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To my mother, Shahin Banou, on her 70th birthday!

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ABSTRACT

This thesis consists of three essays in monetary economics in general equilibrium models. Each deals with a problem that central banks commonly face: uncertainty, inflation stability, and exchange rate policy.

The first essay examines the interdependence of the Canadian and US economies with a view to common policy analysis. The estimated structural vector error correction model applied to post-war data confirms the presence of four long-run equilibrium relationships between the two economies: i) purchasing power parity, ii) technological dependence, iii) interest rate parity, and iv) net foreign assets accumulation. Four common trends are also identified between the two economies: i) technological, ii) interest rate, iii) price, and iv) exchange rate relations. The results highlight that exchange rate appreciation is consistent with the decrease in foreign assets in Canada, that Canada and US cycles are correlated, that monetary shocks have short-run effects on outputs and permanent effects on price levels and exchange rates in both countries, and that the long-run growth for both economies stems from technological innovations. Therefore any expansionary monetary policies in these two countries should be treated cautiously as they might lead to inflation in both economies.

The second essay derives the optimal rate of price inflation by adding the element of long-run growth to a standard New Keynesian model with both price and wage rigidities. The results revive the old paradigm of monetary economics associated with Friedman (1969): mild deflation is the optimal policy. However, in this environment, optimal deflation results from growth. The presence of real growth in the steady-state leads to a wedge between price inflation and wage inflation. In this environment, the steady-state of the model is characterized by four distortions: price dispersion, wage dispersion, and monopolistic mark-ups of price and of wage setters. Optimal inflation is the one that balances these distortions at the margin. The welfare gain of moving from zero inflation to optimal deflation is 0.1% of the steady-state consumption. The cost of inflation in this environment turns out to be higher than that in a model without growth. This highlights the contribution of growth to the cost of inflation. In a stochastic version of the model, the mean of variables is affected by shocks. As growth creates a gap between wage and price inflations, the monetary policy can stabilize wages when targeting a small price deflation rate.

The third essay addresses the issue of optimal exchange rate regimes for emerging economies. It does so through the development of a small open economy model of endowment with nominal flexibility and real rigidity, i.e. international financial market segmentation. This kind of real rigidity, because it leads to heterogeneity among agents, has important implications for the choice of exchange regime in these economies. The simulation exercises reveal that agents who are excluded from the foreign exchange market (non-traders) marginally prefer flexible exchange rates, while those who have access to the foreign exchange market (traders) are better off with fixed rates. Flexible rates yield a potential Pareto improvement if traders represent a very small fraction of the total population. Plausible weights on the two groups in a utilitarian social welfare function give a higher level of social welfare under fixed rates. These results have important implications for policymakers in emerging markets. An optimal monetary policy, in order to increase the average level of welfare, turns out to be distortionary towards the consumption of non-traders.

Key words: Vector error correction model, identification, structural shocks, common trends, price inflation, wage inflation, growth, staggered contracts, welfare evaluation, monetary policy, inflation targeting, exchange rate regimes.

RÉSUMÉ

Cette thèse est composée de trois essais sur l'économie monétaire à l'intérieur du modèle d'équilibre général. Chacun traite d'un problème auquel les banques centrales font souvent face : l'incertitude, l'inflation, et les régimes de taux de change.

Le premier essai examine l'interdépendance des économies canadienne et américaine afin de dégager une analyse des politiques économiques conjoncturelles. Le modèle structurel vectoriel des corrections d'erreurs appliqué aux données de l'après-guerre confirme la présence de quatre relations de long terme entre ces deux économies : i) la parité du pouvoir d'achat, ii) la dépendance technologique, iii) la parité des taux d'intérêts, et iv) l'accumulation nette d'actifs étrangers au Canada. Quatre tendances communes sont également identifiées entre les deux économies : i) technologique, (ii) de taux d'intérêt, (iii) de prix, et iv) de relation de taux de change. Les résultats suggèrent que l'appréciation du taux de change est conforme à la baisse des actifs au Canada, que les cycles des États-Unis et du Canada sont corrélés, que les chocs monétaires ont des effets de court terme sur les productions et des effets permanents sur les niveaux de prix et de taux de change dans les deux pays, et que la croissance de long terme des deux pays découle de l'innovation technologique. Il en résulte que toute politique monétaire expansionniste dans ces deux pays doit être gérée avec prudence car elle pourrait mener à de l'inflation.

Le second essai dérive le taux d'inflation optimal des prix en ajoutant un élément de croissance de long terme non nulle à un modèle néo-keynesien avec rigidité de prix et de salaire. Les résultats raniment le vieux paradigme d'économie monétaire associé à Friedman (1969) : une politique légèrement déflationniste est optimale. Néanmoins, ce résultat n'est pas dû à l'aspect monétaire du modèle, mais plutôt à un aspect réel de la croissance économique. En effet, dans cet environment, le taux d'inflation optimal équilibre les distorsions à l'état stationnaire. Ces distortions se résument ainsi: la dispersion des prix, la dispersion des salaires, et les marges ajoutées des prix et des salaires dûes aux concurrences monopolistiques dans les marchés de biens et du travail sur les coûts marginaux. Le gain de bien-être du fait de passer d'une inflation zéro à l'inflation optimale est de 0.1% de la consommation à l'état stationnaire. En outre, le coût de l'inflation dans cet environnement avec croissance s'avère plus élevé, car la croissance économique crée un écart entre l'inflation de prix et de salaire. Dans une version stochastique du modèle, la moyenne de l'inflation est affectée par les chocs. Il en résulte qu'une politique monétaire qui ajuste le taux d'intérêt nominal selon une règle de Taylor pour atteindre l'objectif de cible d'inflation devrait viser le taux de déflation des prix, afin de stabiliser le taux d'inflation salarial très proche de zéro.

Le troisième essai traite de la question du régime de change optimal pour les économies émergentes. Les résultats sont dérivés à partir d'un modèle d'économie de dotation et ouverte, des prix flexibles et des rigidités réelles en termes d'accès aux marchés financiers. Les simulations du modèle montrent que ceux exclus des marchés préfèrent à la marge un régime de taux de change flexible. Dans cet environemment, un régime fixe augmente le bien-être social de tout le monde. Le coût de bien-être d'un régime de change non-optimal dans cet environnement est élevé, et notamment plus élevé pour les participants aux marchés. Un régime de taux de change flexible aboutit à une amélioration au sens de Pareto si les parts des participants aux marchés deviennent très faible. Ces résultats ont des implications importantes en matière de politiques économiques dans les marchés émergents. Une politique monétaire optimale, afin d'augmenter le niveau moyen de bien-être social, doit porter ses efforts sur l'augmentation de la consommation du groupe d'agents exclus des marchés financiers, bien que cette politique soit distortionnaire.

Mots clés: Modèle vectoriel à correction d'erreur, identification, chocs structurels, tendances communes, inflation des prix, croissance, contrats échelonnés, évaluation de bien être, politique monétaire, cibles d'inflation, régimes de taux de change.

INTRODUCTION

A travers cette thèse je cherche à apporter des éléments de réponse à trois défis auxquels les banques centrales sont souvent confrontées dans un environnement mondial difficile : i) l'incertitude et l'identification des chocs, ii) le choix de taux d'inflation et iii) le régime approprié de change pour les économies émergentes.

Les deux dernières décennies ont été marquées par des changements majeurs dans la manière dont la politique monétaire est menée. De plus en plus de banques centrales à travers le monde sont désormais indépendantes et ont développé des systèmes de prévision sophistiqués. La pratique de cibles d'inflation et le passage à un régime de change flottant font partie de ce processus. Le consensus parmi les experts est qu'un système transparent de prévision macroéconomique, un taux d'inflation bas et stable, et un régime de change flottant, sont des conditions indispensables de la stabilité macroéconomique et de la croissance face à la mondialisation. Bien que les autorités monétaires dans les pays industrialisés et en développement partagent ces mêmes deux premiers objectifs, la structure économique de ces différents pays les a menés à des choix différents en matière de régime de change.

Le premier essai a en même temps une vocation méthodologique relative au développement des modèles économiques structurels, et une vocation normative relative au développement d'outils plus efficaces pour l'étude des conjonctures économiques. Contrairement aux estimations des modèles empiriques, je développe le modèle d'une petite économie ouverte et j'évalue l'équilibre de long terme de ce modèle structurel simple avec les données. Le mot structurel fait ici allusion aux chocs structurels, dérivés et propres aux structures des économies d'une part, et à la structure imposée par les équilibres de long terme d'autre part.

Les études empiriques ont démontré que les prédictions des différents modèles théoriques au sujet des agrégats macroéconomiques ne sont pas toujours conciliables entre elles. Toutefois, ces résultats variés semblent être relativement dépendants de la méthodologie adoptée (Sims (1980), Johansen (1988), Blanchard et Quah (1990), Shapiro et Watson (1998), Galí (1999) et Pesaran, Garratt, Shin et Lee (2003)).

Le développement de mon travail est inspiré par les recherches de Pesaran, Garratt, Shin et Lee (2003) (PGLS) en ce qui concerne la modélisation structurelle, et de King, Plosser, Stock et Watson (1991) (KPSW) pour l'identification des chocs structurels. L'approche de PGLS est générale, simple, flexible et pourra s'appliquer afin de tester les théories économiques, en présence de toutes sortes de frictions de court terme sur le marché, pourvu que l'existence d'un état stationnaire unique soit garanti. Toutefois, cette méthodologie présente des failles en ce qui concerne la dynamique du système pour identifier le type de choc économique.

KPSW (1991) s'inspirent de la méthodologie de la décomposition d'une variable en une composante stationnaire et une composante non-stationnaire. Toutefois leur méthodologie repose sur un grand nombre de restrictions de long terme, sans développer un modèle théorique explicite. Par rapport aux travaux précédents, je franchis une étape supplémentaire en combinant PGLS (2003) avec KPSW (1991), afin de développer une méthode d'analyse plus complète des modèles structurels.

J'utilise ensuite cette méthodologie pour étudier l'évolution de l'économie canadienne en relation avec celle des États-Unis, son principal partenaire économique. J'ai recours dans cette optique à un modèle de croissance néoclassique à un secteur de production, enrichi des sources exogènes de perturbation stochastique. Le modèle est ensuite estimé par la méthode de maximum de vraissemblance pour les vecteurs de cointegration et avec les données canadiennes et États-uniennes de 1961q1-2008q1. Les résultats mettent en évidence la présence de quatre liens de long terme entre les huit variables d'intérêt : la production, les prix, les taux d'intérêts, le taux de change du Canada, et l'accumulation d'actifs nets. Ces relations sont : i) la parité du pouvoir d'achat, ii) la dépendance technologique mutuelle, iii) la parité des taux d'intérêt, et iv) l'accumulation d'actifs nets reliée au taux de change.

L'évolution de long terme entre les deux économies est ensuite déterminée par quatre chocs permanents influant les tendances qui leurs sont communes. Trois de ces tendances communes sont de nature nominales et attestent de ce que les chocs sur ces variables ont seulement un effet permanent sur les variables nominales. La dernière est de nature réelle et démontre que l'évolution de long terme des deux économies dépend des innovations technologiques. L'approche de ce papier constitue un outil prometteur dans la recherche d'une explication théorique des fluctuations et de la croissance économique entre les deux pays.

Dans le deuxième essai, je traite la question de l'inflation optimale qu'une banque centrale devrait chercher à cibler dans un régime de cible d'inflation lorsqu'elle tient compte de la croissance de long terme de l'économie, dans un cadre standard néo-keynesien avec rigidité de prix et de salaires.

Les résultats remettent au goût du jour la règle de Friedman (1969) selon laquelle une faible déflation est optimale. Dans cet essai, la déflation optimale résulte de la croissance de long terme et de son impact sur l'inflation des prix et de salaire. La croissance aboutit à un écart entre l'inflation des prix et l'inflation salariale. L'état stationnaire de ce modèle est caracterisé par quatre distorsions : dispersion des prix et des salaires, et concurrence monopolistique chez les ménages et les firmes. Ainsi une banque centrale avec un objectif de cible d'inflation qui utilise comme instrument le taux d'intérêt par le biais d'une règle de Taylor devrait choisir cette valeur d'inflation optimale négative comme sa cible d'inflation. Comme les moyennes stochastiques des variables sont affectées par les chocs de court terme, la moyenne de déflation optimale s'approchera de zéro.

Cet essai est lié à un certain nombre d'études existantes sur l'impact macroéconomique de la dispersion des prix dans les modèles néo-keynesiens. Le choc technologique permanent et le coût de bien être des politiques monétaires, les autres sujets traités dans ce papier, ont fait l'objet de nombreux débats dans la dernière décennie. Une grande partie de la littérature, cependant, s'appuie sur l'idée de rigidité des prix pour étudier la question du taux optimal d'inflation. King et Wolman (1996), par exemple, furent les premiers à trouver que la marge moyenne ajoutée des prix par rapport aux coûts marginaux des productions varie avec le taux d'inflation. S'inspirant de cette idée, Wolman (2001), sur la base d'un modèle avec contrats échelonnés des prix, a dérivé un niveau légèrement positif pour l'inflation optimale dans l'état stationnaire. Ascari (2005) et Bakhshi, Lombart, Khan, et Rudolf (2003) ont attiré l'attention sur les coûts de bien-être de la dispersion de prix. Amano, Ambler et Rebei (2007), montrent comment la non-linéarité peut aussi jouer un rôle important dans les modèles néo-keynésiens.

Bien que plusieurs papiers récents discutent de l'importance des rigidités salariales pour améliorer la performance des modèles néo-keynésiens, relativement peu d'études ont fait de l'analyse de bien-être en utilisant des modèles avec plus d'une rigidité nominale. Une des rares exceptions est Erceg, Henderson et Levin (ci-après, EHD (2000)), qui furent les premiers à développer un modèle cumulant rigidités de salaire et de prix. Ces derniers ont montré qu'une politique optimale devrait viser une moyenne dûment pondérée de l'inflation des prix et de salaire.

