Government Policies: Redistribution of Incomes or Education Subsidies?", *NBER working paper N°: 7485.*

Jonathan. G (2001), "Does Money Matter? Regression-Discontinuity Estimates from Education Finance Reform in Massachusetts", *NBER WP. 8269.*

Judson. R (1998), "Economic Growth and Investment in Education: How Allocation Matters", *Journal of Economic Growth, 337-359.*

Kane. T (1994), "College Entry by Blacks since 1970: The Role of College Costs, Family Background, and the Returns to Education", *The Journal of Political Economy, 102(5), 878-911.*

Katz. L and D. Autor (1999), "Changes in the Wage Structure and Earnings Inequality", in *Ashenfelter. O and Card. D, ed., Handbook of Labor Economics, North Holland, Amsterdam.*

Keane. M and Wolpin. K (2001), "The Effect of Parental Transfers and Borrowing Constraints on Educational Attainment", *International Economic Review, 42(4), 1051-1103.*

Kelly. B and William O. Brown Jr (2000), "The Allocation of Public School Expenditures" *Working Papers in Economics August 2000, Claremont Colleges.*

Killingsworth. M and J. Heckmen (1986), "Labor Supply of Women: A Survey" in *Ashenfelter. O and Layard. R, ed., Handbook of Labor Economics, North Holland, Amsterdam.*

Knight, J.B and R.H. Sabot (1983), "Education Expansion and the Kuznets Effect", *American Economic Review, vol.73.*

Krueger. A. B and Lindahl. M (2000), "Education for Growth: Why and for Whom?, *NBER WP N° 7591.*

Kuznets. S (1955), "Economic Growth and Income Inequality", *American Economic Review 45.*

Lazear. E.P (1980), "Family Backgrounds and Optimal Schooling Decisions", *Review of Economics and Statistics, 62, 1.*

Li, Squire and Zou (1998), "Explaining International and Inter-temporal Variations in Income Inequality", *The Economic Journal, 108.*

Lloyd-Ellis. H (2000), "Public Education, Occupational Choice and the Growth-Inequality Relationship", *International Economic Review, vol.41, (1).*

Lopez. R, Thomas. V and Wang.Y (2001), "Addressing the Education Puzzle: The Distribution of Education and Economic Reforms", *World Bank Policy Research WP 2031.*

Lorraine. D, J. Ferri and C. Meghir (2000), "The effect of School Quality on Educational Attainment and Wages", *The Institute for Fiscal Studies, WP 00/22.*

Loury. G (1981), "Intergenerational Transfers and the Distribution of Earnings", *Econometrica, vol (94), N° 4.*

Lucas, R.E (1988), "On the Mechanics of Economic Development", *Journal of Monetary Economics 22: 3-22.*

Mankiw, N.G., Romer, D. and Weil D. N (1992), "A Contribution to the Empirics of Economic Growth", *Quarterly Journal of Economics, vol 107: 407-37.*

Maoz. D and Moav. O (1999), "Intergenerational Mobility and the Process of Development", The Economic Journal, October, 677-697.

Milanovic. B (2000), "The Median-voter Hypothesis, Income Inequality and Income Redistribution: An Empirical Test with the Required Data", *European Journal of Political Economy, vol 16, (3).*

Mincer. J (1974), "Schooling, Experience and Earnings", *New York: Columbia University Press.*

Morton I. K and Nancy L. S (1998), "Dynamic Optimization: The Calculus of Variations and Optimal Control in Economics", *Advanced Textbooks in Economics. North-Holland.*

Nelson. R and E. Phelps (1966), "Investment in Humans, Technological Diffusion and Economic Growth", *American Economic Review: Papers and Proceedings 61.*

Nielsen, Soren B. and P.B. Sorensen (1997), "On the Optimality of the Nordic System of Dual Income Taxation", *Journal of Public Economics, 63.*

Orazem. P and L. Tesfatsion (1997), "Macrodynamic Implications of Income-transfer Policies for Human Capital Investment and School Effort", *Journal of Economic Growth, vol 2, (3).*

Oreopoulos. P, M.E. Page, and A.H. Stevens, (2003), "Does Human Capital Transfers From Parent to Child? The Intergenerational Effects of Compulsory Schooling", *NBER WP 10164.*

Owen. A.L and Weil. D.N (1998), "Intergenerational Earnings Mobility, Inequality and Growth", *Journal of Monetary Economics 41, 71-104.*

Penalosa. C.G and K. Wälde (2000), "Efficiency and Equity Effects of Subsidies to Higher Education", *Oxford Economic Papers, vol 52, (4).*

Pencavel. J. (1986), "Labor Supply of Men: A Survey" in *Ashenfelter. O and Layard. R (1986), Handbook of Labor Economics, North Holland, NY.*

Persson. T and G. Tabellini (1994), "Is Inequality Harmful for Growth?", *American Economic Review, 84.*

Pierre-Richard A. and Peter J. M (1999), "Development Macroeconomics", *Princeton University Press.*

Piketty. T (1997), "The Dynamics of the Wealth Distribution and the Interest Rate with Credit-Rationing", *Review of Economic Studies, 64, 173-189.*

Pinera. S and Selowsky. M (1981), "The Optimal Ability-Education Mix and The Misallocation of Resources Within Education Magnitude For Developing Countries", *Journal of Developing Economies, N° 8. 111-131.*

Pritchett. L (1996), "Where Has All the Education Gone?" *World Bank Economic Review, 15(3), 367-391.*

Psacharopoulos. G (1994), "Returns to Investment in Education: A Global Update", *World Development 22(9): 1325-43.*

Psacharopoulos. G and H.A. Patrinos (2004), "Returns to Investment in Education: A Further Update", *Education Economics, 12(2), pp. 111-134.*

Rajhi. T (1996), "Dynamique des Politiques de Croissance", Collection "Approfondissement de la Connaissance Economique", *Economica.*

Romer. P (1990), "Endogenous Technological Change", *Journal of Political Economy, 89(5): 71-102.*

Saint. P and T. Verdier (1993), "Education, Democracy and Growth", *Journal of Development Economics, 42 (2).*

Shea. J (2000), "Does Parent's Money Matter?", *Journal of Public Economics, 77 (2), 155-84.*

Slemrod. J (1995), "What Do Cross-Country Studies Teach About Government Involvement, Prosperity, and Economic Growth", *Brooking Papers on Economic Activity, 373-431.*

Sylwester. K (2000), "Income Inequality, Education Expenditures, and Growth", *Journal of Development Economics, vol 63: 379-398.*

Thomas. V, Y. Wang and X. Fan (2000), "Measuring Education Inequality: Gini Coefficients of Education", *mimeo. The World Bank.*

UNESCO, databases on school enrolments and public education expenditures (2003).

Weal. M (1993), "A critical Evaluation of Rate of Return Analysis", *The Economic Journal, 103 (May).*

Wolff. E (2000), "Human Capital Investment and Economic Growth: Exploring the Cross-country Evidence", *Structural Change and Economic Dynamics, 11: 433-472.*

Xuejuan Su (2004), "The Allocation of Public Funds in A Hierarchical Educational System", *Journal of Economic Dynamics and Control, 28(12), pp. 2485-2510.*

Xuejuan Su (2006), "Endogenous Determination of Public Budget Allocation Across Education Stages", *Journal of Development Economics, 81(2), pp.438-456.*

Zhang. L (2002), "Income Distribution and The Allocation of Public Education Expenditure", *Stanford Institute For Economic policy Research Discussion Paper N° 02-25.*