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Taxes distorsionnaires et dépenses gouvernementales dans les modèles de cycle économique

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Sommaire

La question des effets des politiques fiscales sur l'activité économique a toujours préoccupé les économistes et continue de le faire. Dans cette thèse, j'étudie cette question dans le cadre d'un modèle d'optimisation dynamique d'équilibre général. Ma thèse se compose de trois essais, le premier est théorique et examine les fluctuations de court terme, les deux autres sont empiriques et se concentrent sur les mouvements de long terme.

Les dépenses du gouvernement représentent une part non négligeable du PIB pour la plupart des pays industrialisés et sont variables dans le temps. Des augmentations dans ces dépenses réduisent en général les ressources disponibles au secteur privé et affectent le produit national. Ces accroissements ont un effet richesse négatif sur les individus à travers les taxes plus élevées que ceux-ci devront éventuellement payer. Ceci les aménera à adapter leur comportement de consommation et d'offre de travail en conséquence. L'effet des dépenses publiques dépend aussi en général de leur substitution aux dépenses privées et de leur usage *i.e* pour fin de consommation ou d'investissement.

L'analyse de la taxation est intéressante pour plusieurs raisons. Premièrement, plusieurs études ont montré que différentes méthodes de financer la consommation publique sont associées avec des niveaux de bien-être différents. En second lieu, les effets des achats du gouvernement peuvent dépendre de la façon dont ils sont financés *i.e* par des taxes forfaitaires ou distortionnaires. La substitution intertemporelle par le gouvernment entre dette et taxes peut alors affecter les décisions de consommation et d'offre de travail des agents, étant donné que la maximisation de l'utilité égalise le taux marginal de substitution entre consommation et loisir au salaire réel après impôt.

Le premier essai de cette thèse examine l'importance de changements dans les dépenses publiques et les taxes sur la consommation, le revenu du travail et

le revenu du capital, relativement aux chocs technologiques dans la transmission du cycle économique entre pays. Les modèles existants considèrent souvent les chocs technologiques comme principal moteur de la transmission internationale du cycle, ils ne réussissent pas à expliquer plusieurs observations internationales et nationales. Principalement: Dans les économies théoriques, la corrélation de la consommation entre pays est plus grande que ce qui est observé et plus grande que celle de l'output et de la productivité; la corrélation internationale de l'investissement est souvent négative, alors que dans les donnnées elle est positive; la corrélation entre prix relatif et output relatif est négative dans un modèle où les fluctuations sont dûes à des chocs technologiques, alros que dans les données elle est positive. De plus, la corrélation entre heures travaillées et salaire réel est très élevée dans les modèles alors que dans les données elle est proche de zéro. Le modèle du premier essai est calibré pour deux pays similaires et des simulations numériques sont effectuées en vue de comparer les propriétés des séries générées par le modèle aux données. Les résultats de simulations montrent globalement que des fluctuations dans les taux de taxation et les dépenses du gouvernement ont des effets non négligeables sur les fluctuations agrégées.

Les deuxième et troisième essais examinent de façon empirique les effets de long terme des taxes distortionaires et des dépenses du gouvernement. Le cadre de l'analyse est un modèle d'équilibre général où les composantes des dépenses publiques sont des substituts imparfaits à la consommation privée et des taxes sont payées sur le revenu de travail. Pour évaluer la pertinence de la taxation du revenu de travail aux decisions d'offre de travail, ces deux articles dérivent les prédictions empiriques du modèle et, en se basant sur des tests de racine unitaire, les expriment en termes de relations de co-intégration.

Dans le second essai, les implications de long terme du modèle sont testées sur des données canadiennes entre 1966 et 1993, et dans le troisième, ces relations sont testées en utilisant des données américaines. La motivation pour ces articles vient d'une simple observation. Pour les deux pays, les taux d'imposition du revenu du travail ont présenté une tendance croissante au cours des trente dernières années. Cette tendance s'est accompagnée d'une tendance à la baisse des heures travaillées par semaine par travailleur. Pour le Canada, les résultats montrent que les données sont cohérentes avec la spécification du modèle avec taxes distortionnaires, alors qu'elles rejettent les implications du modèle sans taxes. De plus, les valeurs prédites par le modèle sont trés proches des observations.

Les résultats du troisième essai suggèrent que la situation est différente pour les États-Unis. Les données américaines sont cohérentes avec les deux spécifications du modèle, avec et sans taxes.

Résumé

Dans ma thèse, j'étudie les effets des politiques fiscales sur l'activité économique. La question a toujours préoccupé les économistes et continue de le faire. J'adresse la question dans le cadre d'un modèle d'optimisation dynamique d'équilibre général. Ma thèse se compose de trois essais: le premier est théorique et concerne les fluctuations de court terme, les deux autres sont empiriques et se concentrent sur les mouvements de long terme. L'analyse des dépenses du gouvernement et des taxes distorsionnaires est importante pour plusieurs raisons. Les dépenses du gouvernement représentent une part non négligeable du PIB pour la plupart des pays industrialisés et sont variables dans le temps. Des augmentations dans ces dépenses réduisent les ressources disponibles au secteur privé et affectent le produit national. D'un point de vue théorique, dans des modèles où le capital et le travail peuvent s'ajuster, des augmentations permanentes dans les dépenses du gouvernement, financées par des taxes forfaitaires, ont un effet richesse négatif sur les individus à travers les taxes plus élevées qu'ils devront éventuellement payer. Ceci les amènera à ajuster leur comportement de consommation et d'offre de travail en conséquence. Les heures travaillées, l'investissement et l'output augmenteront. Des accroissements temporaires des dépenses publiques auront en général comme effet de hausser les taux d'intérêt dans les économies fermées (voir, par exemple, Barro[1981]) et de détériorer la balance commerciale dans les économies ouvertes (voir Ahmed [1986, 1987], entre autres). Utilisant des simulations numériques, Baxter et King [1993] trouvent, comme attendu, que les individus réagiront à un accroissement permanent des achats du gouvernement en réduisant leur consommation et leur temps de loisirs. L'output augmentera plus que la hausse des dépenses du gouvernement dans le long terme, puisqu'à court terme, le mécanisme d'accélérateur générera un accroissement important de l'investissement. Inversement, des augmentations temporaires des dépenses du

gouvernement mènent à une baisse immédiate de l'investissement. Dans Baxter et King, la consommation par le gouvernement ne se substitue pas à la consommation privée. De façon plus générale, les effets d'une augmentation dans les dépenses du gouvernement dépendront du degré de substitution entre les dépenses publiques et les dépenses privées et de la productivité des dépenses du gouvernement. Plusieurs études empiriques ont trouvé que les dépenses publiques sur les biens et services ne se substituent pas parfaitement à la consommation privée. Ceci signifie que des accroissements permanents dans ces dépenses auront en général un effet richesse négatif mais moins qu'un pour un. Des estimations du taux marginal de substitution entre consommation publique et privée vont de $-0,02$ à 0,42. Aschauer [1985] rapporte des estimations pour les États-Unis entre 0,23 et 0,42; Ahmed [1986] trouve une valeur de 0,4 pour le Royaume-Uni; Katsaitis [1987] rapporte des valeurs entre 0,35 et 0,42 pour le Canada, et McGrattan [1994] donne une estimation de $-0,02$. Les effets de changements dans les dépenses du gouvernement dépendent aussi de la nature de la dépense, *i.e.* si cette dépense va à des fins de consommation ou d'investissement. Aschauer [1990] trouve que les dépenses publiques sur la consommation et sur l'investissement militaire ont un impact très faible sur le PNB, alors que l'investissement public net en capital d'infrastructure a un effet positif important sur l'output. Kormendi [1983] estime l'utilité marginale des dépenses publiques à 0,28 pour la consommation du gouvernement et 0,07 pour l'investissement. Ahmed et Yoo [1995], utilisant des techniques de co-intégration trouvent un effet de long terme négatif sur le ratio loisir travail d'un accroissement des dépenses du gouvernement indiquant un effet richesse négatif. Cet effet est plus important pour les dépenses sur les structures relativement aux dépenses sur les biens non durables et les services. Des changements dans les dépenses du gouvernement peuvent aussi être importants pour comprendre les fluctuations de cycle économique. Christiano et Eichenbaum [1992] montrent que, lorsque des changements dans la demande agrégée dûs à des changements stochastiques de la consommation du gouvernement sont incorporés dans l'analyse, la performance empirique du modèle est améliorée de façon substantielle. En particulier le modèle réplique la faible corrélation observée entre heures travaillées et salaires réels.

En ce qui concerne la taxation, l'analyse est aussi intéressante pour plusieurs raisons. Premièrement, des études ont suggéré que différentes méthodes de financer la consommation publique sont associées avec des niveaux de bien-être différents (Judd, 1987; Cooley et Hansen, 1992; Ohanian, 1997). Deuxièmement, les effets des achats du gouvernement sur les principales variables aggrégées peuvent dépendre de la façon dont ils sont financés i.e. par des taxes forfaitaires ou distorsionnaires. Dans ce dernier cas, la substitution intertemporelle par le gouvernement entre dette et taxes (distorsionnaires) peut affecter les décisions de consommation et d'offre de travail des agents et mène par conséquent à l'échec de l'équivalence de Ricardo (voir Barro [1989], Trostel [1993] et Cardia [1997]). Parce que la maximisation de l'utilité égalise le taux marginal de substitution entre consommation et loisir au salaire réel après impôt, la taxation du revenu de travail affecte le choix des agents en réduisant leur salaire réel net. Baxter et King [1993] trouvent que le multiplicateur des dépenses du gouvernement est positif lorsque les dépenses sont financées par des taxes forfaitaires, mais négatif lorsqu'elles sont financées par des taxes distorsionnaires. Stuart [1981] construit un modèle à deux secteurs où des taxes sont payées sur des revenus gagnés sur le secteur marchand. Le calibrage du modèle pour l'économie suédoise indique que l'accroissement du taux marginal d'imposition de 58% à 65% réduit l'offre de travail sur le secteur de marché entre 1,8% et 2,5%, dépendamment du scénario considéré. Greenwood et Huffman [1991] montrent que la réduction du taux marginal d'imposition du travail de 35% à 25% fait augmenter l'output et les heures travaillées de 10% . Frenkel et Razin [1992] montrent théoriquement que des déficits impliquant différents types de taxes impliquent des corrélations internationales des taux de croissance de l'investissement et de la consommation différents. Les taxes peuvent aussi être une source importante de fluctuations économiques. McGrattan [1994] trouve que 27% de la variance de l'output est expliqué par les innovations à la taxe sur le travail et 4% est expliqué par les innovations à la taxe sur le capital. Cardia [1994] trouve aussi que des chocs aux dépenses du gouvernement et à la taxe des facteurs expliquent jusqu'à 60% de la variance de l'output, de la consommation et du compte courant pour les États-Unis. Braun [1994] montre que l'introduction des taxes distorsionnaires dans les modèles de cycle économique réel (RBC) améliore leur capacité de reproduire certains faits stylisés de l'économie américaine tels la volatilité des heures travaillées et la faible corrélation entre salaires réels et emploi. Kollmann [1993] trouve que des chocs aux dépenses du gouvernement et à la taxe sur l'output peuvent expliquer la persistance du déficit de la balance commerciale américaine durant les années 80. Tous les papiers mentionnés utilisent des simulations numériques pour étudier les effets de la taxation. Il y a très peu d'articles en macroéconomie empirique qui examinent directement la pertinence des taxes distorsionnaires. Kniesner et Ziliak [1999], utilisant des données de la PSID, trouvent que les heures travaillées par les jeunes hommes diminueront de plus de 0,05% dans le court terme suite à un accroissement de 10% du taux marginal de taxation aux États-Unis. D'autres études en finance publique trouvent des estimations relativement modestes de l'élasticité de l'offre de travail des hommes par rapport au salaire réel, et des estimations un peu plus élevées pour les femmes (voir Pencavel [1986] et Killingsworth et Heckman, [1986] pour des estimations et une revue). Quelques-unes des estimations sont basées sur des modèles statiques et d'autres sur des modèles de cycle de vie, d'autres encore sont basées sur des données expérimentales.

L'analyse des effets de la taxation est en général compliquée à cause de la disponibilité de mesures appropriées pour les taux de taxation. Les taux d'imposition dépendent des échelles de revenus des ménages et générer de bonnes séries n'est pas trivial. Cependant, dans un article relativement récent, Mendoza, Razin et Tesar [1994] ont calculé des taux effectifs de taxation de la consommation et des revenus de travail et de capital cohérents avec les distorsions envisagées par un agent représentatif dans un modèle d'équilibre général. Ils ont aussi montré que les propriétés des séries qu'ils ont générées sont similaires à celles d'autres mesures de taxes qui emploient des données sur la distribution du revenu, les taxes statutaires, et d'autres caractéristiques institutionnelles. Ces données sont intéressantes et, en autant qu'on le sache, n'ont pas été exploitées dans des analyses empiriques. Ces séries seront cruciales pour notre analyse théorique et empirique.

Le premier essai de cette thèse étudie les effets des dépenses du gouvernement et des taux de taxation sur les fluctuations agrégées dans des économies ouvertes. Il examine l'importance de changements dans les politiques gouvernementales, tels la taxation distorsionnaire et les dépenses publiques, relativement aux chocs technologiques dans la transmission du cycle économique entre pays. Dans les modèles de fluctuations internationales, les variations des dépenses du gouvernement et des taux de taxation n'ont pas été vraiment examinées. Les modèles considèrent souvent les chocs technologiques comme principal moteur de la transmission internationale du cycle, et ne réussissent pas à expliquer plusieurs observations. Principalement, dans les économies théoriques, la corrélation de la consommation entre pays est plus grande que ce qui est observé dans les données et plus grande que la corrélation de l'output et de la productivité; la corrélation internationale de l'investissement est souvent négative plutôt que positive; la corrélation entre prix relatif et output relatif est négative plutôt que positive comme dans les données; la corrélation entre heures travaillées et salaire réel est très élevée, alors que dans les données elle est proche de zéro. D'autres observations qui ont été examinées concernent la contre-cyclicité de la balance commerciale et la grande variabilité de la balance commerciale et des termes de l'échange, (voir par exemple Backus, Kehoe et Kydland [1992, 1993, 1995], Stockman et Tesar [1995], Baxter et Crucini [1993]). Dans ces modèles, le lissage de la consommation et le partage international de risque impliquent une corrélation internationale positive et très élevée de la consommation. La mobilité internationale du capital et son allocation à la localisation la plus productive impliquent en général une corrélation internationale négative de l'investissement et de l'output.

Le premier essai explore comment des sources additionnelles de variations provenant de chocs aux politiques fiscales affecteront ces observations. Plusieurs mécanismes ont déjà été proposés dans la littérature en vue de réduire spécifiquement la corrélation internationale de la consommation: marchés incomplets, forme particulière de non- séparabilité entre consommation et loisir, biens non échangeables, chocs aux préférences, chocs à la monnaie avec taux de croissance de la productivité différents (Devereux, Gregory et Smith [1992], Backus et Smith [1993], Tesar [1993], Lewis [1993], Kollmann [1996], Stockman et Tesar [1995], Ricketts et McCurdy [1995]). Ces modifications ont en général réussi à atteindre leur objectif. Nous proposons d'autres canaux de transmission des cycles entre pays, ces canaux étant directement reliés aux variables agrégées qui nous intéressent, *i.e.* consommation, investissement, heures travaillées. Nous examinons les effets de chocs aux dépenses gouvernementales et aux taux de taxation de la consommation, du revenu de travail et de capital, relativement aux effets de chocs technologiques sur les corrélations internationales et domestiques. Le cadre est celui d'un modèle d'optimisation dynamique avec deux pays et deux biens, un bien non échangeable et un bien échangeable. Le modèle est calibré pour deux pays similaires représentant chacun une économie industrialisée moyenne et des simulations numériques sont effectuées en vue de comparer les propriétés empiriques des séries générées par le modèle aux données. Les simulations montrent qu'un modèle avec chocs aux politiques gouvernementales réussit mieux qu'un modèle avec chocs technologiques. Le premier modèle, où les fluctuations sont menées par des chocs aux politiques fiscales et à la technologie, reproduit mieux plusieurs aspects des données. Dans ce modèle la corrélation entre output relatif et prix relatif est positive comme dans les données. Ce premier résultat est dû au fait que, inversement aux chocs technologiques, les chocs aux dépenses gouvernementales agissent sur la demande agrégée. Conséquemment, ils modifient les prix et l'output dans la même direction. Le modèle reproduit les observations relatives au marché du travail, telles la faible corrélation entre heures travaillées et salaire réel et la variance des heures travaillées. L'intuition est que des chocs au taux de taxation du revenu de travail font déplacer l'offre de travail le long d'une courbe de demande fixe. Un résultat similaire est obtenu dans Braun [1994]. De plus, relativement à un modèle avec chocs technologiques seulement, un modèle avec chocs aux politiques fiscales produit une corrélation internationale de la consommation plus faible et une corrélation entre balance commerciale et output plus faible. La raison est que des chocs à la taxation de la consommation et du revenu de travail affaiblissent le lien existant entre consommation domestique et étrangère à cause de la substitution qu'ils impliquent de façon intertemporelle et de façon intratemporelle par la substitution entre consommation et loisir. Par conséquent, ceci mène à une corrélation internationale de la consommation plus faible. De plus, des chocs aux dépenses du gouvernement mènent à une détérioration de la balance commerciale tout en ayant un effet expansionniste sur l'output, ils impliquent ainsi une corrélation plus faible entre balance commerciale et output. Ces résultats montrent globalement que des fluctuations dans les taux de taxation et les dépenses du gouvernement ont des effets non négligeables sur les fluctuations agrégées même si elles ne résolvent pas tous les puzzles des modèles RBC.

Les deuxième et troisième essais examinent de façon empirique les effets de long terme des taxes distorsionnaires et des dépenses du gouvernement sur l'offre de travail pour le Canada et les États-Unis. Le cadre de l'analyse est un modèle d'équilibre général où les composantes des dépenses publiques, *i.e.* consommation publique et investissement public sont des substituts imparfaits à la consommation privée et des taxes sont payées sur le revenu de travail. Des chercheurs suggèrent que, pour un niveau donné des dépenses publiques, la taxation distortionnaire a des effets de "second ordre" (voir par exemple, entre autres, Barro [1989]). La question de savoir si ces effets sont importants ou non est avant tout une question empirique et c'est la question que posent ces deux essais. Pour évaluer la pertinence de la taxation du revenu de travail aux décisions d'offre de travail, ces deux articles dérivent les prédictions empiriques du modèle et, en se basant sur des tests de racine unitaire, les expriment en termes de relations de co-intégration comme dans Ahmed et Yoo [1995]. Plus précisément, il est montré que les conditions de premier ordre et les contraintes de ressources du modèle impliquent qu'une combinaison linéaire des variables est stationnaire même si les variables prises individuellement ne sont pas stationnaires. Les relations dérivées ne sont pas affectées par les propriétés des chocs technologiques ou le fait que les dépenses du gouvernement puissent affecter la productivité des facteurs. Le modèle inclut comme cas particuliers des spécifications sans taxes distortionnaires et sans substitution entre dépenses publiques et privées. Les tests de co-intégration procurent une façon simple d'évaluer les spécifications différentes. Nous employons les deux tests le plus fréquemment utilisés pour tester pour la présence de co-intégration; le test Engle-Granger basé sur le test de stationnarité des résidus et le test de Johansen de maximum de vraisemblance.

Dans le deuxième essai, les relations de long terme prédites par le modèle sont testées en utilisant des données canadiennes entre 1966 et 1993, et dans le troisième, ces relations sont testées sur des données américaines. Une observation intéressante des données canadiennes est que le taux de taxation présente une tendance croissante qui est reflétée presque littéralement par une tendance décroissante des heures travaillées. Alors que plusieurs causes, telles le progrès technologique soutenu et les changements démographiques, peuvent expliquer la baisse dans le nombre d'heures travaillées, le rôle de la taxation et des dépenses du gouvernement semble aussi intéressant à examiner. Les résultats montrent que, pour le Canada, des changements dans le taux d'imposition du travail affectent les décisions concernant l'offre de travail relativement au loisir de manière cohérente avec le modèle. Tandis que la relation de co-intégration prédite par la spécification avec taxe distorsionnaire n'est pas rejetée par les données, elle l'est pour le modèle néoclassique simple de croissance sans taxe. Les paramètres structurels du modèle sont par la suite estimés utilisant la méthodologie de GLS dynamique proposée par Stock et Watson [1990]. La part estimée du loisir dans la fonction d'utilité est significativement différente de zéro et sa valeur est comparable aux estimations trouvées dans des études antérieures utilisant des données américaines et aux valeurs généralement utilisées dans le calibrage des modèles de RBC. De plus, lorsque les valeurs prédites du ratio loisir - travail sont représentées graphiquement avec les séries réelles, les deux séries sont remarquablement proches. De plus, l'analyse de réponse à impulsion montre qu'un accroissement de la taxation du travail diminue l'offre de travail. Une augmentation de 1 point de pourcentage du taux de la taxe réduit les heures travaillées par semaine de 0,3 heure. Étant donné la tendance croissante de la taxe sur le revenu de travail entre 1966 et 1993, la taxation distorsionnaire semble expliquer une part substantielle de la baisse des heures travaillées par personne au Canada. Les résultats montrent aussi qu'une augmentation des dépenses publiques réduit l'offre de travail. Ce résultat est cohérent avec des résultats de simulation obtenus par Baxter et King [1993] où une hausse des dépenses publiques financée par taxe distorsionnaire du travail réduit l'offre de travail et l'output. Cependant, même si leur effet quantitatif potentiel est grand, les changements dans la consommation et l'investissement publics sur la période considérée ne sont pas suffisants pour expliquer la baisse importante dans les heures travaillées.

Le troisième papier examine de façon empirique la même question adressée dans le deuxième essai, *i.e.* les effets des taxes distorsionnaires et des dépenses du gouvernement sur l'offre de travail, utilisant cette fois des données américaines. La motivation vient aussi d'un simple examen des données. Celles-ci montrent que les 30 dernières années ont connu une baisse des heures travaillées par personne active aux États-Unis surtout durant les années 60 et 70. En même temps, cette période a connu une hausse du taux d'imposition du revenu de travail aussi particulièrement durant les années 60 et 70. Donc la question est d'examiner s'il y a un lien entre l'offre de travail et la taxe du travail. McGrattan et Rogerson [1998] rapportent aussi, utilisant des données de recensement depuis 1950, que le nombre d'heures par travailleur a diminué aux États-Unis au niveau agrégé et pour toute catégorie d'âge et de sexe. Les résultats des tests suggèrent que les données sont cohérentes avec les implications du modèle pour les deux spécifications avec et sans taxes. Ces résultats ne paraissent donc pas tranchants comme c'était le cas pour le Canada. Une investigation plus approfondie serait nécessaire pour évaluer l'effet potentiel des taxes. Par ailleurs, les estimations des coefficients de substitution entre dépenses publiques et privées sont plus petits que un et donc cohérents avec ce à quoi on s'attend. Cependant, étant donné les écarts-types élevés, les dépenses publiques semblent se substituer plutôt faiblement à la consommation privée. Des résultats comparables ont été obtenus par McGrattan [1994] dans un contexte un peu différent. Le papier montre aussi que les valeurs prédites par l'estimation répliquent assez bien la tendance observée du ratio loisir travail.

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Distortionary Taxation and International Real Business Cycle Models

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Abstract

The purpose of this paper is to study the role of government spending and tax rates on aggregate fluctuations in open economies. In the context of international real business cycle models, several studies have considered technology shocks as the main source of aggregate fluctuations. These models replicate well many national and international stylized facts. However, some puzzles remain unexplained; for instance, in theoretical economies the correlation of consumption across countries is larger than is observed in the data and larger than output and productivity correlations. The correlation of investment is negative rather than positive. Also the standard deviation of the trade balance is smaller than in the data. Studies that considered fiscal shocks have shown that they have important effects in explaining consumption and output variances (Cardia [1994]; Kollmann [1993]; McGrattan [1994]). This paper examines the importance of changes in government policies (like distortionary taxation and public spending) relatively to technology shocks in the transmission of business cycles across countries. Numerical simulations are conducted in order to confront the empirical properties of the series generated by the model with the data. Shocks to government policies are shown to have important effects.

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1 Introduction

Government spending represents a non negligible share of GDP for most industrialized countries and is variable over time. The different tax rates used to finance public spending have also fluctuated over the last decades for all countries of the G-7.[2] Few studies have explicitly examined the effects of government spending and tax rates on international aggregate fluctuations using calibrated general equilibrium models. This paper addresses this question. In particular, it examines the importance of changes in government policies, like distortionary taxation and public spending, relatively to technology shocks in the transmission of business cycles across countries.

Previous studies that have incorporated a public sector in general equilibrium models have found some interesting results as to the effects of fluctuations in government spending and tax rates on aggregate fluctuations. Christiano and Eichenbaum [1992] propose a model that incorporates aggregate demand changes due to stochastic changes in government consumption, where government consumption substitutes partially for private consumption. With this modification and the allowance for measurement errors, the model's empirical performance is substantially improved relative to a model with only technology shocks. In particular, the model replicates well the variance of hours worked and the observed weak correlation between hours worked and real wages in the US. McGrattan [1994] shows that disturbances in the tax rates on labor and capital income, and in government consumption can account for nearly 60% of the unconditional forecast variance of output and consumption. Cardia [1994] examines the effects of labor taxation in a small open economy context and finds in particular that the tax rate on labor explains 20% to 40% of the variation of output, consumption

[2] Canada, France, Germany, Japan, Italy, the United Kingdom and the United States. We present in the next section some descriptive facts on the dynamics of these fiscal variables.

and the current account. Braun [1994] shows that introducing distortionary taxes in a real business cycle (RBC) model improves its ability to reproduce features of the US economy like the variability of hours worked and the weak correlation between real wages and employment. Also, Kollmann [1993], finds that technology shocks cannot explain the persistence of the deficit of the U.S. trade balance during the 1980's, while adding fiscal shocks allows this explanation. The author also finds that changes in the tax policy are more important than government spending shocks in determining fluctuations of the U.S. trade balance.

The literature on the international transmission of business cycles has often considered productivity shocks as the main source of fluctuations (Backus et al. [1992, 1993]; Baxter and Crucini [1993]; Ahmed et al. [1993]). While replicating several national and international stylized facts, these models have failed to explain several features of the data mainly: the observation that cross-country correlations of consumption and productivity are lower than cross-country correlation of output, the positive international correlation of investment, the observed high volatility of the trade balance and the terms of trade (see for example Backus, Kehoe and Kydland [1992, 1993, 1995], Stockman and Tesar [1995], Baxter and Crucini [1993]). In these models, consumption smoothing and international risk sharing act to yield a positive and very high cross-country correlation of consumption. International mobility of capital and its allocation to its most productive location generally yield a negative cross-country correlation of investment and of output. In two sector economies, these models have also generally failed to explain the observed correlations between relative quantities and relative prices. [3] Several modifications of the basic components of the model have been proposed mainly

[3] With productivity shocks, consumption of a good relative to the other good is expected to be perfectly negatively correlate with its relative price. In the data, this correlation is small. Also, in the theoretical model, relative output is negatively correlated with relative price, while in the data this correlation is positive.

with the focus on reducing the cross-country correlation of consumption. They include: particular forms of non separabilities in consumption and leisure (Devereux, Gregory and Smith [1992]), incomplete markets (Lewis [1993], Kollmann [1996]), non traded goods (Backus and Smith [1992], Tesar [1993], Stockman and Tesar [1995]), taste shocks (Stockman and Tesar [1995]), money shocks with differing rates of trend productivity growth (Ricketts and McCurdy [1995]). These modifications have generally had some success in improving the performance of the models. In particular, Devereux, Gregory and Smith [1992] succeed in lowering the cross-country correlation of consumption by considering a model where consumption and leisure are non separable in the utility function and where the income elasticity of leisure is zero. Backus and Smith [1992] show, in an exchange economy, that non traded goods are an important device for accounting for deviations from PPP and for the imperfect correlation of consumption fluctuations across countries. Tesar [1993] in a numerical simulation exercise also shows that the model with non traded goods yields low international consumption correlation and high correlation between saving and investment consistent with the data when empirical estimates of the parameters describing preferences and technology are used in the simulations[4]. However, the generated consumption correlation always exceeds the cross-country output correlation. Stockman and Tesar [1995] consider also a two-sector economy and introduce taste shocks in addition to technology shocks. They find that when adding these shocks which are essentially demand shocks, the model performs better than with technology shocks alone along several lines. The cross-country consumption correlation, the correlation between the relative price of non traded (to traded) goods with the relative consumption of those goods, and the correlation between the consumption of the two goods are closer to the data. Taste shocks raise the standard deviation of the trade

[4]The estimated elasticity of intertemporal substitution is larger than the elasticity of substitution between traded and non traded goods in that paper.

balance, even though not enough to match the data, but they worsen the correlation between the trade balance and output. Also this model cannot explain the correlation of the traded to non traded sector output with its relative price and does not explore the cross-country correlation of investment. Also, in the theoretical economy, even with taste shocks, relative output is negatively correlated with relative price, while in the data this correlation is positive. Ricketts and McCurdy [1995] develop a two-country model calibrated to the US and Canada and obtain a relative ordering of the cross-country correlation of consumption, productivity and output consistent with the data in the version of the model with no cross-investment between the two countries *i.e.* goods installed as capital stock in a particular country must be produced in that country.

None of the above mentioned papers includes formally a government sector in the analysis [5]. In different contexts, several papers have suggested that government policies can have important effects on the economy (Cardia [1994, 1997], McGrattan [1994], Braun [1994], Christiano and Eichenbaum [1992]). In this paper, we examine the effects of shocks to government spending and to the tax rates on consumption, labor income and capital income, relatively to technology shocks on international and domestic correlations. Frenkel and Razin [1988, 1992], using a deterministic two-country, two-period model, show that deficits involving reductions in the rates of taxation of consumption, labor income or capital income have different implications in terms of cross-country correlations of the growth rates of consumption, and cross-country investment correlations. In that framework, the international transmission of fiscal policies takes place through the interest rate.

We examine the role of fiscal policies, *i.e.* government spending and taxation of consumption, labor income and capital income, in the framework of a dynamic

[5]Except Kollmann [1993] and Ricketts and McCurdy [1995], but in the former paper the focus was on the persistence of the US trade balance deficit during the eighties, and in the latter, the role of government was just that of a central banker.

optimization model. Fluctuations of these variables, considered as exogenous in the model, as well as technology shocks, will drive fluctuations of aggregate consumption, hours worked, investment, output and the trade balance. In our model, transitory and relatively persistent increases in government spending will generally lead to a deterioration of the trade balance and some crowding out of consumption as in Ahmed [1986, 1987] and Cardia [1991] for instance, and will lead to a negative wealth effect which will affect the consumption of goods and of leisure. Fluctuations of the consumption tax could decrease the cross-country consumption correlation as these taxes affect consumption directly. Fluctuations of the labor income tax will affect labor supply as people substitute leisure intertemporally and intratemporally for private consumption of goods. The framework of the analysis is a stochastic two-country model, with three goods, and a public sector where the government has no objective function. Multisector economies allow the understanding of a broader set of relevant variables and perform generally better than one sector models with respect to international correlations (see for instance Backus and Smith [1992], Tesar [1993], Stockman and Tesar [1995] and Lapham and Vigneault [1998]). The model is calibrated for two similar countries and numerical simulations are conducted in order to compare the empirical properties of the series generated by the model with the data.

The rest of the paper is organized as follows. The next section describes stylized features of open economies business cycles and different tax rates and government consumption for the G7 countries. The observed moments provide additional motivation for including fiscal shocks in RBC type models. Section 3 presents the general equilibrium model and gives its solution. Sections 4 and 5 discuss the calibration parameters used and the simulation results as well as the impulse response functions obtained for different cases considered. Section 6 concludes.

2 Some Selected Facts on Tax Rates, Government Consumption and Main Macro-Aggregates

In this section, we describe some salient features of government consumption and tax rates for the G7 countries over the 1965-1988 period. In our study, we focus on government consumption (or government purchases, both terms used interchangeably)[6]. For the measure of tax rates, two types of series are available in the literature, namely the effective marginal tax rate (Joines [1981], Barro and Sahasakul [1983] among others) and the effective average tax rate (as computed in Mendoza, Razin and Tesar [1994]). Effective average tax rates are based on data from national accounts and government revenue statistics. Consequently and following the arguments in Mendoza et al., they are more appropriate for use in macroeconomic models especially for international comparison purposes. For this reason, we adopt this series in our analysis[7]. Tables 1, 2 and 3 report some descriptive statistics on government consumption and tax rates using annual data. As can be noticed from Table 1, government consumption accounts for nearly 19% of GDP for almost all G7 countries[8], except Japan where the ratio is 9%. It can also be noticed from Table 1 that the effective average tax rates can differ sometimes importantly across countries and across time for all countries. The UK, the US, Canada and Japan have relatively lower tax rates on labor income

[6] The broader government spending definition includes also transfers to the private sector. In some cases the difference in magnitude and evolution of the two series (government consumption and government spending) can be important, in particular for Canada and some European countries. However this is not the purpose of the paper.