Même si ce papier est dans l'esprit d'EHL (2000) et Wolman (2001), il s'intéresse uniquement à l'efficacité des politiques monétaires dans un environnement de croissance de long terme non nulle. Je prolonge l'approche de ces auteurs par l'ajout de rigidités nominales de salaire, d'une manière conforme aux contrats de Taylor (1980) pour deux périodes, dans un environnement de croissance positive de la productivité à long terme. Cette fixation faite en avance apporte aux ménages un pouvoir de monopole sur leurs produits et services, par nature différenciés. La concurrence monopolistique entre les firmes et les ménages conduit à un écart entre les prix et les salaires qui est dû à la marge ajoutée des coûts marginaux de ces derniers. En outre, la dispersion des prix et des salaires du fait de la nature échelonnée des contrats représente une autre source d'inefficacité du marché. Dans un travail récent de la Banque du Canada, Amano, Moran, Murchison et Renisson (2007) étudient le coût de l'inflation, dans un modèle semblable à ce travail et trouvent également que la déflation est la politique optimale. Ils expliquent qu'une valeur faible pour la déflation minimise les distortions dans le marché du travail. Puisque ces marchés sont plus distortionnaires, ces auteurs concluent que l'objectif de la politique monétaire sera d'éliminer les distortions propres à ce marché.

Dans mon essai, j'étends l'analyse du taux d'inflation optimal au-delà de l'état stationnaire déterministe. J'analyse la dynamique du modèle suite à deux chocs : un choc transitoire monétaire contractionniste de la règle de Taylor pour la détermination du taux d'intérêt, et un choc technologique permanent, qui est équivalent à un choc transitoire sur la croissance de long terme. L'étude des comportements cycliques des variables et les sentiers de réponse sont conformes aux données. Dans cet environement avec les chocs, la faible déflation reste la politique optimale, car elle permet une stabilisation de l'inflation salariale. Si les tailles de chocs augmentent, ou si la politique monétaire est moins contraignante (les coefficients de la règle de Taylor sont plus faibles), le taux de déflation optimal devient plus négatif.

La contribution apportée par mon dernier essai me situe en faveur d'un régime de change fixe pour les économies émergentes. Ce résultat découle de la structure de ces économies dans lesquelles une partie de la population est exclue des transactions sur le marché de change (marché financier). Les preuves empiriques démontrent aussi que les crises de change sont fortement liées aux structures des marchés financiers dans ces pays, notamment à l'accès limité des agents à ces marchés. Dans une étude récente, Lahiri, Singh, et Vegh (2007) montrent analytiquement comment différentes sortes de frictions peuvent changer le choix de régime de change. Ils concluent que le type de friction est aussi important que le type de choc dans la détermination du régime optimal.

Je m'inspire de leurs papiers pour le choix de modélisation mais m'en éloigne en optant pour une approche numérique par la calibration et simulation. De fait, dans mon modèle simple de dotation en économie ouverte avec des prix flexibles et des rigidités réelles en termes d'accès aux marchés financiers, avec des agents qui ont une contrainte de paiement préalable et qui sont confrontés à des chocs de demande de monnaie et de leur dotation, un régime de change fixe est plus performant en termes de bien-être des agents. En effet, pour un poids raisonable de deux types d'agents dans une fonction de bien-être social utilitariste, le régime fixe est le régime de change optimal, même si pour ceux exclus des marchés financiers, le régime flexible est optimal à la marge. Les variations du taux de change elles-mêmes deviennent le stabilisateur économique pour ce groupe face aux chocs. Par contre, pour ceux participant aux marchés, un régime fixe protège mieux les fluctuations de la consommation suite aux chocs. Cela est vrai jusqu'à ce que la part des participants au marché diminue à moins de 10% de la population. Dans ce cas, la fixité du taux de change sur le marché de change n'est pas possible et un régime de change flexible donne une amélioration au sens de Pareto. Je calibre le modèle avec les données disponible pour l'Argentine. Aussi simple soit-il, le modèle reproduit les comportements cycliques des variables après les chocs.

Le choix d'un régime de change optimal est un vieux paradigme en finance internationale. Le consensus de Mundell (1961) pour le choix de régime de change est que les régimes fixes sont optimaux lorsque l'on a affaire à des chocs monétaires. Ainsi, les régimes flexibles sont optimaux en présence des chocs réels. Helpman et Razin (1979) furent les premiers à conclure que le choix de régime de change est pertinent uniquement lorsque les éléments de rigidité nominale avec chocs sont envisagés. Les avis restent pourtant partagés et une majorité des auteurs semble se prononcer en faveur des régimes polaires.

Ceux en faveur des régimes flexibles (Obstfeld et Rogoff (1995), Edwards et Yeyati (2005) et Edwards et Magendzo (2006)) expliquent la supériorité de ces régimes par leurs capacités d'absorption des chocs et la croissance accrue qu'ils génèrent, ainsi que leur capacité à diminuer la volatilité réelle des variables dans une économie en régime flexible. Ceux défendant le recours à des régimes fixes expliquent l'avantage de crédibilité de tels mécanismes (Dornbusch (2001), Calvo et Reinhart (2002), Calvo (2005), Mendoza (2001), Arellano et Heathcote (2007)). Mes résultats contribuent à cette littérature en attirant l'attention sur les protections qu'un régime de change fixe garantit pour les participants du marché, contre les aléas auxquels les économies ouvertes font face.

CHAPTER I

CLOSE-EMBRACE: CANADA-US COMMON TRENDS

Abstract

This chapter studies the joint dynamics of the Canadian economy with US economic variables. The methodology employed is that of the structural vector error correction model that combines unrestricted short-run dynamics with long-run restrictions derived from growth theory. Common trends, as well as transitory shocks to these two economies are identified. Quarterly data from 1961q1 to 2008q1 suggests four long-run equilibrium relationships: i) purchasing power parity, ii) technological differentials, iii) interest rate parity, and iv) net foreign asset accumulation. Four common trends or permanent common shocks are also identified between the two economies: i) technological, ii) interest rate, iii) price, and iv) exchange rate relations. The model explains that exchange rate appreciation is consistent with the decrease in foreign assets in Canada, that Canada and US cycles are correlated, and that technological innovation is the main driving force of long-run growth for both economies.

Keywords: Vector Error Correction Model, Identification, Structural Shocks.

1.1 Introduction

This paper provides a general model framework for the study of small open economies in the globalized world. It combines recent advances in the analysis of cointegrating systems with those of common trends for a small open economy faced with uncertainties. This strategy is then applied to Canada to study its long-term relationship with the US economy. The work is prompted by the empirical observation that the Canadian and the US economies are heavily interdependent. The relationship between the two seems to be the closest and most extensive in the world economy. The resulting interactions are reflected in the staggering volume of bilateral trade – the equivalent of \$1.5 billion a day, as well as investment partnerships.[1] The conventional economic wisdom is that when the US sneezes, Canada catches a cold.

An important recent line of macroeconomic research addresses the issue of interdependence between countries. Vector error correction models are relevant tools for these analyses, as macroeconomic variables are integrated time series, but their linear combination might become stationary. While considerable emphasis is placed on the idea that the identification of the cointegration vectors should be theoretically consistent, many of the approaches in the literature have focused on the statistical properties of time series, without providing an explicit theory to account for the equilibrium concept.[2]

The methodology here innovates by combining structural vector error correction estimation in an over-identified system with structural shocks derived from the neoclassical growth theory. Through this combination, it provides a structural model in which i) the long-run is the steady-state solution of the model economy, and ii) the shocks are identified within the model. With data for the period 1961q1 to 2008q1, the empirical results highlight four equilibrium relationships between the variables of interest: domestic and foreign outputs, prices, interest rates, nominal exchange rate, and net accumulation of foreign assets. These long-term relations are as follows: i) purchasing power parity, ii) technological differentials, iii) interest rate parity, and iv) net foreign asset accumulation. Deviations from long-run relations explain how Canada and US cycles are correlated. Within the present data set, and with four cointegration relationships among eight variables, four common trends are identified within the two economies, one real (the technological), and three nominal namely i) interest rate, ii) price, and iii) exchange rate relations.

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[1]Statistics Canada (2006) confirms that the U.S. is Canada's largest foreign investor with 61% of total foreign direct investment. These investments are primarily in Canada's mining and smelting industries. Canadian investment in the U.S is mostly concentrated in finance and insurance.

[2]See Johansen (1988).

The impulse responses reveal that while permanent monetary shocks affect outputs only in the short run, their impact on price levels and exchange rates in both countries are permanent. Expansionary monetary policies should therefore be treated with caution as they might lead to higher prices in both countries. The results also indicate that exchange rate appreciation is consistent with decrease of foreign assets in Canada, and that long-run growth stems solely from technological innovations.

The most cited work in the vector error correction literature is the article by King, Plosser, Stock, and Watson ((KPSW), 1991). In that piece, KPSW use US data to identify stochastic trends in the US economy. This is done by extending the structural vector autoregressive (SVAR) approach of Blanchard and Quah (1990) with cointegration vectors. Following their approach, Hercowitz and Sampson (1991), Mellander, Vredin and Warne (1992), Vredin and Söderlind (1995), Crowder, Hoffman and Rasche (1999) examine cointegrating properties of some simple real business cycle models in closed and open economies. A similar method has been used in Shapiro and Watson (1998) to determine which shocks account for business cycle frequencies. Ogaki (1992), Galí and Clarida (1994), and Ogaki and Park (1995) consider the implications of unit-root processes for the estimation of long-run relations in intertemporal rational expectations optimizing models. Ogaki and Jang (2001) investigate the effects of a monetary policy shock to the US economy through a structural vector error correction model.

Pesaran, Garrat, Lee, and Shin ((PGLS), 2003) propose a new flexible structural approach to model the long-run relationships of the UK variables in the euro zone, based on accounting and arbitrage conditions. They explain that their structural model incorporates the structural long-run relationship as its steady-state solution. Although PGLS (2003) develop a joint analysis of cointegration estimation with impulse responses labeled under generalized impulse responses, their methodology still falls short of the exact identification of shocks.

While my contribution in this chapter is closely tied to PGLS (2003) for long-run derivations and estimation method, it differs in terms of the methodology used to derive long-run relations. PGLS (2003) derive their relationships from arbitrage conditions, whereas I derive them explicitly from a standard growth model. I develop a homogenous agent, infinite horizon model of a small open economy interacting with the rest of the world. I then derive the long-run relations from the first order conditions of agents' maximization problems. The model economy is very flexible and the few assumptions on the functional forms of the utility and the production functions are those that ensure that the steady-state exists, is stable, is unique, and guarantees a balanced growth path in the long-run. Furthermore, I add simulation exercises of permanent shocks in the spirit of KPSW (1991). This combination provides a simple and new tool for policy analysis in the complex world of globalized economies.

The chapter is organized as follows. The model economy is characterized in the next section. Section 3 describes the statistical framework. Section 4 reports the empirical results and simulation exercises. Section 5 is devoted to the conclusion.

1.2 The Model

The model is a standard neoclassical growth model of a small open economy, i.e. home is interacting with the rest of the world. An infinitely-lived representative household has preferences over consumption, leisure, and real balances. The necessary restrictions on the functional form of the utility function insure the steady-state growth. The representative agent faces a flow budget constraint in each period. Her combined expenditure on goods and on net accumulation of financial assets (bonds: domestic and foreign) must be equal to her disposable income. There is also a representative firm which maximizes its profits in each period. Households own the firm. The agent's tastes are static over time and are not influenced by exogenous stochastic shocks. There is no population growth. Foreign variables are denoted with asterisks.

1.2.1 The Representative Household

The representative agent maximizes her utility given by the expected discounted sum of her lifetime utility in consumption, leisure and holding of real balances:

$$\max_{\{C_{t+i},L_{t+i}\}_{t=0}^{\infty}} U = E_t \left[\sum_{i=0}^{\infty} \beta^i u(C_{t+i}, L_{t+i}, \frac{M_{t+1+i}}{P_{t+i}}) \right] \tag{1.1}$$

where t is calendar time and i is planning time, E_t is the expectation of future values of consumption C_{t+i}, leisure L_{t+i}, and real balances $\frac{M_{t+1+i}}{P_{t+i}}$ based on the information available at time t. The infinite horizon assumption simplifies the analysis and is justified by the presence of altruistic links across generations. The instantaneous utility function is well behaved in the sense that it satisfies the Inada conditions, it is twice continuously differentiable, concave, and increasing in its arguments. The subjective discount factor β measures the rate of time preference of the economic agents and is between 0 and 1 or $\beta \in (0, 1)$. The representative agent splits her time endowment between work N_t and leisure L_t. The time constraint in each period is then normalized to one:

$$N_t + L_t = 1 \tag{1.2}$$

Although no specific functional form is given to the utility function, this function should respect the balanced growth path conditions as explained by King, Plosser, and Rebelo (1988). These authors discussed that, for balanced growth to be optimal with labor supply chosen by agents, utility must be such that income and substitution effects are exactly offsetting on leisure.[3]

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[3]With only consumption and labor, King, Plosser, an Rebelo (1988) proposed the following utility additive separable function

$$U(C_t, L_t) = \log(C_t) + v(L_t)$$

All that is required here is that v(L) to be increasing and concave. If the utility is multiplicatively separable, more conditions are needed.

The household then maximizes her utility (1.1) subject to the time constraint (1.2) and the sequence of budget constraints as follows:

$$C_t+\frac{M_{t+1}}{P_t}+B_{t+1}+e_tB^*_{t+1}+I_t \leqslant w_tN_t+r_tK_t+\frac{M_t}{P_t}+B_t(1+r_t)+e_tB^*_t(1+r^*_t)+\frac{T_t}{P_t} \quad (1.3)$$

where B_t is a domestic real asset, and B^*_t is a foreign real asset in each period. These assets are one period risk-free indexed bonds. The domestic asset is denominated in home country currency with the respective net real short-term interest rate r_t, for the holding of bonds between time t and $t+1$. The foreign bond is denominated in foreign currency with a short-term real interest rate equal to r^*_t. The current real exchange rate e_t is expressed as the domestic price of the foreign currency, i.e. $\frac{P^*_tS_t}{P_t}$ with S_t as the nominal exchange rate. The real foreign asset or B^*_t is then multiplied in each period by this real exchange rate to give real units of domestic output. Furthermore, purchasing power parity or the equilibrium in the goods markets is assumed to hold in the long-run. This means that absent natural or governmentally imposed trade barriers, a commodity should sell for the same price everywhere, at home or in a foreign country, when prices are measured in a common numeraire. The foreign bond when maturing with its gross real return of $(1+r^*_t)$ is converted into real units of domestic output. Money M_t is held due to the utility it brings for the agent. The real balance is the amount of money adjusted by the price level P_t in each period. The real wage w_t is the hourly amount of wages given to the household or $\frac{W_t}{P_t}$. Household holds the stock of capital and rents it to the firm. The short-term interest rate r_t is also the opportunity cost of holding capital K_t. The evolution of the stock of capital gives investment or I_t. The government transfers a lump-sum amount of T_t to the household in each period. The stock of capital

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Ambler, Rebei, and Dib (2004) with also real balances in the utility function, proposed the following functional form and explained that this led to a simple money demand equation:

$$u\left(C_t, L_t, \frac{M_t}{P_t}\right) =$$
$$\frac{\gamma_1}{1-\gamma_1}\ln\left(C_t^{\frac{(1-\gamma_1)}{\gamma_1}}+b_t^{\frac{1}{\gamma_1}}\left(\frac{M_t}{P_t}\right)^{\frac{\gamma_1-1}{\gamma_1}}\right)-\frac{\theta}{1+\gamma_2}L_t^{(1+\gamma_2)}$$

where b_t is a money demand shock.

evolves according to:

$$K_{t+1} + \psi(I_t/K_t) = (1-\delta)K_t + I_t \tag{1.4}$$

where $\delta \in (0,1)$ is the depreciation rate and $\psi(I_t/K_t)$ is the relative capital adjustment cost for investment.[4] This function is strictly convex; i.e. $\psi(I_t/K_t)' > 0$, $\psi(I_t/K_t)'' > 0$. This means that intertemporally adjusting the stock of capital is costly. This assumption helps to lower substantially the variability of investment and to produce procyclical investment, as confirmed by data. However, the only reason to include such a cost function is to show the robustness of the long-run economy to the short-run restrictions.

1.2.2 The Government

The government has a balanced budget constraint. It prints a total amount of money $M_{t+1} - M_t$ and transfers to the household the amount of T_t in each period.

$$M_{t+1} - M_t = T_t \tag{1.5}$$

1.2.3 The Representative Firm

Labor is rented out each period to a representative competitive firm. This firm also rents capital that was accumulated in the last period by the representative household. There is no labor mobility across borders. The firm maximizes its profit at each point in time by producing output according to a standard constant return to scale neoclassical production function. The constant return to scale assumption leads to the natural aggregation of output by the representative firm. The production function Y_t is twice continuously differentiable, is strictly increasing, is homogeneous of degree one, and is a strictly quasi-concave function, satisfying the usual Inada conditions. In this simple neoclassical economy, there is only one commodity that can either be consumed or invested, i.e. stored for use in production in the next period. The production function

[4] See Hayashi (1982).

is written as follows:

$$Y_t = F(K_t, \exp(A_t)N_t) = \exp(A_t)N_t F(\frac{K_t}{\exp(A_t)N_t}, 1) = \exp(A_t)N_t f(k_t) \tag{1.6}$$

where A_t is the log of the level of labor-augmenting technological progress. Given the assumption of constant returns to scale and the competitive nature of the economy, total production is equal to factor payments. There are two factor markets here, one for labor and one for capital services. The rental price of labor is w_t or the real wage, and the rental price of capital is r_t or real interest rate.

$$Y_t = w_t N_t + r_t K_t \tag{1.7}$$

The levels of technological progress in the two economies are integrated series $I(1)$, following a random walk process with drift. However, productivity differentials exist between the two countries due to initial differences in technologies and endowments θ_1, and θ_2. In any period, the actual growth rate will deviate by some unpredictable amount of ε_t^A and $\varepsilon_t^{A^*}$. The vector of error terms are serially independent, normally distributed with mean zero and variance σ^2. The relationship between technologies is:

$$\begin{pmatrix} A_t \\ A_t^* \end{pmatrix} = \begin{pmatrix} \theta_1 \\ \theta_2 \end{pmatrix} + \begin{pmatrix} 1-\tilde{\theta} & \alpha\tilde{\theta} \\ 0 & 1 \end{pmatrix} * \begin{pmatrix} A_{t-1} \\ A_{t-1}^* \end{pmatrix} + \begin{pmatrix} \varepsilon_t^A \\ \varepsilon_t^{A^*} \end{pmatrix}, \tag{1.8}$$

where A_t and A_t^* are the log of home and foreign technologies, $\begin{pmatrix} 1-\tilde{\theta} & \alpha\tilde{\theta} \\ 0 & 1 \end{pmatrix} = \Psi(\tilde{\theta})$ is a matrix polynomial of coefficient of adjustment to the long-run equilibrium, and α is the negative speed of adjustment to the long-run equilibrium. The matrix $\Psi(\tilde{\theta})$ has two roots, i.e. $\lambda = 1 - \tilde{\theta}$ or 1, and ensures the stability of the system.[5]

This representation of technologies captures the idea that the PPP theory is a long-run property of the model and deviations from this theory are only gradually over

[5]See Hamilton (1994) for a detailed discussion on the general characterization of the cointegrating vector, pp. 574-575.

time, through spillover of the technology shock from the foreign country to the home economy. In the long-run, domestic technological progress, is determined by the level of technological progress in the rest of the world, and technological progress is cointegrated with a cointegration vector equal to $(1, -1)$.

1.2.4 National Accounting

In equilibrium, there is no holding of domestic bonds by the household, i.e. private debt $B_t = 0$. This is explained by the fact that the government does not issue bonds and that they are not traded internationally. Adding together the budget constraints of the household, firm, and the government, and by assumption that household own the firm and all profits are distributed by firm to the household, the following resource constraint is obtained:

$$Y_t - C_t - I_t = e_t(B^*_{t+1} - B^*_t) + e_t r^*_t B^*_t \tag{1.9}$$

This equation gives the economy's current account, i.e. the difference between national income with aggregate consumption and investment. The current account is also equal to the change in the economy's net foreign asset position.

1.2.5 The First Order Conditions

Euler equations, by linking the intertemporal decisions between prices and asset returns in the economy, describe optimal behavior by the representative agent. I define $U_i(t)$, with $i = C_t, L_t, \frac{M_{t+1}}{P_t}$ as the partial derivative of the utility function with respect to its arguments: consumption, labor, and real money balances. The representative household chooses the following sequence $\left\{ C_t, L_t, B_{t+1}, B^*_{t+1}, K_{t+1}, \frac{M_{t+1}}{P_t} \right\}_{t=0}^{\infty}$ in each period to maximize its utility flows subject to its budget constraint and the following non-negativity constraints:

$$K_0 > 0, M_0 > 0 \tag{1.10}$$

$$C_t \geqslant 0, L_t \geqslant 0, K_{t+1} \geqslant 0, M_{t+1} \geqslant 0, \ \forall t \tag{1.11}$$

The complete set of the first order conditions and the long-run solvency conditions is given in Appendix B.1. These equations give the equilibrium conditions; marginal utilities of consumption and labor, the euler equations for holdings of bonds, the evolution of capital or the investment, the money demand equation, the rental rate of capital and the equation for wages.

1.2.6 Equilibrium Conditions

Long-run relations are the steady-state solutions of the theoretical model under consideration. The theoretical model implies the existence of a few long-run relations between variables, at least one for the equilibrium condition of each market, and one for each of the steady-state solutions of the model economy. Combining these first order conditions (FOCs) provides the long-run relationships between macroeconomic variables that can be tested with data (Appendix B gives a detailed derivation of these equations).

However, as in the tradition of PGLS (2003), only a sub-set of the long-run relationships are tested with data here. The choice of these relationships is based on the fact that no special functional form has been given to the utility function. The model economy developed in this paper is too stylized for short-run frictions (KPSW, (1991)), and the long-run equations are consistent with the steady-state solutions of a wide range of small open economy models.

The long-run relationships are categorized in three main blocks. The first one is a real block, combining technologies in two economies. The second one is nominal, resulting from the optimization behaviors of the household. It contains interest and exchange rate parities between domestic and foreign interest rate, and between domestic and foreign price levels expressed in the same currency. The last block is a stock-flow identity, describing how the representative agent allocates wealth among domestic and foreign bonds.

Then, a subset of the equilibrium conditions is chosen to be tested with data.[6] These are the following relations where $\zeta_{i,t}, i = 1...4$, are structural transitory and stationary innovations, i.e. the error correction terms. The lower-case variables denote log-deviations from steady-state values (see Appendix B.2).

$$\begin{aligned} \zeta_{1,t} &= b_t^* - y_t \sim I(0) \\ \zeta_{2,t} &= r_{t+1} - r_{t+1}^* \sim I(0) \\ \zeta_{3,t} &= s_t + p_t^* - p_t \sim I(0) \\ \zeta_{4,t} &= y_t - y_t^* \sim I(0) \end{aligned} \tag{1.12}$$

The first equation gives the net external position of the country (NFA) relative to GDP. Schmitt-Grohé and Uribe (2003) explain different conditions to ensure stationarity of debt in a small open economy. The second equation links the domestic and foreign real interest rates (interest rate parity, IR). This equation states that in the steady-state, domestic and foreign bonds become perfect substitutes, and their expected rates of return are equal. The neoclassical nature of the economy here implies that real interest rates are stationary. However, the stationarity of the interest rate is often rejected by data (see Perron and Moon, (2007)). The main reasons for the non-stationarity of the interest rate are the presence of risk premia and regime switches. Purchasing power parity (PPP) or the return to unique long-run real exchange rate is the third equation. The PPP is a long-run relationship and is based on the presence of goods market arbitrage. Information disparities, commercial barriers, and transportation costs are likely to create considerable deviations from PPP in the short-run. The Harrod-Balassa-Samuelson effect explains how the price of a basket of traded and non-traded goods rises more rapidly in countries with higher productivity growth in the traded sector. Then, in small open economies models where home and foreign economy produce goods that are imperfect substitutes, a positive technology shock in one country, by increasing the

[6]This choice is partly motivated by data availability, and the interest of the equations for the study of interrelation of two open economies.

supply of its output, would reduce its relative price. The return to the unique long-run real exchange rate would occur gradually through technology spillover to the other country. The last equation explains this output gap, due to different technologies and initial endowment gap between two economies. The level of output in the long-run is driven by the level of foreign technology.

The econometric technique of vector error correction (VECM) applied in the next section is the best choice for analyzing the long-run relationships of my model. This technique is consistent with a wide variety of economic mechanisms. It focuses on the deviations from the long-run equilibrium and gives a unified framework for studying long-run growth with short-term fluctuations, and the interactions between them.

1.3 Econometric Method

This section describes the general econometric strategy and identification method used to test the model economy with the data. The vector error correction model (VECM), which forms the basis of my investigation, is as follows:

$$\Delta z_t = a_{z_0} + a_{z_1} t - \alpha_{z_2} \zeta_t + \sum_{j=1}^{p-1} \Gamma_{zj} \Delta z_{t-j} + \upsilon_{zt} \tag{1.13}$$

with $z_t = (y_t', x_t')'$, where y_t is a vector of endogenous and x_t is a vector of exogenous non-stationary but integrated $I(1)$ variables. $a_{z_0} = \binom{b_0}{\delta}$ is a vector of fixed intercepts, α_{z_1} defines the trend coefficients in the model that are restricted to zero as will be explained further, α_{z_2} is a matrix of adjustment coefficients, $\zeta_t = \beta^{'} z_{t-1}$ is a matrix of long-run reduced form disturbances or short-term deviations from the long-term equilibrium, $\Gamma_{zj} = \binom{\Gamma_y}{\Gamma_x}$ is a matrix of the short-run coefficients, and $\upsilon_{zt} = \binom{u_{yt}}{u_{xt}}$ is a vector of disturbances, identically and independently distributed innovations with covariance matrix of Σ.

The right choice of the deterministic components of the error correction specification (constants and trends) ensures that the long-run reduced form error have zero means. One general way to choose these components is to consider both in estimation and to eliminate the coefficients with a $t-$test statistic. However, Pesaran, Shin, and Smith (2000) demonstrate that this elimination method might produce misleading inferences. They conclude that if the trend coefficient is not restricted to zero, the mean of variables will vary with the assumed number of the cointegration relations and result in biased estimates. This is the reason why the trend coefficient α_{z_1} is restricted to zero in the estimation part of our VECM.

The estimation procedure begins by estimating the reduced form errors (ζ_t) or the transitory deviations from the long-run equilibrium. As explained by Lütkepohl (1991), when $\alpha_{z_2}\beta' = \Pi_z$ is of full rank (of m for example), the parameters can be consistently estimated by ordinary least squares (OLS). However, if Π_z is rank-deficient; its rank is $r < m$, and there are r cointegration vectors between variables, then ordinary least squares estimation is no longer efficient. Gonzalo (1994) compares different estimation methods for a cointegrating system; ordinary least squares by Engel and Granger (1987), non-linear least squares by Stock (1987), three-step estimation by Engel and Yoo (1989), principal components by Stock and Watson (1988), canonical correlations by Bossaerts (1988), full information maximum likelihood (FIML) by Johansen (1988), instrument variables (IV) by Hansen and Phillips (1990), and spectral regression (SR) by Phillips (1987). He concludes that FIML estimations provide coefficients estimate that are median unbiased, asymptotically efficient (smallest variances for the estimators), and symmetrically distributed. Therefore, hypothesis tests may be conducted using a standard asymptotic chi-squared test. Furthermore, the Monte Carlo studies indicate that the finite sample properties of FIML estimates are consistent even when the errors are non-Gaussian and/or dynamics are unknown. These studies solve the problem of inference in cointegrated systems.

1.3.1 Identification

In the traditional identification approaches of VAR and VECM models, e.g. Freidman and Schwartz (1963), Blanchard and Watson (1986), Sims (1986), Blanchard and Quah (1990), Shapiro and Watson (1998), KPSW (1991), Christiano, Eichenbaum and

Evans (1998), Sims and Zha (1996), Galí (1999), and Romer and Romer (1990, 1994), the dynamics of the model are tightly constrained with difficult a-priori, sometimes subjective justifications: i.e. exclusion restrictions, variance-covariance restrictions, normalization, etc.