[7] It's also worth noting in order to illustrate differences between effective rates and statutory rates, that for instance, in 1988, the effective average tax rates on labor were almost equal for the USA and Japan (28% and 26% respectively). Whereas the statutory individual income tax rates ranged from 16% to 34% for the US, and 15% to 65% in Japan (ref. Pechman and Engelhardt [1990]).

[8] This result is also true for almost all industrialized countries.

than the three other countries. The US and Japan are also among the countries that tax consumption the least; the effective average tax rate on consumption for these countries averaged 5% over the period considered, whereas the largest average recorded was 21% (France). As for capital income tax rates, the UK had the highest rate on average (57%), while France had the lowest rate (23%). The effective average tax rates on labor income have followed an increasing trend for the series observed in almost all countries. As well cross-country differences of these rates were narrower in the late eighties relatively to the late sixties [9]. Finally, it is also noticed in Table 1 that the ratio of the budget deficit to GDP differs across countries. This ratio averaged 3.3% for all countries considered for the period studied. We can see from Table 2 that the H-P filtered series display noticeable variability over time. The standard deviation of government consumption exceeded that of output for most countries. This series is also relatively highly autocorrelated (the AR(1) coefficients range from .41 [U.K] to .79 [Japan]). The effective average tax rate series are also variable for all countries considered. Mendoza et al. argue that effective average tax rates have varied over time because of policy changes in statutory taxes and tax credits and exemptions. The standard deviations of labor income and capital income tax rates are comparable to those of government consumption, while the variability of consumption tax rates is slightly lower. These tax rates also display serial persistence. The average autocorrelation coefficients for the seven countries are .82, .71 and .62 for the labor, consumption and capital income tax rates respectively. On the other hand, cross-country correlations of public consumption are negative for some countries and positive for others, (see Table 3). These correlations range from $-.42$ (US vs Germany) to .75 (Japan vs Germany), and average .15. Regarding tax rates, it can be noted

[9] For more details and graphical representation, we refer the reader to Mendoza et al. [1994]. Note that these figures are just presented for illustration. The averages should be interpreted carefully because the series are often far from being smooth or stationary.

that, with H-P filtered series, the correlations are also of mixed signs except for consumption where they are always positive. The average coefficient of correlation is .05 for the labor tax rate, .38 for consumption and .14 for capital.

To summarize, fiscal policies seem to be quite different across countries and no clear systematic cross-country correlations of the tax rates or public spending seem to emerge from the data considered. Our descriptive analysis suggests that fluctuations of government spending and tax rates over the last decades have been important and with high persistence. The variability and persistence of these variables are particularly important when the series are used for calibration in a general equilibrium model.

Tables 4 and 5 report some important stylized facts of the international business cycle. The series have been Hodrick-Prescott filtered, and correspond to annual data from IFS. The statistical moments reported are quite standard, we note: the positive cross-country correlation of consumption, output and investment; the international correlation of output being on average higher than that of consumption. We also note that investment is more volatile than output for all countries while consumption is less volatile (except for the UK). Similar and additional stylized facts are broadly documented in Backus, Kehoe and Kydland [1992, 1993], Stockman and Tesar [1995], and Ambler, Cardia and Zimmerman [1995]. We present these stylized facts in the last lines of each table for further reference. Stockman and Tesar numbers relate to annual data and are averages for a group of the G-7 countries. The figures in Backus et al., and Ambler et al. relate to quarterly data (OECD National Accounts), for US variables versus a European aggregate variables in the former and for 19 industrialized countries in the latter. All these figures show basically the same features as those of Tables 4 and 5. In Ambler et al. the cross country correlations are generally lower than in the other two sources as they consider a broader set of countries. In the next section we describe the model.

3 The Model

We consider a stochastic two-country model with a government sector. The model is an extension of Cardia [1991, 1997] for two countries and two sectors[10], consumers have finite horizons as in Blanchard [1985][11]. The two countries are linked via the exchange of consumption goods, capital goods and financial assets. Each country produces one non tradable good for domestic consumption, and one homogeneous tradable good that can be used for consumption and production in both sectors and both countries. All variables are expressed in terms of the traded good. Capital is perfectly mobile between the two countries and the two sectors. Labor is perfectly mobile between the two sectors within a country, but immobile across countries.

3.1 Production

The representative firm in each country and in each sector j ($j = T$ for tradable, and N for non-tradable) faces strictly convex adjustment costs for capital and maximizes the expected present value of its profits:

$$V_t^j = E_t \sum_{s=0}^{\infty} R_{t,s} \left[\frac{P_{t+s}^j}{P_{t+s}^T} Q_{t+s}^j - w_{t+s}^j N_{t+s}^j - I_{t+s}^j - \frac{\Psi \left(K_{t+s}^j - K_{t+s-1}^j \right)^2}{2K_{t+s}^j} \right] \qquad (1)$$

where $R_{t,s} = \left(\prod_{i=1}^{s} (1 + r_{t+i-1})\right)^{-1}$ is the discount factor, and $R_{t,0} = 1$

Q_t^j is output and N_t^j hours worked in sector j, w_t^j is the real wage, and Ψ the cost of adjustment of capital parameter. r_t is the rental price of capital and P_t^j is the

[10] International real business cycle models with infinite horizons can be found in particular in Backus, Kehoe and Kydland [1992, 1993], and Stockman and Tesar [1995].

[11] Finite horizons are particularly important in international models with decentralized equilibria, see for instance Giavazzi and Wyplosz [1984]. With infinite horizons, the existence of a deterministic steady-state requires the equality of the subjective discount rates of the two countries.

price of good j. Capital accumulates according to:

$$I_t^j = K_t^j - K_{t-1}^j + dK_t^j \tag{2}$$

The capital stock at time $t-1$, K_{t-1}, is given. Investment, I_t, becomes productive in the same period. The timing for capital is used for convenience, it does not affect the results. d is the depreciation rate of capital and is the same for both sectors and countries. We consider a Cobb-Douglas production function :

$$Q_t^j = a_t^j \left(K_t^j\right)^{1-\phi} \left(N_t^j\right)^{\phi}$$

where a_t^j is a technology parameter in sector j, a_t^j follows an exogenous stochastic process to be specified later. ϕ is the labor share in production.

Value maximization by the firm yields the following first order conditions:

$$w_t = \frac{P_t^j}{P_t^T} Q_{N,t}^j = \frac{P_t^j}{P_t^T} \phi a_t^j \left(\frac{K_t^j}{N_t^j}\right)^{1-\phi} \tag{3}$$

$$K_t^j - K_{t-1}^j = \frac{K_t^j}{\Psi}\left(q_t^j - 1\right) \tag{4}$$

$$E_t q_{t+1}^j = (1+r_t)\left[q_t^j - \frac{P_t^j}{P_t^T} Q_{k,t}^j - \frac{\Psi}{2}\left(\frac{K_t^j - K_{t-1}^j}{K_t^j}\right)^2 + d\right] \tag{5}$$

Q_N and Q_K are the derivatives of output with respect to labor and capital. The first condition states that the firm chooses the number of hours worked such that the marginal productivity of labor equals the real wage. In equilibrium, the real wage is the same for both sectors due to intersectoral labor mobility. The second condition gives the evolution of the capital stock as a function of Tobin's q and the third gives the dynamic equation for Tobin's q.[12] In addition, the transversality condition must also be imposed to insure optimality that the terminal value of capital converges to zero in the long run.

[12] q is the Lagrange multiplier of the constraint on capital accumulation and represents the shadow price of capital given adjustment costs.

3.2 Preferences and Utility Maximization

Individuals face a constant probability p of death each period, this probability is assumed to be age independent and the same across agents in the two countries, the population is normalized to one.[13] An individual of age s allocates his working time to the production of both goods, and derives utility from consumption of the tradable good $\left(C^T\right)$, the non tradable good $\left(C^N\right)$ and of leisure (L). At time t, he maximizes, subject to his budget constraint, the separable utility function:

$$U_{s,t} = E_{s,t} \sum_{i=0}^{\infty} \left(\frac{1}{1+p}\right)^i \beta^i u\left(C_{s,t+i}^T, C_{s,t+i}^N, L_{s,t+i}\right), \tag{6}$$

β is the subjective discount factor of the agent. $\left(1/\left(1+p\right)\right)^i$ is the probability that an individual born at time t is alive at time $t+i$. $\beta/\left(1+p\right)$ is the effective discount factor. In the rest we omit the subscript s for simplicity. We consider a separable logarithmic instantaneous utility function[14]

$$u\left(C_t^T, C_t^N, L_t\right) = \theta_1 \log\left(C_t^T\right) + \theta_2\left(C_t^N\right) + \theta_3 \log\left(L_t\right) \text{ with } \quad \theta_1 + \theta_2 + \theta_3 = 1$$

The financial wealth of the individual is given by:

$$A_t = B_t + F_t + V_t^T + V_t^N = B_t + F_t + q_t^T K_{t-1}^T + q_t^N K_{t-1}^N \tag{7}$$

B_t stands for government bonds held by the consumer and F_t for assets held on the foreign country. $V_t^j = q_t^j K_{t-1}^j$ is the value of the firms in each sector j (Hayashi [1982]) as Tobin's q represents also the shadow price of capital.

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[13] For more details on models with finite horizons see Blanchard [1985] for the continuous time and Cardia [1991] and Frenkel and Razin [1992] for the discrete time version.

[14] A log utility function implying an elasticity of substitution between goods of one and an intertemporal elasticity of substitution of one, is consistent with a large number of empirical studies who estimate the intertemporal elasticity of substitution to be between 0.5 and 2. See for example Tesar [1993] for a survey, and McGrattan [1994] for an estimation for the US in a context similar to ours. Note also that in Stockman and Tesar, utility was not separable in both goods. Recall that a log utility function implies elasticities of substitution of unity.

The consumer's budget constraint is:

$$A_{t+1} = (1+p)(1+(1-\tau_{k,t})r_t) \quad [A_t + (1-\tau_{h,t})w_t N_t - T_t - (1+\tau_{c,t})(C_t^T + P_t C_t^N)] \tag{8}$$

where $P_t = P_t^N / P_t^T$ is the relative price of the non traded good, the traded good being the numeraire. T_t represents lump-sum taxes net of transfers. $\tau_{h,t}$, $\tau_{k,t}$ and $\tau_{c,t}$ are the proportional tax rates on labor income, capital income[15] and consumption respectively. All taxes are assumed to follow exogenous stochastic processes to be specified later. Finally, total time endowment is normalized to 1:

$$L_t + N_t^T + N_t^N = 1$$

The consumer's first order conditions are:

$$\frac{U_{c_t^T}}{(1+\tau_{c,t})} = \beta E_t \frac{U_{c_{t+1}^T}}{(1+\tau_{c,t+1})}[1+(1-\tau_{k,t})r_t] \tag{9}$$

$$\frac{U_{c_t^N}}{(1+\tau_{c,t})P_t} = \beta E_t \frac{U_{c_{t+1}^N}}{(1+\tau_{c,t+1})P_{t+1}}[1+(1-\tau_{k,t})r_t] \tag{10}$$

Using a first order Taylor expansion, we can write these equations as:

$$E_t(1+\tau_{c,t+1})C_{t+1}^T = \beta[1+(1-\tau_{k,t})r_t](1+\tau_{c,t})C_t^T \tag{11}$$

$$E_t(1+\tau_{c,t+1})P_{t+1}C_{t+1}^N = \beta[1+(1-\tau_{k,t})r_t](1+\tau_{c,t})P_t C_t^N \tag{12}$$

These are the Euler equations describing the optimal dynamic behaviour of consumption of each good. We also have that the marginal rate of substitution between the two types of consumption is equal to their relative price, and the marginal rate of substitution between leisure and consumption is equal to the after tax real wage:

$$\frac{U_{c_t^T}}{U_{c_t^N}} = \frac{1}{P_t} \Longrightarrow C_t^N = \frac{\theta_2 C_t^T}{\theta_1 P_t} \tag{13}$$

$$\frac{U_{L_t}}{U_{c_t^T}} = \frac{(1-\tau_{h,t})w_t}{(1+\tau_{c,t})} \Longrightarrow L_t = \frac{\theta_3(1+\tau_{c,t})C_t^T}{\theta_1(1-\tau_{h,t})w_t} \tag{14}$$

[15] Capital income is all revenues from wealth and savings.

Individual total consumption is $C = C^T + PC^N$, its dynamic behaviour is given by:

$$E_t\left(1+\tau_{c,t+1}\right)C_{t+1} = \beta\left[1+\left(1-\tau_{k,t}\right)r_t\right]\left(1+\tau_{c,t}\right)C_t \tag{15}$$

Using equations (8) and (14), and aggregating over all individuals alive at time t, we can derive an expression for aggregate consumption as a function of aggregate human and financial wealth[16]:

$$\left(1+\tau_{c,t}\right)C_t^a = \alpha\left(H_t^a + A_t^a\right) \tag{16}$$

where $\alpha = \frac{(1+p)(1+\delta)-1}{(1+p)(1+\delta)}$

and $H_t^a = E_t \sum_{i=0}^{\infty} R_{t+i}\left(1+p\right)^{-i}\left(\left(1-\tau_{h,t+i}\right)w_{t+i}N_{t+i}^a - T_{t+i}^a\right)$

where the superscript a denotes an aggregate variable.

Using (15) and taking $E_t\left(1+\tau_{c,t+1}\right)C_{t+1}^a - \left(1+p\right)\left[1+\left(1-\tau_{k,t}\right)r_t\right]\left(1+\tau_{c,t}\right)C_t^a$, we have the dynamic equation of aggregate consumption:

$$E_t\left(1+\tau_{c,t+1}\right)C_{t+1}^a = \beta\left[1+\left(1-\tau_{k,t}\right)r_t\right]\left(1+\tau_{c,t}\right)C_t^a - \alpha p E_t A_{t+1}^a \tag{17}$$

Notice that the probability of dying enters now in the expression of consumption. If $p = 0$, we have the expression for consumption in the infinite horizon case. A_t^a is aggregate financial wealth which evolves according to:

$$A_{t+1}^a = \left[1+\left(1-\tau_{k,t}\right)r_t\right]\left[A_t^a + \left(1-\tau_{h,t}\right)w_tN_t^a - T_t^a - \left(1+\tau_{c,t}\right)C_t^a\right]$$

The probability of survival does not appear in this aggregate budget constraint. The reason is that when an individual dies, his wealth is transferred to insurance companies, so that at the aggregate level there is no change in wealth. The expression for aggregate human wealth is the same as the individual one, because when an individual dies, his human wealth vanishes. In the rest, all variables are in aggregate form, we omit the superscript a for clarity.

[16] An aggregate variable is defined as $x_t = \sum_{s=-\infty}^{t} \frac{p}{1+p}\left(\frac{1}{1+p}\right)^{t-s} x_{s,t}$, where $x_{s,t}$ is a variable relating to an individual born at time s.

3.3 The Public Sector

Government finances its purchases by taxing private consumption, labor income and capital income, collecting lump-sum taxes and by issuing bonds. At each time period the following budget constraint has to be satisfied:

$$\begin{aligned} B_{t+1} = & \left(1+r_t\right)\left(B_t+G_t-T_t-\tau_{h,t}w_tN_t-\tau_{c,t}C_t\right) \\ & -\tau_{k,t}r_t\left(A_t+\left(1-\tau_{h,t}\right)w_tN_t-\left(1+\tau_{c,t}\right)C_t-T_t\right) \end{aligned} \tag{18}$$

Government consumes from both the traded and non traded goods, $G_t = G_t^T + P_tG_t^N$. Lump-sum taxes are related to the level of public debt and given by $T_t = \gamma B_t + T_0$ where T_0 is constant. This specification of T is chosen in order to have a stable difference equation for government debt.[17] To rule out Ponzi games, we assume that:

$$r \leq \frac{\gamma}{\left(1-\left(1-\tau_k\right)\gamma\right)}$$

3.4 Equilibrium Conditions

As mentioned earlier, the traded good can be used for consumption and production in both sectors, while the non traded good can only be consumed. Accordingly, the following conditions must hold at each period of time:

$$Q_t^T = C_t^T + G_t^T + I_t^T + I_t^N + \frac{\Psi}{2}\frac{\left(K_t^T-K_{t-1}^T\right)^2}{K_t^T} + \frac{\Psi}{2}\frac{\left(K_t^N-K_{t-1}^N\right)^2}{K_t^N} + TB_t \tag{19}$$

$$Q_t^N = C_t^N + G_t^N \tag{20}$$

The current account is given by the relation:

$$F_{t+1} = \left(1+r_t\right)\left(F_t+TB_t\right) \tag{21}$$

[17] See Cardia [1991 and 1994], Kollmann [1993], Buiter [1990].

where TB is the trade balance. The same conditions must hold for the foreign country:

$$\begin{aligned} Q_t^{T^*} &= \begin{array}{l} C_t^{T^*} + G_t^{T^*} + I_t^{T^*} + I_t^{N^*} \\ + \frac{\Psi}{2}\frac{\left(K_t^{T^*} - K_{t-1}^{T^*}\right)^2}{K_t^{T^*}} + \frac{\Psi}{2}\frac{\left(K_t^{N^*} - K_{t-1}^{N^*}\right)^2}{K_t^{N^*}} + TB_t^* \end{array} & (22) \\ Q_t^{N^*} &= C_t^{N^*} + G_t^{N^*} & (23) \\ F_{t+1}^* &= (1 + r_t^*)(F_t^* + TB_t^*) & (24) \end{aligned}$$

Finally, the world equilibrium requires that the real interest rate be the same for both countries and that the net assets position equilibrates:

$$r_t = r_t^* \tag{25}$$

and

$$F_t = -F_t^* \tag{26}$$

3.5 Solution

To solve the model, we use numerical simulations since no analytical solution can be derived. We linearize the first order conditions and the equilibrium conditions of the model around the deterministic steady state (as in King, Plosser and Rebelo, [1988]) by taking first order Taylor expansions. The steady state corresponds to a constant consumption level and a constant capital stock.

The linearized equations describing the general equilibrium solution of the model can be written in the following matrix form:

$$\begin{aligned} E_t X_{t+1} &= \Gamma_1 E_t X_{t+1} + \Gamma_2 X_t + \Gamma_3 Y_t + \Gamma_4 Z_t + \Gamma_5 E_t Z_{t+1} & (27) \\ Y_t &= \Psi_1 E_t X_{t+1} + \Psi_2 X_t + \Psi_3 Z_t + \Psi_4 Z_t + \Psi_5 E_t Z_{t+1} & (28) \end{aligned}$$

Where

$$\begin{aligned} X_t &= [\hat{K}^N_{t-1}, \hat{K}^{N^*}_{t-1}, \hat{K}^T_{t-1}, \hat{K}^{T^*}_{t-1}, \hat{B}_t, \hat{B}^*_t, \hat{F}_t, \hat{F}^*_t, \hat{C}_t, \hat{C}^*_t, \hat{q}^T_t, \hat{q}^{T^*}_t, \hat{q}^N_t, \hat{q}^{N^*}_t]' \\ Y_t &= \begin{bmatrix} \hat{N}^T_t, \hat{N}^{T^*}_t, \hat{N}^N_t, \hat{N}^{N^*}_t, \hat{r}_t, \hat{w}_t, \hat{w}^*_t, \hat{P}_t, \hat{P}^*_t, \hat{C}^N_t, \hat{C}^{N^*}_t, \hat{N}^T_{t+1}, \hat{N}^{T^*}_{t+1}, \\ \hat{N}^N_{t+1}, \hat{N}^{N^*}_{t+1}, \hat{w}_{t+1}, \hat{w}^*_{t+1}, \hat{P}_{t+1}, \hat{P}^*_{t+1} \end{bmatrix}' \\ Z_t &= \left[\hat{T}_0, \hat{T}^*_0, \hat{G}^T_t, \hat{G}^{T^*}_t, \hat{G}^N_t, \hat{G}^{N^*}_t, \hat{a}^T_t, \hat{a}^{T^*}_t, \hat{a}^N_t, \hat{a}^{N^*}_t, \hat{\tau}_{h,t}, \hat{\tau}^*_{h,t}, \hat{\tau}_{c,t}, \hat{\tau}^*_{c,t}, \hat{\tau}_{k,t}, \hat{\tau}^*_{k,t}\right]' \end{aligned}$$

The "^" symbol on a variable denotes deviation from its steady-state value. The vector X contains eight predetermined variables $\left[\hat{K}^N_{t-1}\hat{K}^{N^*}_{t-1}\hat{K}^T_{t-1}\hat{K}^{T^*}_{t-1}\hat{B}_t\hat{B}^*_t\hat{F}_t\hat{F}^*_t\right]'$, and six non-predetermined variables $\left[\hat{C}_t\hat{C}^*_t\hat{q}^T_t\hat{q}^{T^*}_t\,\hat{q}^N_t\hat{q}^{N^*}_t\right]'$. Y comprises the non dynamic endogenous variables of the system and Z the exogenous forcing variables. Elements of the matrices Γ_1 to Γ_5, Ψ_1 to Ψ_5 are composites of the parameters of the structural form. The exogenous variables are assumed to follow an AR(1) stationary process:

$$Z_{t+1} = \Omega Z_t + \varepsilon_{t+1}, \text{ with } \quad E(\varepsilon_t) = 0 \quad \textit{and} \quad E(\varepsilon_t \varepsilon_t') = \Sigma.$$

The elements of Ω will be calibrated based on estimation of the process followed by each of government spending and tax rates as well as technology.

$$ZX_{t+1} = \gamma_1 ZX_t + \gamma_2 \xi_{t+1} \quad \text{where} \quad ZX_t = \begin{bmatrix} Z_t \\ X_t \end{bmatrix} \quad \text{and} \quad \xi_t = \begin{bmatrix} \varepsilon_t \\ 0 \end{bmatrix}$$

In order to have a unique non explosive solution, the number of eigenvalues of γ_1 outside the unit circle should equal the number of non predetermined variables, six in our case, (see Blanchard and Kahn, [1980]). In the results presented, this condition was always satisfied.

4 Model Parameterization and Simulation:

Tables 6, 7 and 8 present the parameter values used for calibration. These values are mainly taken in the existing literature (namely Prescott [1986]; Cardia [1991, 1997]; Stockman and Tesar [1995] and Backus, Kehoe and Kydland [1992, 1993]). The main parameters for which values have to be assigned are the labor shares in the production function, the weight of leisure and of the two goods in the utility function, the cost of adjustment coefficient, and the coefficients of the processes governing technology shocks, shocks to the tax rates and to government consumption. For technology shocks parameters, we consider two sets of estimates. The first is taken from Stockman and Tesar [1995], which we label the base case, and the second is taken from the paper by Backus et al. [1992]. The model is calibrated for annual data for two similar countries or an "average" industrialized country[18]. This is done by taking averages over the G-7 countries for all variables except fiscal variables where we take averages over only four countries for which data is available for the period 1965-1988. [19]

All simulation results presented correspond to infinite horizons approximated by assuming a small value for the probability of death (p = .0000135).[20] The annual world rate of interest is fixed at 4% in the steady state as in Prescott [1986], and the capital depreciation rate is 10% per year. The adjustment cost parameter ψ is fixed at .5 as to match the observed volatility of investment relative to output which is of approximately threefold[21]. The sensitivity of the results with respect to this parameter is discussed later on. Following Stockman and Tesar [1995], labor share in output ϕ is set equal to .61 for the traded sector and .56 for the

[18]The choice of annual data is motivated by the availability of the data on tax rates.

[19] These four countries are the USA, Canada, Germany and Japan.

[20] In the finite horizon case, a value of p of .0135 corresponds to life expectancy of 74 years. In a sensitivity analysis with respect to the finiteness of horizon, it is noticed that the cross-country consumption correlation is slightly lower than the case with infinite horizon. Otherwise, the results are quite similar.

[21]Some authors have estimated this cost of adjustment parameter in different contexts, among others, Shapiro (1986). He finds, using GMM, a value of the marginal cost of adjustment of 0.7% of the output of the quarter, or about 9% of the cost of investment. This would yield a value of ψ of .36 per year.

non traded sector, these are averages over the G7 countries. The steady state allocation of work effort is 56% to the traded good industry and 44% to the non traded industry, consistent with equal shares of traded and non traded outputs in total output, also as in Stockman and Tesar [1995]. The weights of consumption and leisure in utility are derived from the consumers' first order conditions at the steady state and are consistent with a share of 30% of total non sleeping time allocated to work. This gives $\theta_1 = .091$, $\theta_2 = .291$ and $\theta_3 = .618$. [22] With regards to the public sector, we have no available estimates of the share of each good in total government consumption. We assign a relatively higher share to the consumption of the non traded good, as services are an important component of government expenditure. The ratio of government consumption to GDP is fixed at .19 for the non tradable sector and .14 for the tradable. This yields a ratio of total government consumption to aggregate GDP of .16 similar to the expenditure average observed in the data. Government debt and lump sum taxes in the steady state are calculated as to correspond to a ratio of budget deficit to GDP of 2.6% which is an average for the G-4 (see Table 1). The tax rates on labor income, consumption and capital income are .26, .10, and .36 respectively at the steady state. These numbers are averages of the effective average tax rates series calculated by Mendoza et al. for the four countries considered. The parameter of adjustment of lump-sum taxes to debt γ is equal to .045.[23] The intertemporal subjective discount rate δ is set equal to .0256, equal to the after tax real interest rate[24]. The net foreign holdings of each country are null at the steady state since the two countries are similar. Table 6 summarizes these parameter values for preferences, production and the government sector.

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22 To note that with these values, the share of traded good consumption in total consumption is only 24% at the steady state.

23 The results are robust to this parameter value. Experiences with values of .08 and .5 were conducted and the results were almost the same.

24 The subjective discount factor is then .975.

Concerning the processes driving the exogenous variables which are technology and government spending in the traded and non traded sectors, labor income tax rates, capital income tax rates and consumption tax rates, we assume that these variables have the same structure and properties in both countries. For the tax rates and government consumption, we assume in addition no cross-country correlations for all of these variables due to the lack of readily available evidence from the data on the signs and magnitudes of these correlations [25]. We also assume that they are uncorrelated with technology shocks and among themselves. The standard deviations of innovations to labor income tax rates, consumption tax rates and capital income tax rates are set at 0.00694, 0.00477 and 0.0209 respectively [26]. The standard deviation of innovations affecting government consumption is estimated to be 0.01 for both sectors[27].

For the process driving technology shocks, in the base case simulations, we use the statistics for the Solow residuals derived in Stockman and Tesar [1995]. The standard deviations of innovations to technology are 0.019 and 0.014 for the traded and non traded sector respectively. The cross-country correlation of innovations is 0.33 for the traded sector and 0.14 for the non traded sector, and the cross-sectoral correlation within a country is 0.46. Table 7 summarizes the processes for the technology and fiscal shocks.

[25] As shown in Table 3, no systematic relationship seems to exist between fluctuations of tax rates or government consumption across countries. One exception is the filtered consumption tax rate for which the correlations are positive for all pairs of countries considered. A sensitivity analysis with respect to this correlation being different from zero showed that the results are not affected.

[26] These are averages across countries of the standard deviations of residuals of the AR(1) regressions for each variable.

[27] Actually we have no available data on government consumption of traded and non traded goods, we assume that the variance and persistence of available total government consumption series hold also for each sector.

A second set of simulation uses the Backus et al. [1992, 1993] specifications for the statistics describing the technology process. These shocks are highly persistent (.906), the standard deviation of innovations to technology is 0.0085 and the cross-country correlation of innovations is 0.258. In our calibration we assume that the non traded sector has the same properties as the traded good, and that technology shocks affecting both sectors are independent.

5 Simulation Results

Tables 9A and 9B present national and international correlations and standard deviations of output, consumption, investment and hours worked, for the series generated by the model in the base case simulations. The different columns correspond to the model being subjected to different combinations of the shocks (technology, government spending and tax rates) in the two countries. In the last two columns, we present, for comparison purposes, the results obtained in Stockman and Tesar [1995], (which we refer to as ST), and Backus et al. [1993], (BKK).

5.1 Simulations with Technology Shocks

We first describe the simulation results obtained for the case with only technology shocks. The model reproduces the results usually obtained in the real business cycle literature. For instance, the model replicates: i) the positive and high cross-country correlation of consumption, ii) the positive correlation of investment with savings, iii) the positive correlation of output with consumption, investment, employment and average productivity of labor, iv) the positive sectoral correlation of output and of consumption, v) the positive cross-country correlation of investment. Other features of the data replicated by the simulations are that hours worked and consumption are less volatile than output while investment is more volatile than output. Result (v) was not found in BKK and is also not found in Table 10 which reports results using the BKK calibration. Several factors can provide the explanation. An important reason may be the low persistence of technology shocks as calculated in ST and the presence of spillovers; transitory technology shocks lead to small investment response. In BKK, with no adjustment costs for capital (but time-to-build), persistent technology shocks lead to negatively correlated investment across countries as, following a shock, resources are shifted to the most productive location. The presence of non traded goods subject to technology shocks which are positively correlated with the traded sector technology shocks also limits the international migration of capital, as some migration takes place within a country. Also, the positive correlation of investment across countries may be due to the presence of adjustment costs which limit the migration of capital following a shock. In a sensitivity analysis with $\psi = .1$ (instead of .5), this correlation turns out to be negative.

It can also be noticed that some results depart somewhat from those found in ST. For instance, the cross-country correlation of output, even though positive, is lower than that obtained in ST. The correlation of consumption with output is low, the correlation of the trade balance with output is positive while in ST (and in the data) this correlation is negative, the standard deviation of consumption is too low relative to ST (and relative to the data). These discrepancies may result from features of our model which depart from ST assumptions. The first is the assumption of perfect substitutability between domestic and foreign capital and the assumption that only the traded good can be used for production. In ST, each good is produced using a sector-specific capital, whereas in our model only the traded good can be used for production. Consequently, in our case, following a shock to either sector and either country, international and intersectoral capital flows result in different production patterns across countries and therefore the implied international output correlation is lower. The other feature of our theoretical economy is that the utility function is separable in both goods and in leisure. In ST, the complementarity between both types of goods implies that a shock to non traded technology will increase consumption of the non traded good but also increase the demand for the traded good, leading to a trade deficit. Our separable logarithmic utility function does not yield this result[28].

In our case, following a shock to the non traded good technology, production of the traded good only increases due to the spillover effects. These elements (perfect substitutability between domestic and foreign capital, the assumption that only the traded good can be used for production and the assumption of separable utility) can also explain the low correlation between both types of consumption mentioned earlier, and the low standard deviation of the traded good consumption and of aggregate consumption. The procyclicity of the trade balance is enhanced by the presence of adjustment costs for capital which limit the movement in investment following a shock. Typically, in other models, following a positive technology shock, output, consumption and investment increase, however, given the persistence of the shocks, and the absence of adjustment costs for capital, the movement in investment is the largest leading to a countercyclical trade balance. A positive correlation of the trade balance with output and a low even negative correlation of consumption with output were also obtained in Lapham and Vigneault(1998) in a multisector economy with adjustment costs.

[28] In ST, the elasticity of substitution between traded and non traded goods is .44 and the intertemporal elasticity of substitution is .5 for both goods and $-.31$ for leisure. In our model, each of these elasticities is unity. In general with higher elasticity of substitution, less consumption smoothing takes place. In an international context, this has the effect of yielding higher cross-country correlation of consumption.