The identification strategy in this paper takes into account any set of linear restrictions that are imposed directly on the matrix of long-run coefficients β. The dynamics of the short-run defined by adjustment coefficients α_{z_2} are left unrestricted. Let me write:

$$R\text{vec}(\beta) = b \tag{1.14}$$

where R is an $s \times rm$ matrix with s as the total number of restrictions to be tested and is also equal to Rank(R), r is the number of cointegration relations (columns of β), and $vec(\beta)$ is an $rm \times 1$ vector of long-run coefficients which stacks columns of β into a vector. Three cases of interest can be distinguished. First, the under-identified case is when $s < r^2$. Second, the exactly or just-identified case is when $s = r^2$. Finally, the over-identified case is when $s > r^2$. The necessary and sufficient conditions for identification are then given by order and rank conditions as follows. The order condition states that the number of restrictions, s, should be greater than the number of just-identified restrictions:

$$s \geq r^2 \tag{1.15}$$

The rank condition asserts that there must be at least r restrictions per each of r cointegrated vectors:

$$\text{Rank}\left[R(I_r \otimes \beta)\right] = r^2 \tag{1.16}$$

The just-identified model is sensitive to the choice of restrictions and is thus non-unique. However, PGLS' (2003) strategy makes the model unique by imposing at most $s - r^2$ over-identifying restrictions on β. The cointegrating space is written as follows:

$$\alpha_z \beta' = \Pi_z \tag{1.17}$$

The number of cointegrating vectors is determined on the basis of two tests: the trace test and the maximum eigenvalue test. These statistics test the null hypothesis of no cointegration between the variables. The number of cointegrating vectors is equal to the (reduced) rank of the matrix Π_z, or r. This rank is determined on the basis of the Johansen trace and the maximum eigenvalue test statistics for the 95% and 90% critical values in Table (1.4). These statistics test the null hypothesis of no cointegration between the variables. The maximum eigenvalue test is obtained when testing the null hypothesis of r cointegrating relationships against the alternative of $r+1$. For the trace test statistic, under the null hypothesis, there are m cointegrating relationships. However, Cheung and Lai (1993), among others, demonstrate that the maximal eigenvalue statistic is less robust when higher moments, such as skewness and kurtosis in the error terms, are present. Pitarakis (1998) explains that these tests perform poorly in finite samples when compared to their asymptotic critical values. Monte Carlo simulations also show that in small samples the cointegration rank test statistics generally tend towards under-rejection. Shin (1994) proposes an OLS estimations of the individual relation of interest. Under the null hypothesis, then, the residuals are stationary and therefore the relations are cointegrated.

1.4 Empirical Analysis

The VECM to be estimated is written as follows:

$$\Delta \begin{pmatrix} b_t^* \\ y_t \\ p_t \\ r_t \\ s_t \\ y_t^* \\ p_t^* \\ r_t^* \end{pmatrix} = a_{z_0} - \alpha_{z_2}\beta' \begin{pmatrix} b_{t-1}^* \\ y_{t-1} \\ p_{t-1} \\ r_{t-1} \\ s_{t-1} \\ y_{t-1}^* \\ p_{t-1}^* \\ r_{t-1}^* \end{pmatrix} + \sum_{j=1}^{p-1} \Gamma_{zj} \Delta \begin{pmatrix} b_{t-j}^* \\ y_{t-j} \\ p_{t-j} \\ r_{t-j} \\ s_{t-j} \\ y_{t-j}^* \\ p_{t-j}^* \\ r_{t-j}^* \end{pmatrix} + \upsilon_{zt} \tag{1.18}$$

where a_{z_0} is a 8×1 vector of intercepts, α_{z_2} is a 8×5 loading matrix, i.e. feedback or error-correcting coefficients, β' is a 5×8 matrix of long-run restrictions, Γ_i is a 8×8 matrix of short-run coefficients, and υ_{zt} is a 8×1 vector of normal independent innovations. Estimating this equation requires taking three steps. First, the data are chosen and are checked to consist of non-stationary series or $I(1)$. Second, the number of cointegrating vectors is identified. This gives the degree of consistency between the data and the theoretical framework discussed above. Third, the lag-length p and the deterministic component are chosen. This is an essential requirement for the correct statistical inference.

1.4.1 Data

The data employed in this paper is obtained from the International Financial Statistics (IFS) database (2008) compiled by the International Monetary Fund. Table (1.1) contains a full description of the data. All series are seasonally adjusted, quarterly observation ranging from 1961:q1 (the first quarter) to 2008:q1.

1.4.2 Unit Root Tests

The econometric strategy for estimating the structural parameters (outlined in the previous section) is valid only if the level of variables is non-stationary or integrated of order one $I(1)$, but their combinations become stationary or cointegrated $I(0)$. For this reason, the order of integration of variables is examined. Table (1.2) presents the results of the univariate unit root tests for the above variables. Augmented Dicky-Fuller (ADF) and Phillips-Perron (PP) are known for not being powerful enough, meaning that one will not often reject the null hypothesis of the unit root, even when it is false. Therefore some recent tests such as DFGLS (Dicky-Fuller Generalized Least Squares) and KPSS (Kwiatkowski, Phillips, Schmidt, and Shin, (1992)) are also considered. These tests seem to have the desirable size and power properties. The DFGLS test is a simple modification of the ADF test in which the data is detrended. The KPSS (1992) uses LM statistics, based on the residuals from the OLS regression of the dependant variable on the exogenous variables. However, unlike the other tests, KPSS assumes the stationarity of the series under the null hypothesis. The results for the variables in level confirm that the null hypothesis of unit root could not be rejected at 5% significance level (Tables (1.2) and (1.3)). However, the first differences of variables are stationary and confirm that all variables are $I(1)$.

1.4.3 Cointegration Tests

With eight endogenous variables in the system, there could be at most seven cointegrating vectors. The cointegrating space is:

$$\alpha_z \beta' = \Pi_z \tag{1.19}$$

The trace and the maximum eigenvalue tests reveal at most 3 cointegration relationships among variables in 10% significant level in Table (1.4). Insofar as economic theory proposes four relationships between the variables, I proceed to test the null hypothesis of cointegration following Shin (1994). The results are reported in Table (1.5). The null hypothesis of cointegration between the equations cannot be rejected at a 5% significance level.

1.4.4 Estimation and Testing of the Model

Before estimation of the model, the lag-length of the VECM should be chosen. This is done based on the usual optimal lag-length selection criteria in Table (1.6). Five criteria are considered as follows: i) the Akaike information criterion (AIC) suggests choosing two lags for the model, the ii) Hannan and Quinn (HQ) and iii) Schwartz (SC) criteria, and iv) the Final Prediction Error (FPE) suggest a model with only one lag, while v) LR sequential modified test statistics (Likelihood-based system reduction tests of LR(p/p-1) and LR(pmax/p)) choose a three-lag model at a 5% significance level. Kilian (1998) argues that the consequences of over-estimating the order of VAR/

VECM are more serious than under-estimating it. Following this argument, a two-lag model is chosen for estimation.

The order and rank conditions of identification should then be checked. The order condition for identification is met when the total number of restrictions satisfies the following conditions: $s \geq r^2$,[7] where s is the total number of restriction and r is the number of cointegrating vectors. With 4 cointegration vectors among 8 variables, the total number of restrictions is 32. The rank condition implies that the number of restrictions on each vector is equal to the number of vectors of cointegration. This means that 4 restrictions should be imposed on each of the 4 cointegrating vectors or each row of β. The just-identified model has $r^2 = 16$ restrictions. However, the just-identified system is not conclusive, as the exact place of the cointegration vectors can not be determined. The methodology applied in this paper allows to test an over-identified system where the exact coefficients of the cointegration vectors from the theory are tested. The total number of over-identified restrictions is equal to s-r^2. This implies the total number of over-identified restrictions to be equal to 16.

A VECM(2) is then estimated. The lower part of the Table (1.8) reports the main statistical properties of each time series within the cointegration space. Unit root tests are consistent with the assumption that all variables are $I(1)$. Excludability tests indicate that none of the variables can be excluded from the cointegration space without losing useful information. The diagnostic tests of serial correlation, functional forms, and heteroscedasticity are satisfactory at a 5% significance level. The misspecification and diagnostic tests indicate an adequate fit of this chosen order specification to the data set. Estimated residuals match the multi-normal distribution in a satisfactory way. Chow tests for parameter stability do not indicate the presence of significant instability at the system level. The exogeneity test confirms that the foreign output and the foreign interest rate are weakly exogenous with respect to home variables.

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[7]For four cointegration relations between eight variables, the total number of restrictions s is equal to $8 * 4 = 32$.

The long-run structure of the model is estimated as follows, where $\zeta_{i,t}$,$i = 1...4$, are long-run reduced form errors.

$$\begin{aligned}
\zeta_{1,t} &= b_t^* - y_t + \underset{\underset{(0)}{[36.18]}}{2.5} \\
\zeta_{2,t} &= r_t - r_t^* - \underset{\underset{(0.38)}{[0.3077]}}{0.265} \\
\zeta_{3,t} &= p_t^* + s_t - p_t - \underset{\underset{(0)}{[0.037]}}{0.7009} \\
\zeta_{4,t} &= y_t - y_t^* - \underset{\underset{(0)}{[0.032]}}{0.258}
\end{aligned} \tag{1.20}$$

Standard errors are given in square brackets. The p-values are given in round brackets. The first equation is a proxy for the current account or the net accumulation of foreign assets (NFA). The net external position then emerges as a function of domestic GDP-per capita, denoted by y_t and the net holdings of foreign debt, b_t^*. The p-value of the constant term is equal to zero. This means that I can reject the null hypothesis that the intercept is not significant at any conventional significance levels. The second long-run relationship is the interest rate parity (IR). The p-value for the intercept is equal to 0.38. Therefore, the null hypothesis of no intercept is not rejected in the data. The third long-run relationship describes the PPP relationships or the stationarity of the real exchange rate between two countries. The p-value for testing the null hypothesis that the intercept is equal to zero is zero. So the null hypothesis that the coefficient is zero is rejected here. The last equation is the technological output gap (OG). Again, with a p-value of zero for the intercept, the null hypothesis is rejected and the intercept is significant.

The fact that these theories cannot be rejected here is an interesting contribution to the empirical literature that has investigated these relationships for a long time. One explanation for these results draws on the work of PGLS (2003). In their view, long-run theories are best estimated via VECM. This is because feedbacks and interactions that are omitted from more partial analysis are all considered in such estimations.

1.4.5 Permanent Shocks or Common Trends

Not only does the methodology in this paper let me identify the driving force behind fluctuations by deviating from long-run relationships, it also identifies the long-run common forces of the two economies. This is done through common trend analysis.

Following Beveridge and Nelson (1981), the effects of structural shocks on the evolution of the economy can be either permanent or transitory. With this in mind, transitory shocks are those which give the economy its cyclical evolution, or deviations from the long-run equilibrium. Permanent shocks or common trends are those shocks with long-run impacts on the economy. In an integrated world, the long-run evolutions of small economies are affected by the rest of the world's shocks. This strategy here suggests that any vector of non-stationary variable X_t with $(m \times 1)$ dimensions can be decomposed into a constant term γ, a transitory term X_t^s, and a permanent or stochastic trend counterpart X_t^p:

$$X_t = \gamma + X_t^s + X_t^p \tag{1.21}$$

Engel and Granger (1987) argue that when there are r cointegration relations within a vector X_t of m variables, there exist $m - r = k$ common stochastic trends between these variables. The common trend representation is as follows:

$$X_t = \gamma + D(L)\zeta_t + A\tau_t \tag{1.22}$$

where τ_t is the stochastic trend:

$$\tau_t = \mu + \tau_{t-1} + \eta_t \tag{1.23}$$

$D(L)$ is a $(m \times k)$ matrix of lag polynomials with L as the lag operator, ζ_t is a $(m \times 1)$ vector of serially non-correlated, mean zero, structural transitory innovations, A is a loading coefficient matrix with dimension $(m \times m)$, τ_t is a vector of common trends with the dimension of $(m \times k)$ following random walks with drift, and η_t is a vector of independent structural permanent shocks with covariance Σ_η. It follows that:

$$X_t^s = D(L)\zeta_t,\ X_t^p = A\tau_t \tag{1.24}$$

The deviations from the long-run relations will disappear in the long-run. This translates into the following orthogonality conditions:

$$\beta'.A\tau_t = 0 \tag{1.25}$$

where β' is defined in the last section as a matrix of long-run coefficients, A is a loading coefficient matrix for the long-run shocks, and τ_t is a matrix of permanent stochastic components.

Empirical Results

With four cointegration vectors among eight variables, four common stochastic trends can be identified. As home is a small open economy that shares shocks with abroad, the source of these common trends or the permanent shocks should come from abroad. This is to say that common trends are shocks to foreign variables that are weakly exogenous to the home variables. These permanent shocks, furthermore, can be real or monetary. Real shocks are the innovations to technology that directly affect productivity, and hence outputs in both countries. Innovations in foreign interest rate, foreign price, and exchange rate are the monetary permanent shocks. However, the attention is restricted to the impact of shocks on the Canadian variables. Structural impulse responses provide further information on the linkages among variables.

Structural permanent shocks are in a (4×1) vector of η_t. These are foreign interest rate shock $\eta_t^{r_t^*}$, output shock $\eta_t^{y_t^*}$, price shock $\eta_t^{p_t^*}$, and nominal exchange rate shock $\eta_t^{s_t}$. The orthogonality condition implies that these shocks create short-run deviations from the long-run equilibrium. Their effects disappear in the long-run as follows:

$$\beta' A = \begin{pmatrix} 1 & -1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & 1 & 0 & -1 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & -1 \end{pmatrix} \begin{pmatrix} 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 1 & 1 & 0 \\ 1 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 0 \\ 0 & 1 & 1 & 0 \\ 1 & 0 & 0 & 1 \end{pmatrix} = 0 \qquad (1.26)$$

Then, following the permanent decomposition of X_t, long-run levels of variables are determined by the permanent shocks:

$$\begin{pmatrix} b_t^* \\ y_t \\ p_t \\ r_t \\ s_t \\ y_t^* \\ p_t^* \\ r_t^* \end{pmatrix} = \begin{pmatrix} 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 1 & 1 & 0 \\ 1 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 0 \\ 0 & 1 & 1 & 0 \\ 1 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} \eta_t^{r_t^*} \\ \eta_t^{y_t^*} \\ \eta_t^{p_t^*} \\ \eta_t^{s_t} \end{pmatrix} \qquad (1.27)$$

The above-mentioned decomposition explains the effects of permanent innovations on Canadian and US variables in the long-run. The key determinant of the accumulation of assets in Canada is the productivity. The higher the productivity is, the higher the incentives to invest and to accumulate assets in Canada. The long-run level of Canadian output is determined by technological innovations in the US economy. Higher productivity, by reducing the costs of production, reduces the long-run level of prices. As PPP holds in the long-run, the real exchange rate reverts to unity ultimately and prices at home become equal to foreign prices. The US and Canada cycles are correlated, and their monetary policies are closely tied to each other in the long-run. Within an integrated financial market, the key policy rate of the Bank of Canada and the Fed funds rate are positively correlated to each other. The exchange rate variability is resulted from the perturbations of exchange rate markets. Foreign variables are affected by foreign innovations; output by output innovations, and prices by prices and productivity innovations. Within a flexible exchange rate regime, interest rates react to exchange rate variations to guarantee the spontaneous adjustment of supply and demand of national currency versus foreign currencies on the exchange market.

The predictive power of the model economy is then tested by running a simulation exercise on the following four above-mentioned shocks; $\eta_t^{r_t^*}, \eta_t^{y_t^*}, \eta_t^{p_t^*}, \eta_t^{s_t}$. These shocks derive the common cycles between two economies, as they affect both economies simultaneously. As these shocks affect the first differences of variables, their impacts on these first differences are stationary and die-out after a few periods. 95% confidence intervals around impulse responses are calculated by the Kilian (1998) approach of Bootstrap after Bootstrap for a 1000 periods time simulation.

Figures 1.1 to 1.9 show the impact of permanent shocks, as defined above on the variables. The horizontal axes are time horizons. i.e. quarters. The vertical axes are percentage deviations from steady-state values. The model predicts that a one positive percent deviation shock into the Fed fund's rate (contractionary monetary shock) has a small recessionary impact at home and reduces output by 0.04% (Figure 1.1). Following the same shock, the key policy rate in Canada increases only by 0.14% (Figure 1.2). One percent foreign productivity improvement reduces the cost of production and the long-run prices by 0.15% (Figure 1.3). This productivity improvement leads to a monetary ease or an interest rate decrease of 40 basis points (Figure 1.4). Following the same shock of productivity, the Canadian dollar appreciates (Figure 1.5). Productivity improvement increases Canadian output by 0.4% (Figure 1.6).

Many of the benefits of international financial integration between the two economies are tied to the holdings of net foreign assets, rather than to capital flows between the two countries. This view is consistent with the recent evidence on international diversification and integration of world capital markets. A one percent increase in the exchange rate, decreases the net accumulations of assets by 2% (Figure 1.7), while it increases output by 0.1% (Figure 1.8). The key policy rate increases in consequence by 1% (Figure 1.9).

These results also confirm that monetary shocks have short-run effects on output, but permanent effects on the price level and exchange rate. The long-run paths for outputs are solely driven by technology innovations in the US.

1.5 Conclusions

I used post-war data for Canada and the US to determine the dynamics of macroeconomic variables between these two countries. This is done through the development of a growth model of a small open economy and the long-run relations between domestic and foreign variables. The vector error correction strategy is combined with common trends analysis to identify the effects of transitory and permanent shocks between the two economies. Four long-run relationships and four common trends are identified and tested with data among eight variables of interest. Those trends determine the impact of permanent shocks on the Canadian economy. The simulation results reveal that shocks between the two economies are interrelated. The results explain financial integration, as well as commercial exchange agreements that make the two neighbors closely tied to each other. This particular strategy provides a new policy instrument for the study of small open economies in the face of globalization.

APPENDIX A

TABLES

Table 1.1 List of Variables and their Descriptions

Variables	International Financial Statistics References	Definition
b_t^*	15631...NZF	Net foreign assets in Canada
y_t	15698BNCZF	Natural log of real GDP per capita (divided by population series 99Z...ZF)
y_t^*	11199BCZF	Natural log of real GDP per capita (divided by population series 99Z...ZF)
r_t	15660...ZF	Bank rate (end of period)
r_t^*	1160...BZF	Federal funds rate
p_t	15699BIRZF	Natural log of GDP deflator in Canada (2000=100)
p_t^*	11199BIRZF	Natural log of GDP deflator in the State (2000=100)
s_t	156NECZF	Natural log of eeffective exchange rate for the Canadian dollar

Table 1.2 Unit Root Tests

(a) Variables in levels with constants

Variables	Constants			
Tests	ADF	PP	DFGLS	KPSS
95% cv.	**-2.87**	**-2.87**	**-1.94**	**0.46**
y_t	-1.83	-2.16	0.74	1.53
y_t^*	-1.37	-1.15	1.08	1.55
r_t	-2.32	-2.117	-1.177	0.443
r_t^*	-2.21	-1.94	-1.34	0.4
p_t	-2.83	-0.94	0.47	1.57
p_t^*	-1.72	-1.03	0.78	1.53
s_t	-1.16	-0.98	0.056	1.32
b_t^*	-1.64	-0.41	0.74	1.2

(b) Variables in levels with constants and trends

Variables	Constant and Trends			
Tests	ADF	PP	DFGLS	KPSS
95% cv.	**-3.43**	**-3.43**	**-2.96**	**0.146**
y_t	-2.49	-2.76	-0.73	0.27
y_t^*	-3.38	-2.24	-1.842	0.177
r_t	-2.48	-2.12	-1.32	0.33
r_t^*	-2.33	-1.91	-1.6	0.29
p_t	0.52	-0.6	-1.39	0.28
p_t^*	-0.36	-0.66	-1.46	0.31
s_t	0.01	-2.16	-1.91	0.134
b_t^*	-1.47	-1.43	-1.45	0.21

Table 1.3 Unit Root Tests

(a) Variables in first differences with constants

Variables	Constants			
Tests	ADF	PP	DFGLS	KPSS
95% cv.	**-2.107**	**-2.87**	**-1.94**	**0.46**
Δy_t	-4.7	-8.63	-1.14	0.42
Δy_t^*	-4.56	-9.12	-1.37	0.31
Δr_t	-6.4	-12.24	-1.84	0.14
Δr_t^*	-4.31	-9.24	-4.29	0.16
Δp_t	-2.73	-5.45	-2.09	0.3
Δp_t^*	-2.18	-6.877	-0.81	0.28
Δs_t	-3.84	-12.9	-0.65	0.059
Δb_t^*	-2.9	-13.7	-1.52	0.134

(b) Variables in first differences with constants and trends

Variables	Constant and Trends			
Tests	ADF	PP	DFGLS	KPSS
95% cv.	**-3.43**	**-3.43**	**-2.96**	**0.146**
Δy_t	-4.9	-8.87	-2.98	0.12
Δy_t^*	-4.65	-9.27	-3.96	0.07
Δr_t	-6.47	-12.3	-2.96	0.029
Δr_t^*	-4.36	-9.25	-3.9	0.03
Δp_t	-2.86	-5.53	-2.48	0.22
Δp_t^*	-3.26	-6.91	-1.42	0.189
Δs_t	-3.85	-12.87	-2.97	0.05
Δb_t^*	-2.91	-13.67	-2.54	0.106

Table 1.4 Cointegration Rank Tests

Hypothesis		Max-Eigenvalue			Trace		
$H0$	$H1$	Statistics	95% cv.	90% cv.	Statistics	95% cv.	90% cv.
$r = 0$	$r = 1$	$82.25^{\times}$	51.3	48.23	$264.76^{\times}$	158.16	152.33
$r \leq 1$	$r = 2$	$70.94^{\times}$	45.45	42.72	$182.5^{\times}$	125.86	120.11
$r \leq 2$	$r = 3$	$40.54^{\times}$	39.76	36.93	$111.55^{\times}$	96.79	91.9
$r \leq 3$	$r = 4$	$31.35^{\times}$	33.14	30.70	71.01	69.87	66.14
$r \leq 4$	$r = 5$	18.19	27.27	24.84	39.65	49.56	45.95
$r \leq 5$	$r = 6$	11.55	21.16	18.96	21.46	32.16	29.08
$r \leq 6$	$r = 7$	7.83	14.79	12.83	9.91	17.79	15.83
$r \leq 7$	$r = 8$	2.07	8.13	6.49	2.07	8.13	6.49

Note: The underlying VAR model is of order 2 and contains unrestricted intercepts and restricted trend coefficients. The statistics are computed using 184 observations for the period 1961q1-2007q3. Max and Trace represent Johansen's log-likelihood-based trace and maximum eigenvalue statistics, respectively, and cv stands for critical value of the tests, generated by the software Microfit4, and which are obtained from Pesaran, Shin and Smith bootstrap values (1997). Sign$^{\times}$ indicates significance at, at least, 10% significance level.

Table 1.5 Residual-Based Test of the Null of Cointegration Against the Alternative of No Cointegration

Relationships	LM-statistic constant	5% level
$p_t^* + s_t - p_t$	0.087	0.46
$r_t - r_t^*$	0.22	0.46
$y_t - y_t^*$	0.35	0.46
$b_t^* - y_t$	0.40	0.46

Table 1.6 VAR Lag Length Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	983.3396	NA	3.85E-17	-12.25584	-12.08213	-12.18530
1	2829.153	3459.450	8.81E-27*	-34.45476	-32.71764*	-33.74933*
2	2910.882	143.9247	8.80E-27	-34.46392*	-31.16340	-33.12362
3	2974.861	105.4248*	1.12E-26	-34.24983	-29.38590	-32.27464
4	3033.764	90.39232	1.54E-26	-33.97188	-27.54455	-31.36181
5	3092.540	83.54301	2.20E-26	-33.69233	-25.70160	-30.44738

$*$ indicates lag order selected by the criterion LogL: Log likelihood function

LR: Sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwartz information criterion
HQ: Hannan-Quinn information criterion

Table 1.7 Test of Weak Exogeneity

Variables	$\varkappa^2(5)$	p-values
r_t^*	10.9	0.053
y_t^*	25.71	0.051

Table 1.8 Error Correction Specification of the Model Economy

Equation	Δb_t^*	Δy_t	Δp_t	Δr_t	Δs_t	Δy_t^*	Δp_t^*	Δr_t^*
$\hat{\xi}_{1,t}$	−0.06 [0.04]	−0.01 [0.17]	−0.22 [0.97]	−1.62 [0.06]	0.06 [0.3]	0.01 [0.05]	0.005 [0.02]	−1.5 [0.001]
$\hat{\xi}_{2,t}$	1.18 [0.90]	−0.0 [0.17]	−0.0 [0.76]	−0.48 [0.3]	0.04 [0.0]	0.006 [0.07]	0.005 [0.017]	−0.9 [0.007]
$\hat{\xi}_{3,t}$	4.6 [0.01]	−0.35 [0.35]	−0.7 [0.07]	−0.08 [0.04]	0.0 [0.4]	0.33 [0.003]	0.33 [0.009]	−0.05 [0.003]
$\hat{\xi}_{4,t}$	3.12 [0.009]	−0.01 [0.05]	0.14 [0.00]	−2.5 [0.2]	0.03 [0.4]	0.01 [0.02]	0.01 [0.03]	1.05 [−2.9]
Δb_{t-1}^*	−0.19 [0.01]	−0.03 [0.85]	0.02 [0.02]	0.9 [0.06]	−0.01 [0.5]	−0.01 [0.12]	−0.01 [0.12]	2.5 [0.03]
Δy_{t-1}	33.28 [0.84]	0.04 [0.09]	0.13 [0.003]	2.6 [0.08]	−0.01 [0.82]	0.01 [0.4]	0.06 [0.4]	8.2 [0.08]
Δp_{t-1}	23.70 [0.62]	0.1 [0.09]	0.3 [0.07]	0.06 [0.08]	0.01 [0.66]	0.00 [0.6]	0.01 [0.66]	3.5 [0.00]
Δr_{t-1}	−0.66 [0.82]	−0.001 [0.115]	0.0 [0.33]	−0.77 [0.83]	0.06 [0.07]	0.06 [0.3]	0.0 [0.4]	0.17 [0.86]
Δs_{t-1}	−2.24 [0.88]	−0.002 [0.05]	−0.7 [0.07]	0.85 [0.01]	0 [0.75]	1.74 [0.12]	1.5 [0.3]	0.6 [0.5]
Δy_{t-1}^*	−43.08 [0.35]	0.04 [0.0]	0.3 [0.01]	0.46 [0.06]	0.00 [0.4]	0.00 [0.4]	0.00 [0.4]	1.74 [0.08]
Δp_{t-1}^*	−102.5 [0.34]	0.001 [0.35]	0.7 [0.07]	−2 [0.87]	0.43 [0.3]	0.43 [0.3]	0.06 [0.3]	1.6 [0.1]
Δr_{t-1}^*	0.99 [0.73]	0.004 [0.5]	0.47 [0.07]	−0.16 [0.05]	0.16 [0.87]	0.0 [0.3]	0.0 [0.3]	0.17 [0.8]
R^2	0.65	0.25	0.47	0.22	0.16	0.3	0.82	0.3
$\varkappa_{SC}^2$ [4]	10.25 [0.03]	6.4 [0.17]	24.2 [0.00]	7.8 [0.1]	2.87 [0.58]	12.3 [0.02]	9.7 [0.04]	35.13 [0]
$\varkappa_{FF}^2$ [1]	29.55 [0.0]	0.45 [0.5]	7.5 [0.0]	0.17 [0.7]	3.33 [0.07]	0.07 [0.8]	6.92 [0.01	8.09 [0.01]
$\varkappa_N^2$ [2]	122.8 [0.0]	49 [0.02]	107 [0.00]	49 [0.00]	200 [0.02]	100 [0.60]	11.4 [0.00]	1.9 [0.4]
$\varkappa_H^2$ [1]	14.96 [0.0]	0.06 [0.8]	4.46 [0.03]	5.97 [0.17]	8.8 [0.22]	0.04 [0.5]	11.98 [0.00]	1.99 [0.03]

Notes: The p-values are given in brackets for the diagnostic tests. The corresponding degree of freedom are given with the chi-squared statistic. The diagnostics are: 1) Lagrange multiplier test of no serial correlation of residual $\sim \varkappa_{sc}^2$, 2) Ramsey's RESET test using the square of the fitted values for the functional form $\sim \varkappa_{FF}^2$, 3) Normality in residuals, based on a test of skewness and kurtosis of residuals $\sim \varkappa_N^2$, and 4) Homoscedasticity $\sim \varkappa_H^2$, based on the regression of squared residuals on squared fitted values.