5.2 Effects of Fiscal Shocks

We now examine the effects of including fiscal shocks on the performance of the model. It is noticed that considering shocks to the tax rates jointly with technology shocks improves some of the results relative to the case with only technology shocks in a number of ways. For instance, consider the case with technology shocks and shocks to the labor income tax rate, column $\{a, \tau_h\}$, the persistence and standard deviations of the shocks are as described earlier in table 6. In this case the cross-country correlation of consumption is lowered relative to the case with only technology shocks, the case $Z = \{a\}$. The cross-country consumption correlation is reduced further in the case where all shocks are considered $Z = \{a, G, \tau_h, \tau_c, \tau_k\}$. The intuition is the following: an increase in the tax on labor income tends to reduce hours worked and also consequently consumption without affecting foreign consumption; a transitory increase in the consumption tax in one country reduces consumption in this country relative to the other.[29] All this dampens the effect of technology shocks on consumption in the home country and consequently lowers the cross-country consumption correlation. It seems that the effect of the consumption tax is the most important, while the other taxes have rather marginal effects on this correlation. Another interesting observation is that, in the case with only shocks to technology and to tax rates, $Z = \{a, \tau_h, \tau_c, \tau_k\}$, the cross-country correlation of consumption is much lower than the case $Z = \{a, G, \tau_h, \tau_c, \tau_k\}$, with all shocks including government spending (.30 vs .72). The reason is in part given by the fact that government consumption shocks drive private consumption in both countries in the same direction, while taxes, and in particular consumption taxes make them move in opposite directions. In fact, a shock to government spending increases aggregate demand in the country where it takes place, and partially crowds out

[29] A tax on capital income reduces investment, output and also consequently consumption, this effect seems however to be small.

consumption. In the other country consumption also decreases to allow the net exports and investment to increase, (see also impulse response function in the following paragraph). In the case $Z = \{a, \tau_h, \tau_c, \tau_k\}$, the correlation of consumption with output is higher than that obtained when shocks to government consumption are included and closer to the data. However, the correlation of the trade balance with output is also higher, and farther from the data. One can also note that in all cases where shocks to government spending are considered, the correlation of the trade balance with output is driven down relatively to the case with no government spending shocks. The increase in government spending while causing output to increase leads to a deterioration of the trade balance due to the increased demand. Also, in general, government consumption breaks the positive link between private consumption and output, and investment and output.[30] Other observed effects of considering shocks to government consumption are that they increase the variance of output and consumption at the aggregate and the sectoral levels (except traded output) in a direction closer to the data. They do however also increase the variance of the trade balance which is already higher than in the data. Regarding sectoral co-movements, we observe an improvement in the correlation of the output of the non traded good relative to that of the traded good with its relative price, in the sense that this correlation becomes positive, like it is in the data. This last result is due to the fact that unlike shocks to technology, shocks to government consumption affect demand and drive up both outputs and prices.

On the other hand, in all cases when shocks to labor taxation are included, the notable results concern the labor market. The correlation of hours worked and

[30] Another observation is that since in our calibration government spending in the non traded sector is more important than that in the traded sector, shocks to both types of public consumption affect more non traded output, and yield a negative correlation between both types of production.

output with average productivity of labor is lower than when labor tax shocks are not taken into account, and are closer to the data. In these cases, it is also observed that standard deviations of hours worked and average productivity of labor are higher and closer to the data. Similar results were also obtained in Braun [1994] in a closed economy context. In fact, temporary increases in the labor tax rate imply a negative response of hours worked as people substitute leisure intertemporally and intratemporally substitute private consumption for leisure.

Finally, notice that with the separable logarithmic utility function considered, the correlation between relative consumption and relative prices is always -1, regardless of the shocks considered. This is the reason why we do not discuss or report this correlation in the tables. The log utility function was chosen for its tractability given the dimension of the problem and as we mentioned earlier does not seem to contradict empirical studies that have estimated intertemporal and intratemporal elasticities of substitution (see for example, McGrattan, 1994).

The second set of results pertains to calibration of technology shocks as estimated in Backus et al. [1993]. These shocks are uncorrelated across sectors and are more persistent than the ones of the base case. The corresponding simulation results are presented in Table 10. In the case with only technology shocks, $Z = \{a\}$, the cross-country consumption correlation is slightly lower than that in the base case. Cross-country output and investment correlations are negative, whereas in the base case they are positive. This is expected since, in the base case, the processes for technology shocks are less autocorrelated, allow for cross-sectoral correlations, and are more variable. Moreover, standard deviations of aggregate and sectoral output and consumption (except consumption in the traded sector) as well as hours worked and the trade balance are lower relative to the base case. The results on the labor market, *i.e.* very low correlation of productivity with hours worked, indicate that in this case, the substitution effects of the change in technology are lower than the wealth effects. When considering technology shocks jointly with shocks to tax rates and government consumption, the results change in a way similar to what was obtained previously. In the case $Z = \{a, G, \tau_h, \tau_c, \tau_k\}$, we get in particular, lower cross-country consumption correlation relative to the case $Z = \{a\}$, and also lower investment and output correlations (in absolute value), the correlation of relative price with relative output becomes positive. New results relative to the base case are the following: the correlation of the trade balance with output and the correlation of hours worked with average productivity of labor become negative. This is implied by the properties of technology shocks which are more persistent. [31] However these results come at the expense of the correlation of consumption with output which becomes too low even negative, and the sectoral output correlation.

To summarize, the results show that combining fiscal shocks with technology shocks, *i.e.* the case $Z = \{a, G, \tau_h, \tau_c, \tau_k\}$, yields a cross-country consumption correlation lower than with technology shocks alone. The correlation of the trade balance with output is smaller, the correlation of relative output with relative price is positive, the correlation of output and labor with productivity are lower and closer to the data. The significant contribution of shocks to government consumption is to increase the variance of consumption, reduce the correlation of the trade balance with output, and yield a positive correlation between relative price and relative output. The main contribution of shocks to taxes on consumption is to reduce the cross-country consumption correlation. Disturbances to labor taxes improve the correlations obtained on the labor market.

However, this model faces some problems relatively to the data, most of them already recognized in the previous literature, in particular: i) the cross-country

[31] Given that in our calibration shocks to non traded goods technology are uncorrelated with shocks to the traded sector, and that only the traded good can be used as capital, shocks to government spending lead to an important increase in investment in both sectors and to a smaller decrease in consumption such that the trade balance deteriorates.

correlation of output is always lower than that of consumption (the quantity anomaly emphasized in Backus et al., 1993), ii) the variance of consumption is low relative to that of output, iii) in cases where the correlation of the trade balance with output is negative as in the data, the correlation of consumption with output is too low relative to what is observed[32].

The results can be sensitive with respect to some parameters. In particular, the high adjustment cost parameter of capital ψ, helps to yield a positive cross-country correlation of investment and output, and a low variance of the trade balance. The results are also sensitive to the persistence of technology shocks, and spillover effects. The low persistence yields higher cross-country correlations of investment and output, and lower variance of the trade balance than other studies using highly autocorrelated technology shocks (BKK for instance). However, the conclusions concerning the effects of fiscal variables are not affected by the value of the parameters. Some observed effects may be due to the assumptions concerning capital accumulation and preferences. In particular the low correlations of consumption and output across sectors and the low variance of consumption may be due to the assumption that only the traded good can be used for production, the separability of consumption and leisure in the utility function and to the relatively important share of non traded goods.

5.3 Impulse Response Functions

In this section we examine the impulse response functions of the main variables following a one time disturbance to: i) a positive technology shock in the traded sector, ii) a shock to government consumption in the traded sector, iii) a shock

[32]As noted earlier, a positive correlation of the trade balance with output and a negative correlation of consumption with output were also obtained in Lapham and Vigneault(1998), in a multisector economy with adjustment costs. They consider this result as a new puzzle in international macroeconomics. However they have only technology shocks.

to the tax rate on labor income, and iv) a shock to the consumption tax rate. For technology shocks, we consider two cases. In the first case, we assume low persistence and spillover effects as in ST, and in the second case, we assume no spillover effects and higher persistence. Figures 1.a to 1.d plot, for both countries, the dynamic response of output, investment, consumption and the trade balance to a 1% temporary change in the technology of the traded sector in the first case. It can be seen that the productivity increase is associated with an increase in domestic investment, output and consumption.The responses die out quite rapidly as the shocks aren't very persistent. The increase in consumption is small because of consumption smoothing. Hours worked in the traded sector also increase[33]. In the foreign country, consumption increases due to the increase in world production and to the technology spillover effects. Investment and output decrease initially as capital is shifted to its most productive location, *i.e.* the home country, then due to the technology spillover effects investment goes up afterwards.

In the case of uncorrelated and more highly autocorrelated shocks (fig 1'.a to 1'd), the same mechanism globally takes place except that foreign investment initially decreases by more than it does in the preceding case and then slowly and smoothly goes up again. The increase in investment of the home country is also more important and the return to the initial steady state smoother. In this case, the correlation between home and foreign investment is negative.

Following an increase in government spending in the traded sector (Fig 2.a to 2.d), consumption is partially crowded out, while hours worked, investment and output increase. Since the initial decrease in private consumption is smaller than the increase in public consumption, net exports decrease. In the foreign country, consumption decreases while output and investment increase especially

[33] The substitution effect of the rise in productivity (and consequently in real wages) is to decrease leisure, and the wealth effect is to increase it. Here however, the substitution effect dominates.

in the traded sector in response to the increased world demand. Overall, shocks to government spending decreases the correlation between output and the trade balance, and between output and consumption, relatively to the case with only technology shocks.

Following a 1% increase in the tax rate on labor income (fig. 3.a to 3.d), hours worked decrease as leisure becomes less expensive. In fact, due to the substitution effect, hours worked are reduced while the reduced wealth has an adverse effect, however the substitution effect is more important. Investment and output decrease in both sectors but more in the traded sector as capital is shifted towards the foreign country, consumption also decreases but by a small amount. Net exports initially increase due to the reduced consumption, afterwards they decrease. In the foreign country, output, investment and hours worked increase especially in the traded sector. Consumption is reduced as resources are shifted towards investment. So this tax decreases the cross-country investment and output correlations besides affecting the labor market.

The effects of an increase in the consumption tax rate are shown in fig. 4.a to 4.d. This increase leads to a fall in consumption and an increase in leisure as consumption becomes more expensive. Hours worked and consequently output are reduced, the decrease is more pronounced in the non traded sector. The fall in consumption leads to an increase in net exports. In the foreign country, consumption rises and output initially decreases due to the reduced international demand. Then when the shock disappears, investment and output increase. We can say that the basic implication of this shock is a negative cross-country correlation of consumption.

An increase in the capital income tax rate leads to a decrease in investment in the traded sector, and to a small increase in non traded sector investment initially. Hours worked as well as output of the traded sector also decrease. Consumption increases in the first place as saving becomes less attractive. In the foreign country, the reverse takes place. Investment and output in the traded sector increase while total consumption is reduced.

Turning to shocks to the non traded sector, it is shown in fig. 5.a to 5.d that a technology shock to the non traded sector increases the output of this sector. At the time of the shock, output and capital are reduced in the traded sector, also consumption falls slightly due to the increase in its relative price. In the foreign country things are almost unchanged. Following a shock to non traded government spending in the home country, resources are shifted to the non traded sector to satisfy the increased demand, output increases while consumption in both sectors goes down. In the foreign country investment and output in the traded sector increase while consumption is reduced. As expected, in general, shocks to the non traded sector affect more domestic variables and marginally foreign variables.

6 Conclusion

This paper has presented an international two-sector model with government. Our objective was to explore the effects of shocks to government spending and taxation jointly with technology shocks on aggregate fluctuations, in particular cross-country and sectoral co-movements. It was found that shocks to the tax rates (in particular shocks to the consumption tax rate) produce a much lower cross-country correlation of consumption than implied by a model with only technology shocks. Shocks to government spending and tax rates produced, as in the data, a positive correlation between relative non-traded to traded output and its relative price. With only technology shocks this correlation is negative. Shocks to government spending are typically demand shocks that increase both output and prices and make this correlation positive. Shocks to government consumption also yield higher standard errors of aggregate and sectoral output and consumption than those obtained in a model with only technology shocks and consequently closer to the data. Moreover these shocks lead to a deterioration of the trade balance while having an expansionary effect on output which decreases the correlation of the trade balance with output. When shocks to labor taxation are taken into account, correlations pertaining to the labor market are generally closer to the data. In this case the model reproduces well the low correlation between hours worked and the real wage (this result was already documented in Christiano and Eichenbaum [1992], and Braun [1994]). Overall, our study strongly suggests that government policies can be an important determinant of business cycles fluctuations and they can affect the international transmission of business cycles in an important way.

It should be noted that some results rely on the set of assumptions we use, for instance the similarity of both countries, the separability of the utility function, the free movement of capital, the homogeneity of the traded goods etc. It would be interesting to examine the effects of relaxing some of the assumptions in future work, in particular the assumption that the two countries are similar in all respects. We would like to examine how different tax systems affect international comovements, and how the model would fare when applied to two particular countries instead of two "average" countries.

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Table 1: Mean of effective tax rates and government consumption[1]

	Mean					[Min,Max]		
	GC/GDP	Def/GDP	τ_h	τ_c	τ_k	τ_h	τ_c	τ_k
USA	19.5	2.5	25.1	5.7	43.1	[17.5, 29.3] (1965, 1982)	[5.1, 6.4] (1987, 1965)	[37.2, 49.2] (1965, 1970)
Germany	18.5	1.1	36.5	15.6	25.2	[29.4, 41.0] (1965, 1988)	[14.4, 17.5] (1977, 1969)	[20.5, 29.3] (1967, 1980)
Canada	18.6	2.9	22.3	12.3	40.5	[12.5, 29.1] (1965, 1987)	[9.8, 13.6] (1978, 1981)	[35.3, 46.4] (1965, 1969)
Japan	8.9	3.8	20.5	5.1	33.5	[15.1, 26.6] (1965, 1988)	[4.3, 6.0] (1976, 1969)	[19.5, 56.3] (1966, 1988)
UK	19.5	2.8	26.6	14.4	57.2	[20.4, 30.4] (1965, 1982)	[11.8, 17.8] (1973, 1985)	[39.3, 74.2] (1965, 1981)
France	15.2	1.3	43.5	21.5	23.5	[33.3, 47.3] (1971, 1987)	[20.7, 22.8] (1977, 1979)	[16.1, 29.4] (1980, 1986)
Italy	16.2	9.1	38.3	12.5	25.6	[34.2, 40.9] (1980, 1988)	[10.8, 14.3] (1975, 1988)	[20.3, 28.0] (1980, 1986)
7-country average	16.6	3.3	30.4	12.4	35.5	–	–	–
4-country average[2]	16.4	2.6	26.1	9.7	35.6	–	–	–

1 τ_h, τ_c and τ_k are respectively tax rates on labor income, consumption and capital income. Data are series calculated in Mendoza et al. (1994) of effective average tax rates. The corresponding period is 1965-1988, except for Italy (1980-1988 for labor and capital tax rates and 1970-1988 for consumption tax rates), and France (1970-1988 for labor and capital and 1977-1988 for consumption tax rates). GC is government consumption and Def is the general government budget deficit, both from International Financial Statistics. Data is annual for the period 1965-1988. The mean is the average over the corresponding period.

2 USA, Canada, Germany, Japan.

Table 2: Autocorrelations and standard deviations of government consumption and tax rates[3]

	Standard Deviations					Autocorrelations $[\rho(x_t x_{t-1})]$			
	GDP	GC	τ_h	τ_c	τ_k	τ_h	τ_c	τ_k	GC
USA	2.9	3.1	3.6	.40	3.2	.91	.79	.42	.72
Germany	3.3	3.6	3.7	.91	2.9	.93	.80	.82	.73
Canada	2.7	2.5	3.9	1.1	3.2	.86	.67	.68	.69
Japan	3.6	2.7	3.8	.49	10.6	.64[4]	.85	.40[4]	.79
UK	2.3	3.0	2.3	1.9	9.5	.68	.91	.66	.41
France	1.9	3.7	5.1	.53	4.5	.99	.25	.87	.62
Italy	2.9	3.4	2.6	.99	2.5	.74	.68	.50	.56
7-country average	2.8	3.2	3.6	1.0	5.9	.82	.71	.62	.65
4-country average	3.1	2.9	3.7	.72	4.9	.84	.77	.58	.73

[3] GC is government consumption from IFS. τ_h, τ_c and τ_k are respectively tax rates on labor income, consumption and capital income, as described earlier. GC and GDP refer to the Hodrick Prescott filter of the log of the real series. The tax rates are unfiltered except when mentioned. Standard deviations are in %.

[4] This figure corresponds to the detrended series using the Hodrick-Prescott filter, because the series displays increasing trend (the autocorrelation coefficient of the unfiltered series is greater than 1).

Table 3: Cross-country correlations of H-P filtered fiscal variables (1965-1988)[5]

(A) Government consumption

	Germany	Canada	Japan	UK	France	Italy
USA	−.43	.08	−.24	.03	−.24	−.34
Germany		.03	.75	.33	−.19	.28
Canada			.27	.19	.00	−.50
Japan				.44	−.48	.09
UK					−.57	−.23
France						−.00

(B) Labor income tax rate

	Germany	Canada	Japan	UK
USA	−.48	.38	.32	.58
Germany		−.25	−.39	−.37
Canada			.03	.44
Japan				−.21

(C) Consumption tax rate

	Germany	Canada	Japan	UK
USA	.44	.68	.19	.42
Germany		.26	.71	.44
Canada			.02	.31
Japan				.33

(D) Capital income tax rate

	Germany	Canada	Japan	UK
USA	.09	.58	.01	.44
Germany		−.20	.28	.00
Canada			−.18	.32
Japan				.10

5 The smoothing coefficient used is 100.

Table 4: Cross-country correlations of detrended consumption, output and investment[6]

(A) Private consumption

	Germany	Canada	Japan	UK	France	Italy	
USA	.14	.61	.34	.55	.17	−.07	
Germany		.27	.33	.24	.36	.41	
Canada			.01	.46	.42	.25	
Japan				.60	.48	.43	
UK					.51	.39	
France						.36	
Zim							.14
BKK							.51
ST							.53

(B) Output

	Germany	Canada	Japan	UK	France	Italy	
USA	.21	.49	.23	.67	.42	.00	
Germany		.28	.49	.51	.83	.72	
Canada			−.08	.47	.46	.23	
Japan				.48	.46	.62	
UK					.63	.41	
France						.69	
Zim							.24
BKK							.66
ST							.64

(C) Private Investment

	Germany	Canada	Japan	UK	France	Italy	
USA	.30	.13	.11	.38	.25	−.19	
Germany		.01	.47	−.01	.43	.49	
Canada			−.08	.51	.69	.01	
Japan				.30	.34	.73	
UK					.49	.16	
France						.29	
Zim							.16
BKK							.53
ST							–

6 The series are detrended using the Hodrick-Prescott filter. The smoothing coefficient used is 100. Data source is IFS, data in national currencies, deflated by the CPI.The corresponding period is 1965-1988.

Table 5: Standard deviations of detrended consumption, output and investment

	Output	Private Consumption	Investment
USA	2.97	2.67	6.94
Germany	3.26	2.39	8.12
Canada	2.73	2.45	7.28
Japan	3.63	2.01	7.29
UK	2.33	2.82	5.88
France	1.95	1.44	4.11
Italy	2.91	2.04	8.34
7-country average	2.82	2.26	6.85
4-country average	3.14	2.38	7.41
Zim	1.62	.48	4.81
BKK	1.92	1.44	6.27
ST	2.53	1.60	5.53

Table 6: Calibration parameters:

Probability of death	$p = .0000135$
Preferences	$\rho = .975$ $\theta_1 = .091$ $\theta_2 = .291$ $\theta_3 = .618$
Production	$N_0 = .3$ $N_0^T/N_0 = .56$ $\Phi^T = .61$ $\Phi^N = .56$ $\psi = .5$ $d = .1$ $K_0^T/Q_0^T = 2.82$ $K_0^N/Q_0^N = 3.18$
Government	$G_0^T/GDP^T = .14$ $G_0^N/GDP^N = .19$ $\tau_{h,0} = .26$ $\tau_{c,0} = .10$ $\tau_{k,0} = .36$ deficit$/GDP = .026$ $\Rightarrow B_0/\left(Q_0^T + Q_0^N\right) = .52$ $T_{00} = -.036$ $\gamma = .045$
Real interest rate and assets position	$r_0 = .04$ $F_0 = 0$

Table 7: Stochastic process for the exogenous shocks in the base case simulations

$$Z_{t+1} = \Omega Z_t + \xi_{t+1};\; E\left(\xi_t \xi_t'\right) = \Sigma$$

$$Z_t = \left[\hat{a}_t^T \hat{a}_t^{T^*} \hat{a}_t^N \hat{a}_t^{N^*} \hat{\tau}_{h,t} \hat{\tau}_{h,t}^* \hat{\tau}_{c,t} \hat{\tau}_{c,t}^* \hat{\tau}_{k,t} \hat{\tau}_{k,t}^* G_t^T \hat{G}_t^{T^*} \hat{G}_t^N \hat{G}_t^{N^*}\right]'$$

$$\Omega = \begin{bmatrix}
.154 & -.199 & .04 & .262 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
-.199 & .154 & .262 & .04 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
-.015 & -.11 & .632 & .125 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
-.110 & -.015 & .125 & .632 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & .84 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & .84 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & .77 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & .77 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & .58 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & .58 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & .73 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & .73 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & .73 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & .73
\end{bmatrix}$$

$$\Sigma = \begin{bmatrix}
3.62E-4 & 1.21E-4 & 1.23E-4 & 0.51E-4 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
1.21E-4 & 3.62E-4 & 0.5E-4 & 1.23E-4 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
1.23E-4 & 0.51E-4 & 1.99E-4 & 0.27E-4 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0.51E-4 & 1.23E-4 & 0.27E-4 & 1.99E-4 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0.48E-4 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0.48E-4 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0.227E-4 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.227E-4 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 4.0E-4 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 4.0E-4 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1.0E-4 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1.0E-4 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1.0E-4 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1.0E-4
\end{bmatrix}$$

Table 8: Stochastic process for the exogenous shocks in case 2[7]

$$\Omega = \begin{bmatrix}
.906 & .088 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
.088 & .906 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & .906 & .088 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & .088 & .906 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & .84 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & .84 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & .77 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & .77 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & .58 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & .58 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & .73 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & .73 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & .73 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & .73
\end{bmatrix}$$

$$E\xi_t\xi_t' = \begin{bmatrix}
0.72E-4 & 1.8E-7 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
1.8E-7 & 0.72E-4 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0.72E-4 & 1.8E-7 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 1.8E-7 & 0.72E-4 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0.48E-4 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0.48E-4 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0.227E-4 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.227E-4 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 4.0E-4 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 4.0E-4 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1.0E-4 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1.0E-4 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1.0E-4 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1.0E-4
\end{bmatrix}$$

[7] In this case, properties of technology shocks are from Backus et al. (1993). They correspond to the US vs a European aggregate Solow Residuals in a one sector economy,. (one homogeneous tradable good)

Table 9: Simulation results in the base case

A) Correlations generated by the model

	a	a,τ_h	a,G	a,G,τ_h	a,G,τ_h,τ_c	a,G,τ_h,τ_c,τ_k	a,τ_h,τ_c,τ_k	Models ST	Models BKK	Data[8] ST
(C,C^*)	.95	.87	.95	.92	.68	.72	.30	.78	.88	.53
	(.03)	(.06)	(.03)	(.06)	(.12)	(.19)	(.25)			
(Y,Y^*)	.16	.14	.15	.10	.04	.11	.09	.64	−.21	.64
	(.21)	(.19)	(.19)	(.21)	(.23)	(.21)	(.20)			
(I,I^*)	.41	.35	.29	.25	.18	.32	.31	–	−.94[9]	.53[10]
	(.19)	(.20)	(.23)	(.21)	(.28)	(.22)	(.19)			
(C,Y)	.55	.57	.05	.08	.06	.12	.37	.92	.77	.88
	(.15)	(.13)	(.19)	(.17)	(.25)	(.22)	(.22)			
$(TB/Y,Y)$	.43	.43	.09	.12	.10	.15	.43	−.42[11]	.01[12]	−.28[10]
	(.16)	(.13)	(.19)	(.20)	(.22)	(.20)	(.16)			
(I,Y)	.83	.83	.63	.60	.61	.59	.81	.95	.27[13]	.87
	(.05)	(.04)	(.09)	(.11)	(.09)	(.13)	(.04)			
(N,Y)	.98	.94	.96	.92	.93	.92	.94	.76[15]	.93	.79[15]
	(.00)	(.03)	(.02)	(.03)	(.02)	(.03)	(.02)			
(S,I)	.82	.82	.67	.65	.67	.68	.81	.89	.28	.74
	(.06)	(.05)	(.11)	(.13)	(.14)	(.13)	(.04)			
$(Y/N,Y)$	.85	.34	.68	.39	.45	.45	.36	.52[15]	–	.51[15]
	(.05)	(.17)	(.09)	(.17)	(.16)	(.15)	(.18)			
$(N,Y/N)$	.73	.01	.45	.00	.11	.06	.02	−.16[14]	–	−.12[15]
	(.11)	(.20)	(.14)	(.19)	(.22)	(.18)	(.20)			
$(P^N/P^T,Y^N/Y^T)$	−.17	−.15	.15	.20	.24	.20	−.15	−.70	–	.28
	(.18)	(.21)	(.19)	(.17)	(.17)	(.19)	(.21)			
(C^T,C^N)	.33	.26	.36	.34	.38	.38	.32	.83	–	.57
	(.21)	(.21)	(.22)	(.19)	(.18)	(.19)	(.23)			
(Y^T,Y^N)	.16	.16	−.05	−.11	−.00	−.05	.12	.45	–	.70
	(.20)	(.20)	(.25)	(.21)	(.21)	(.24)	(.21)			
(a^T,Y^T)	.98	.95	.94	.91	.91	.91	.95	–	.89	.96[10]
	(.01)	(.02)	(.02)	(.04)	(.05)	(.04)	(.01)			

8 Unless otherwise noted, the Data column refers to what is reported in Stockman and Tesar.

9 This is -.31 in the autarky case, and -.48 in the case with transport cost.

10 Source: Backus, Kehoe and Kydland (1993).

11 This number corresponds to the correlation of the trade balance (measured as detrended exports less detrended imports) with output, and not of the ratio trade balance to output with output. With taste shocks this correlation becomes -.05.

12 This is .23 in the case with transport cost.

13 .96 in the autarky case.

14 Ref.: Braun[1994]. Christiano and Eichenbaum find, with H-P filtered series, correlations of Y/N with N ranging from -.20 to .97 depending on the model considered.

15 Ref.: Braun [1994].

(B) Standard deviations generated by the model

	a	a, τ_h	a, G	a, G, τ_h	a, G, τ_h, τ_c	$a, G\tau_h, \tau_c, \tau_k$	$a, \tau_h, \tau_c, \tau_k$	Models ST	Models BKK	Data ST
Y	1.84 (.29)	1.93 (.26)	2.15 (.34)	1.95 (.28)	2.24 (.31)	2.16 (.31)	1.96 (.27)	2.58	1.50	2.53
C	.32 (.06)	.34 (.08)	.68 (.15)	.62 (.13)	.74 (.10)	.81 (.17)	.52 (.11)	1.54	.63	1.60
I	5.44 (.75)	5.71 (.68)	6.39 (.83)	6.19 (.97)	6.65 (1.2)	6.46 (1.4)	5.82 (.90)	5.84	16.5[16]	5.53
TB/Y	1.02 (.16)	1.07 (.16)	1.70 (.27)	1.68 (.27)	1.72 (.33)	1.70 (.22)	1.13 (.16)	.45	3.77	.52[17]
Y/N	.41 (.08)	.65 (.10)	.66 (.09)	.77 (.12)	.81 (.11)	.81 (.11)	.67 (.08)	.66[18]	–	.61[18]
N	1.50 (.24)	1.81 (.22)	1.76 (.27)	1.88 (.25)	2.01 (.28)	1.93 (.29)	1.83 (.27)	1.90	.75	1.61
C^T	.07 (.01)	.08 (.02)	.16 (.04)	.15 (.03)	.17 (.02)	.19 (.04)	.12 (.02)	1.36	–	1.77
C^N	1.50 (.28)	1.38 (.23)	2.0 (.24)	1.92 (.26)	2.00 (.33)	2.03 (.31)	1.35 (.15)	1.86	–	1.78
Y^T	3.69 (.61)	3.85 (.50)	3.79 (.51)	3.59 (.75)	3.93 (.63)	3.91 (.50)	3.91 (.57)	3.21	–	3.45
Y^N	1.19 (.22)	1.09 (.18)	1.91 (.36)	1.88 (.35)	1.99 (.41)	1.97 (.32)	1.06 (.13)	2.86	–	2.02
P^N/P^T	1.29 (.28)	1.14 (.24)	1.64 (.31)	1.67 (.32)	1.61 (.29)	1.68 (.30)	1.39 (.27)	–	–	–

Notes: All variables, except TB, refer to logs of the series and are Hodrick-Prescott filtered. C is total consumption, Y total output, I investment, N total hours worked. Superscripts T and N refer to tradable and non tradable values respectively. * denotes the foreign country. Standard deviations are in %.

Results are averages over 30 simulations of 30 periods each. Standard deviations are given in brackets.

The S.T. column under the header Models refers to simulation results obtained in Stockman and Tesar [1995] in the benchmark case with only technology shocks. (When they consider taste shocks the figures don't change much except when mentioned). The BKK columns refer to simulation results and data reported in Backus, Kehoe and Kydland [1993]; The figures in the column Data correspond to an average over the G7 countries or a subset of these countries depending on data availability from Stockman and Tesar, except when otherwise mentioned. In their calculations, Stockman and Tesar exclude durable and semidurable goods from the measure of consumption.

16 A reason why we obtain a much lower volatility of investment relative to that reported in Backus et. al. is probably the presence in our model of adjustment costs for capital, absent in their benchmark case. In fact, this standard deviation is 3.93 in BKK in the case with transport cost.

17 Source: BKK. The standard deviation of the trade balance is 6.63 in ST. It becomes 2.33 with taste shocks.

18 Ref. Braun[1994].

Table 10: Simulation results in case 2:

(A) Correlations generated by the model

			Models		Data
	a	$a, G, \tau_h, \tau_c, \tau_k$	ST	BKK	ST
(C, C^*)	.88 (.05)	.59 (.13)	.78	.88	.53
(Y, Y^*)	−.19 (.27)	−.09 (.25)	.64	−.21	.64
(I, I^*)	−.28 (.23)	−.17 (.23)	–	−.94	.53
(C, Y)	.31 (.24)	−.10 (.23)	.92	.77	.88
$(TB/Y, Y)$	.38 (.15)	−.14 (.21)	−.42	.01	−.47
(I, Y)	.62 (.13)	.31 (.17)	.95	.27	.87
(S, I)	.61 (.09)	.42 (.17)	.89	.28	.74
$(Y/N, Y)$	.59 (.18)	.28 (.21)	.52	–	.51
$(N, Y/N)$	.17 (.20)	−.27 (.19)	−.16	–	−.12
(N, Y)	.88 (.04)	.83 (.05)	–	.93	.88
(N, W)	.51 (.13)	−.19 (.19)	–	.52	–
$(P^N/P^T, Y^N/Y^T)$	−.43 (.18)	.31 (.18)	−.70	–	.28
(C^T, C^N)	.05 (.22)	.33 (.19)	.83	–	.57
(Y^T, Y^N)	−.11 (.25)	−.27 (.22)	.45	–	.70
(C^T, G^T)	–	−.19 (.25)	–	–	–

(B) Standard deviations generated by the model

	a	$a, G, \tau_h, \tau_c, \tau_k$	Models ST	Models BKK	Data ST
Y	.89 (.16)	1.44 (.28)	2.58	1.50	2.53
C	.43 (.09)	.79 (.16)	1.54	.63	1.60
I	2.83 (.55)	4.64 (.78)	5.84	16.48	5.53
TB/Y	.72 (.12)	1.57 (.32)	.45	3.77	.52
Y/N	.41 (.09)	.82 (.13)	.66	–	.61
N	.72 (.12)	1.44 (.27)	1.90	.75	1.61
CT	.10 (.02)	.18 (.04)	1.36	–	1.77
CN	.87 (.17)	1.63 (.29)	1.86	–	1.78
YT	1.69 (.28)	2.06 (.33)	3.21	–	3.45
YN	.70 (.14)	1.73 (.26)	2.86	–	2.02
P^N/P^T	1.07 (.16)	1.46 (.24)	–	–	–

Fig.1.a Home Country Response to a 1% increase in traded sector technology

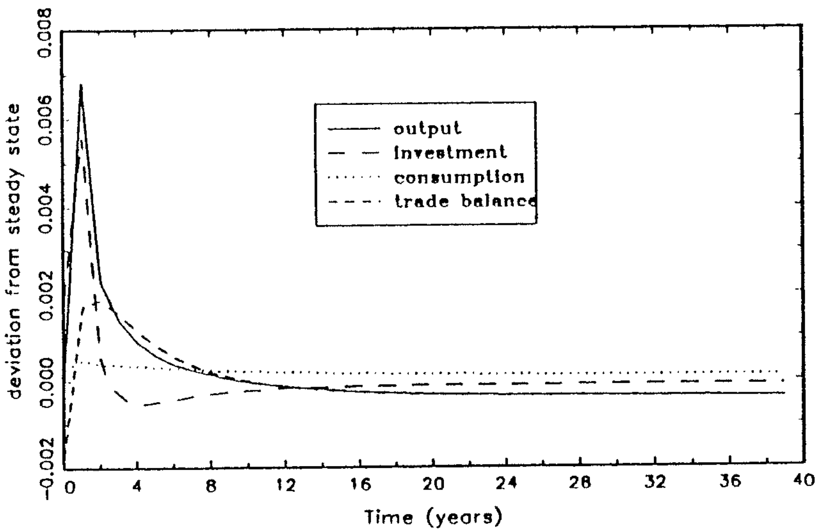


Fig. 1.b Foreign Country Response to techn.

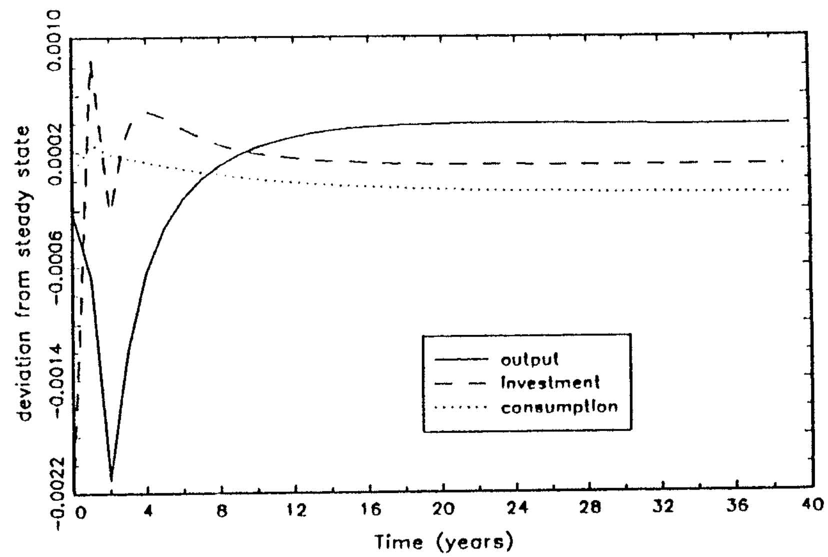


Fig. 1.c Home Country Response to techn.

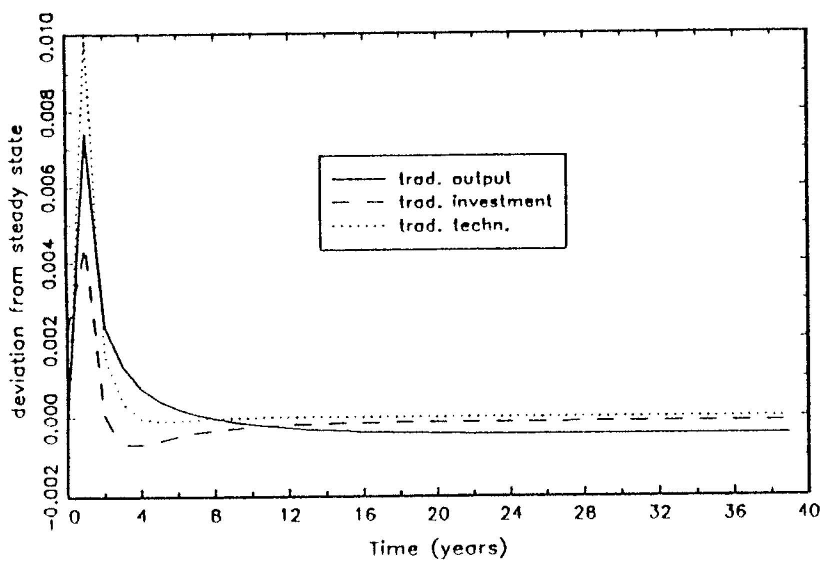


Fig. 1.d Foreign country Response to techn.

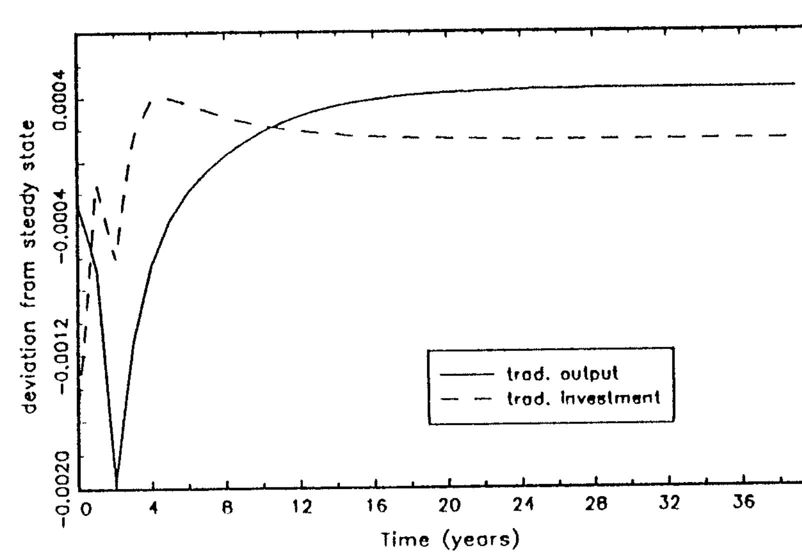


Fig.1'.a Home Country Response to a 1% increase in traded sector technology(with no spillover)

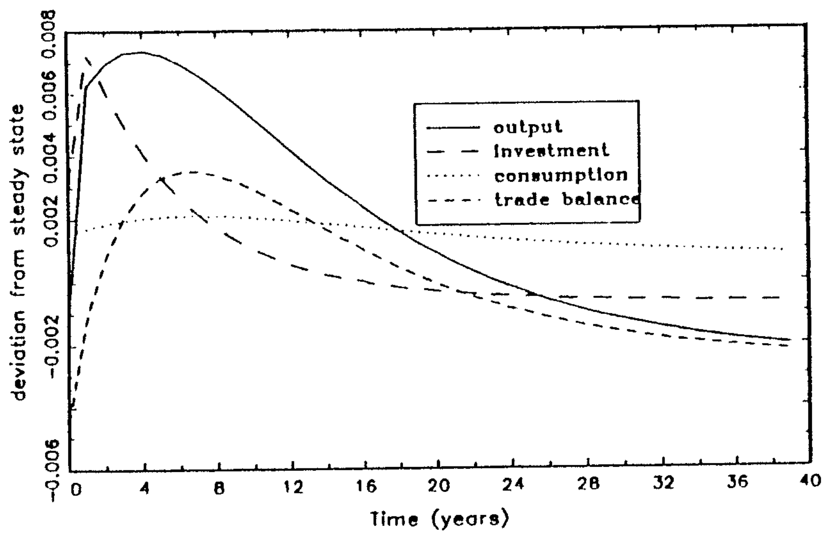


Fig. 1'.b Foreign Country Response to techn.

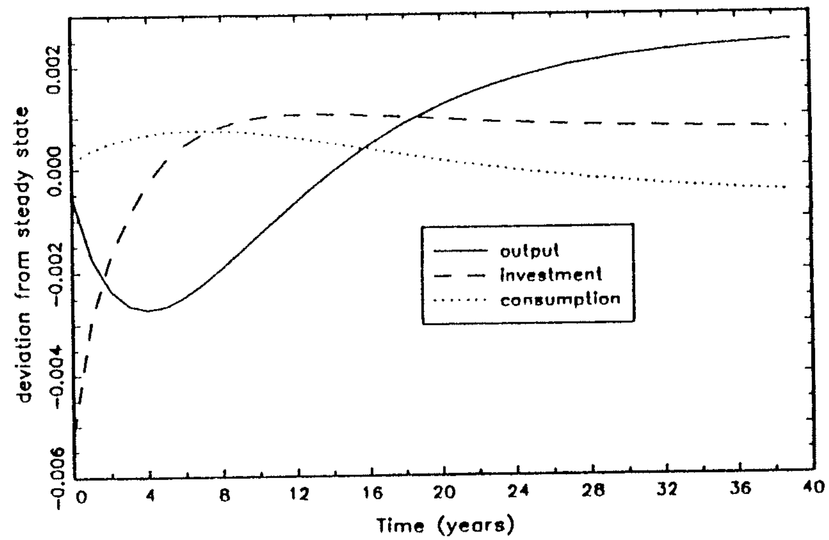


Fig. 1'.c Home Country Response to techn.

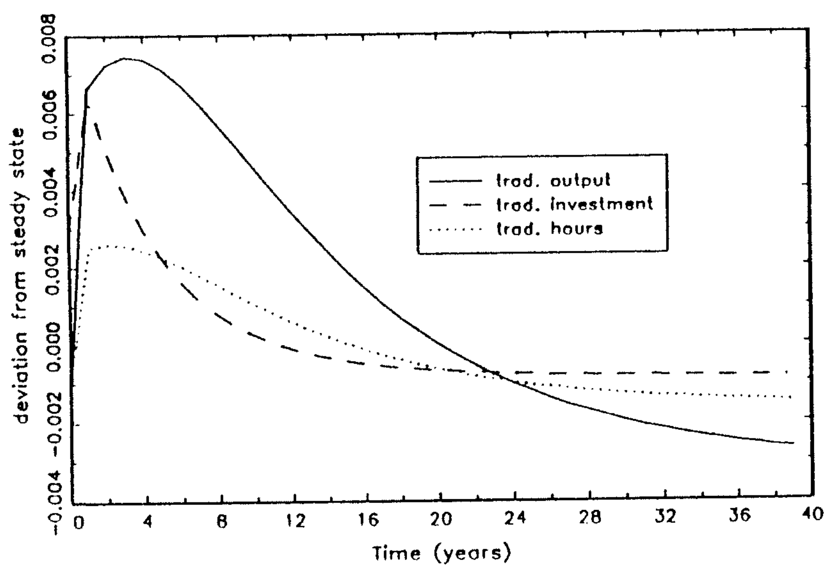


Fig. 1'.d Foreign country Response to techn.

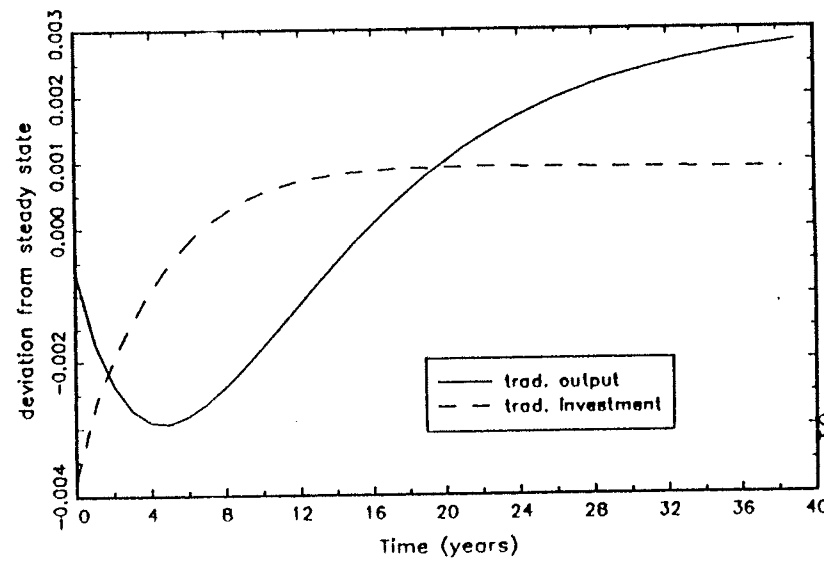


Fig.2.a Home Country Response to a 1% Increase in traded gov. consumption

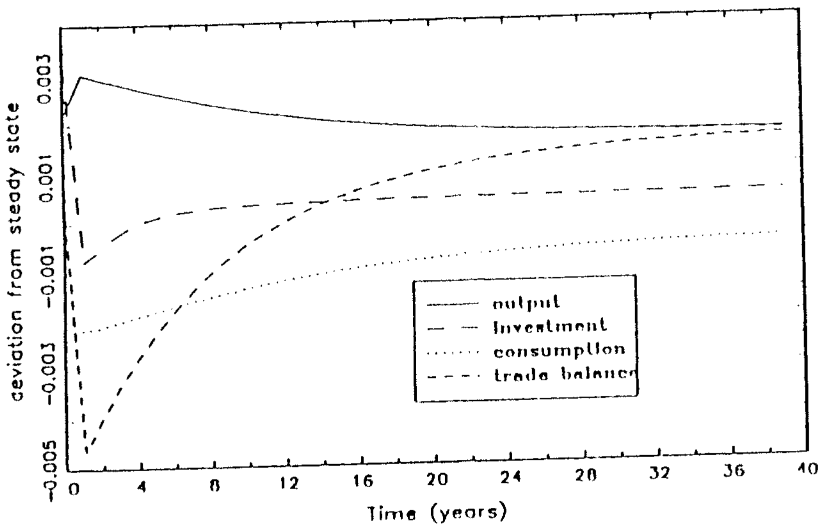


Fig. 2.b Foreign country response to gov. cons.

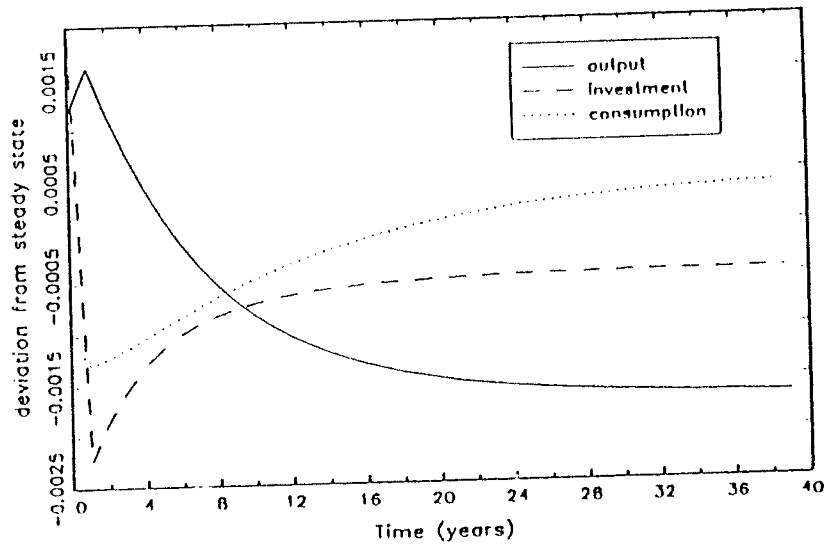


Fig. 2.c Home Country Response to gov. cons.

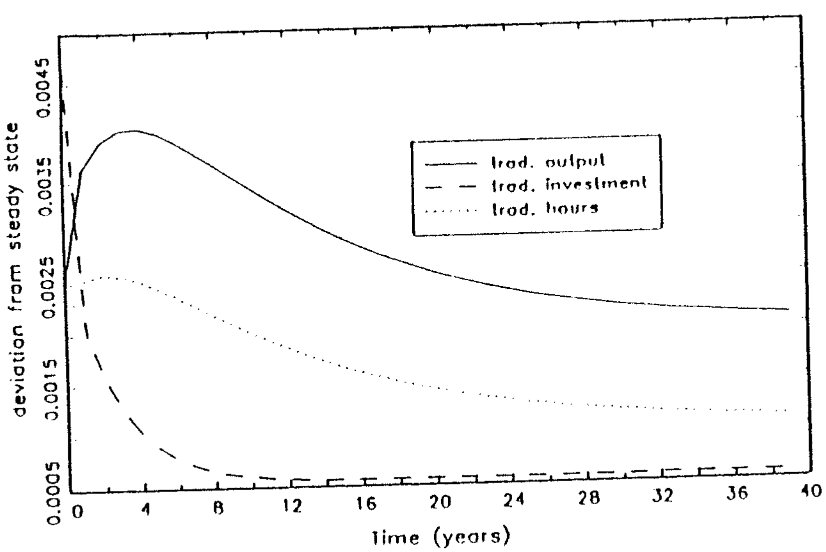


Fig. 2.d Foreign country Response to gov. cons.

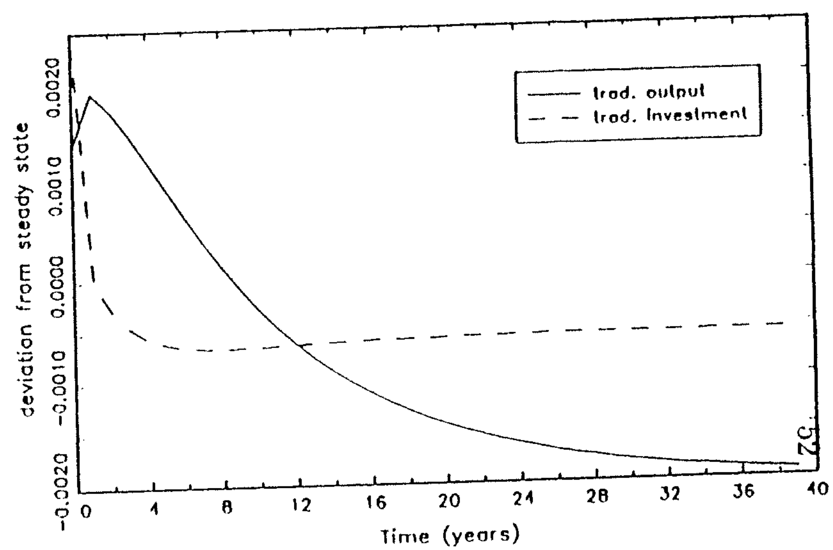


Fig.3.a Home Country Response to a 1% Increase in tax rate on labor

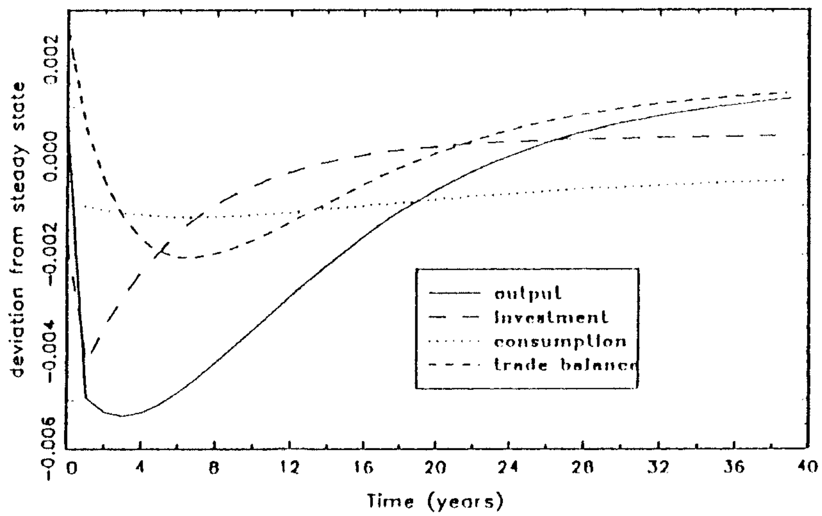


Fig. 3.b Foreign country response to labor tax

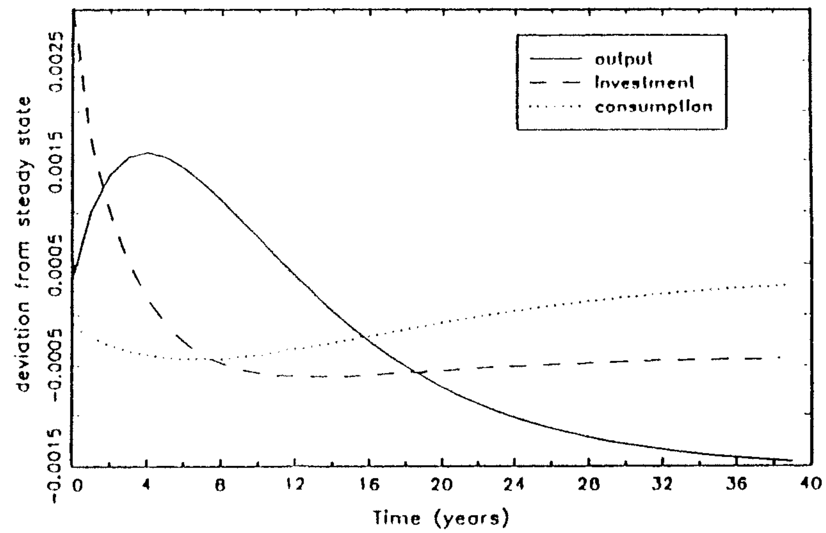


Fig. 3.c Home Country Response to labor tax

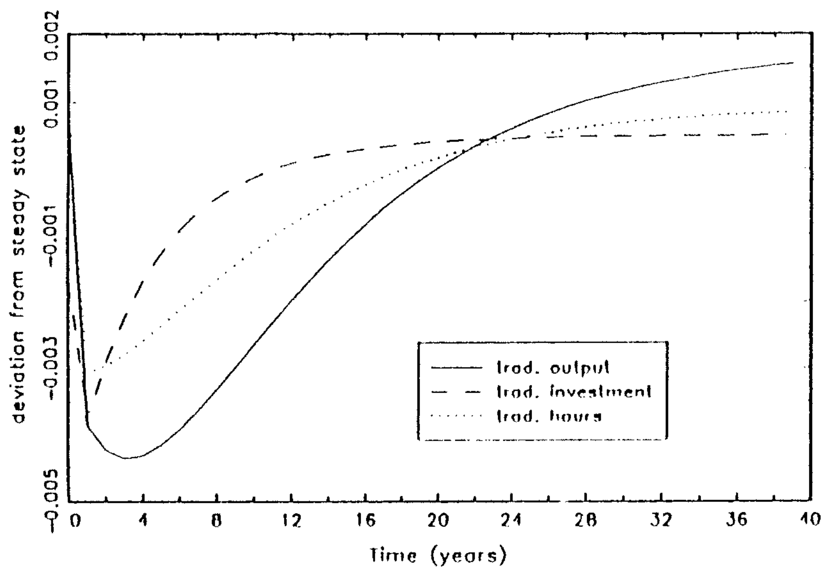


Fig. 3.d Foreign country Response to labor tax

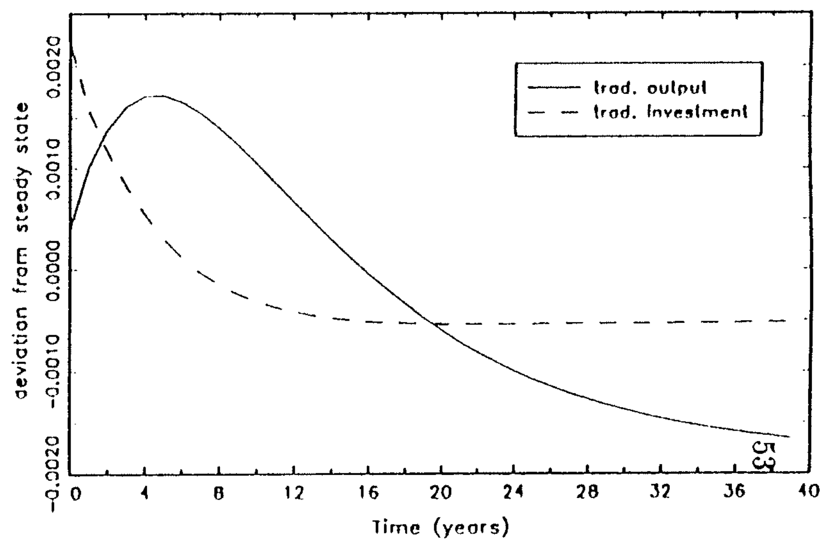


Fig.4.a Home Country Response to a 1% increase in consumption tax rate

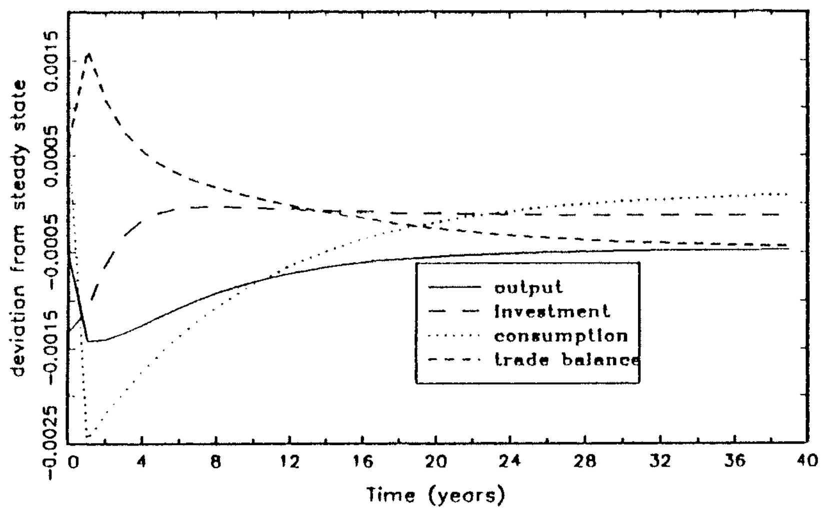


Fig. 4.b Foreign country response to cons. tax

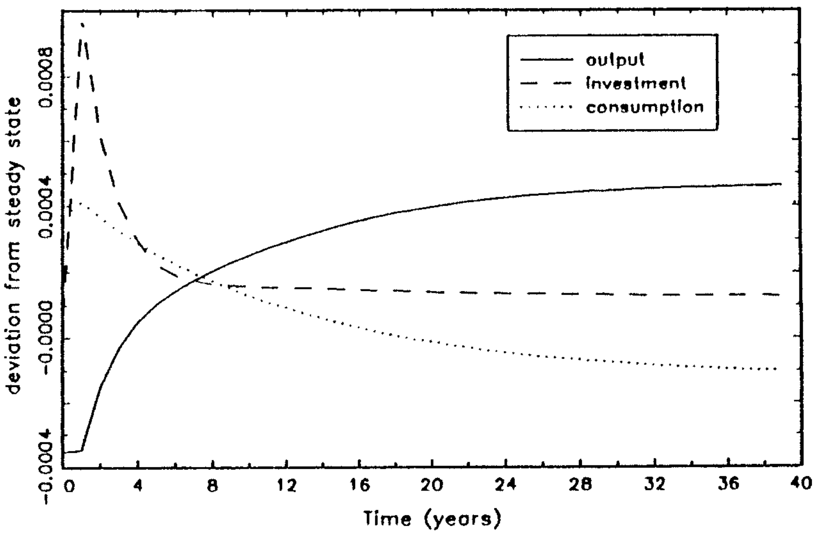


Fig. 4.c Home Country Response to cons. tax

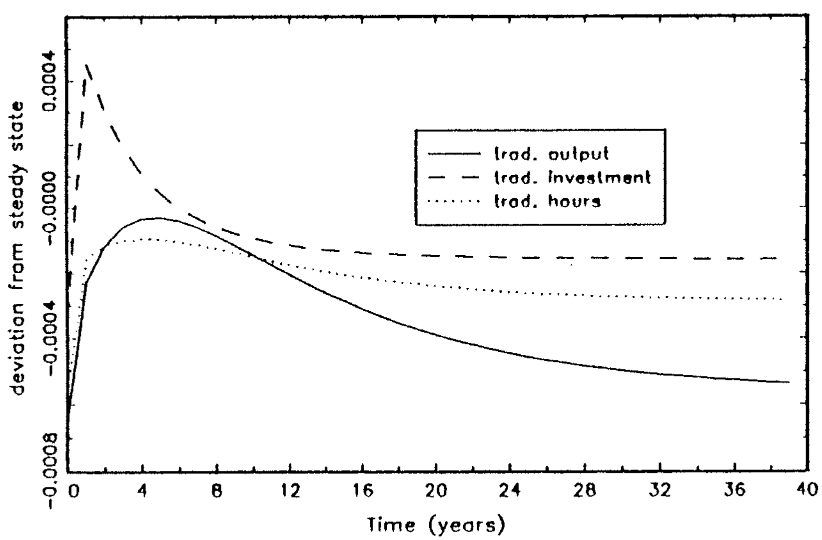


Fig. 4.d Foreign country Response to cons. tax

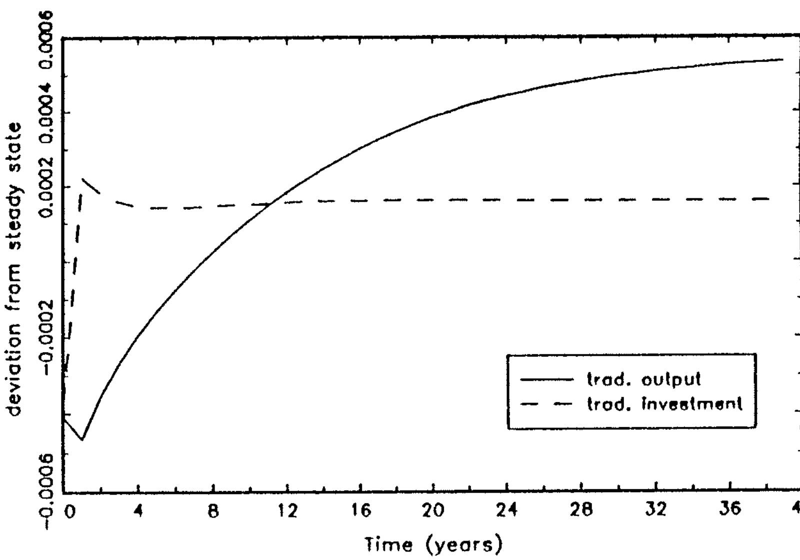


Fig.5.a Home Country Response to a 1% increase in non traded sector technology

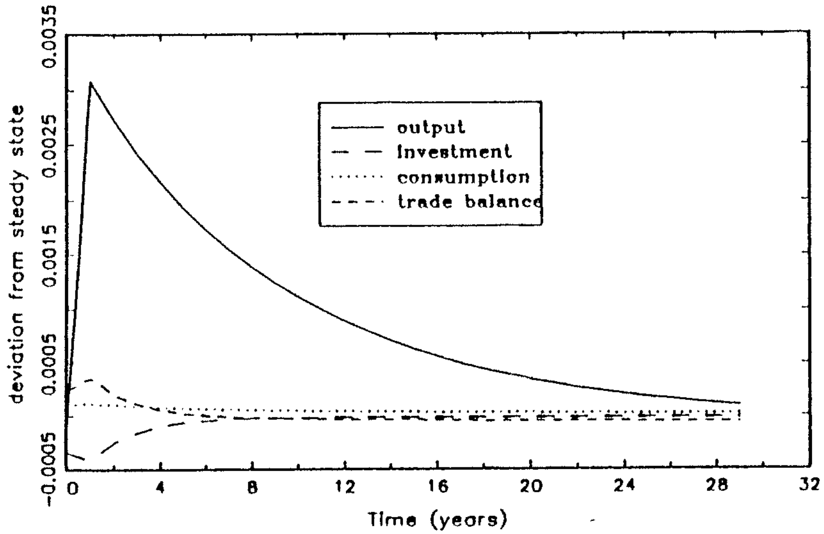


Fig. 5.b Foreign Country Response to techn.

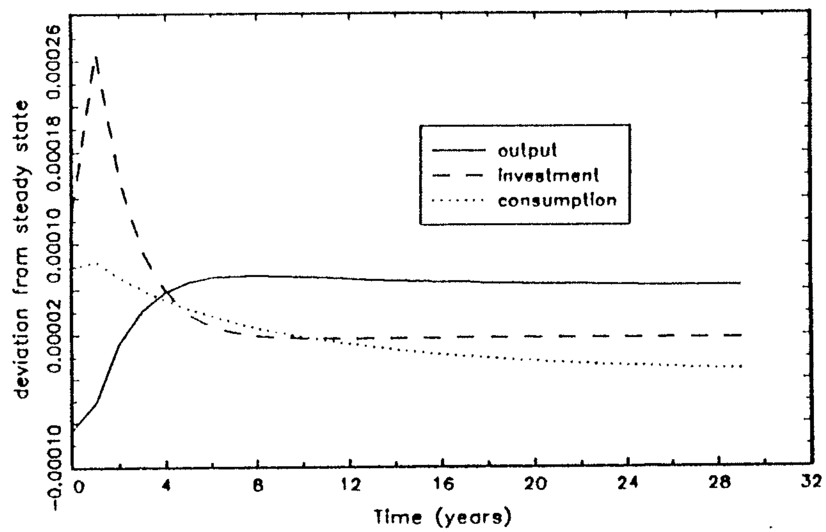


Fig. 5.c Home Country Response to techn.

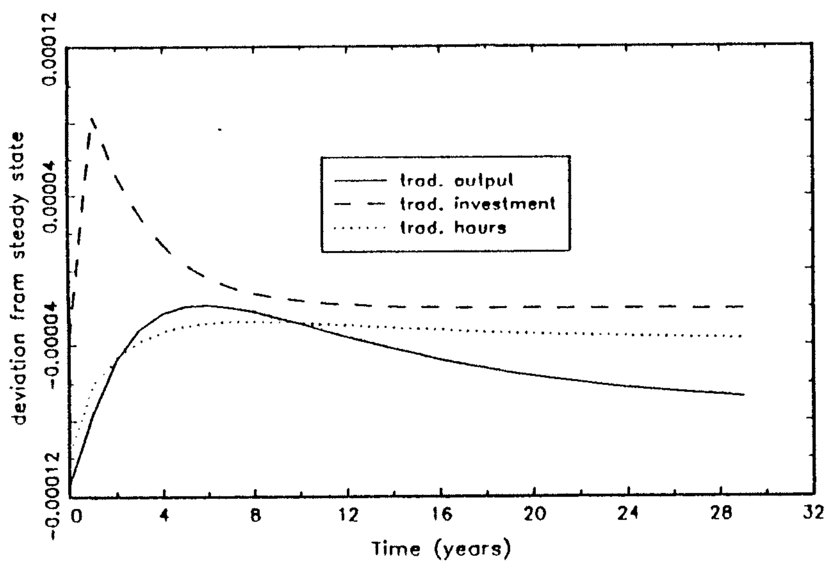


Fig. 5.d Foreign country Response to techn.