APPENDIX B

EQUILIBRIUM CONDITIONS

B.1 First Order Conditions

This appendix provides a derivation of the long-run relationships from the theoretical model. Long-run relationships have been derived from the steady-state solutions. All variables should first be transformed to stationary ones. This is done by dividing all real variables by the level of technical progress A_t to produce a stationary economy. This is equal to a steady-state growth under certainty as in King, Plosser and Rebelo (1988). The necessary conditions for the existence of a balanced growth path are then i) the additive separability of the utility function in consumption and leisure, and ii) labor-augmenting technical process. Both assumptions have already been introduced in the presentation of the theoretical model.

$$\{C_t\} : U_{C_t} = \lambda_t \tag{B.1}$$

$$\{L_t\} : -U_{L_t} = \lambda_t w_t \tag{B.2}$$

$$\{B_{t+1}\} : \lambda_t = \beta E_t(1 + r_{t+1})\lambda_{t+1} \tag{B.3}$$

$$\{B^*_{t+1}\} : \lambda_t = \beta E_t(1 + r^*_{t+1})\lambda_{t+1}(\frac{e_{t+1}}{e_t}) \tag{B.4}$$

$$\{K_{t+1}\} : \lambda_t - \beta(1 - \delta)E_t\lambda_{t+1} + \partial\psi(I_{t+1})/\partial K_{t+1} = 0 \tag{B.5}$$

$$\{\frac{M_{t+1}}{P_t}\} : \lambda_t = \beta E_t\{\lambda_{t+1} + U_{\frac{M}{P}t+1}\} \tag{B.6}$$

Combining these equations gives the following Euler equations and parities:

$$U_{C_t} = \beta E_t(1 + r_{t+1})U_{C_{t+1}} \tag{B.7}$$

$$U_{C_t} = \frac{-U_{L_t}}{w_t} \tag{B.8}$$

$$E_t(1 + r^*_{t+1})(\frac{e_{t+1}}{e_t}) = E_t(1 + r_{t+1}) \tag{B.9}$$

$$\beta(1 - \delta)E_t U_{C_{t+1}} - U_{C_t} = \partial\psi(I_{t+1})/\partial K_{t+1} \tag{B.10}$$

$$U_{\frac{M}{P}}(t) = U_{C_t} - \beta E_t U_{C_{t+1}} \tag{B.11}$$

The non-Ponzi games for bond holding explain that debts cannot increase exponentially and yield long-run solvency conditions as follows:

$$\lim_{T\to\infty}(1 + r_t)^{-T} B_{t+T+1} \geq 0 \tag{B.12}$$

$$\lim_{T\to\infty}(1 + r^*_t)^{-T} B^*_{t+T+1} \geq 0 \tag{B.13}$$

$$\lim_{T\to\infty}(1 + r_t)^{-T} B_{t+T+1} = 0 \tag{B.14}$$

$$\lim_{T\to\infty}(1 + r^*_t)^{-T} B^*_{t+T+1} = 0 \tag{B.15}$$

The firm's problem is given by maximizing its profit:

$$\Pi_t = \max\{F(K_t, A_t N_t) - r_t K_t - w_t N_t\} \tag{B.16}$$

$$\{K_t\} : F_K(K_t, A_t N_t) = f^{'}(k_t) = r_t \tag{B.17}$$

$$\{N_t\} : A_t F_N(K_t, A_t N_t) = A_t[f(k_t) - k_t f'(k_t)] = w_t \tag{B.18}$$

And from the production function:

$$Y_t = F(K_t, \exp(A_t)N_t) = \exp(A_t)N_t F(\frac{K_t}{\exp(A_t)N_t}, 1) = \exp(A_t)N_t f(k_t) \tag{B.19}$$

Since the equilibrium cannot be solved analytically, a linearized system around the steady-state values is considered. Log-levels of stationary variables are not necessarily stationary. However, economic theory suggests that some of their linear combinations become stationary. The long-run log-linear relationships to be tested by data are as follows:

$$\log Y_t = A_t + \log N_t + \log(f(k_t)) \tag{B.20}$$

$$\log Y_t^* = A_t^* + \log N_t^* + \log(f(k_t^*)) \tag{B.21}$$

Taking the difference between these equations gives us the technological differences between home and abroad:

$$(\log Y_t - \log N_t) - (\log Y_t^* - \log N_t^*) = A_t - A_t^* + \log(f(k_t)) - \log(f(k_t^*)) \tag{B.22}$$

Log-deviations of the transformed variables are written in small cases. y_t and y_t^* are the real per-capita outputs.

$$y_t = (\log Y_t - \log N_t) \tag{B.23}$$

$$y_t^* = (\log Y_t^* - \log N_t^*) \tag{B.24}$$

$$y_t - y_t^* = A_t - A_t^* + \log(f(k_t)) - \log(f(k_t^*)) \tag{B.25}$$

This equation gives the long-run relations between production at home and abroad.

B.2 Derivation of Long-run Relations

The technology output gap is given by:

$$y_t - y_t^* \sim I(0) \tag{B.26}$$

In the goods market, absent natural or government-imposed trade barriers, a commodity should sell for the same price everywhere, at home or in a foreign country, when prices are measured in a common numeraire. This implies the following purchasing power parity PPP or market clearing condition in the long-run.

$$\log e_t = \log S_t + \log P_t^* - \log P_t \tag{B.27}$$

Defining q_t as the log of the real exchange rate, e_t the real exchange rate itself, s_t the log of the nominal exchange rate S_t, p_t the log of the home price level, and p_t^* the log of the foreign price level. Under fully flexible prices in the long-run, the equilibrium real exchange rate will be:

$$q_t \equiv s_t + p_t^* - p_t \sim I(0) \tag{B.28}$$

From the FOCs of holding domestic or foreign real bonds, the Uncovered Interest Parity equation is resulted:

$$\log(1 + r_{t+1}^*) + \log(\frac{e_{t+1}}{e_t}) = \log(1 + r_{t+1}) \tag{B.29}$$

Up to a first-order Taylor expansion:

$$\log(1 + r_{t+1}^*) \simeq r_{t+1}^* \tag{B.30}$$

and I can write for the interest rate differential as follows:

$$r_{t+1} - r_{t+1}^* \sim I(0) \tag{B.31}$$

Then finally, from the net foreign asset condition or current account:

$$Y_t - C_t - I_t = e_t(B_{t+1}^* - B_t^*) + e_t r_t^* B_t^* \tag{B.32}$$

$$\frac{Y_t}{Y_t} - \frac{C_t}{Y_t} - \frac{I_t}{Y_t} = e_t(\frac{B_{t+1}^*}{Y_{t+1}}(\frac{Y_{t+1}}{Y_t}) - \frac{B_t^*}{Y_t}) + \frac{e_t r_t^* B_t^*}{Y_t} \tag{B.33}$$

On the left hand side of the equation are the great ratios in the spirit of KPSW (1991) which turn out in empirical analysis to be stationary. Consumption and output are cointegrated, and investment and output are cointegrated. This means that the ratios of the levels are $I(0)$.

The right hand side of the equation is the change in the debt-ratio corrected for the real growth rate of the economy. Given the fact that PPP holds and e_t is stationary, and that there is a relationship between foreign interest rate and real exchange rate, the test of stationarity can be reduced to a debt-ratio $\frac{B_t^*}{Y_t}$. The following log equation is tested with data:

$$b_t^* - y_t \sim I(0) \tag{B.34}$$

APPENDIX C

FIGURES

Figure 1.1 Impulse response function of one percent deviation shock to foreign interest rate on output

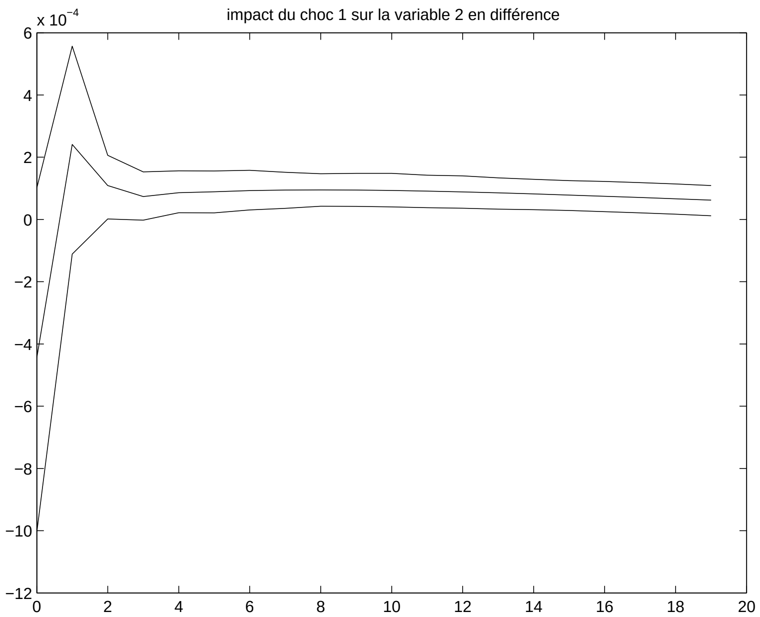


Figure 1.2 Impulse response function of one percent deviation shock to foreign interest rate on interest rate

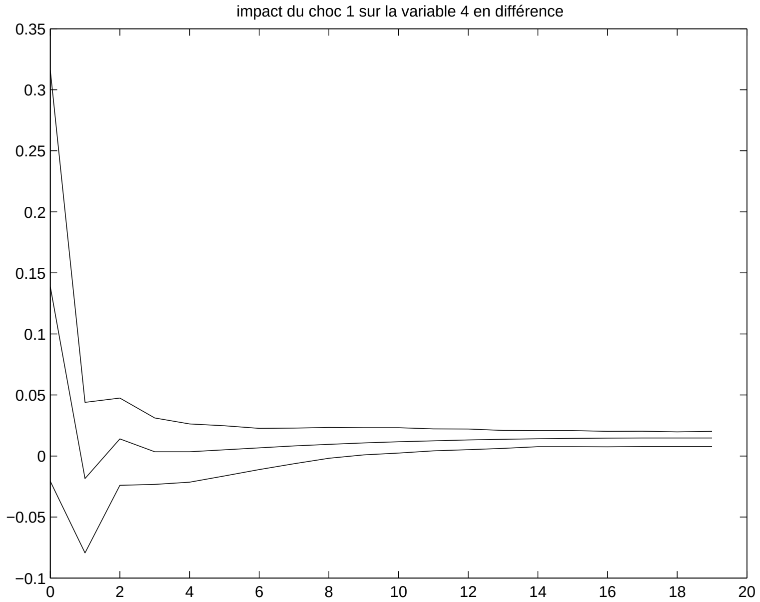


Figure 1.3 Impulse response function of one percent deviation shock to foreign output on prices

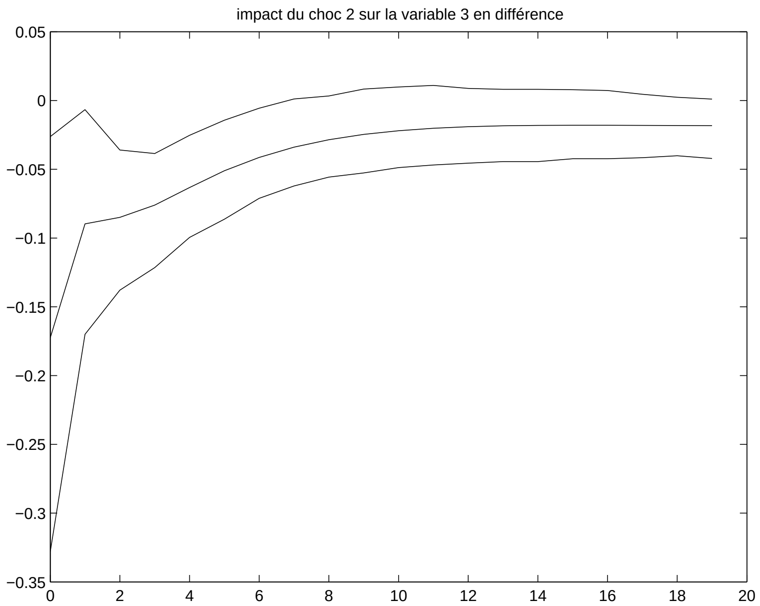


Figure 1.4 Impulse response function of one percent deviation shock to foreign output on interest rate

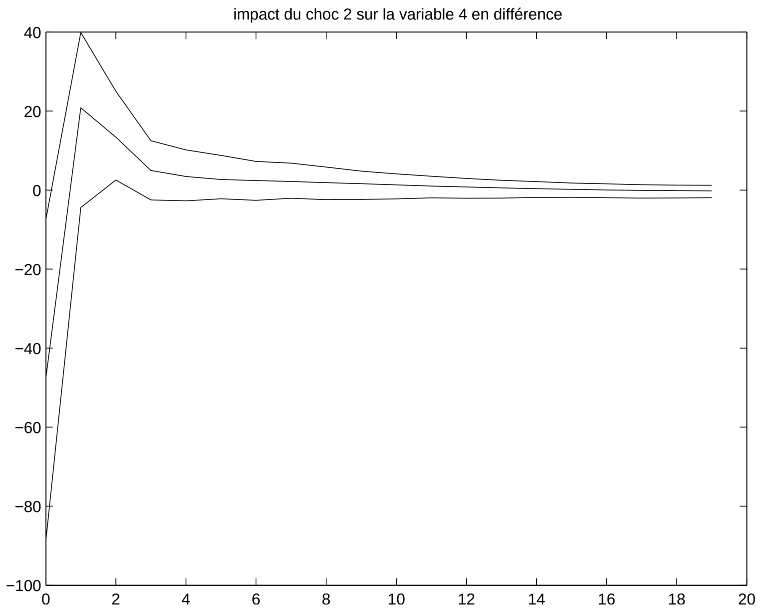


Figure 1.5 Impulse response function of one percent deviation shock to foreign output on exchange rate

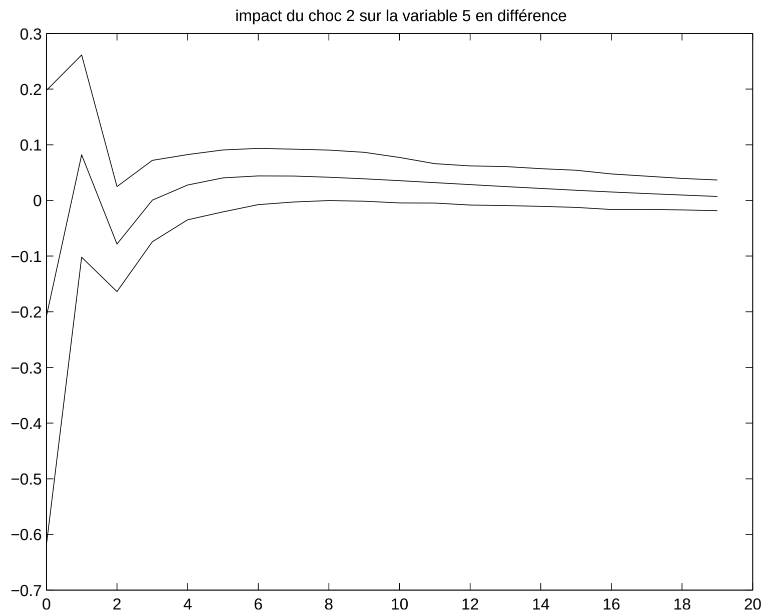


Figure 1.6 Impulse response function of one percent deviation shock to foreign output on output