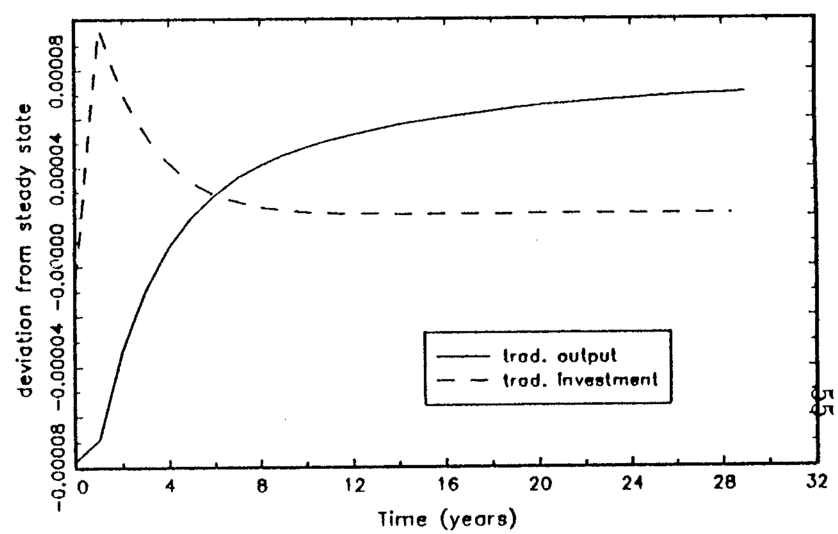


Fig.6.a Home Country Response to a 1% increase in non traded sector gov. cons.)

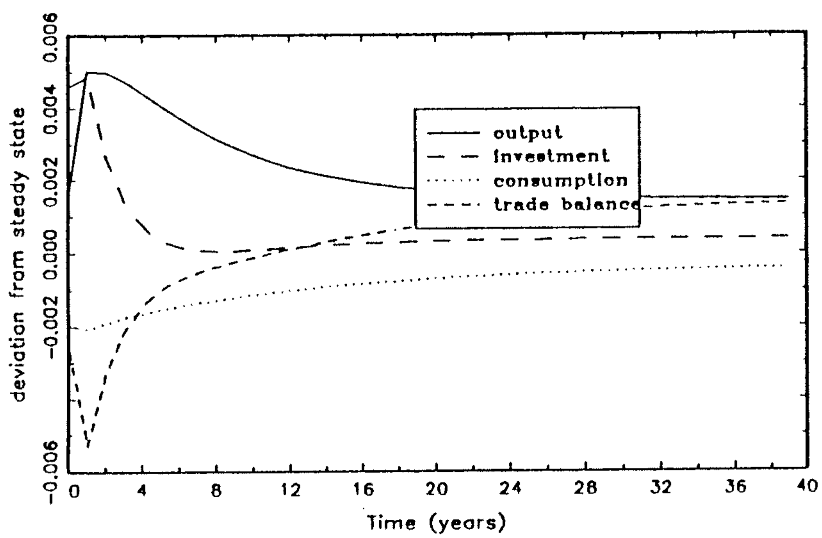


Fig.6.b Foreign Country Response to non trad gov. cons.

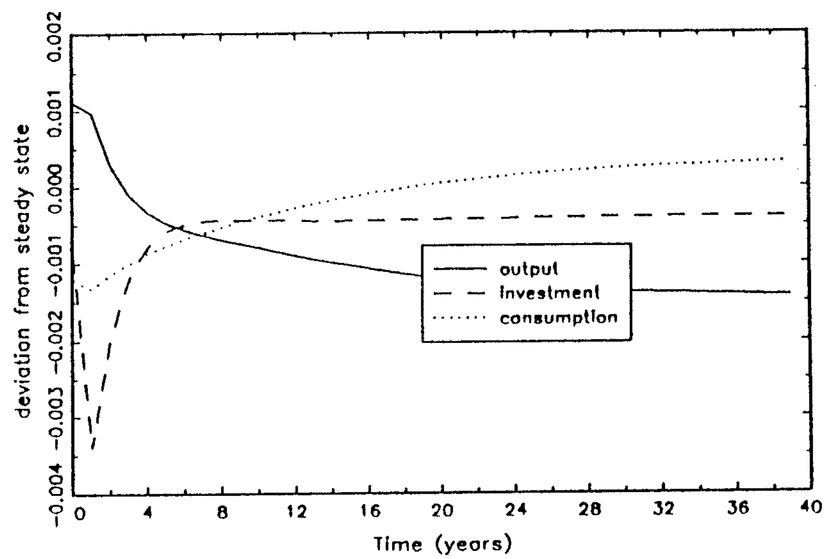


Fig. 6.c Home Country Response to gov. cons.

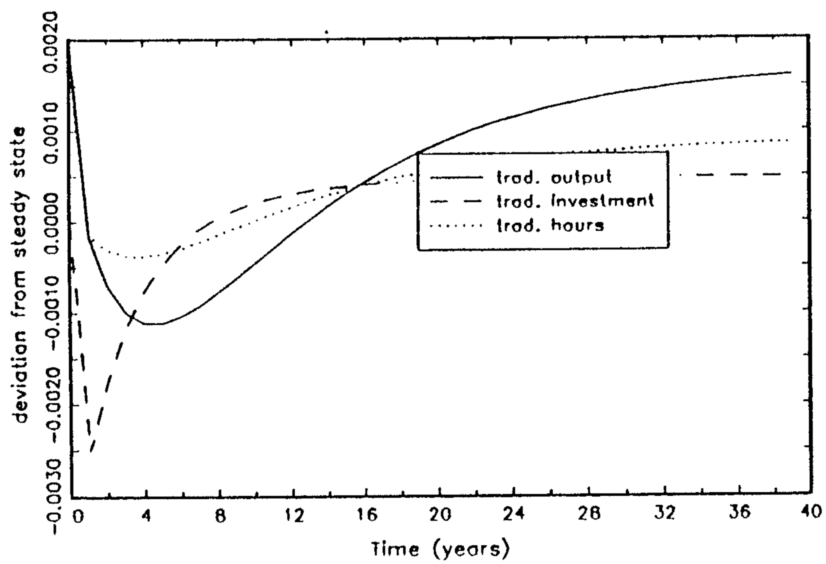


Fig.6.d Foreign country Response to gov.cons

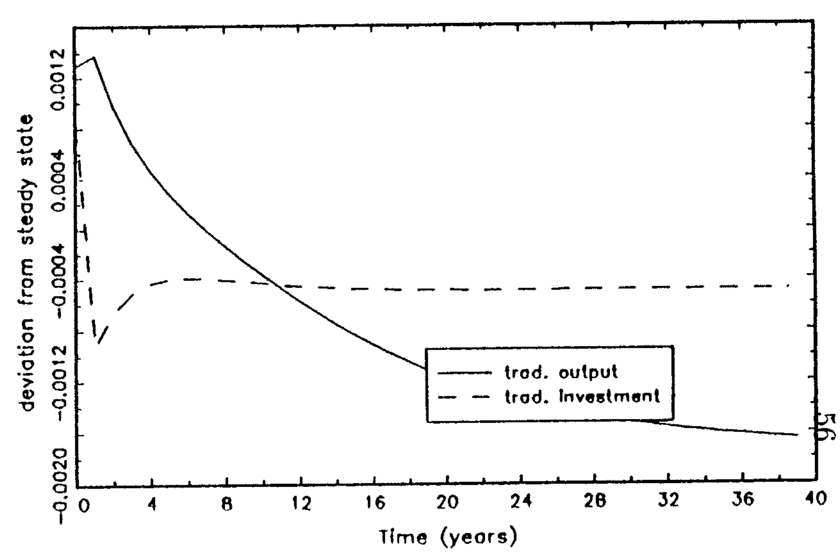


Fig.7.a Home Country Response to a 1% increase in capital tax rate)

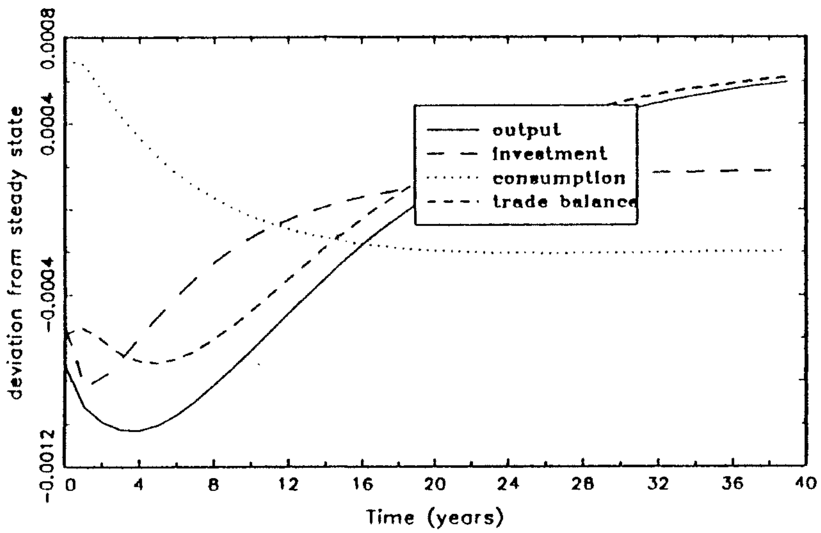


Fig.7.b Foreign Country Response to cap. tax

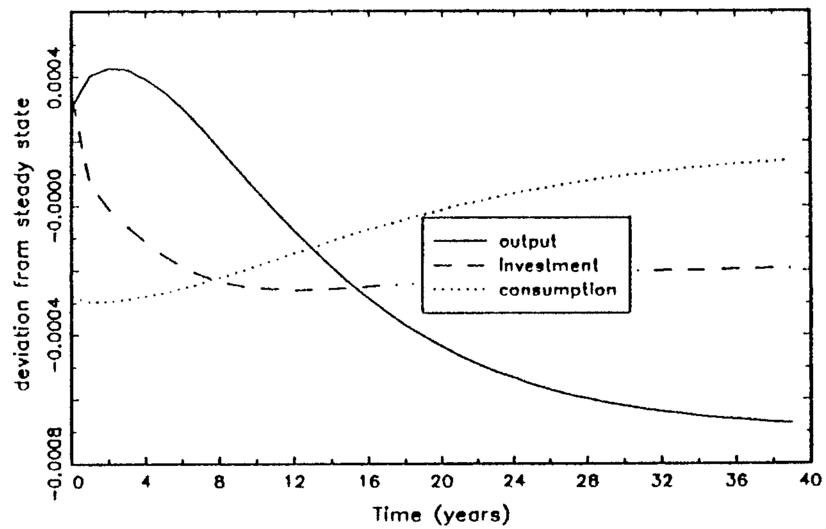


Fig.7.c Home Country Response to cap. tax

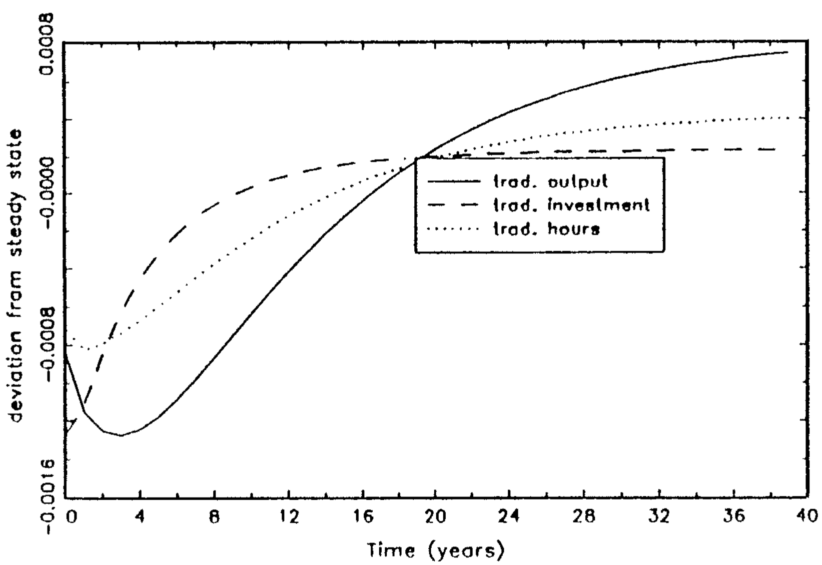
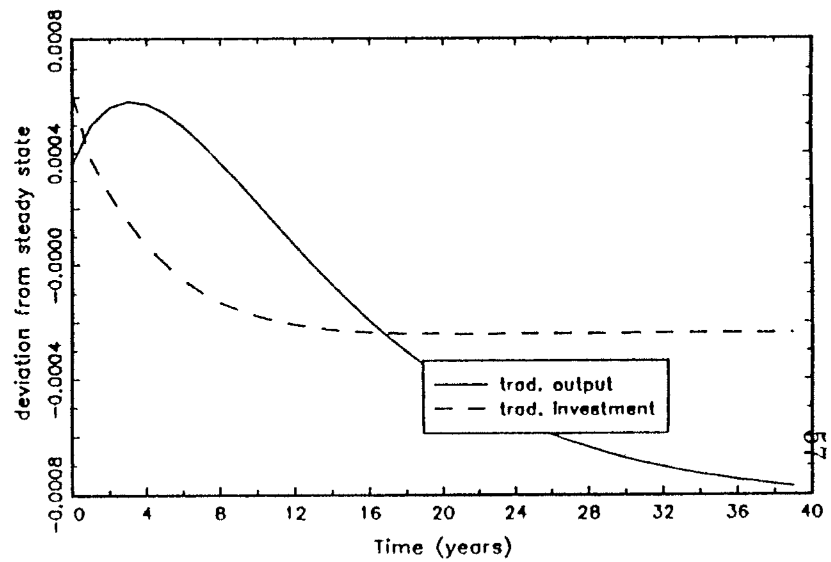


Fig.7.d Foreign country Response to cap. tax



Distortionary Taxation and Labor Supply: Evidence from Canada

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University of Montreal and C.R.D.E.

Abstract

This paper examines empirically the effects of distortionary taxation and government spending on labor supply using a general equilibrium framework. The long-term relations predicted by the model are derived and tested using Canadian data between 1966 and 1993. While the cointegrating predictions of the model without taxation are rejected, the ones of the model with labor taxation are not. Persistent labor tax rate increases appear to play an important role in the observed downward trend in hours worked.

Keywords: Labor Taxation, Labor Supply, Cointegration, Canada

JEL Classification: E62, J22, C32

1 Introduction

This paper examines empirically the effects of distortionary taxation and government expenditure on labor supply. The analysis is carried out using a general equilibrium model where the components of public spending can act as partial substitutes of private consumption and taxes are paid on labor income. At the theoretical level, it is clear that because utility maximization equates the marginal rate of substitution of consumption and leisure to the real wage, labor taxation alters the agents' choice by reducing their take-home real wage. Since the government's intertemporal substitution of debt for (distortionary) taxes can affect the agents' consumption and labor supply decisions, Ricardian equivalence fails [see Barro (1989), Trostel (1993), and Cardia (1997)]. Although some researchers suggest that, for a given level of fiscal spending, distortionary taxation has only second-order implications [see, among others, Barro (1989)], the question of whether the magnitude of the effects just described is economically and statistically important is primarily an empirical question.

That distortionary taxation could affect labor supply is suggested by figure 1 that plots the effective labor tax rate and the number of hours worked per person per week in Canada between 1966 and 1993.[1] Notice that the upward trend in the tax rate is mirrored (almost literally) by a downward trend in hours worked. While other causes, like sustained technological progress and demographic shifts, could also account for the reduction in the number of hours worked, figure 1 is certainly provocative and motivates the inquiry of this paper.

More generally, the analysis of distortionary taxation is important for several reasons. First, alternative methods of public financing are associated with different levels of social welfare. Cooley and Hansen (1992) quantify the costs

[1] The tax rates for this graph were taken from Mendoza, Razin, and Tesar (1994) and Ruggeri, Laroche, and Vincent (1997). The series of hours worked was constructed by the authors using data on total hours worked per week and labor force (in persons) supplied by Statistics Canada.

of various forms of taxation and find that replacing labor-income with lump-sum taxes reduces the welfare loss by 5.2% of GNP compared with a benchmark model that represents current US tax policy. Ohanian (1997) compares war-financing by debt or taxes and concludes that would have World War II been financed solely with distorting capital and labor taxes, the welfare loss would have been approximately 2-percent of steady-state GDP. Second, the effect of government purchases might depend on whether they are financed by means of lump-sum or distortionary taxes. Baxter and King (1993) find that the government spending multiplier is positive when expenditure is financed by lump-sum taxes but negative when financed by distortionary taxes. Finally, taxes can be an important source of economic disturbances and/or play an important role in the transmission of shocks. For example, McGrattan (1994) finds that 27% (4%) of the variance of output is explained by innovations to the labor (capital) tax rate.

In related research, Stuart (1981) constructs a two-sector model where labor taxes are paid on income earned in the market sector. The calibration of the model to the Swedish economy indicates that increasing the marginal tax rate from 58% to 65% reduces labor supplied to the market sector by between 1.8% and 2.5% depending on the scenario considered. Braun (1994) shows that introducing distortionary taxes in a real business cycle (RBC) model improves its ability to reproduce features of the US economy like the variability of hours worked and the weak correlation between real wages and employment. Braun suggests that substantial intertemporal substitution effects in the labor supply decision may be the result of changes in taxes.

The papers above employ as analytical tool different versions of the neoclassical growth model and provide evidence primarily in the form of simulations of the model economy. Rather than using calibration to asses the relevance of taxation on labor supply, this paper derives the empirical predictions of the model and, based on unit-roots tests, frames these predictions in terms of cointegration as in

Ahmed and Yoo (1995). More precisely, it is shown that the behavioral rules and resource constraints of the model imply that a precise combination of the variables should be stationary. Because our model includes as special cases specifications without distortionary taxation and no substitutability of public spending and private consumption, cointegration tests provide a simple and transparent strategy to evaluate the competing theories. Although our methodology and date set differ from Braun's, we validate his conclusion that distortionary taxation can be an important determinant of the agents' labor supply decision.

Most of the empirical macroeconomics literature on the effects of taxation examines only indirectly the relevance of distortionary taxes. For example, reduced-form estimation designed to capture the effects of government debt and taxation on private consumption yields conflicting results [on this see Cardia (1997)]. Even in the cases when Ricardian equivalence is rejected, it is not possible to distinguish between the possible sources of the failure (whether finite horizons, liquidity constraints, or distortionary taxation). Empirical analysis is also complicated by the fact that labor income tax rates depend on the household's income bracket and generating aggregate tax series is nontrivial. However, in a recent paper, Mendoza, Razin and Tesar (1994) compute effective tax rates consistent with the tax distortions faced by a representative agent in a general equilibrium model and show that their time series properties are similar to other tax measures that employ data on income distribution, statutory taxes, and other institutional characteristics.

Our results show that changes in the labor tax rate affect the leisure/labor supply decision in a manner consistent with the theoretical model. While the cointegrating predictions of the specification with distortionary taxation are not rejected by the data , they are rejected for the simple neoclassical growth model without taxes. The parameter estimate for the leisure preference parameter in the utility function is statistically different from zero and its magnitude is comparable to previous estimates based on US data and the values generally used in calibration by the RBC literature. When the predicted values for the leisure-to-employment ratio are plotted against the actual series, the fitted values and the actual series are remarkably close.

Impulse-response analysis shows that an increase in labor taxation decreases labor supply. Roughly speaking, an increase of a 1 percentage point in the labor tax rate decreases weekly hours worked (or equivalently, increases leisure) by 0.3 hours. Given the upward trend in the labor tax rate between 1966 and 1993 (when this rate rose from 15.1% to 31%), distortionary taxation appears to explain a substantial part of the decrease in hours worked per person in Canada documented in figure 1. While these results do no constitute direct evidence against Ricardian Equivalence, they show that the weight of leisure in the utility function is at least as large as the one of consumption[2] and that distortionary taxation can affect labor supply. Hence the intertemporal substitution of debt for taxes could produce real effects.

It is also shown that increases in fiscal spending decrease labor supply and that the effect is 2.25 times larger for government consumption than for government investment. This finding is consistent with calibration results obtained by Baxter and King (1993) where an increase in fiscal spending financed by distortionary labor taxation decreases labor supply and output. However, although their potential quantitative effect is large, changes in government consumption and investment are too small to explain the downward trend in the hours worked.

The paper is organized as follows: section 2 presents and solves the general equilibrium model; section 3 analyses the univariate properties of the series, defines the model predictions in terms of cointegrating relations, tests the impli-

[2]This is important because if leisure is not a quantitatively important component of utility, labor taxation does not distort the agents' labor supply decision and all taxation is effectively lump-sum.

cations of the competing specifications, and obtains estimates of the structural parameters; section 4 employs impulse-response analysis to examine the short- and long-term effect of changes in taxes and government spending on the leisure-labor decision; and section 5 concludes.

2 The Model

2.1 Preferences and Utility Maximization

The economy is populated by identical, infinitely-lived agents who choose optimal sequences of consumption and leisure to maximize their life-time utility. Formally, the representative agent's problem is,

$$\underset{\{C_{t+i}, L_{t+i}\}_{i=0}^{\infty}}{Max} \qquad E_t \sum_{i=0}^{\infty} \beta^i u(C^*_{t+i}, L_{t+i}) \tag{1}$$

where $\beta \in (0,1)$ is the subjective discount factor, $u(\cdot)$ is the instantaneous utility function assumed concave and strictly increasing in both of its arguments, L_t is leisure, and C^*_t is effective consumption. Effective consumption is a composite of private consumption, public consumption, and the flow of services from the stock of public capital:

$$C^*_t = C_t + \theta_c G_{c,t} + \theta_i K^g_t,$$

where C_t is private consumption, $G_{c,t}$ is government consumption, K^g_t is public capital stock, and the coefficients θ_c and θ_i measure respectively the contribution of public consumption and capital to the agent's well-being. Under this specification, a unit of government consumption (public capital) is equivalent to $\theta_c(\theta_i)$ units of private consumption in utility terms [see, among others, Barro (1981), Aschauer (1985) and Ahmed and Yoo (1995)].

Because data on public capital is not readily available, it will be useful to anticipate steady-state results and rewrite effective consumption in terms of government investment. To that effect note that the law of motion of public capital is

$$K_t^g = (1-\delta)K_{t-1}^g + G_{i,t},$$

where $G_{i,t}$ is government investment and $0 < \delta < 1$ is the depreciation rate. Hence in steady-state

$$K_t^g = (1/\delta)G_{i,t}. \tag{2}$$

Using (2) it is possible to rewrite effective consumption as

$$C_t^* = C_t + \theta_c G_{c,t} + (\theta_i/\delta)G_{i,t}. \tag{3}$$

Notice that because the coefficients on $G_{c,t}$ and $G_{i,t}$ need not be equal, the specification in (3) permits different degrees of substitution for different types of public expenditure, and because a given θ can be set or found to be equal to zero, it does not require that all spending components be substitutes of private consumption.[3]

In the rest of the analysis we specialize instantaneous utility to the logarithmic form [see also Baxter and King (1993) and Braun (1994)]:

$$u(C_t^*, L_t) = \log(C_t^*) + \gamma \log(L_t), \tag{4}$$

where γ is a positive constant that measures the relative weight of leisure in $u(\cdot)$.[4] The agent's budget constraint is given by

$$A_{t+1} = (1+r_t)A_t + (1-\tau_t)w_t N_t - T_t - C_t,$$

[3]In principle, it would be desirable to work with a finer disaggregation of government expenditure. Unfortunately, the data base of Statistics Canada only distinguishes between the two components above, namely government consumption and investment. Baxter and King (1993) also include an additive function, say $\Gamma(G_{c,t}, G_{i,t})$, in the instantaneous utility to capture the notion that certain government purchases (for example, military expenditures) increase the agent's welfare without affecting her consumption/leisure decision.

[4]Another specification of the utility function assumes that it is linear on leisure [see, for

where A_t is financial wealth, r_t is the real interest rate, τ_t is the tax rate on labor income, and T_t is a lump-sum tax (net of transfers).[5] In equilibrium, financial wealth is held only in the form of private capital. That is,

$$A_t = K_t,$$

where K_t denotes private capital. Finally the total time endowment is normalized to 1 so that

$$L_t + N_t = 1. \tag{5}$$

In addition to the transversality condition, the first-order conditions that characterize the solution of the dynamic programing problem above are

$$1/C_t^* = \beta(1 + r_t)E_t\left(1/C_{t+1}^*\right) \tag{6}$$

and

$$\gamma C_t^*/L_t = (1 - \tau_t)w_t. \tag{7}$$

Equation (6) describes the optimal rate of substitution between current and future consumption while (7) dictates that the marginal rate of substitution between leisure and consumption should equal the after-tax real wage.

Relations (6) and (7) imply that the intertemporal substitution of leisure follows

$$1/((1 - \tau_t)w_t L_t) = \beta(1 + r_t)E_t\left(1/((1 - \tau_{t+1})w_{t+1}L_{t+1})\right).$$

example, Hansen and Cooley (1992) and Ohanian (1997)]. Hansen's (1985) model where households can work only a fixed number of hours or none at all (*i.e.*, labor is indivisible) also yields a linear dependence of instantaneous utility on leisure. These specifications imply that the marginal disutility of work is constant, the intertemporal elasticity of substitution is infinity, and agents readily substitute labor across periods. Hence, under linear utility, changes in labor taxes are likely to have a larger effect on labor supply than under logarithmic preferences. For some evidence in favor of logarithmically separable utility see McGrattan (1994).

[5]Because our focus is on the effect of labor taxes on labor supply, we abstain from explicitly incorporating capital and consumption taxes.

In order to illustrate the implications of the above relation, it is useful to consider the case of perfect-foresight (so that the expectations operator drops), take logs and rearrange the resulting expression to obtain

$$\Delta \log(L_{t+1}) = \log(\beta(1 + r_t)) + (\tau_{t+1} - \tau_t) - \Delta \log(w_{t+1}),$$

where $\Delta \log(L_{t+1}) = \log(L_{t+1}) - \log(L_t)$, $\Delta \log(w_{t+1}) = \log(w_{t+1}) - \log(w_t)$, and we have approximated $\log(1 - \tau_t)$ by $-\tau_t$. Hence, an increase in the real interest rate and a transitory decrease (increase) in labor tax rate (wage) at time t, constitute incentives for the intertemporal substitution of leisure for labor. In all these instances, agents reduce current leisure *vis a vis* future leisure, or equivalently, increase their labor supply at time t compared with time $t + 1$. The prediction that the agents' labor supply reacts not only to movements in the real wages and interest rates, but also to changes in the labor tax rate, is important for two reasons. First, as pointed out by Braun (1994), it can explain the weak correlation observed in aggregate data between hours worked and real wage. Second, as recognized by Barro (1989), it means that distortionary taxation could lead to the empirical failure of Ricardian Equivalence.

Notice, however, that the intertemporal effects of movements in the tax rate and real wage do depend on the time-series properties of the variables. If all tax/wage changes are perceived by agents to be largely permanent, then there is no reason to substitute intertemporally labor supply. An illustrative example is the case when the log of the real wage and the tax rate follow random walks. Then, their first-difference are white noise and the changes in (the log of) leisure are also white noise around the time-varying component $\log(\beta(1 + r_t))$.

On the other hand, regardless of the persistence associated with tax changes, labor taxation has a level, intratemporal effect as seen from the Euler condition (7). Thus, increases in the labor tax rate, reduce the take-home real wage and motivate agents to substitute consumption for leisure within the period. As we will see below, this could partly explain labor supply changes in Canada during the post-war period when labor tax movements have been persistent [see figure 1].

2.2 Production and Public Sectors

Production of the (single) consumption good is carried out by perfectly competitive firms using a constant-returns-to-scale technology of the form

$$Q_t = a_t K_t^{1-\phi} N_t^{\phi}, \tag{8}$$

where Q_t is output, K_t is private capital stock, N_t is labor (measured in hours worked), ϕ is a constant coefficient that satisfies $0 < \phi < 1$, and a_t is an exogenous productivity shock. As shown below, the equilibrium condition examined empirically in section 3 is robust to allowing government expenditure and/or public capital to increase factor productivity [as in Baxter and King (1993) and Ahmed and Yoo (1995)] and to the precise time-series specification of the technology shock.

The representative firm chooses labor demand and the level of capital to maximize profits:

$$\pi_t = Q_t - r_t K_t - w_t N_t - \delta K_t, \tag{9}$$

where the price of the good has been normalized to 1, r_t is the rental price of capital, w_t is the real wage, and the depreciation rate of private capital, δ, is assumed to be the same of public capital. As usual, necessary conditions for the maximization of (9) subject to (8) are

$$a_t \phi \left(K_t/N_t\right)^{1-\phi} = w_t, \tag{10}$$

and

$$a_t(1-\phi)\left(K_t/N_t\right)^{-\phi} - \delta = r_t. \tag{11}$$

The first condition simply states that the firm's demand for labor equates the marginal productivity of labor and the real wage while the second condition determines the optimal level of capital as a function of its rental price. In turn, private capital accumulates according to

$$K_t = (1-\delta)K_{t-1} + I_t.$$

Following the literature [see, for example, Cooley and Hansen (1992), Braun (1994), and McGrattan (1994)], we abstract from assigning a utility function to the government and instead model it as an exogenous sequence of expenditures and taxes. This sequence satisfies in every period the government's budget constraint:[6]

$$G_{c,t} + G_{i,t} = \tau_t w_t N_t + T_t.$$

2.3 Equilibrium Conditions

Replacing the factor prices that solve the firm's profit maximization, (10) and (11), into the agent's Euler equations yield the arbitrage relations

$$1/C_t^* = \beta\left(1 + a_t(1-\phi)\left(K_t/N_t\right)^{-\phi} - \delta\right) E_t\left(1/C_{t+1}^*\right) \tag{12}$$

and

$$\gamma C_t^*/L_t = (1-\tau_t)a_t\phi(K_t/N_t)^{1-\phi}. \tag{13}$$

Finally, the goods-market equilibrium condition for the economy is[7]

$$Q_t = C_t + I_t + G_{c,t} + G_{i,t},$$

or, dividing both sides by output, Q_t,

$$1 = c_t + i_t + g_{c,t} + g_{i,t}, \tag{14}$$

[6]It is easy to show that allowing for government debt does not alter the empirical predictions of the model.

[7]This condition implicitly treats the economy as closed. However, as shown in the following section, econometric results are robust to modeling the economy as open.

where the lower-case letters denote ratios-to-GDP.

Equation (12) describes the optimal consumption smoothing behavior on the part of agents and has been extensively examined, both in partial and general equilibrium, in previous literature. More interesting, from the perspective of examining the effects of taxation, is relation (13) that describes the intratemporal substitution of consumption and leisure. Plugging (3) and (5) into (13), dividing by Q_t, using (8), and imposing the equilibrium condition (14) yield

$$(1-\tau_t)x_t = (\gamma/\phi)\left[1-(1-\theta_c)g_{c,t}-(1-\theta_i/\delta)g_{i,t}-i_t\right], \tag{15}$$

where the term

$$x_t = (1-N_t)/N_t,$$

is the leisure-labor ratio. Equation (15) encapsulates the optimizing choices of agents and firms and the economy's resource constraint. It also relates at the theoretical level, fiscal policy to the agents' labor supply decision and (as we will see below) generates empirical predictions that can be readily compared with actual data. Its tractable form is the deliberate result of using a logarithmic specification for the utility function and a constant-returns-to-scale technology. Notice that by examining the variables as percentages of GDP, any trend effect associated with population growth is eliminated. Also, multiplicative increases in factor productivity (whether due to technology shocks, public capital, or government consumption) cancel out in the derivation of (15) and, as a result, have no bearing on its empirical predictions. This is important because it means that the econometric results below are robust to specific assumptions regarding the time-series properties of productivity shocks.

The above model includes two interesting specifications as special cases. First, by setting $\tau_t = 0$ for all t one obtains a model with no distortionary labor taxation. Because an important goal of this paper is to examine empirically the effects of taxation on labor supply, this restricted model constitutes a natural alternative. It is easy to see that the equivalent expression of (15) for this restricted specification is

$$x_t = (\gamma/\phi)\left[1 - (1-\theta_c)g_{c,t} - (1-\theta_i/\delta)g_{i,t} - i_t\right]. \tag{16}$$

Second, one could consider the case where government expenditures are not substitutes of private consumption by setting $\theta_j = 0$ for $j = c, i$, in (15) to obtain

$$(1-\tau_t)x_t = (\gamma/\phi)\left[1 - g_{c,t} - g_{i,t} - i_t\right]. \tag{17}$$

3 Econometric Analysis

3.1 The Data

The data set consists of 112 quarterly, seasonally-adjusted observations of output, consumption, investment, government consumption (that includes both durables and nondurables), government investment and the leisure-labor ratio for Canada. All variables, except for the leisure-labor ratio, are in constant 1986 Canadian dollars. The sample period from 1966:1 to 1993:4 was determined by the availability of data on effective tax rates. These rates were computed by Mendoza, Razin, and Tesar (1994) for 1965-1988, and later extended by Ruggeri, Laroche, and Vincent (1997) until 1993. In addition, because Statistics Canada collects the series of hours worked on a quarterly basis only since 1966, the year 1965 could not be included in the analysis.

For the calculation of the leisure-labor ratio, we followed Ahmed and Yoo (1995). The total endowment of time available to the economy is defined as $EE = 12 * 7 * 16 * LF$, where LF is the labor force (in thousand of persons), 12 is the number of weeks in a quarter, 7 is the number of days in a week, and 16 is the number of (non-sleeping) hours in the day. The leisure-labor ratio is then computed as $x = (EE - TN)/TN$ with TN denoting the total number of hours worked. The tax-adjusted leisure-labor ratio, $(1-\tau_t)x_t$, is calculated assuming that the annual tax rate applies equally in all four quarters of the year.[8]

3.2 Univariate Properties of the Series

Prior to the econometric analysis of the equilibrium relations derived in section 2, we examine the time-series properties of the data. Graphical analysis appears to indicate that the series are characterized by nonstationary processes. Consider first figure 2 that contains the plots of consumption, investment, government consumption, and government investment as percent of GDP and the leisure-labor ratio (both adjusted and unadjusted for taxes). These graphs suggest that the variables are very persistent and likely to be integrated of order 1. This intuition is statistically confirmed by the results of Augmented Dickey-Fuller (ADF) unit-root tests reported in table 1. For all ADF tests, the choice of the optimal level of augmentation, (*i.e.,* the number of lagged first differences included in the OLS regression) was based on the recursive application of t-tests as suggested in Ng and Perron (1995). In order to assess the robustness of the results, we also employed the Modified Information Criterion (MIC) [see Ng and Perron (1998)] with similar conclusions. For most of the variables under consideration, the natural alternative to estimate in the ADF test is that of an autoregression with constant term but no trend [see Hamilton (1994, ch. 17)].[9] Consequently, the estimation below is based primarily on the results reported in column 3. These results indicate that the null hypothesis of a unit root cannot be rejected at standard significance levels

[8] We also considered the alternative approach of interpolating the available annual tax rates to construct quarterly estimates. However, results were basically the same as the ones reported below.

[9] Recall that the ADF test is a Wald-type test. Since most of the variables are ratios to GDP it could be argued that perhaps a nonlinear alternative would be even more plausible. However, since standard unit root tests are derived under the assumption of linearity, we do not pursue this proposition further.

for any of the variables considered.

For completeness, we also present the test results obtained for the alternative of stationarity around a deterministic time trend (see column 5). Note however that, with the sole exception of investment, the econometric conclusions are the same regardless of the alternative considered. Similar results are reported by Ahmed and Yoo (1995) using US data for the somewhat-larger sample period 1955:1 to 1993:1. Ahmed and Yoo find that the leisure-labor ratio and the ratios of consumption and various government expenditure components to output are nonstationary but that the investment to output ratio is stationary.[10]

In addition, we also test whether the effective labor-tax rate for Canada is persistent enough to be described by a nonstationary time-series process. To that effect we carry out ADF tests using raw annual data from Mendoza, Razin, and Tesar (1994) and Ruggeri, Laroche, and Vincent (1997). The alternatives estimated are stationary processes with and without deterministic trends and, as before, the level of augmentation of the test is determined using the *t-sig* criterion. Results are presented in the last row of table 1 (columns 3 and 5, respectively) and indicate that the hypothesis of a unit root cannot be rejected at standard significance levels. This conclusion is in line with Mendoza, Razin, and Tesar's observation that the tax rate on labor income has followed an upward trend for all countries in their sample. The evidence in table 1 simply suggests that this trend appears to be stochastic rather than deterministic.

[10]King *et al.* (1991) present some empirical evidence that, for the United States, the consumption/output and investment/output ratios are stationary. The discrepancy in the results could be partly attributed to the fact that King *et al.* measure output as private output alone (since there is no government in their model) while Ahmed and Yoo (1995) and this paper use GDP.

3.3 Tests of the Empirical Implications

The above results are important because they allow us to frame empirically the equilibrium conditions derived in section 2 in terms of cointegrating relations [Engle and Granger (1987)]. That is, even if individual variables are characterized by nonstationary processes, the behavioral rules and resource constraints that underlie (15), (16), and (17) imply that a precise combination of these variables should be stationary. Because these equations are based on different assumptions about the relevance of distortionary taxation and the substitutability between public and private consumption, cointegration tests provide a simple and transparent strategy to evaluate the competing models.

Two types of cointegration tests are employed. First, the null hypothesis of no cointegration is tested using the residual-based approach proposed by Engle and Granger (1987). Gonzalo and Lee (1998) show that this test is more robust than Johansen's trace test [Johansen (1991)] to certain departures from unit root behavior like long memory and stochastic unit roots. Still, as an additional check, we use Johansen's Maximum Likelihood (ML) procedure to determine the number of cointegrating relations among the model variables.

Engle and Granger's test evaluates the null hypothesis of no cointegration and requires running OLS on the relation of interest and then testing the hypothesis that the regression residuals have a unit root. Nonstationarity of the residuals constitutes evidence against cointegration. Results for relations (15), (16), and (17) are respectively presented in the three top rows in table 2. Recall that (15) includes both taxation and partial substitution of public spending and private consumption, (16) ignores distortionary taxation by assuming that the labor tax rate is zero in all periods, and (17) corresponds to the case of no substitutability between public expenditure and private consumption obtained when $\theta_c = \theta_i = 0$. The restriction that the coefficients on government consumption, government investment, and investment are the same in (17) is imposed by running the OLS regression of the tax-adjusted leisure-labor ratio on a constant and the sum of the three variables. The test statistics in column 3 indicate that the null hypothesis of no cointegration is rejected at the 5% level for (15) (the p-value is approximately 3%), and at the 10% level for (17) (in this case the p-value is approximately 9.6%). In contrast, the same hypothesis cannot be rejected for the relation without taxes (16) at any standard significance level.

These results constitute evidence in favor of the model with distortionary taxation in that (*i*) its econometric prediction – that the model variables form a stable long-run relation – is supported by the data, and (*ii*) the same prediction by the alternative specification without taxation is rejected. This conclusion is robust to different time-series specifications of the technology shocks, to relaxing the assumption that public expenditures and private consumption are partial substitutes, and to modeling the economy as open.[11] Hence, labor taxation appears to be an important consideration in the agents' labor supply decision. The non-negligible difference in the p-values associated with the rejection of the hypothesis of no cointegration of (17) and (15), suggests that the partial substitutability of public spending and private consumption reinforces the finding that (15) is a cointegrating relation and implies that government expenditure might also affect the leisure/labor choice. A comparable result for the US is reported by Ahmed and Yoo (1995) where fiscal trends associated with government spending reduce the consumption-to-output ratio and the leisure-labor ratio.

In addition to the above test, we also employ the trace test [Johansen (1991)] to verify the number of cointegrating relations among the variables. The number of lags to be included in the Vector Error Correction (VEC) model were chosen using a sequence of Likelihood Ratio tests in a vector autoregression in levels as

[11] In this case, the trade balance (as percentage of GDP) also appears in the right-hand-side of the cointegrating relations. Test statistics for the null hypothesis of no cointegration in the open-economy model with (without) distortionary taxation are -4.53 (-2.57), respectively.

suggested by Enders (1995). Results for this test are presented in table 3 and indicate the presence of two cointegrating relations at the 1% significance level (though 3 at the 5% level) for the model with distortionary taxation and none (1 at the 5% level) for the model without taxes. Although, Gonzalo and Lee (1998) show that in certain circumstances Johansen's test tends to overestimate the number of cointegrating relations, it seems worthwhile to explore the possibility of a second cointegrating relation among the variables. A natural candidate is a cointegrating relation between the two components of government expenditure. A residual based test [see the fourth row of table 2] suggested that indeed the government consumption and investment are cointegrated.[12]

3.4 Estimates of the Structural Parameters

The estimation of the cointegrating relation (15) is of particular interest because it provides us with estimates of the structural parameters of the model. A number of strategies to estimate cointegrating vectors (some of them asymptotically equivalent) have been proposed in the literature. A nonexhaustive list includes OLS [Engle and Granger (1987)], nonlinear least squares [Stock (1987)], canonical correlations [Bossaerts (1988)], maximum likelihood in a fully specified VEC model [Johansen (1991)], three-step-estimation [Engle and Yoo (1989)] and dynamic generalized least squares (DGLS) [Stock and Watson (1993)]. Gonzalo (1994) uses

[12]The result reported in table 2 corresponds to the one obtained regressing government investment on a constant term and government consumption. Notice however that for the inverse regression (that is government consumption on a constant and government investment), the hypothesis of no cointegration cannot be rejected at the 5% significance level. This result highlights the well-known fact that normalizations can play a nontrivial role in cointegration testing [see Hamilton (1994, ch. 19)]. Additional evidence on the cointegration of the expenditure components is provided by Johansen's trace statistic that rejects the null hypothesis of no cointegrating vector between g_c and g_i at the 5% level.

Monte Carlo simulations to compare some, but not all, the above methods[13] and concludes that in finite samples the maximum likelihood method has the smallest variance among the estimators considered. On the other hand, this approach has the disadvantage that it only delivers the basis of the cointegrating vectors rather than the cointegrating relations themselves. Phillips (1991) stresses that if researchers want to make structural interpretations on the separate cointegrating relations, this logically requires the use of restrictions from economic theory.

With the above considerations in mind, we employ the DGLS method proposed by Stock and Watson (1993) that is asymptotically equivalent to maximum likelihood [see Gonzalo (1994, p. 204)] but makes use of the restrictions of the general-equilibrium model. This approach involves running the OLS regression

$$\begin{aligned}(1-\tau)x_t = \; & \alpha + \rho_1 g_{c,t} + \rho_2 g_{i,t} + \rho_3 i_t + \sum_{s=-p}^{p} \xi_{1,s}\Delta g_{c,t-s} \\ & + \sum_{s=-p}^{p} \xi_{2,s}\Delta g_{i,t-s} + \sum_{s=-p}^{p} \xi_{3,s}\Delta i_{t-s} + u_t \end{aligned} \tag{18}$$

where α is an intercept, ρ_j and $\xi_{j,s}$ for $j = 1,2,3$ denote constant coefficients, and u_t is a disturbance term. The serial correlation of the residuals (if any) is then characterized in a parametric time-series model and the equation is reestimated using GLS. We selected the appropriate number of leads and lags by the sequential application of F-tests starting with the maximum number $p = 4$. Test results indicated that the most parsimonious yet statistically accurate representation involved setting $p = 0$, so that only the lagged first-difference of the variables were included in (18). The residuals of the OLS regression were parameterized as an AR(1) process based on a regression of $\hat{u}_t$ on four of its lags but no constant.[14] Results for the GLS regression are presented in table 4.[15]

[13]The author explains (see p. 204) that some estimators, most notably the dynamic GLS procedure by Stock and Watson, were proposed after his article was submitted.

[14]The coefficients of the second to fourth lag were not significantly different from zero at standard levels. For the first lag the estimate was only 0.40 (0.10) but, since it is statistically different from zero, efficiency gains are possible by using GLS.

[15]Elliot (1998) shows that even if the model variables have roots near but not exactly equal to

Using the reduced-form parameters, it is possible to construct estimates of the structural parameters of interest. Note, however, that the share of labor to total income (ϕ) and the weight of leisure in the utility function (γ) are not separately identified because the estimated intercept corresponds to the ratio γ/ϕ. This issue can be addressed by constructing an estimate of the share of labor on the basis of national income data. Mankiw and Scarth (1995, p. 78) report that this share has been roughly constant in Canada at $\phi = 0.67$ since 1945. Multiplying the intercept estimate, $\gamma/\phi = 1.95$ (0.31), by this figure yields an estimate of $\gamma = 1.31$ (0.21), where the terms in parenthesis denote standard errors.[16] This estimate is somewhat smaller but still consistent with the ones reported by Braun (1994), who finds values ranging from 4.21 to 5.59 for different tax specifications, and McGrattan (1994) whose preference estimates imply that $\gamma = 2.95$.[17] In calibrated models, Hansen (1985) and Ohanian (1997) employ values of γ of 2 and 1.5, respectively. Thus, Canadian data appears to confirm earlier estimates of γ obtained using postwar US data and suggests that the weight of leisure in the utility function is comparable to the one assigned to consumption.

The fact that the DGLS procedure involves lags and leads of the variables complicates the structural interpretation of the remaining coefficients. However from the estimates of the level and lagged difference of government consumption and government investment and the intercept (see table 4) it is possible to recover point estimates of the θ-coefficients. For example, an estimate of θ_c can be computed as $\theta_c = (\rho_1 + \xi_{1,0})/(\gamma/\phi) + 1 = (3.06 - 1.33)/1.95 + 1 = 1.89$ (0.70) where the standard error is obtained using the delta method. Similarly, $\theta_i/\delta = 4.24$

one, the point estimates of the cointegrating vector are consistent. However, hypothesis tests regarding the coefficients that do not have an exact unit root can be subject to size distortions.

[16] Note that the calculation of the standard error of γ implicitly assumes that the labor share is measured without error.

[17] McGrattan employs a different specification of the utility function than the one used in this paper. However a simple log transformation implies that $(1-\gamma)/\gamma$ (in her notation) corresponds to our parameter γ.

(2.17) so that assuming a quarterly rate of depreciation of 2.4% (equivalent to an annual rate of approximately 10%) one obtains $\theta_i = 4.24 * 0.024 = 0.10$ (0.05). These estimates are positive as predicted by theory and significantly different from zero. Though the point estimate of θ_c appears numerically large, it is not possible to reject the hypothesis that its true value is smaller than 1, as would be expected if government consumption were an imperfect substitute for private consumption. To see this, construct the 95% confidence interval for θ_c to obtain (0.52, 3.26) and note that any null hypothesis $\theta_c = \tilde{\theta}$ for $\tilde{\theta} \in (0.52, 0.99)$ would not be rejected at the 5% significance level.

Other estimates of θ_c and θ_i obtained by earlier researchers using US data include Kormendi (1983) who finds $\theta_c = 0.28$ (0.15) and $\theta_i = 0.07$ (0.14),[18] and Ahmed and Yoo (1995) who obtain 0.59 for durable government consumption and 0.94 for nondurable consumption. Using total government expenditure, Aschauer (1985) reports values between 0.23 and 0.42 depending on the number of lags employed in the estimation procedure, McGrattan (1994) finds −0.026 (0.126), and Katsaitis (1987) (using Canadian data) estimates values ranging from 0.35 to 0.42. Our findings are in agreement with the above estimates (except McGrattan's) and provide independent support for the idea that public spending can act as partial substitute of private consumption.

The Euler equation derived from the model determines the variables that enter (18) and, taken literally, predicts that the coefficients of their leads and lags should not be significantly different from zero. Results reported above provide some support for this implication of the model in that F-tests indicate that the coefficients of leads and lags for $p > 0$ in (18) are not statistically different from zero. For the estimated equation (with $p = 0$) only lagged government investment

[18]Because Kormendi's actually estimates $-\theta_c$ and $-\theta_i$ from an OLS regression of consumption on government consumption, government investment and other variables, he reports −0.28 and −0.07 in his article (see table 6 in p. 1006).

has a significant coefficient.

Finally, consider figure 3 that contains plots of realized and fitted values of the tax-adjusted leisure-labor ratio and notice that the model successfully tracks the behavior of the leisure-labor ratio along the business cycle.

4 Effects of Taxes and Government Spending on the Leisure/Labor Supply Decision

While the above results establish the empirical importance of distortionary taxation, more precise statements about the effect of taxes and government expenditure on labor supply are obtained in this section. To that end we linearize (15) around the steady-state, estimate the associated VEC model and perform impulse-response analysis. Consider first the linear Taylor-series expansion of (15):

$$x_t = \alpha + \lambda_1 g_{c,t} + \lambda_2 g_{i,t} + \lambda_3 i_t + \lambda_4 \tau_t + v_t, \tag{19}$$

where α is an intercept, λ_1 through λ_4 are constant coefficients, and v_t is a random term that includes approximation error. The advantage of this linearization is apparent from (19) as taxes now affect the leisure-labor ratio additively, rather than multiplicatively, and allow the separate inclusion of τ_t in the VEC model below.

As an intermediate step, it is important to verify that the linearization has not fundamentally altered the long-run relation among the variables. The residual-based test reported in the last row of table 2 indicates that the linear version (19) still constitutes a cointegrating relation, and the Johansen's trace test reported in table 3 confirms that (as before) two cointegrating vectors are present among the variables. Thus , these results are consistent with the ones found in the previous section for the exact, nonlinear version of the model.

A VEC model (with two cointegrating vectors) was then estimated and impulse-responses were calculated. Specifically, we examined the response of the leisure-labor ratio to innovations in effective labor tax rates and government spending. This exercise requires the orthogonalization of the disturbances. A possible strategy is to impose structural identification restrictions [for example, as in King *et al.* (1991)]. Alternatively, one could use the Choleski decomposition of the variance-covariance matrix [for example, as in McGrattan (1994)]. A possible drawback of the latter approach is that results are not usually independent of the ordering of the variables in the system. Fortunately, for the purpose of assessing the individual effect of tax/spending changes on the leisure-labor ratio, this characteristic of the Choleski decomposition is not restrictive. For example, if we want to measure the effect of taxation alone on the leisure-labor ratio, we can consider the ordering (τ, x, g_c, g_i, i), where the last three variables could be interchanged without affecting the final result and only shocks to the tax rate can be interpreted as truly exogenous. Similarly, in order to examine the direct effect of government consumption and investment on the leisure-labor ratio we employ the orderings (g_c, x, g_i, τ, i) and (g_i, x, g_c, τ, i), respectively.

The associated impulse responses are presented in figures 4 through 6. Consider first figure 4 that contains the effect of a tax rate innovation on the leisure-labor ratio. Because the tax rate is persistent (persistent enough that the hypothesis of a unit root could not be rejected), the effect of a positive tax disturbance is pretty much permanent and as predicted by theory entails an increase in leisure relative to labor. More precisely, a one-standard-deviation shock to the labor tax rate yields a long-run increase of 0.33 percentage points in the labor tax rate and an increase of 0.0106 in the leisure-labor ratio. Equivalently, an increase of 1 percentage point in the tax rate (say from 15% to 16%) raises the leisure-labor ratio by 0.032.

Computing elasticities requires the level of the variables in addition to their relative change. Since the variables are not stationary, no well-defined benchmark (like the mean) is available. Still, with this consideration in mind, we perform some illustrative calculations using the sample average of the variables. These values are approximately 2.3 for the leisure-labor ratio and 23% for the tax rate. For these figures, an estimate of the (long-run) elasticity of the leisure-labor ratio with respect to the labor tax rate is 0.32.[19] This implies that an increase of the tax rate from 23% to 24% would prompt agents to increase their leisure-labor ratio to $2.3 + 0.032 = 2.332$, or equivalently, reduce the number of hours worked per week by 0.3, from 33.9 to 33.6.[20] Using simulations of a general equilibrium model with taxation, Greenwood and Huffman (1991) show that reducing the labor tax rate from 35% to 25% increases output and hours worked by 10%. Our estimates predict that, starting from the benchmark 23%, the same reduction of 10% points in the tax rate would increase weekly hours worked by 8.8%.

Figures 5 and 6 plot the response of the leisure-labor ratio to a one-standard-deviation innovation to government consumption and investment respectively. In both cases, leisure increases and, consequently, output falls. This result supports empirically the finding by Baxter and King (1993) that government spending increases financed by distortionary taxation could lead to decreases in output. Numerically, a one-standard-deviation innovation in government consumption yields a permanent increase of 0.082 percentage points in its share of total output and an increase of 0.00855 in the leisure-labor ratio. For government investment, the equivalent figures are 0.087 and 0.0038 respectively. While the long-run increase in government consumption is approximately the same as in government investment, the associated response in the leisure-labor ratio is 2.25 times larger.

[19]While not directly comparable, our results are consistent with Ziliak and Kniesner (1999) that use PSID data to estimate a labor tax elasticity of -0.06.

[20]Using the definition of the leisure-labor ratio, it is possible to calculate the number of hours worked per week as $(7 * 16)/(1 + x)$, where 7 is the number of days of the week and 16 is the number of (non-sleeping) hours in the day.

Employing as useful benchmark the average GDP shares of government consumption and investment during the sample period (21% and 3%, respectively), it is possible to calculate an elasticity of the leisure-labor ratio with respect to both aggregates. This calculation yields 0.95 for government consumption and 0.057 for government investment. Thus, a 1% increase in the share of government consumption (from 21% to 22%) would induce agents to increase their leisure-labor ratio by 0.1 (from 2.3 to 2.4). In terms of hours worked per week this represents a reduction of 1 hour (from 33.9 to 32.9). Regarding government investment, an increase from 3% to 4% of GDP would raise the leisure-labor ratio by 0.044 (from 2.3 to 2.344) and reduce the number of hours worked per week by 0.4 (from 33.9 to 33.5).

These results are quantitatively larger than the ones found above for labor taxation. However, for the period under consideration the share of GDP devoted to government consumption is roughly the same at the start and at the end of the sample (approximately 20%), with maximum and minimum levels of 23.2% (in 1970:4) and 19.1% (1988:4) respectively [see figure 2]. Hence, despite their large potential impact, changes in government consumption are unlikely to explain the downward trend in hours worked in Canada. On the other hand, government investment as proportion of GDP does present a downward trend, dropping from roughly 4% of GDP in 1966 to 2.9% in 1993 [see figure 2]. But, while the reduction in government investment might contribute to the observed trend in hours worked, it seems quantitatively too small to account for a substantial part of the reduction of hours worked during this period.

5 Conclusions

This paper has examined the empirical relevance of fiscal policy for the agents' leisure/labor supply decision in Canada during the period 1966 to 1993. A dynamic general equilibrium model predicts that though the leisure/labor ratio might be nonstationary, a precise combination of this series and other model variables should be stationary. It is shown that this implication is rejected for the model without taxation but cannot be rejected for the model with distortionary taxation. The latter result is robust to allowing substitutability between private consumption and government spending and to the time-series properties of the productivity shock. The estimated leisure-to-labor ratio replicates well changes of the actual series during the sample period, including the large reduction of hours worked during the 1980s. Impulse-response analysis indicate that the effects of changes in the labor tax rate on the leisure/labor ratio are quantitatively important. Some back-of-the envelope calculations suggest that a 1 percentage point increase in the labor tax rate reduces weekly hours worked by 0.3. While fiscal spending can have important effects on the leisure-labor ratio, changes in government consumption and investment are unlikely to account for the downward trend in hours worked. Our empirical results are consistent with earlier general equilibrium models that include labor income taxation and fiscal spending, and suggest that most of the important changes in hours worked during the period considered can be explained by the explicit inclusion of fiscal policy variables and in particular by changes in the labor income tax rate.

Table 1. Augmented Dickey-Fuller Test Results

Canada

Variable	Without Trend		With Trend	
	k	t-Statistic	k	t-Statistic
c	1	−2.41	1	−2.78
i	4	−1.77	10	−4.29**
g	1	−1.61	1	−2.74
g_c	1	−2.06	5	−2.72
g_i	10	−2.22	8	−0.56
$(1-\tau)x$	9	−2.06	9	−2.35
x	8	−2.28	6	−3.08
τ	1	−1.46	5	−2.56

Notes: k denotes the level of augmentation of the test and was chosen using the *t-sig* criterion [see Ng and Perron (1995)]. All data is quarterly except for the effective tax rates that are on an annual basis. The superscripts ** and * denote the rejection of the null hypothesis of a unit root at the 1% and 5% significance levels, respectively.

Table 2. Residual-Based Cointegration Test Results

Variables	k	t-Statistic
$(1-\tau)x, g_c, g_i, i$	1	-4.49^{*}
x, g_c, g_i, i	7	-2.79
$(1-\tau)x, g_c + g_i + i$	9	$-3.09^{\dagger}$
g_c, g_i	1	-3.38^{*}
$x, (1-\tau), g_c, g_i, i$	1	$-4.19^{\dagger}$

Notes: k denotes the level of augmentation of the test and was chosen using the *t-sig* criterion [see Ng and Perron (1995)]. In all cases a constant term was included in the regression. The superscripts **, *, and † denote the rejection of the null hypothesis of no cointegration at the 1%, 5%, and 10% significance levels, respectively.

Table 3. Johansen Cointegration Test Results

Variables	k	Eigenvalue	LR Statistic	5% (1%) Critical Value	Null Hypothesis
$(1-\tau)x, g_c, g_i, i$	4	0.20	65.81	53.12 (60.16)	None**
		0.18	42.12	34.91 (41.07)	At most 1**
		0.11	21.41	19.96 (24.60)	At most 2*
		0.08	8.83	9.24 (12.97)	At most 3
x, g_c, g_i, i	7	0.20	57.07	53.12 (60.16)	None*
		0.17	33.45	34.91 (41.07)	At most 1
		0.08	14.02	19.96 (24.60)	At most 2
		0.05	5.39	9.24 (12.97)	At most 3
$(1-\tau), x, g_c, g_i, i$	4	0.23	82.18	76.07 (84.45)	None*
		0.20	53.24	53.12 (60.16)	At most 1*
		0.11	28.79	34.91 (41.07)	At most 2
		0.09	15.90	19.96 (24.60)	At most 3
		0.05	5.71	9.24 (12.97)	At most 4

Notes: k denotes the level of augmentation of the test and was chosen using the procedure suggested by Enders (1995). In all cases a constant term was included in the regression. The superscripts ** and * denote the rejection of the null hypothesis at the 1% and 5% significance levels, respectively.

Table 4. Estimates of Cointegrating Relation

Variable	Estimate	Standard Error	t-Statistic
intercept	1.95	0.31	6.22**
$g_{c,t}$	3.06	1.07	2.85**
$g_{i,t}$	−11.22	1.63	−6.89**
i_t	−2.95	0.61	−4.87**
$\Delta g_{c,t}$	−1.33	1.23	−1.08
$\Delta g_{i,t}$	17.54	4.13	4.25**
Δi_t	0.97	0.60	1.61

Notes: The superscripts **, *, and † denote the rejection of the null hypothesis that the coefficient is zero at the 1%, 5%, and 10% significance levels, respectively.

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Figure 1. Hours Worked per Person per Week and Labor Tax Rate in Canada