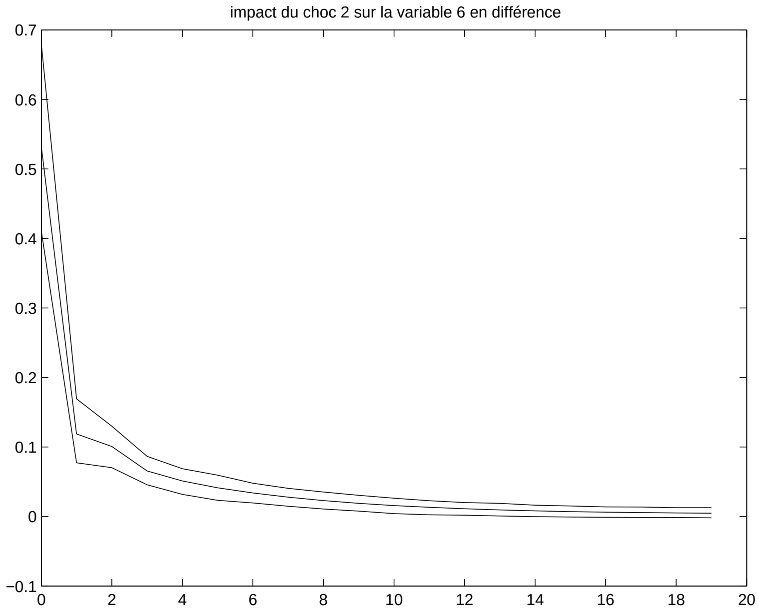


Figure 1.7 Impulse response function of one percent deviation shock to exchange rate on net accumulation of assets

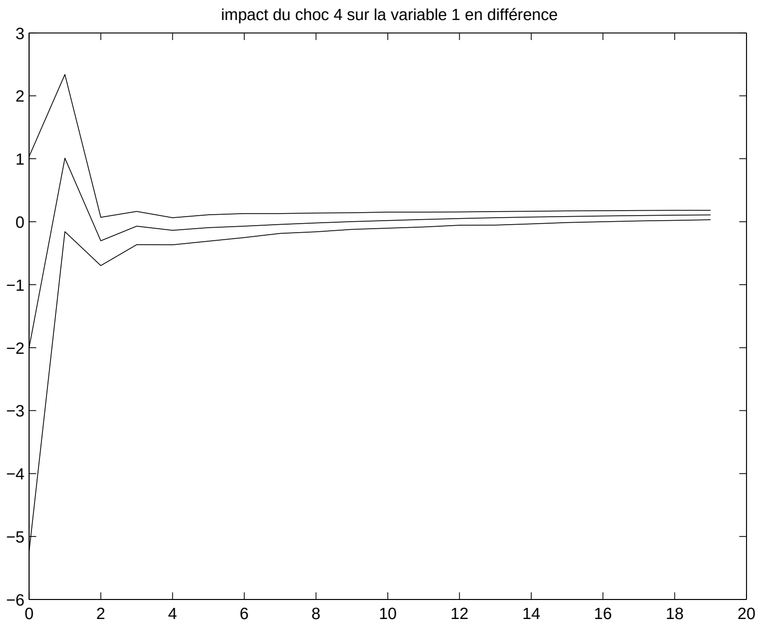


Figure 1.8 Impulse response function of one percent deviation shock to exchange rate on output

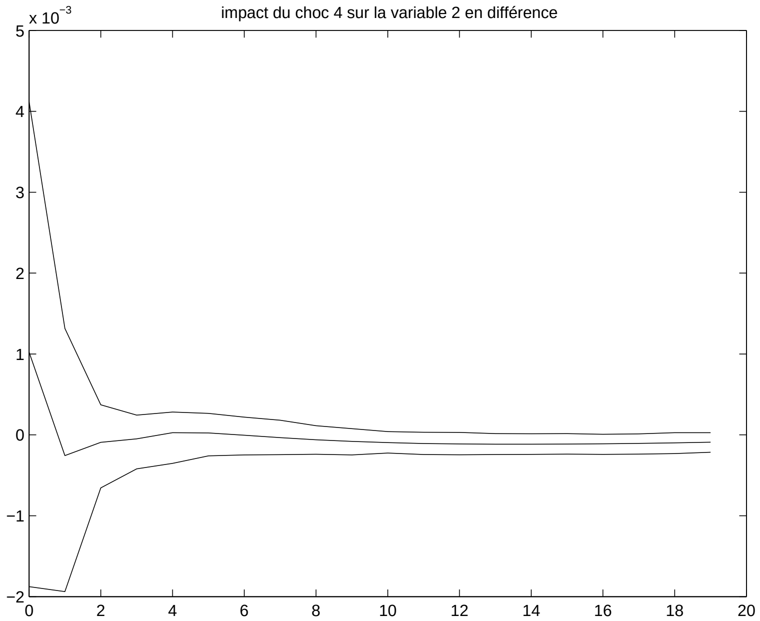
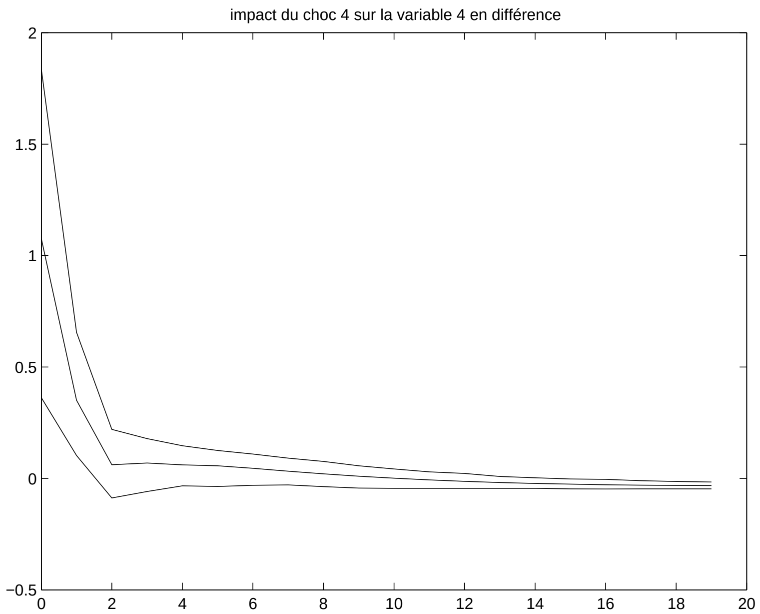


Figure 1.9 Impulse response function of one percent deviation shock to exchange rate on interest rate



CHAPTER II

TECHNICAL CHANGE, WAGE AND PRICE DISPERSION, AND THE OPTIMAL RATE OF INFLATION

Abstract

This essay derives the optimal rate of price inflation by adding long-run real output growth to a standard New Keynesian model. The results revive the old paradigm of monetary economics associated with Friedman (1969): mild deflation is the optimal policy. However, in this essay, optimal deflation results from the presence of growth in the steady-state that leads to a wedge between price inflation and wage inflation. In this situation, the steady-state of the model is characterized by four distortions: price dispersion, wage dispersion, and monopolistic mark-ups of price and of wage setters. Optimal inflation is the one that balances these distortions at the margin. In a stochastic version of the model, the mean of variables is affected by shocks. As a result, monetary policy can stabilize wages when targeting a small price deflation rate.
Keywords: Price Inflation, Wage Inflation, Real Output Growth, Staggered Contracts, Welfare Evaluation.

2.1 Introduction

This chapter studies the consequence of real output growth on the design of monetary policy. It brings new elements to revive the old monetary economics paradigm of the Friedman era (1969) which considered deflation as the optimal monetary policy. This it does by adding long-run real output growth to a simple New Keynesian model, with both price and wage rigidities. The long-run real output growth creates a wedge between price and wage inflations and leads to a slightly negative price inflation rate being optimal.

Empirical observation reveals that real output growth and inflation have not been zero (higher for developing as opposed to developed economies) for the post-war era. The relationship between these two variables is an inverse one. Also, while many central banks have opted for explicit inflation targets during the last decade and as a result have reduced both inflation and output variability in their economies, the choice of the level of inflation target remains at the heart of debates.

I derive the steady-state rate of inflation in a calibrated model to US data, from a welfare point of view. This rate that later becomes the target level of the monetary policy is negative, i.e. deflation. The results reveal that real output growth slightly increases the welfare cost of inflation. A sensitivity analysis highlights how the optimal inflation rate varies with specific structure and parameter values of the economy. Finally, the impact of real output growth on the stabilization policies of a central bank faced with shocks is briefly discussed.

Since the aim of this paper is not to explore what leads to real output growth, an exogenous persistent process for technology is considered. The time-series literature highlights that autocorrelation of output growth in the US is positive. I follow the Cogley and Nason (1995) argument in this regard and design an autoregressive model for real output growth.

The main results are as follows. Higher real output growth in the steady-state leads to a larger wedge between price inflation and wage inflation. For a range of parameter values, this exercise leads to an optimal rate of price inflation that turns out to be slightly negative. Sensitivity analysis confirms an inverse relationship between the optimal rate of price inflation and elasticities of substitution between different types of labor and products. The gain from moving from zero inflation to the optimal price deflation rate of 0.72% on an annual basis is equal to 0.1% of non-stochastic steady-state consumption.

The intuitions that explain the results follow. In a New Keynesian environment with both good and labor markets (i.e. imperfect markets and staggered contracts), there exists four types of distortions. These are distortions caused by the staggered nature of price and wage contracts and the monopolistic nature of (intermediate) good and labor markets. Staggered price setting by firms distorts relative prices across different cohorts of firms, and leads to an inefficient use of resources. The same argument applies for the labor market. Furthermore, due to the monopolistically competitive nature of goods and labor markets, prices and wages do not reflect marginal costs. In such an environment, real output growth creates a wedge between steady-state price and wage inflations.

The optimal inflation rate balances these costs at the margin: price dispersion across different types of goods, wage dispersion across different types of labor, the average mark-up of prices over marginal costs, and the average mark-up of wages over the opportunity cost of foregone leisure. In consequence, price and wage distortions cannot simultaneously be eliminated at a steady-state with a zero rate of their respective inflations. Furthermore, due to the presence of monopolistic firms, a slightly positive level of price inflation is optimal to reduce the mark-up of prices over marginal costs. This is also the case for monopolistic households: a slightly positive wage inflation is optimal to reduce the markups of labor over the marginal cost of leisure. All other things being equal, real output growth lowers the rate of price inflation that minimizes the distortions due to nominal wage distortion and households' mark-up of nominal wages over the marginal cost of foregone leisure.

The monetary policy follows a Taylor type of interest rate rule for its key policy rate, and will choose the optimal deflation rate as its target level. It is to be noted that the kind of deflation that is examined here is not necessarily harmful for the economy. Following Mishkin and Takatoshi (2006), when deflation is a result of a favorable productivity shock, it does not necessarily lead to negative consequences. The paper then discusses the dynamic of the economy under shocks to this nominal interest rate rule and real output growth. The presence of inflation at the steady-state affects the mean of variables after shocks.[1] The analysis shows that when long-run deflation is considered as the target level of inflation, on average the wage inflation rate will get very close to zero and monetary policy can stabilize wages. This is an important finding, as wage inflation in this model turns out to be more costly than price inflation. The analysis of the cyclical behavior of variables also confirms that the model does quite well to match the true behavior of data after a monetary and a technology growth shock.

The determination of the target level of inflation has been considered by a number of authors. Friedman (1969) argued that inflation should be negative in order to equalize the real rate of return of money with that of bonds. However, there is a vast literature on why deflation might not be the optimal policy. For example, Bailey (1956) argued, based on public finance, that an inflation tax should be used as one among a number of different distortionary taxes to balance distortions in the economy at the margin. Akerlof, Dickens and Perry (2000) explain that nominal wages resist negative changes following deflation. Buiter and Panagirzoglou (2003) explain that deflation might lead the economy into a liquidity trap. However, as Mishkin *et al.* (2006) explain, one should consider recent observations in China (1997-2003) and in the US (in 90s) to conclude that deflation is not always negative for the economy. Favorable supply shocks can increase the productivity and lead to deflation. Deflation caused by this mechanism would be accompanied by faster growth of output.

This paper is also related to previous studies of the macroeconomic impact of nominal contracts in New Keynesian models. The technology shock and the welfare cost of monetary policy, the other topics dealt with in this paper, have been the subject of many debates during the last decade. However, much of the literature implements the perspective of price rigidities to study the topic of the optimal rate of inflation. King and Wolman (1996), for example, find that the average mark-up of prices over marginal cost varies with the inflation rate. Following this idea, Wolman (2001), with only price staggering, derives a slightly positive level for optimal inflation in the steady-state.

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[1] See Amano *et al.* (2007).

Bakhshi, Lombart, Khan, and Rudolf (2003) highlight the welfare costs of price dispersion. Khan, King and Wolman (2003) and Schmitt-Grohé and Uribe (2004) analyze the trade-off among the different costs and benefits of inflation in models with nominal price rigidity. Wolman (2005) develops a two-sector model with price dispersions, and finds that deflation is optimal as prices adjust less frequently in the sector with an increasing relative price. Recent papers in the field such as those by Ascari (2004), and Amano, Ambler, and Rebei (2007) show how nonlinearity may play an important role in New Keynesian models. Ambler, Guay and Phaneuf (2004) and Christiano, Eichenbaum and Evans (2001), among a few others, highlight the importance of real wage rigidities to explain the sluggish behavior of inflation.

However, relatively few studies have done welfare analysis in models with more than one type of nominal rigidity. One of the few exceptions is Erceg, Henderson, and Levin (henceforth referred to as EHL (2000)), who develop a model with both wage and price rigidity. They show that optimal policy should target an appropriately chosen weighted average of price and wage inflation. Based on EHL (2000), a recent working paper of the Bank of Canada by Amano, Moran, Murchison, and Renisson (2007) studies the welfare costs of inflation in a model close in spirit to the model developed in this paper. These authors also find that optimal long-run inflation is negative and explain that labor market frictions are responsible for their results.

While my paper is closest to Amano *et al.* (2007) and EHL (2000), it differs from theirs in several ways. First, in the design of the real output growth, a stochastic process with persistent drift, based on recent observations on the Solow residuals from the experience of industrial countries, is used. Furthermore, physical capital is not part of the modeling. This is due to the fact that the main purpose of the paper is the determination of long-run inflation. While macroeconomic models reveal the importance of physical capital for the study of the short-run, the long-run property of the models are not affected by this variable. Third, my analysis is not solely static. EHL (2000) linearized their model around zero steady-state inflation, but this paper accounts for the impact of second-order approximations on the equilibrium conditions after shocks.