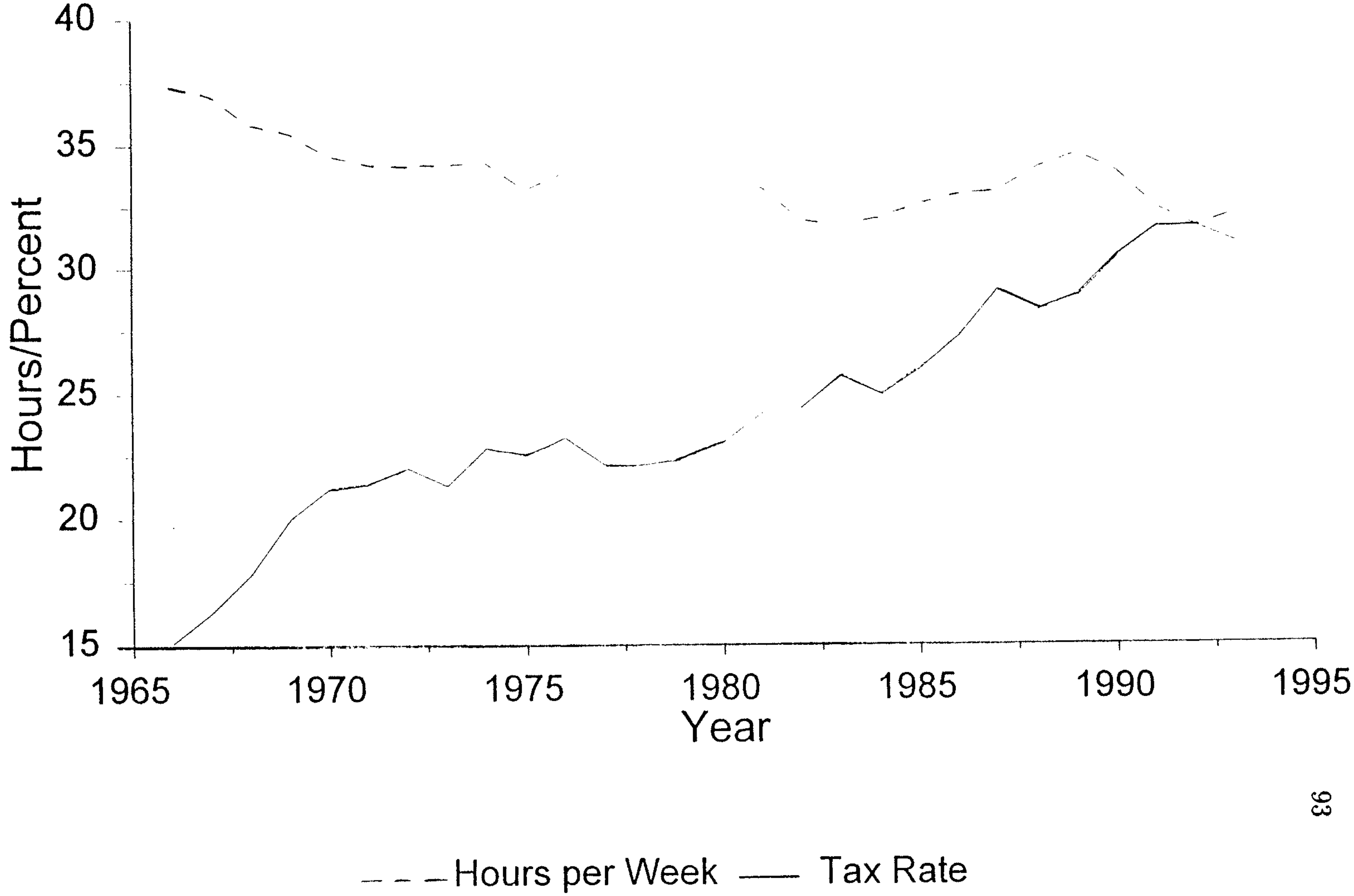


Figure 2. Aggregate Data for Canada

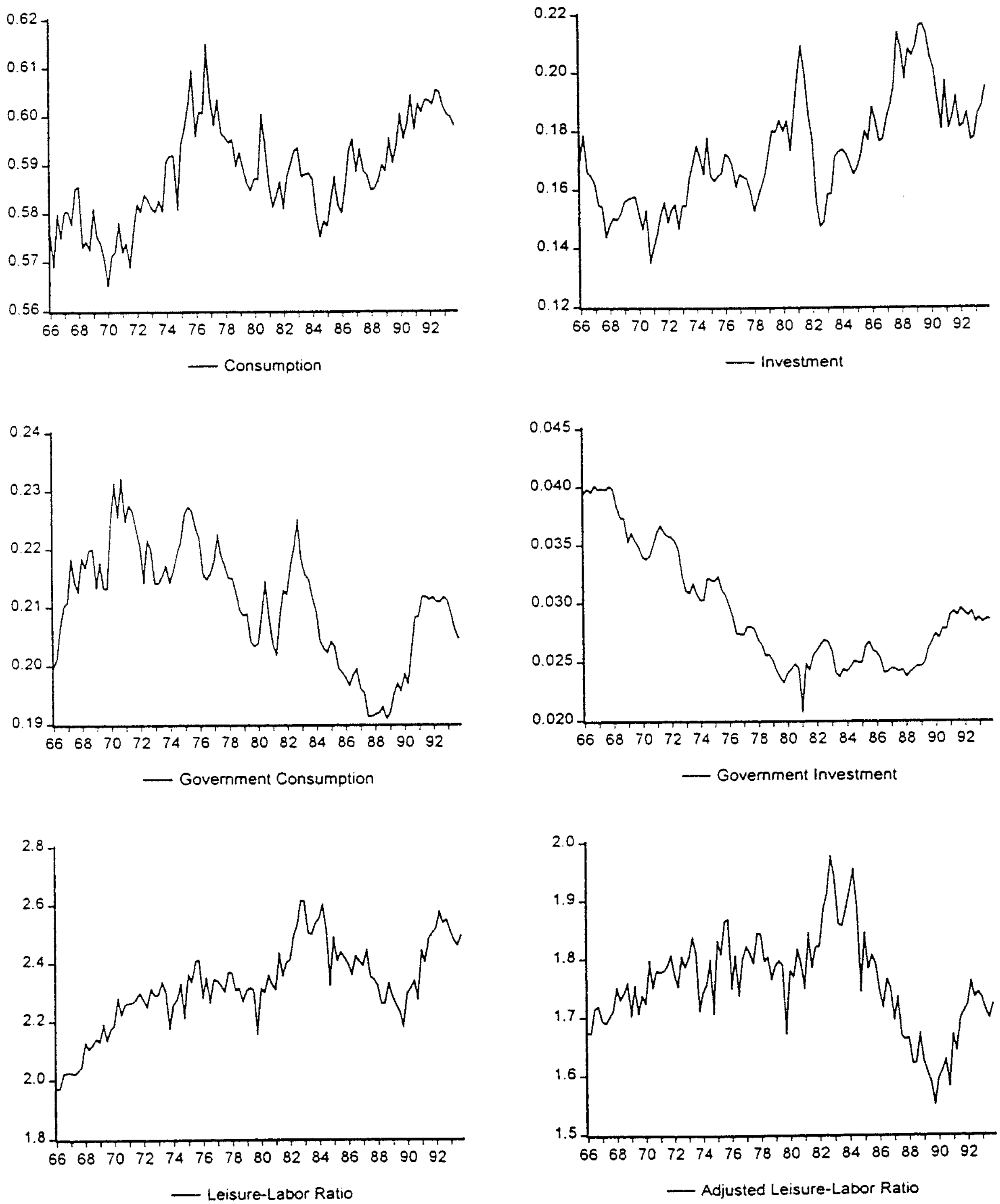


Figure 3. Realized and Fitted Values Using DGLS

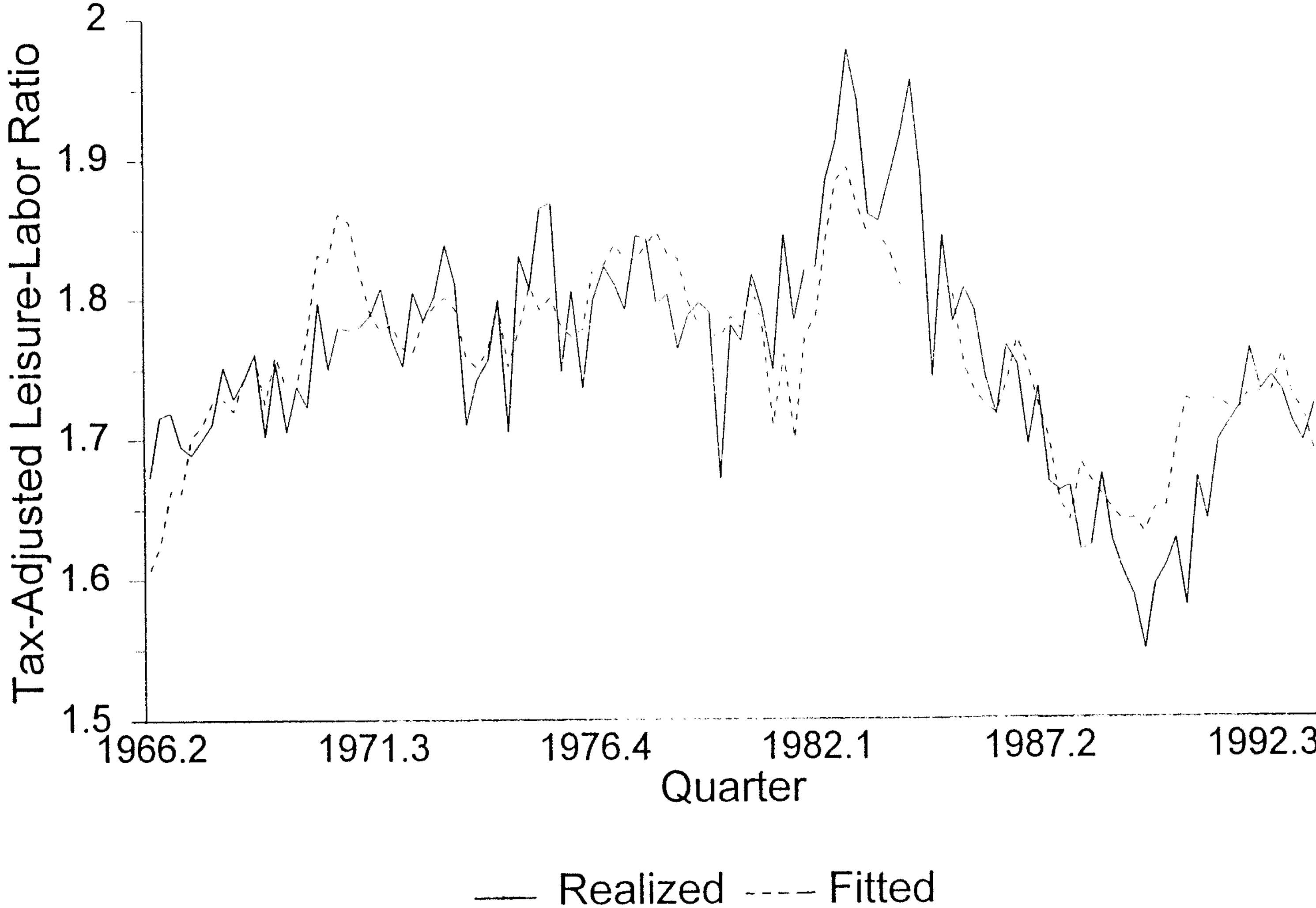


Figure 4. Response to Labor Tax Rate Innovation

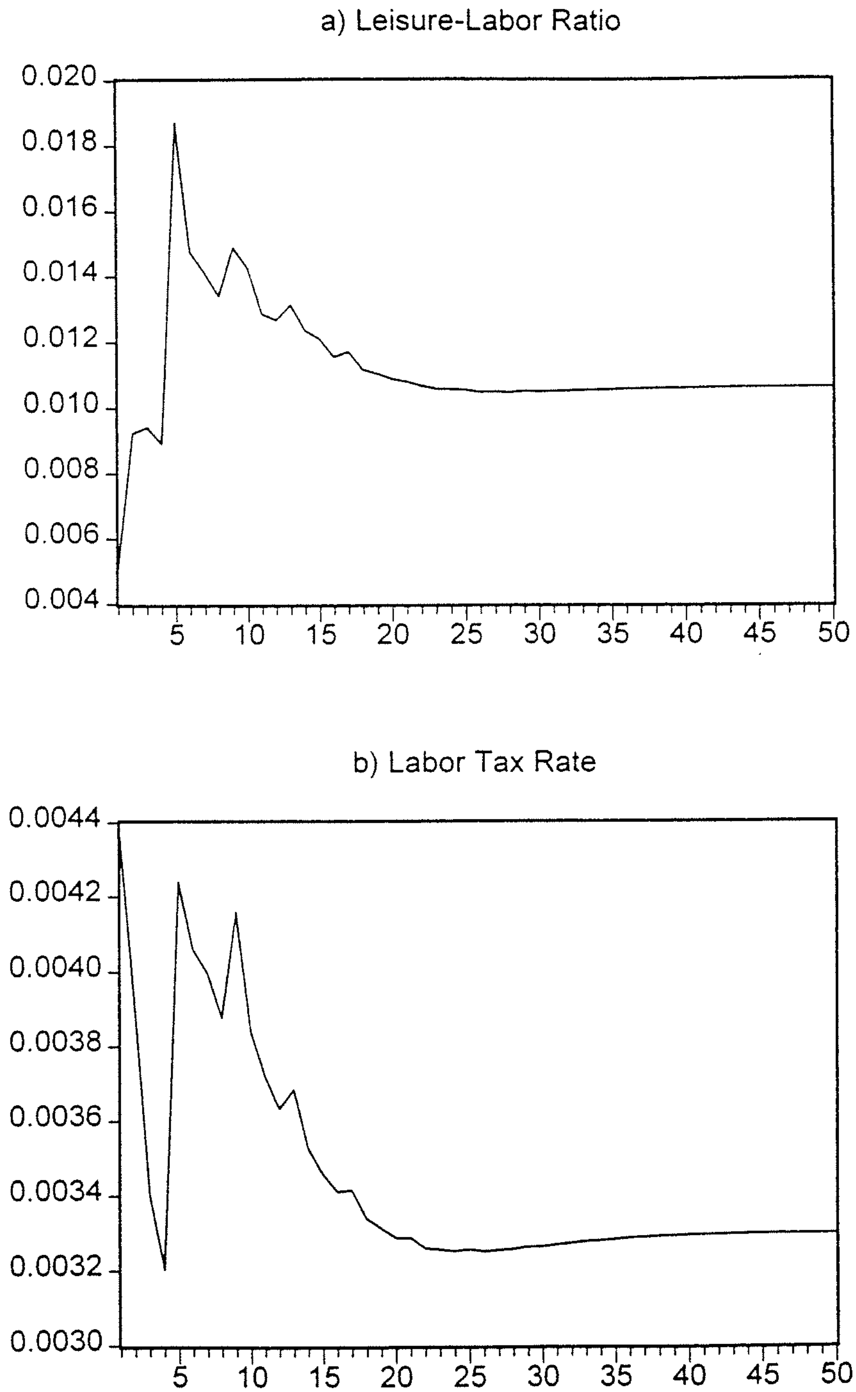
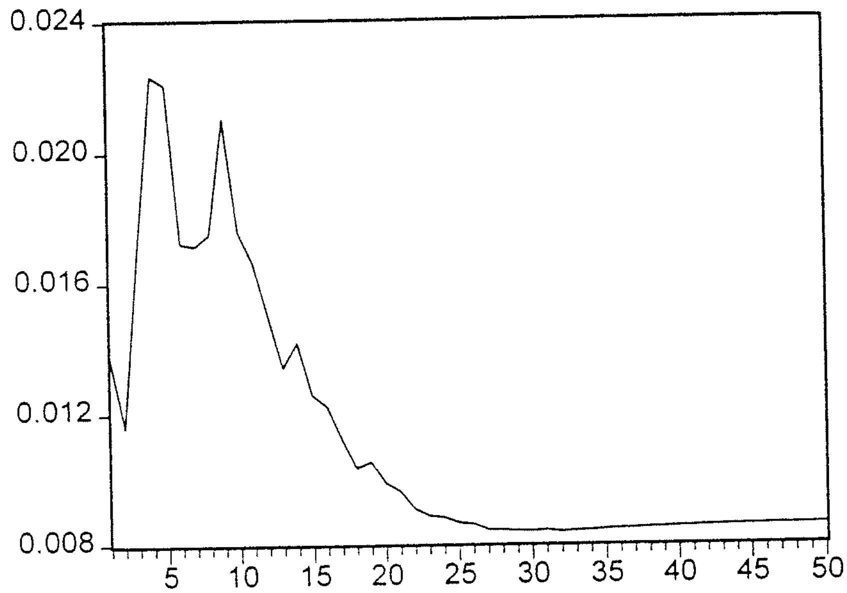


Figure 5. Response to Government Consumption Innovation

a) Leisure-Labor Ratio



b) Government Consumption

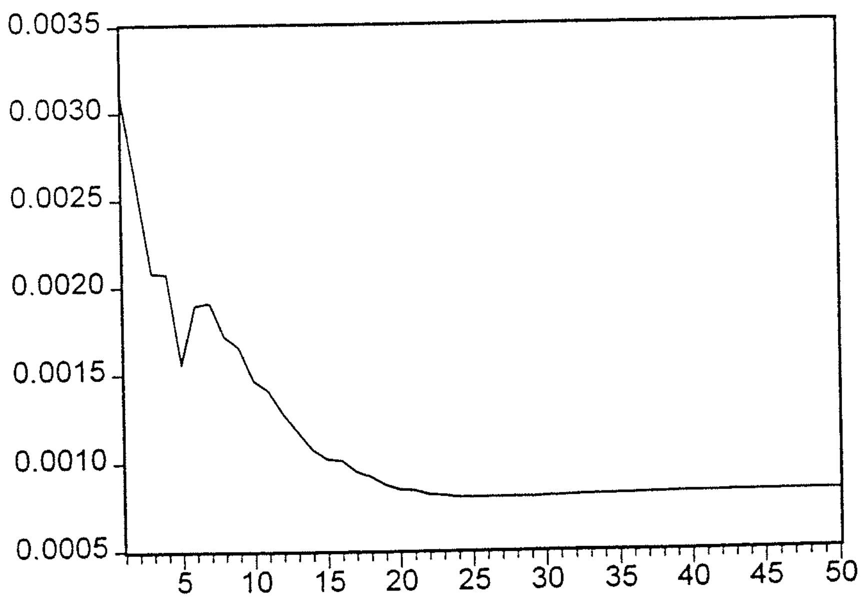
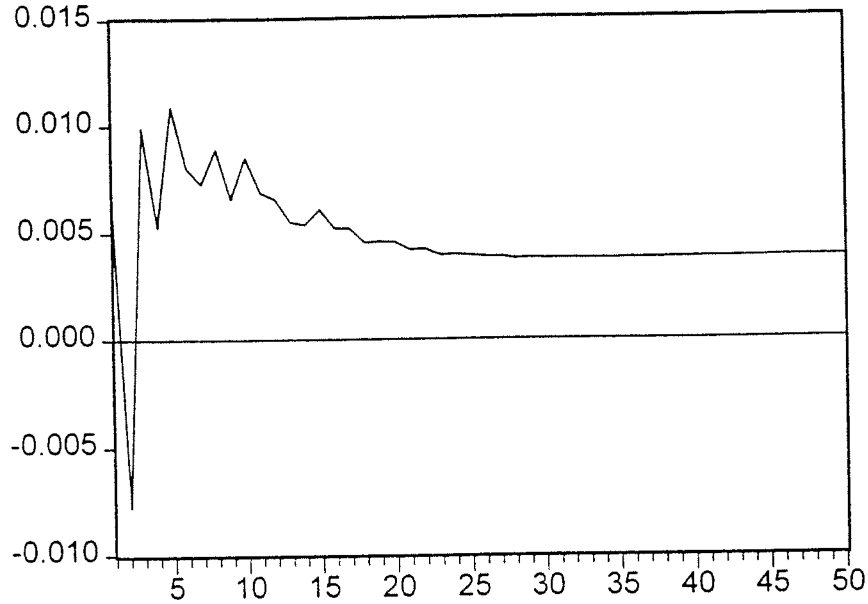
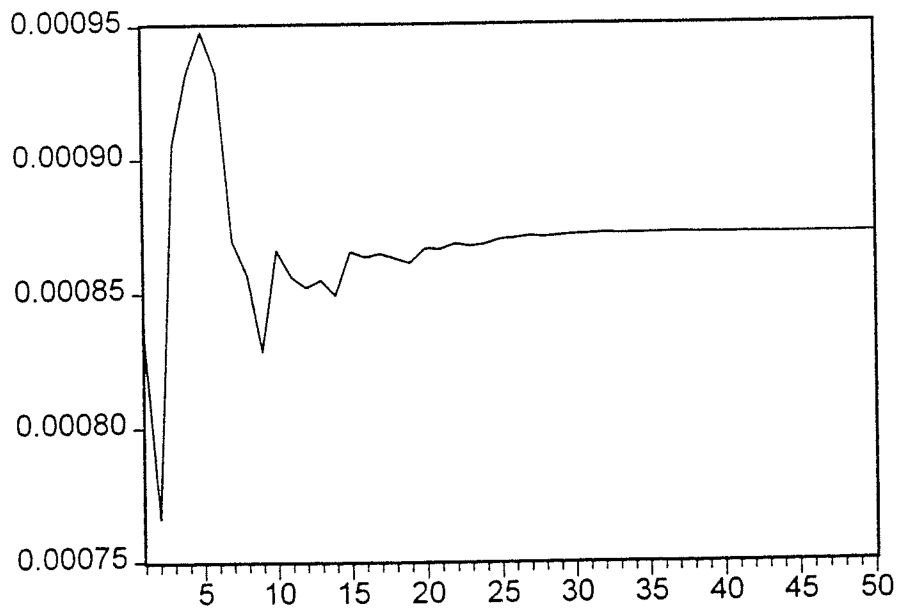


Figure 6. Response to Government Investment Innovation

a) Leisure-Labor Ratio



b) Government Investment



Labor Income Taxation, Government Spending and Labor Supply: Evidence from the USA

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1 Introduction

This paper examines empirically the effects of labor income taxation and government expenditure on labor supply using US data. As in the previous essay, the analysis is carried out using a general equilibrium model where the components of public spending can act as partial substitutes of private consumption and taxes are paid on labor income. Barro (1989a), among others, has suggested that, for a given level of fiscal spending, distortionary taxation has only second-order implications. Here we reassess this issue empirically in a general equilibrium framework. The motivation for our work comes from the following observation: Over the last thirty years, whereas labor income taxation was rising in the US, hours worked have mainly decreased, (see Fig. 1 for plots of the effective labor tax rate and the number of hours worked per person per week in the US between 1966 and 1993).[1] It is seen in Fig. 1 that the tax rate trended upward in the sixties and seventies then leveled off in the eighties.[2] In contrast, hours worked per active person trended downward in the sixties and seventies then somewhat picked up through the eighties. In connection, McGrattan and Rogerson (1998) report, using decennial censuses on population, that the number of hours per worker has decreased on aggregate and for every age and sex category between 1950 and 1990.

Several factors may explain the decline in hours worked, *e.g.* technological progress (and the ensuing rise in real wages) and increases in social security benefits, among others. Yet, taxation and government spending may have a non negligible effect on hours worked. In this paper, we reassess this issue empirically. We study the long run effects of labor income taxation and public spending on

[1]The tax rates for this graph were taken from Mendoza, Razin, and Tesar (1994) and Ruggeri, Laroche, and Vincent (1997). The series of hours worked was constructed using data on total hours worked per week and the labor force (in persons) generously provided by S. Ahmed.

[2]Recall the several tax reforms that took place in the eighties, the Economic Recovery Act, The Tax equity and fiscal responsibility act, and subsequently the deficit reduction policies in the eighties, (see for example Lee, [1995].

labor supply. We also examine whether government consumption and government investment have comparable effects on labor supply.[3] Available results on this issue (see for example Aschauer [1989, 1990], Ahmed and Yoo [1995]), suggest that changes in government investment and government consumption yield different multiplier and wealth effects.

Our results suggest that the data supports both specifications of the model with and without labor income taxation. Government spending seems to affect hours worked importantly. Moreover, our estimates imply that government spending substitutes rather poorly for private consumption.

The paper is organized as follows. Section 2 presents briefly the general equilibrium model and its solution. In section 3, we analyze the univariate properties of the series at hand, we assess the empirical implications of the model and obtain estimates for the structural parameters. Section 4 concludes.

2 The Model

2.1 Preferences and Utility Maximization

To allow comparison with the case of Canada, we build a neoclassical model along the lines of the previous essay. Specifically, we divide government spending into two categories: i) government spending on nondurable goods and services (G_1), and, ii) spending on structures and durable goods (G_2). In this manner, we attempt to distinguish public consumption from public investment. We identify G_1 as public consumption and G_2 as public investment. One must keep in mind however that government spending on structures and durables only approximates public investment given that some spending on durables can be considered as

[3]It is known that in the eighties, the composition of the US federal spending has shifted from nondefense investment towards defense and consumption purchases (see for example Lee [1995]).

consumption. In the following, we present the model's main equations. The notation and framework are as set in chapter 2.

The representative agent's problem is,

$$\underset{\{C_{t+i}, L_{t+i}\}_{i=0}^{\infty}}{Max} \quad E_t \sum_{i=0}^{\infty} \beta^i u(C^*_{t+i}, L_{t+i}) \tag{1}$$

where $\beta \in (0,1)$ is the subjective discount factor, $u(\cdot)$ is the instantaneous utility function. [4] L_t is leisure, and C^*_t is effective consumption.

As defined in chapter 2, effective consumption is a composite of private consumption (C_t), public consumption ($G_{1,t}$), and the flow of services from the stock of public capital (K^g_t) as follows:

$$C^*_t = C_t + \theta_1 G_{1,t} + \theta_2 K^g_t,$$

where θ_1 and θ_2 measure the contribution of public consumption and public capital to the agent's well-being. [5] The law of motion of public capital is

$$K^g_t = (1-\delta)K^g_{t-1} + G_{2,t}.$$

As in the previous essay, we rewrite effective consumption in terms of the flow of government spending which is readily available from the national accounts rather than in terms in the stock of capital. At the steady-state, we have:

$$K^g_t = (1/\delta)G_{2,t}. \tag{2}$$

Since our analysis focuses on the long term, it is possible then to use (2) and rewrite effective consumption as

$$C^*_t = C_t + \theta_1 G_{1,t} + (\theta_2/\delta)G_{2,t}. \tag{3}$$

---

[4] $u(\cdot)$ is concave and strictly increasing in both of its arguments as is standard.

[5] An argument for including the stock of public capital in the utility function is the following example given in Aschauer [1990]: the stock of public highways would complement automobiles in producing vacations. Alternatively, one could include government investment as an argument.

The specification in (3) allows for different degrees of substitution of G_1 and G_2 for private consumption.

We use a logarithmic utility function

$$u(C_t^*, L_t) = \log(C_t^*) + \gamma \log(L_t), \tag{4}$$

where γ is a positive constant. The agent's budget constraint is given by

$$A_{t+1} = (1 + r_t)A_t + (1 - \tau_t)w_t N_t - T_t - C_t,$$

where A_t is financial wealth, r_t is the real interest rate, τ_t is the tax rate on labor income, and T_t is a lump-sum tax (net of transfers). It is assumed that financial wealth can be held in the form of private capital [6] that is,

$$A_t = K_t,$$

Finally the total time endowment is normalized to 1 so that

$$L_t + N_t = 1. \tag{5}$$

In addition to the transversality condition, the first-order conditions that characterize the solution of the dynamic programming problem above are

$$1/C_t^* = \beta(1 + r_t)E_t\left(1/C_{t+1}^*\right) \tag{6}$$

and

$$\gamma C_t^*/L_t = (1 - \tau_t)w_t. \tag{7}$$

2.2 Production and Public Sectors

Production of the (single) consumption good is carried out by perfectly competitive firms using a constant-returns-to-scale technology of the form

$$Q_t = a_t K_t^{1-\phi} N_t^{\phi}, \tag{8}$$

[6] The results derived later are not sensitive to allowing additionally for government debt.

where Q_t is output, K_t is the private capital stock, N_t is labor (measured in hours worked), ϕ is labor share, and a_t is an exogenous productivity shock.

The representative firm chooses labor demand and the level of capital to maximize profits:

$$\pi_t = Q_t - r_t K_t - w_t N_t - \delta K_t, \tag{9}$$

where the price of the good has been normalized to 1, r_t is the rental price of capital and w_t is the real wage. The usual necessary conditions for the maximization of (9) subject to (8) obtain. They involve equalization of the rental prices of factors to their marginal productivity.

$$a_t \phi \left(K_t/N_t\right)^{1-\phi} = w_t, \tag{10}$$

and

$$a_t(1-\phi)\left(K_t/N_t\right)^{-\phi} - \delta = r_t. \tag{11}$$

Finally, the government equilibrates its budget every period:

$$G_{1,t} + G_{2,t} = \tau_t w_t N_t + T_t$$

2.3 Equilibrium Conditions

The goods-market equilibrium condition for the economy is [7]

$$Q_t = C_t + I_t + G_{1,t} + G_{2,t},$$

or, dividing both sides by output, Q_t,

$$1 = c_t + i_t + g_{1,t} + g_{2,t}, \tag{12}$$

[7] This condition implicitly treats the economy as closed.

where the lower-case letters denote ratios-to-GNP.

Using the first order conditions for the consumers and the firms, the definition of effective consumption and the equilibrium condition (12) yield

$$(1-\tau_t)x_t = (\gamma/\phi)\left[1-(1-\theta_1)g_{1,t}-(1-\theta_2/\delta)g_{2,t}-i_t\right], \tag{13}$$

where the term

$$x_t = (1-N_t)/N_t,$$

is the leisure-labor ratio. Equation (13) is the same as in the previous essay. It relates fiscal policy and the agents' labor supply decision and generates empirical predictions that can be compared with actual data. Notice that by examining the variables as percentages of GNP, any trend effect associated with population growth is eliminated. Also, multiplicative increases in factor productivity (whether due to technology shocks, public capital, or government consumption) cancel out in the derivation of (13) and, as a result, have no bearing on its empirical predictions.

The above model includes several interesting specifications as special cases. First, by setting $\tau_t = 0$ for all t one obtains a model with no distortionary labor taxation, (as in Ahmed and Yoo [1995]). [8] The expression of (13) for this restricted version of the model is

$$x_t = (\gamma/\phi)\left[1-(1-\theta_1)g_{1,t}-(1-\theta_2/\delta)g_{2,t}-i_t\right]. \tag{15}$$

[8] Actually Ahmed and Yoo(1995) consider separately government spending on structures (g_2), and government spending on durables (g_3). Government spending on structures does not enter the expression of effective consumption and therefore its coefficient is 1. The corresponding estimated equation is

$$x_t = (\gamma/\phi)\left[1-i-(1-\theta_1)g_1-g_2-(1-\theta_3)g_3\right]. \tag{14}$$

Second, one could consider the case where government expenditure does not substitute for private consumption by setting $\theta_j = 0$ for $j = 1, 2$, in (13) to obtain:

$$(1 - \tau_t)x_t = (\gamma/\phi)\left[1 - g_{1,t} - g_{2,t} - i_t\right]. \tag{16}$$

Finally, one could consider the case with no taxes and where government expenditure does not substitute for private consumption by setting $\tau = 0$ and $\theta_j = 0$ for $j = 1, 2$ in (13) to obtain:

$$x_t = (\gamma/\phi)\left[1 - g_{1,t} - g_{2,t} - i_t\right]. \tag{17}$$

3 Econometric Analysis

3.1 The Data

The data set consists of 109 quarterly, seasonally-adjusted observations of consumption, investment, government spending on nondurable goods and services, government spending on structures and on durables, and the leisure-labor ratio for the US. [9] All variables, except for the leisure-labor ratio, are in constant 1987 dollars. The sample period is from 1966:1 to 1993:1. The leisure-labor ratio was obtained using the calculation suggested in Ahmed and Yoo [1995]. The total endowment of time available to the economy per year is defined as $EE = 12 * 365 * LF/4$, where LF is the labor force (in thousand of persons) and 12 is the number of hours per day excluding sleep and personal care. The leisure-labor ratio is then computed as $x = (EE - TN)/TN$ with TN denoting the total number of hours worked. The tax-adjusted leisure-labor ratio, $(1-\tau_t)x_t$, is calculated assuming that the annual tax rate applies equally in all four quarters of the year.

[9] The data was generously provided by S. Ahmed, the source is Citibase.

3.2 Univariate Properties of the Series

We examine in this section the time-series properties of the data. Figure 2 contains the plots of private consumption, private investment, government consumption (g_1), as well as public investment (g_2), as percentages of GNP. It also contains plots of the leisure-labor ratio, both adjusted for the tax and unadjusted. The graphs suggest that, except for the ratio of investment to GNP, the variables are likely to be integrated of order 1. This is confirmed by the results of Augmented Dickey-Fuller (ADF) unit-root tests reported in table 1. In all ADF tests, the choice of the optimal level of augmentation, (*i.e.,* the number of lagged first differences included in the OLS regression) was based on the recursive application of t-tests as suggested in Perron and Ng [1995]. For most of the variables under consideration, the natural alternative to estimate in the ADF test is that of an autoregression with a constant term but no trend. These results indicate that the null hypothesis of a unit root cannot be rejected at standard significance levels for any of the variables considered, except the private investment to GNP ratio. For completeness, we also present the test results obtained for the alternative of stationarity around a deterministic time trend (see column 5). Similar results are also reported by Ahmed and Yoo [1995] using US data for the somewhat-larger sample period 1955:1 to 1993:1. [10]

In addition, the hypothesis of a unit root cannot be rejected at standard significance levels for the effective labor tax rate series . This conclusion is in line with Mendoza, Razin, and Tesar's observation that while taxes on consumption and capital income appear stationary, the tax rate on labor income has followed an upward trend for all countries in their sample. This trend appears to be stochastic rather than deterministic. Comparable results were obtained for Canada. The

[10] Again, in Ahmed and Yoo, g_2 includes only spending on structures while durables enter as a separate category. However results of stationarity are generally the same, (g_1), (g_2) and (g_3) are all I(1).

fact that the US investment to output ratio is found stationary is consistent with the implication of the neoclassical growth model that this ratio is constant (or stationary) at the steady state. [11]

3.3 Tests of the Empirical Implications

The above results allow us to empirically frame the equilibrium conditions derived in section 2 in terms of cointegrating relations [Engle and Granger (1987)]. Since the private investment to GNP ratio was found to be stationary, we focus for the rest on the non-stationary variables of the model, i.e. government consumption, government investment as ratios to GNP and the leisure-labor ratio both adjusted for the tax and non adjusted. Two types of cointegration tests are employed. First, the null hypothesis of no cointegration is tested using the residual-based approach proposed by Engle and Granger (1987), (EG). We also use Johansen's Maximum Likelihood (ML) procedure [Johansen (1988, 1991)].

Results for equations (13), (15), (16), and (17) are respectively presented in the top four rows of table 2. Recall that (15) ignores distortionary taxation by assuming that the labor tax rate is zero in all periods, and that (17) corresponds to the case with no tax and no substitutability between public expenditure and private consumption obtained when $\theta_1 = \theta_2 = 0$ in (15). Equation (16) corresponds to the case with no substitution between public and private consumption in (13). The test statistics in column 3 indicate that the null hypothesis of no

[11] This well known result is related to the fact that the interest rate is constant in the steady state and determined by the rate of time preference. We also present in the last row of the table the ADF test result for the sum of public and private consumption ($c + g_1 + g_2$) which theoretically should be stationary given that i is stationary (see equation (12)). The unit root null for this aggregate can not be rejected. This may indicate one of two things. The tests have low power or the ratio of the current account to GNP ratio is not stationary. Actually, for the period considered it is known that the deficit of the US current account has been very persistent, probably persistent enough to be described by a non stationary process.

cointegration is rejected at the 5% significance level for (13), that includes labor taxation and at the 1% level for (15), that does not include taxation. The results are the same for the specifications where public expenditure does not substitute for private consumption, this is done by regressing x (or alternatively $(1-\tau)x$) on the sum $(g_1 + g_2)$; the null hypothesis of no cointegration is rejected at the 5% level for (16) that includes taxation and the 1% for (17) that does not. Therefore, the rejection is stronger for the cases without tax. These results seem to indicate that the presence of distortionary taxation *per se* does not affect the cointegrating properties of the model.

We also employ the trace test [Johansen (1988, 1991)] to verify the number of cointegrating relations among the variables. The number of lags to be included in the Vector Error Correction (VEC) model was chosen using a sequence of Likelihood Ratio tests in a vector autoregression in levels as suggested by Enders (1995). Results for this test are presented in table 3. They indicate the presence of one cointegrating relation at the 5% (none at the 1%) significance level for the model with taxes, and two (one at the 1%) for the specification without taxes. They also indicate the presence of one cointegration vector in the case where g_1 and g_2 are summed up. This globally confirms the Engle Granger test results. Therefore, the data is compatible with both specifications of the model with and without labor income taxes. The cointegration relations hold with the leisure labor ratio and the tax-adjusted leisure labor ratio as regressand. In order to discriminate between the two specifications, further analysis would be required.[12] Given these results, we proceed to estimate the corresponding cointegrating vectors in the next section, and compare them to previous findings in the literature.

[12]This would probably imply the use of different econometric techniques such as non nested testing, or also take account of changes in taxation by structural shifts etc. however, this is not the topic of the paper. The same remark holds also for Canada, but, there, the results were different in terms of cointegration.

3.4 Estimates of the Structural Parameters

The estimation of the cointegrating relations (13) and (15) provides us with estimates of the structural parameters of the model. We employ the DGLS method proposed by Stock and Watson (1993) that is asymptotically equivalent to maximum likelihood [Gonzalo (1994, p. 204)] but makes use of the restrictions of the general-equilibrium model; that is the coefficient estimates are asymptotically efficient. This approach involves running the OLS regression

$$\begin{aligned}(1-\tau)x_t = \; & \alpha + \rho_1 g_{1,t} + \rho_2 g_{2,t} + \sum_{s=-p}^{p} \xi_{1,s}\Delta g_{1,t-s} \\ & + \sum_{s=-p}^{p} \xi_{2,s}\Delta g_{2,t-s} + u_t \end{aligned} \tag{18}$$

or alternatively:

$$\begin{aligned} x_t = \; & \alpha + \rho_1 g_{1,t} + \rho_2 g_{2,t} + \sum_{s=-p}^{p} \xi_{1,s}\Delta g_{1,t-s} \\ & + \sum_{s=-p}^{p} \xi_{2,s}\Delta g_{2,t-s} + u_t \end{aligned} \tag{19}$$

where α is an intercept, ρ_i and ξ_i denote constant coefficients, and u_t is a disturbance term. The serial correlation of the residuals (if any) is then characterized and the model is reestimated using GLS. The appropriate number of leads and lags is selected by the sequential application of F-tests starting with the maximum number $p = 5$. Test results indicate for (18) that the fifth lags and leads are not significant but the fourth are. For (19) the fifth leads and lags are significant, and so equations (18), (19), are estimated with $p = 4$ and $p = 5$ respectively. The residuals of the OLS regression were parameterized as an AR(1) process based on the regression of $\hat{u}_t$ on four of its lags but no constant [13]. Results for the GLS regressions are presented in table 4.

From the reduced-form parameters, it is possible to construct estimates of the structural parameters of interest, mainly the $\theta's$ and γ. From the estimates

[13]The coefficients of the second to fourth lag were not significantly different from zero at standard levels for both equations.

of the intercept and the level and first difference of government consumption and investment, it is possible to have point estimates of the θ-coefficients. For example, an estimate of θ_1 can be computed from the estimation of (18), (see table 4.a), as $\theta_1 = (\rho_1 + \xi_{1,0})/\alpha + 1 = (1.84 - 2.36)/1.69 + 1 = .69$ (1.03) where the standard error (in parenthesis) is obtained using the delta method. Similarly, $\theta_2 = ((-8.50 + 9.09)/1.69 + 1) * .025 = .03$ (.05), where .025 is the rate of depreciation of capital per quarter. Note also that the estimated intercept corresponds to the ratio γ/ϕ. Prescott (1986) reports that labor share has been roughly constant in the US at $\phi = 0.64$ over the postwar period. Therefore, multiplying the intercept estimate, $\alpha = \gamma/\phi = 1.69$ (.27), by 0.64 yields an estimate of $\gamma = 1.08$ (.18), where the terms in parenthesis denote standard errors. This estimate is somewhat smaller than the ones estimated by other authors but still significantly different from 0. Braun (1994) finds values between 4.21 and 5.29. McGrattan (1994a) estimates $\gamma = 2.95$. In calibrated models, Hansen (1985), Prescott (1986), McGrattan (1994b) and Ohanian (1997) employ values of γ between 1.5 and 2.366. Recall that γ measures the weight of leisure in utility. A larger value of γ implies a larger substitution between consumption and leisure following a change in the after-tax real wage.

Using the cointegrating relation between the leisure labor ratio, x, and g_1, g_2, (table 4.b), we obtain $\gamma = 2.29$ (.19), and the estimates $\theta_1 = .65$ (.67), and $\theta_2 = .007$ (.03).

Our estimates of the θ's are positive and smaller than 1 as usually expected, the estimates of θ_1 are close to what is obtained in the existing literature. Using US data, Kormendi (1983) finds $\theta_1 = 0.28$ (0.15), and $\theta_2 = -.07$, [14] Ahmed and Yoo (1995) obtain $\theta_1 = 0.94$ for nondurable government consumption. Using

[14]Because Kormendi's actually estimates $-\theta_c$ and $-\theta_i$ from an OLS regression of consumption on government consumption, government investment and other variables, he reports -0.28 and -0.07 in his article (see table 6 in p. 1006).

total government expenditure, Aschauer (1985) reports values between 0.23 and 0.42 depending on the number of lags employed in the estimation procedure and McGrattan (1994a) finds $\theta = -0.026$ (0.126).

The finding that θ_1 is several times larger than θ_2 implies that the negative wealth effect on the consumers from an increase in government investment is greater (in absolute value) than the effect from an increase in government consumption. This result is consistent with Aschauer's finding (Aschauer, 1990) that public net investment in infrastructure capital has a dramatically larger impact on output than does military investment or public consumption expenditure.[15] However the standard deviations we obtain are large so that the estimates from both (18) and (19) are not statistically different from 0. Estimates smaller than 0 are also included in a one standard deviation confidence interval. These findings are again consistent with findings in the existing literature, particularly McGrattan's and suggest that public spending substitutes rather poorly for private consumption.

The estimate of γ obtained using the leisure labor ratio as regressand is found to be larger than that obtained from the tax adjusted leisure labor ratio (2.29 and 1.08 respectively). This suggests that the marginal rate of substitution between consumption and leisure in the latter case is less important than in the former. In other words, the weight of leisure in utility in the case with taxes is smaller, the substitution between consumption and leisure being mitigated by the effect of the tax. This is theoretically expected due to the presence of a tax on labor income, especially that consumption is not taxed in this model. Braun (1994) finds a value of 4.21 for the specification with taxes on labor income and capital income and a larger value of 5.59 for the specification with lump-sum taxes.

[15]In our case, we do not distinguish military from non military government expenditure, however the comparison between the effects of public consumption and public investment is still relevant.

In brief, the data supported both steady state implications of the model with and without labor income taxation. Estimates of θ are smaller than one and close to what is found in the literature. This suggests a negative but less than one for one wealth effect of an increase in government spending. However these estimates do not seem to be significantly different from zero, in particular θ_2. For the period under consideration, g_1 which is the most important component of public spending, has decreased by 3 percentage points, or by 17%, g_2 has decreased from .06 to .04, or by 33 % , and the leisure labor has increased by 36% (from 1.74 to 2.36). These observations are consistent with a negative wealth effect of an increase in government spending. In the data it is the case for a positive effect on leisure of a decrease in g.

As an additional but informal check of the relative performance of the different specifications, consider figures 3 and 4 that contain plots of realized and fitted values (fitted by DGLS estimation) of the tax-adjusted and unadjusted leisure-labor ratio. Figure 3 uses as regressors g_1 and g_2 separately while figure 4 uses their sum. It can be noticed first that the fitted values in figure 3 track well the movement of the actual series both the leisure labor ratio (panel b) and the tax-adjusted leisure labor ratio (panel a).[16] Also, the model with g_1 and g_2 separate, (figure 3) track more successfully the trend of the actual variable relative to the case where they are summed up (figure 4). This result suggests that it might be important to distinguish between public consumption and public investment in order to evaluate the effects of government spending on the labor supply and consequently on output. This distinction is potentially more important than taking account of distortionary taxation.

To the contrary, the study for Canada has established the empirical importance of distortionary taxation. The difference in results for the two countries

[16]The correlation between the fitted value and the actual value in figure 3 is .93 for the leisure labor ratio, and .84 for the tax adjusted leisure labor ratio.

shouldn't be surprising. The reason may be due to institutional differences between the two countries. Several authors who have examined the widening gap in the unemployment rate between the US and Canada have advanced several explanations; mainly, the differing degree of unionization, government social transfers programs, payroll taxes (Card and Freeman (1996), Côté and Hostland (1997), St-Amant and Tessier (1998) among others). While we do not directly examine the unemployment rate in this paper, we can still relate to these analysis but by examining a different measure of the labor market performance which is the leisure labor ratio. Consequently these institutional differences may explain the different results obtained for the two countries.

4 Conclusion

This paper has examined the role of labor income taxation on labor supply. The above results suggest that both specifications of the model *i.e* with and without taxation are supported by the data in the USA. Changes in government spending are important for the leisure labor choice, with government consumption and government investment being distinguished. The estimated coefficients of substitution between public and private spending are close to what is expected even though they are not significantly different from zero. Also, the fitted values from estimation replicate well the observed trend in the leisure labor ratio. Finally, further analysis is needed in order to assess the distortionary nature of the tax. We leave also for later research the implied long run effects of the two types of government spending on consumption and leisure when financed by lump-sum taxes relatively to labor income taxation financing.

Table 1. Augmented Dickey-Fuller Test Results

USA, (1966:1 1993:1)

Variable	Without Trend		With Trend	
	k	t-Statistic	k	t-Statistic
c	1	−1.78	1	−2.86
i	6	-4.05^{**}	6	-4.05^{**}
g	3	−2.48	3	−2.44
g_1	1	−1.60	1	−1.71
g_2	0	−1.79	0	−1.09
$(1-\tau)x$	1	−2.23	1	−2.60
x	1	−2.24	1	−2.42
τ	1	−2.63	1	−1.30
$c+g$	0	−2.15	0	−2.19

Notes: k denotes the level of augmentation of the test (*i.e.*, the number of lagged first differences included in the OLS regression) and was chosen using the *t-sig* criterion in Perron and Ng (1995). All data is quarterly except for the effective tax rates that are on an annual basis. The superscripts ** and * denote the rejection of the null hypothesis of a unit root at the 1% and 5% significance levels, respectively; $g = g_1 + g_2$.

Table 2. Residual-Based Cointegration Test Results

Variables	k	t-Statistic
$(1-\tau)x, g_1, g_2$	2	-3.96^{*}
x, g_1, g_2	3	-4.51^{**}
$(1-\tau)x, g_1 + g_2$	1	-3.68^{*}
$x, g_1 + g_2$	3	-4.46^{**}
x, τ, g_1, g_2	2	-3.41

Notes: k denotes the level of augmentation of the test (*i.e.*, the number of lagged first differences included in the OLS regression) and was chosen using the *t-sig* criterion in Perron and Ng (1995). In all cases a constant term was included in the regression. The superscripts **, *, and † denote the rejection of the null hypothesis of no cointegration at the 1%, 5%, and 10% significance levels, respectively.

Table 3. Johansen Cointegration Test Results

Variables	k	Eigenvalue	LR Statistic	5% (1%) Critical Value	Null Hypothesis
$(1-\tau)x, g_1, g_2$	4	0.18	40.80	34.91 (41.07)	None*
		0.13	19.76	19.96 (24.60)	At most 1
		0.04	4.59	9.24 (12.97)	At most 2
x, g_1, g_2	4	0.17	44.81	34.91 (41.07)	None**
		0.15	24.53	19.96 (24.60)	At most 1*
		0.07	7.43	9.24 (12.97)	At most 2
$(1-\tau)x, g_1 + g_2$	2	0.16	25.33	19.96 (24.60)	None**
		0.05	6.26	9.24 (12.97)	At most 1
$x, g_1 + g_2$	8	0.15	24.86	19.96 (24.60)	None**
		0.08	8.47	9.24 (12.97)	At most 1

Notes: k denotes the level of augmentation of the test (*i.e.*, the number of lagged first differences included in the VECM) and was chosen using the procedure suggested by Enders (1995). In all cases a constant term was included in the regression. The superscripts ** and * denote the rejection of the null hypothesis at the 1% and 5% significance levels, respectively.

Table 4.a. Estimates of Cointegrating Relation, (18)

Dependent variable $(1-\tau)x$

Variable	Estimate	Standard Error	t-Statistic
intercept	1.69	0.27	6.32^{**}
$g_{1,t}$	1.84	2.32	.79
$g_{2,t}$	−8.50	3.06	-2.78^{**}
$\Delta g_{1,t}$	−2.36	1.98	−1.19
$\Delta g_{2,t}$	9.09	3.74	2.43^{*}

Table 4.b. Estimates of Cointegrating Relation, (19)

Dependent variable x

Variable	Estimate	Standard Error	t-Statistic
intercept	3.58	0.30	11.88^{**}
$g_{1,t}$	−5.93	2.60	-2.28^{*}
$g_{2,t}$	−11.22	3.43	-3.27^{**}
$\Delta g_{1,t}$	4.69	2.77	$1.69^{\dagger}$
$\Delta g_{2,t}$	8.73	4.97	$1.76^{\dagger}$

Notes: The superscripts **, *, and † denote the rejection of the null hypothesis that the coefficient is zero at the 1%, 5%, and 10% significance levels, respectively.

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FIG.1 HOURS WORKED & LABOR TAX RATE (USA)

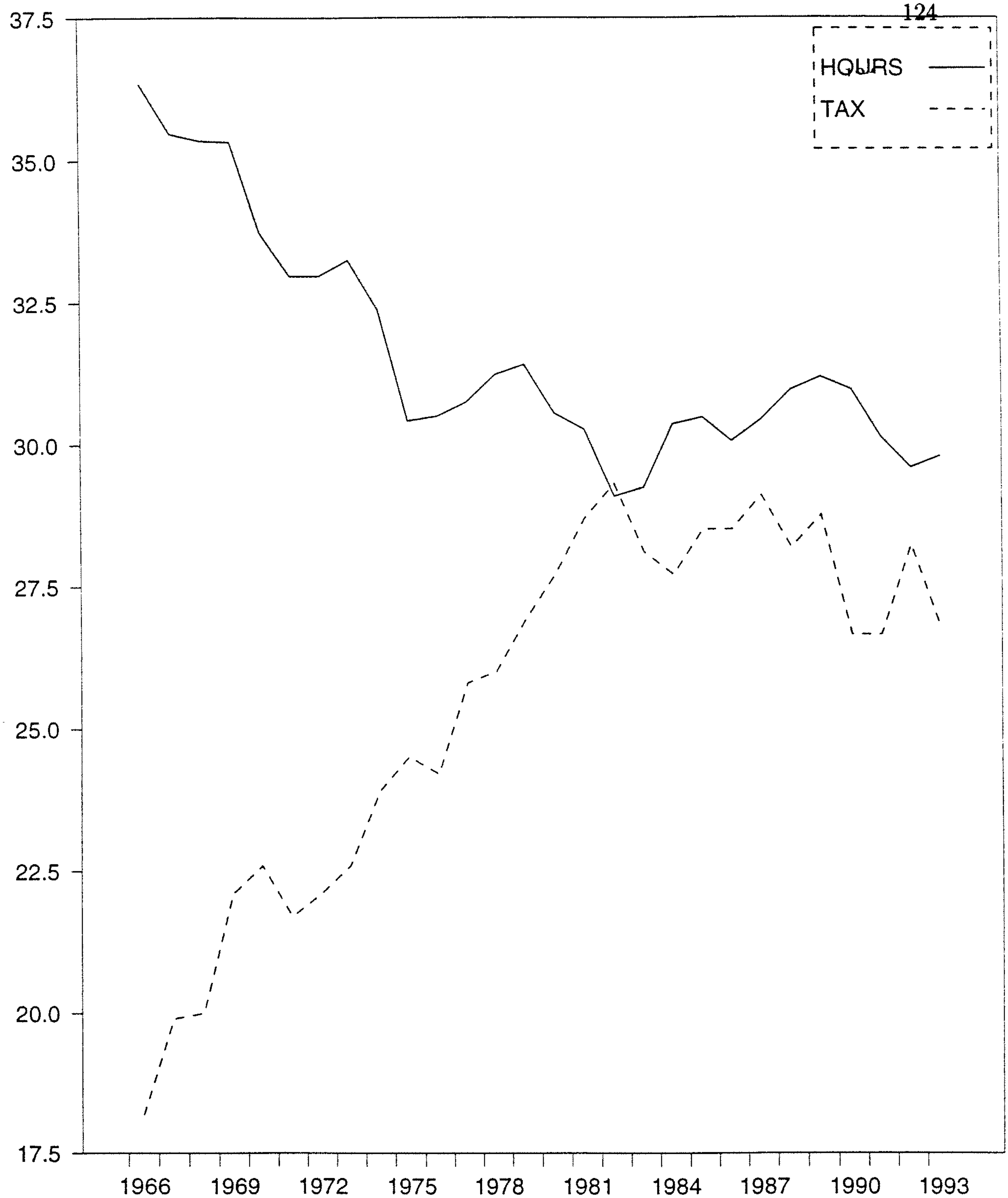


FIG.2 PLOTS OF AGGREGATE DATA FOR THE US

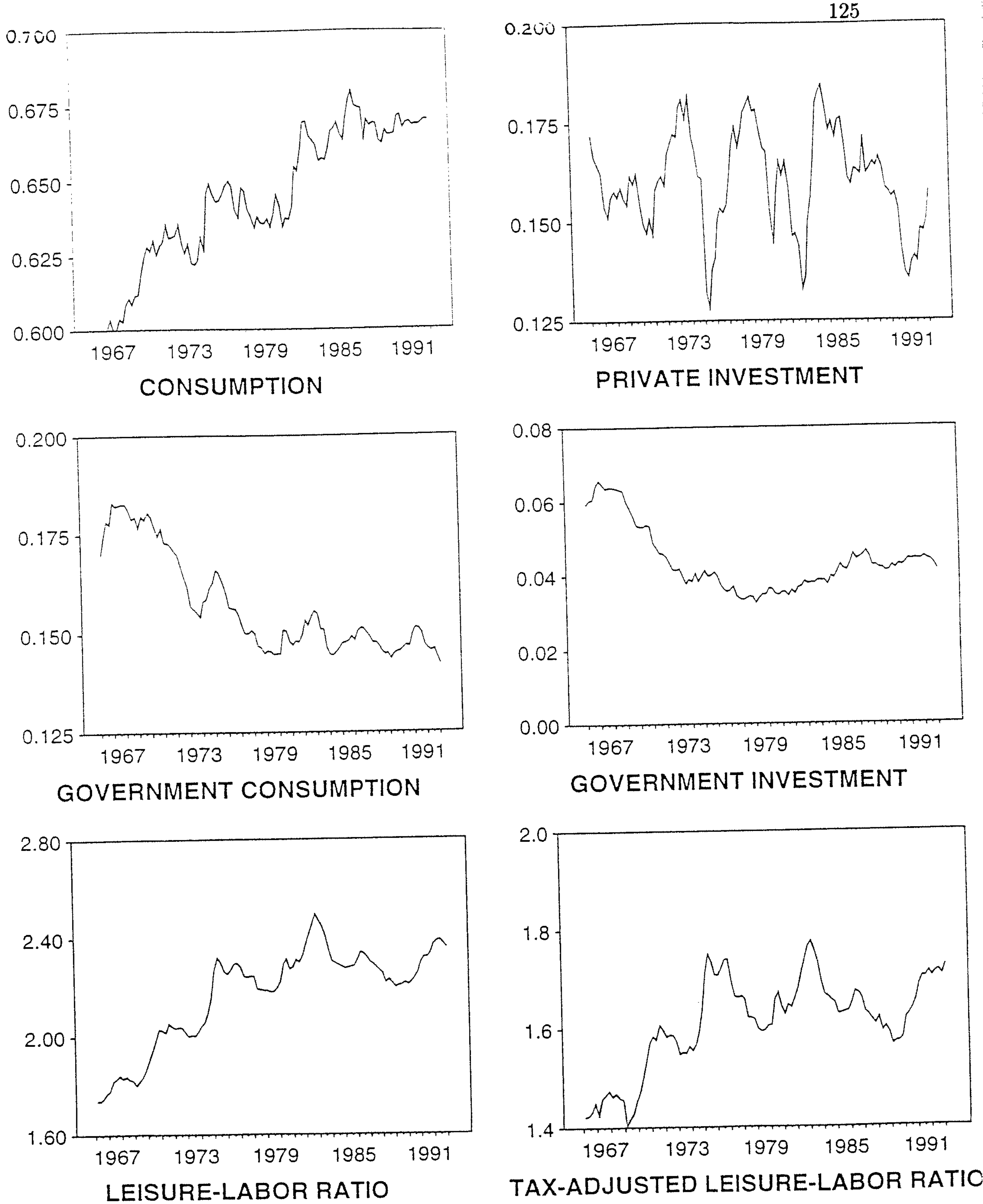


Fig.3 Realized & Fitted values

a.Regression of (1-l)x on g1,g2

b.Regression of x on g1,g2

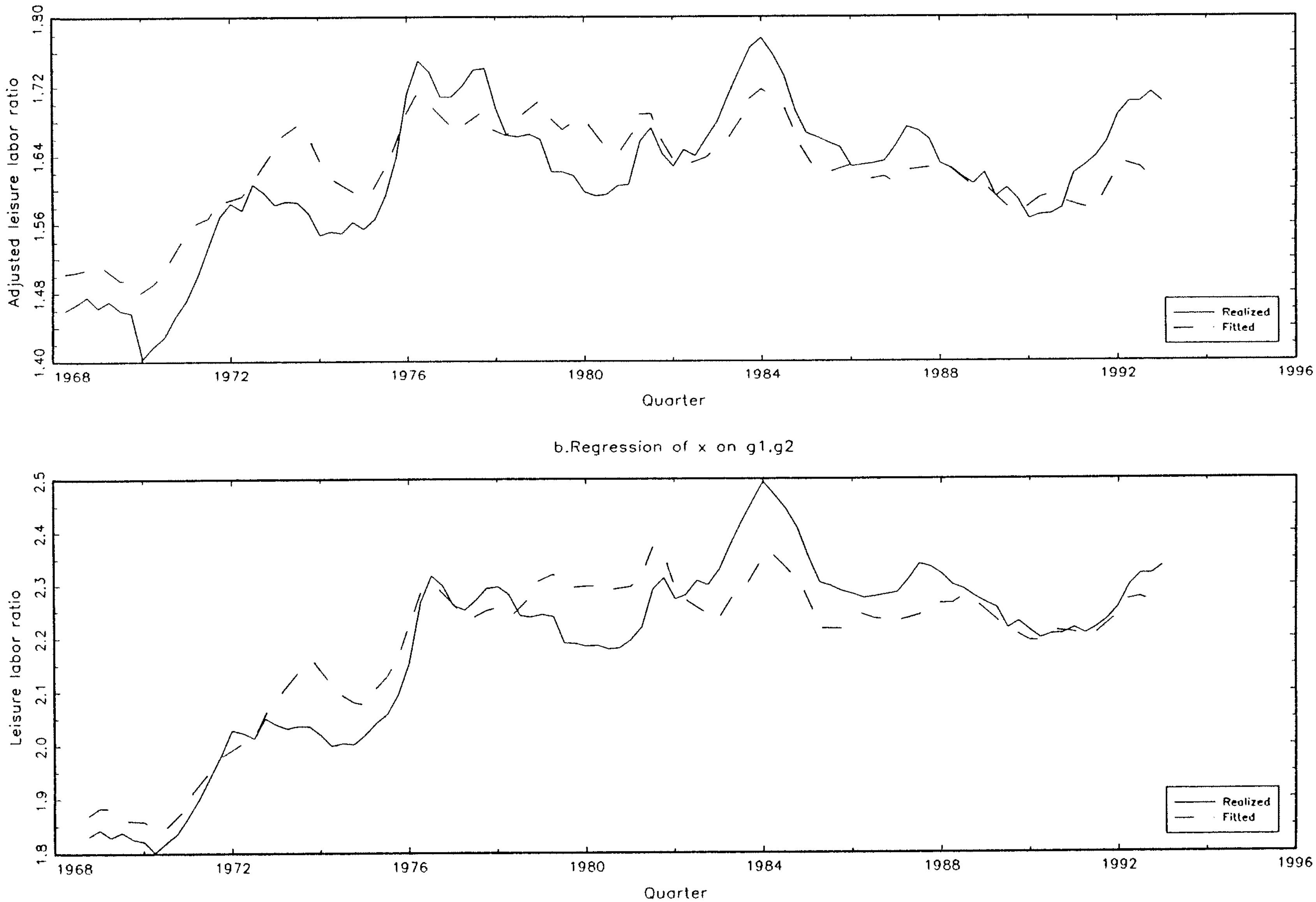
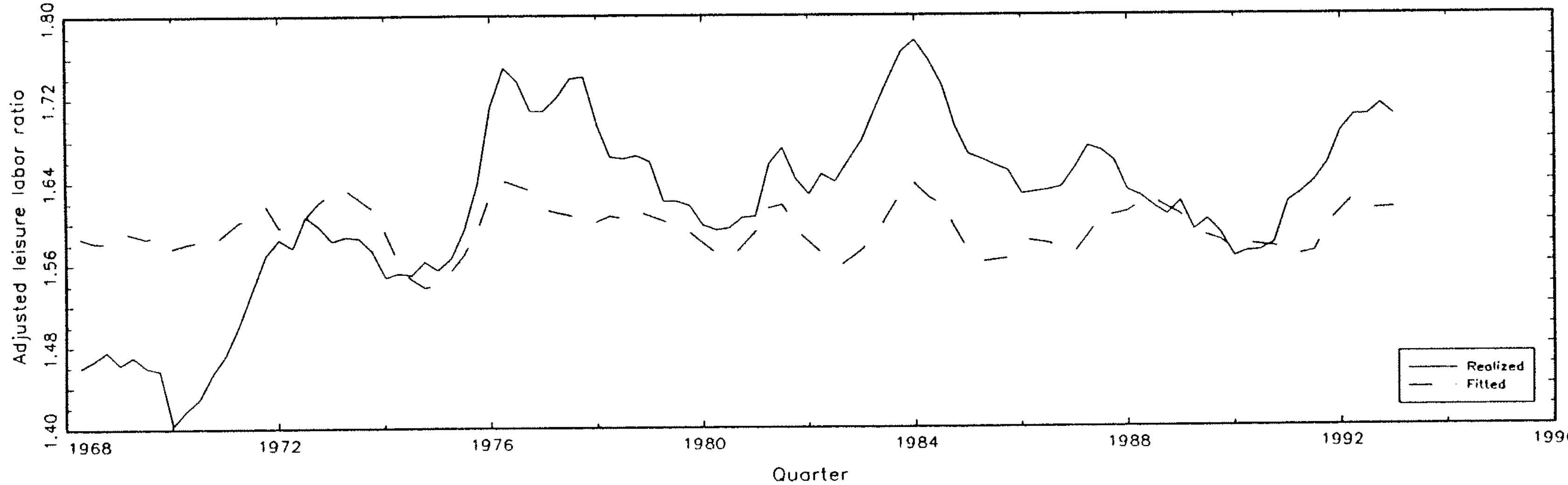
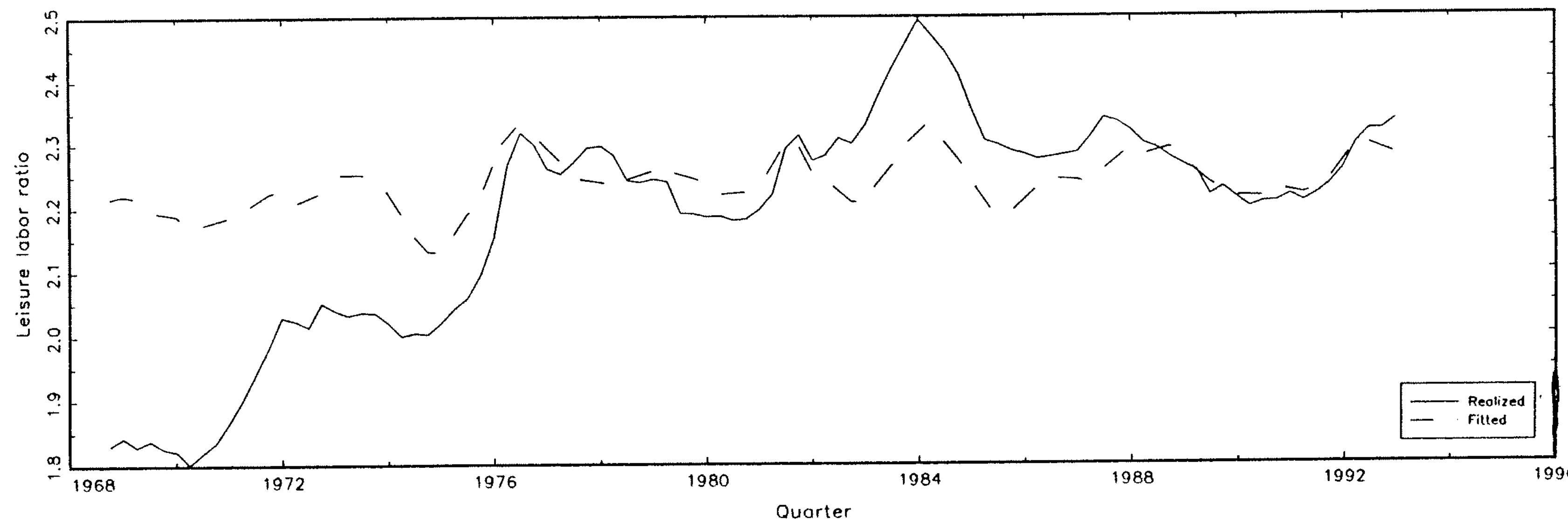


Fig.4 Realized & Fitted values

a.Regression of (1−t)x on g



b.Regression of x on g



Conclusion

Dans cette thèse, j'ai étudié les effets des politiques fiscales sur l'activité économique dans le cadre d'un modèle stochastique d'optimisation dynamique d'équilibre général . Dans le premier essai, j'ai utilisé un modèle calibré étendu à un cadre international et incluant des biens échangeables et des biens non échangeables pour étudier les effets de chocs de nature fiscale. Les fluctutations des dépenses publiques et de trois taux de taxation ont été considérées: la taxation de la consommation, du revenu du travail et du revenu de capital. Les résultats ont montré qu'un modèle avec chocs aux politiques gouvernementales performe relativement mieux comparé à un modèle avec chocs technologiques seulement comme source des fluctuations agrégées. Les chocs aux politiques fiscales semblent avoir des efffets importants sur les fluctuations du cycle économique international, même s'ils ne réussissent pas à résoudre tous les puzzles observés. Un modèle avec de tels chocs reproduit bien la corrélation négative entre output relatif et prix relatif retrouvée dans les données. L'intuition pour ce premier résultat est que, inversement aux chocs technolgiques, les chocs aux dépenses publiques affectent la demande et poussent l'output et le prix dans une même direction. Le modèle réplique bien également les observations sur le marché du travail telles la faible corrélation entre salaires réels et heures travaillées. L'intuition est que les chocs à la taxe du travail provoquent un déplacement de l'offre de travail le long d'une courbe de demande fixe. De plus, relativement à un modèle avec chocs technologiques seulement, ce modèle avec chocs fiscaux produit une corrélation entre balance commerciale et output plus faible et une corrélation internationale de la consommation plus faible. La taxation du revenu de travail et de la consommation provoquent des substitutions intertemporelles et intratemporelles entre consommation et loisir et réduisent la corrélation entre les variables domestiques et étrangères par rappport à ce qui est produit par un modèle avec chocs technologiques seulement. En gros, nos résultats montrent que les fluctuations dans les taux de taxation et les dépenses du government ont des effets non négligeables sur les fluctuations aggrégées internationales.

Il faut noter que certains des résultats sont contraints par les hypothèses du modèle, *i.e* similarité des pays, mobilité parfaite du capital, homogénéité du bien échangeable. Il serait intéressant de relâcher certaines de ces hypothèses. En particulier il serait intéressant de considérer un modèle calibré pour deux pays particuliers et évaluer alors sa performance quant à sa capacité de reproduire les faits relatifs à ces pays. Ceci est un projet de recherche future.

Le second et troisième essais ont examiné de façon empirique les effets de long terme des dépenses du gouvernment et des taxes du revenu du travail sur l'offre de travail en utilisant des données canadiennes et américaines. D'un point de vue théorique la taxation du revenu de travail peut affecter les décisions de consommation et d'offre de travail des agents, étant donné que la maximisation de l'utilité égalise le taux marginal de substitution entre consommation et loisir au salaire réel après impôt. Les deux essais tentent de tester empiriquement cette implication du modèle d'optimisation dynamique.

Les résultats ont montré que, pour le Canada, les changements du taux de taxation du revenu de travail affectent le ratio loisir/labor de façon cohérente avec les implications du modèle théorique. Les prédictions de cointégration de la spécification du modèle avec taxes distortionnaires ne sont pas rejetées par les données, alors qu'elles le sont pour le modèle néoclassique simple de croissance sans taxes. Les valeurs prédites par l'estimation répliquent remarquablement bien la tendance observée du ratio loisir-travail ajusté pour la taxe. Cette taxe distortionnaire semble également expliquer une part substantielle de la baisse des heures travaillées par personne au Canada.

Au contraire, les résultats du troisième papier pour les É-U ne permettent pas d'évaluer l'effet distortionnaire de la taxe. Le rôle des changements dans les dépenses du gouvernement semble trés important, probablement plus important que l'effet de la taxe du travail. Les estimations des coefficients de substitution entre dépenses publiques et privées sont proches de ce qui est attendu, en particulier plus faibles que un, cependant les écarts-types estimés sont substantiels. La consommation publique se substituerait donc faiblement à la consommation privée. Par ailleurs, les valeurs obtenues par l'estimation répliquent relativement bien la tendance observée dans le ratio loisir travail.

Notons finalement que la différence dans les résultats canadiens et américains ne devrait pas être surprenante. Des auteurs qui ont examiné les écarts de taux de chômage entre les deux pays ont suggéré des facteurs d'ordre insitutionnel comme variables explicatives. Des études plus poussées dans cette direction seraient sûrement enrichissantes et utiles pour comprendre les effets de la taxation du revenu de travail sur l'activité économique.