Furthermore, my paper abstracts from output subsidies to keep the model as simple as possible for the study of the other costs of inflation, i.e. prices and wages staggering and mark-up dispersion distortions in presence of real output growth.

The paper is organized as follows. Section 2 presents the model and its equilibrium conditions. Section 3 studies the steady-state inflation. Section 4 analyzes the dynamic model. Section 5 concludes.

2.2 The Model

The economy is a standard New Keynesian model, populated by dynastic households and firms. In every period two competitive markets open; for final consumption goods and for final labor services. There are also two intermediate markets: households sell differentiated labor services and act as monopolistic competitors in the labor market, and monopolistically competitive firms produce differentiated intermediate goods using labor as their input. Following Taylor (1980), households and firms are divided into two cohorts based on the timing of their wage and price setting decisions. Households are price takers in the goods market and monopolistic competitors in the labor market. Firms are wage takers in the labor market and monopolistic competitors in the goods market. The choice of Taylor versus Calvo pricing (1983) is due to the fact that faced by small inflation rates, Taylor contracts do not suffer from relative price distortions that may even prevent the existence of a well defined steady-state as explained by Bakhshi *et al.* (2003).

There is no government spending here to be financed via distortionary taxes, as that would create a motive for the stabilization of the real distortions created by monopolistic competition through an output subsidy channel. The model also abstracts from the opportunity cost of holding money, and has no capital in its design. There is also no money in the economy as in the cashless models of Woodford (2003). No indexation in wages is considered as all firms in each period have identical marginal costs. Finally, the model abstracts from the shoe leather cost of inflation, calculated by the area under the money demand function. The monetary models explain this cost as the one that individuals incur as a time cost in response to an increase in the inflation rate. Wolman (1997) explains why considering the area under the money demand curve may lead to a mistake in the welfare cost of inflation, as this does not measure agents' preferences. By abstracting from this cost, the focus of the paper is solely on the costs that arise from staggered contracts in monopolistic markets with real output growth.

2.2.1 Households: Intermediate Labor Market

Households have instantaneous and separable utility functions in consumption and hours worked. They maximize their utility subject to a sequence of budget constraints. They supply labor to firms and set nominal wages for two periods. Labor supply is divided into two cohorts, differing in the time of wage setting.

The representative household's problem is:

$$\max_{C_{t+\tau}, n_{t+\tau}, w^0_{t+\tau}} U = E_0 \sum_{\tau=0}^{\infty} \beta^\tau \left\{ \ln(C_{t+\tau}) - \varkappa \frac{(n_{t+\tau})^{1+\psi}}{1+\psi} \right\} \tag{2.1}$$

where $C_{t+\tau}$ is consumption, $n_{t+\tau}$ is hours worked, $w^0_{t+\tau}$ is the wage rate of the current period, $0 < \beta < 1$ is the subjective discount rate, and $\varkappa$ and ψ are positive parameters, reflecting the disutility of working. The period t budget constraint is written as:

$$\frac{B_t}{(1+i_t)} + P_t C_t = w^0_t n^0_t + w^1_t n^1_t + \Pi_t + B_{t-1} \tag{2.2}$$

where n^0_t denotes hours supplied at the wage rate fixed in the current period given by w^0_t, and n^1_t denotes hours supplied at the wage rate fixed in the preceding period, given by w^1_t. Households hold nominal one-period bonds B_t. The net nominal interest rate is given by i_t. The price of the consumption basket is given by P_t. Π_t denotes nominal profits distributed by firms to households.

The consumption index is a Dixit and Stiglitz (1977) index of unit measure and aggregates together with the consumption of goods produced by firms that set their prices in two different periods:

$$C_t = 2^{-\frac{1}{1-\epsilon_g}} \left(C_t^{0\,\frac{\epsilon_g - 1}{\epsilon_g}} + C_t^{1\,\frac{\epsilon_g - 1}{\epsilon_g}} \right)^{\frac{\epsilon_g}{\epsilon_g - 1}} \tag{2.3}$$

where C_t^0 is the quantity of goods supplied by firms that fix their prices in the current period, C_t^1 is the quantity of goods supplied by firms that fix their price in the preceding period, $\epsilon_g > 1$ is the elasticity of substitution between differentiated goods produced by firms, and the constant term $2^{-\frac{1}{1-\epsilon_g}}$ is a normalization that eliminates "economies of specialization" meaning that a greater division of labor may increase productivity (Ambler and Cardia (1998) and Devereux, Head and Lapham (1996)).

The first order conditions for the household's problem lead to the following equation for wage setting (see Appendix B for details):

$$\frac{w_t^0}{w_t} = \varkappa \left(\frac{\epsilon_l}{\epsilon_l - 1} \right) \left(\frac{n_t + \beta E_t (\pi_{t+1}^w)^{\epsilon_l} n_{t+1}}{\lambda_t \frac{w_t}{P_t} n_t + E_t \lambda_{t+1} \frac{w_{t+1}}{P_{t+1}} (\pi_{t+1}^w)^{\epsilon_l - 1} n_{t+1}} \right) \tag{2.4}$$

where w_t is the aggregate wage index, w_t^0 is the wage rate revised this period, n_t denotes aggregate labor services that is also defined below, π_{t+1}^w denotes the rate of change of the exact wage index between periods t and $t+1$, and λ_t is the marginal utility of consumption.

This is the equation of relative wage setting. It states that the wage is set based on an average mark-up during the life of the wage contract and is inversely related to the opportunity cost of foregone leisure for the household.

2.2.2 Labor Broker

There is a labor broker who hires different types of labor, aggregates them together, and then sells the labor services to the intermediate goods firms. Each intermediate firm then demands aggregate labor.

The problem of the labor broker is to minimize the cost of producing an amount of labor, given the labor demand. This is written as:

$$\min_{n_t^0, n_t^1} \left(w_t^0 n_t^0 + w_t^1 n_t^1 \right) \tag{2.5}$$

subject to the following aggregated demand function:

$$n_t = 2^{-\frac{1}{1-\epsilon_l}} \left({n_t^0}^{\frac{\epsilon_l-1}{\epsilon_l}} + {n_t^1}^{\frac{\epsilon_l-1}{\epsilon_l}} \right)^{\frac{\epsilon_l}{\epsilon_l-1}} \tag{2.6}$$

where $\epsilon_l > 1$ is the elasticity of substitution between different labor skills. The factor of normalization $2^{-\frac{1}{1-\epsilon_l}}$ enables us to abstract from economies of specialization, where a greater division of labor increases productivity.

The labor demands are given as follows. These are the demands for those who revise their wage in the period n_t^0 and for those who did so n_t^1 in the last period:

$$n_t^0 = \frac{n_t}{2} \left(\frac{w_t^0}{w_t} \right)^{-\epsilon_l} \tag{2.7}$$

$$n_t^1 = \frac{n_t}{2} \left(\frac{w_t^1}{w_t} \right)^{-\epsilon_l} \tag{2.8}$$

These equations stipulate that the demand for each type of labor is a decreasing function of relative wages and an increasing function of the employment level. The labor broker sells each unit of labor to the final firm at their unit cost of w_t. This average wage index is given by:

$$w_t = 2^{-\frac{1}{1-\epsilon_l}} \left({w_t^0}^{1-\epsilon_l} + {w_t^1}^{1-\epsilon_l} \right)^{\frac{1}{1-\epsilon_l}} \tag{2.9}$$

The relationship between wages is given by the fact that wage inflation erodes the wages that have been set in the last period:

$$w_t^1 = \frac{w_t^0}{\pi_t^w} \tag{2.10}$$

Dispersion in relative wages across cohorts leads to a distortion in the use of labor inputs. The wage dispersion index S_t^l measures this loss in two periods:

$$S_t^l = \frac{1}{2} \left(\left(\frac{w_t^0}{w_t} \right)^{1-\epsilon_l} + \left(\frac{w_t^1}{w_t} \right)^{1-\epsilon_l} \right)^{\frac{1}{1-\epsilon_l}} \tag{2.11}$$

Because there are decreasing marginal returns to each type of labor in the aggregated demand function, and because different labor types enter symmetrically into this function, the dispersion index is minimized when wages of both types of labor are the same.

In other words, the dispersion index reaches its minimum value of one when gross wage inflation rate is equal to one. Hence, the relative wage dispersion is eliminated.

2.2.3 Technology

Technology follows a stochastic trend. As suggested by Cogley and Nason (1995), among others, real output growth follows a persistent process. This is compatible with empirical observations of US data that show Solow residuals are not the appropriate measure of technology shocks. In this case, the output growth g_t follows a persistent autoregressive process. The shock ε_t^g has constant variance and a mean of zero. The technology level A_t is given by:

$$A_t = A_{t-1} g_t \tag{2.12}$$

with:

$$g_t = g_{t-1}^{\rho} g^{(1-\rho)} \exp(\varepsilon_t^g) \tag{2.13}$$

where g is the non-zero real output growth at the steady-state, and ρ is the measure of persistence of real output growth, calibrated to match the autocorrelation function of the real output growth for US data.

2.2.4 Intermediate Goods Firms

Intermediate goods firms produce output with linear technology in labor and are subject to random variations in productivity growth g_t that are common across all firms.

The output for the firm i (i indicates the timing for the price setting) with i = 0, 1 is given by:

$$Y_t^i = A_t n_t^i \tag{2.14}$$

There are two equal cohorts of firms that set their prices in staggered fashion for two periods. Half of the firms adjust their prices in any period. When firms adjust their prices, they choose a price that will maximize their present discounted profits over the two periods for which the price is fixed. Then, any firm adjusting its price will do so optimally. In the spirit of Blanchard and Kiyotaki (1987), every producer faces a downward-sloping demand curve in the market for intermediate goods. Constant elasticity of substitution between differentiated goods is in the elastic part of the demand curve and is in consequence, greater than one ($\epsilon_g > 1$). The labor input n_t is a composite of two labor types.

The firm that resets its price P_t^0, maximizes the discounted sum of expected future real profits over the two periods that its price will remain fixed. The maximization is subject to the firm's production function as follows:

$$\max_{n_t^0, P_t^0, n_{t+1}^0} \left(\frac{P_t^0}{P_t} Y_t^0 - \frac{w_t}{P_t} n_t^0 - \Psi_{it}(Y_t^0 - A_t n_t^0)\right) + \tag{2.15}$$
$$\beta E_t \frac{\lambda_{t+1}}{\lambda_t} \left(\frac{P_t^0}{P_{t+1}} Y_{t+1}^0 - \frac{w_{t+1}}{P_{t+1}} n_{t+1}^0 - \Psi_{it}(Y_{t+1}^0 - A_{t+1} n_{t+1}^0) \right)$$

where $\beta E_t \frac{\lambda_{t+1}}{\lambda_t}$ is the expected intertemporal rate of substitution of consumption of households and λ_t represents households' marginal utility of consumption.

The first order condition with respect to n_t^0 gives the following equation for the real wage:

$$\Psi_{it} = \frac{w_t}{P_t A_t} \tag{2.16}$$

Since wages and prices are the same and the technology is equal for all firms, Ψ_{it} can be replaced by Ψ_t. This implies that the marginal costs are the same for all firms.

First order conditions with respect to labor demands and prices give the equation for optimal pricing as follows (see Appendix B for detailed derivations):

$$\frac{P_t^0}{P_t} = \frac{\epsilon_g}{\epsilon_g - 1} \left(\frac{\Psi_t C_t + \beta E_t \frac{\lambda_{t+1}}{\lambda_t} \Psi_{t+1} C_{t+1} \pi_{t+1}^{\epsilon_g}}{C_t + \beta E_t \frac{\lambda_{t+1}}{\lambda_t} C_{t+1} \pi_{t+1}^{\epsilon_g - 1}} \right) \tag{2.17}$$

All variables in this equation have already been defined.

The optimal pricing equation states that the marginal product of good exceeds the marginal payments due to the monopolistic power of the firms; $\epsilon_g > 1$. An adjusting firm sets a relative price that is a weighted average of the real marginal cost over the next two periods, corrected by expected inflation. During the life of any pricing contract, firms resetting prices all behave identically. Then, an adjusting firm sets a relative price that is a weighted average of the real marginal cost over the next two periods, corrected by expected inflation. This implies that when inflation is higher, the firm sets a price which is higher, knowing that the relative price is going to be eroded in the second period due to inflation. Only if prices are flexible will the mark-up of prices over marginal cost be constant.

2.2.5 Final Goods Firm

In each period the final good is produced by a perfectly competitive firm which combines the inputs produced by two types of firms in an intermediate market. Given the prices, this firm chooses the quantities of intermediate goods that maximize its profit at each period:

$$\max_{Y_t^0, Y_t^1} \left\{ P_t Y_t - P_t^0 Y_t^0 - P_t^1 Y_t^1 \right\} \tag{2.18}$$

The maximization is subject to a constant return to scale technology function given by:

$$Y_t = 2^{-\frac{1}{1-\epsilon_g}} \left(Y_t^{0\frac{\epsilon_g - 1}{\epsilon_g}} + Y_t^{1\frac{\epsilon_g - 1}{\epsilon_g}} \right)^{\frac{\epsilon_g}{\epsilon_g - 1}} \tag{2.19}$$

where 0 indicates the current period and 1 is for the preceding period, ϵ_g gives the constant elasticity of substitution between different types of goods in production of the final good, and is imposed to be in the elastic part of the demand curve $\epsilon_g > 1$. The term $2^{-\frac{1}{1-\epsilon_g}}$ implies that there are "economies of specialization" in the production. Profit maximization of the broker leads to the following conditional demand functions for intermediate goods:

$$Y_t^0 = \frac{1}{2} \left(\frac{P_t^0}{P_t} \right)^{-\epsilon_g} C_t \tag{2.20}$$

$$Y_t^1 = \frac{1}{2} \left(\frac{P_t^1}{P_t} \right)^{-\epsilon_g} C_t \tag{2.21}$$

The output is sold at its nominal price index P_t to the households. This price index is given by:

$$P_t = 2^{-\frac{1}{1-\epsilon_g}} \left(P_t^{0^{1-\epsilon_g}} + P_t^{1^{1-\epsilon_g}} \right)^{\frac{1}{1-\epsilon_g}} \tag{2.22}$$

P_t^i (with $i = 0, 1$), is the nominal price at time t of any good whose price was set i periods ago. Variations in the prices of each period compared to the average price index are known as relative prices. This variation leads to a gap between the maximum level of production from a given technology and labor supply, and actual production. The following price dispersion index (S_t), accounts for this gap as follows:

$$S_t = \frac{1}{2} \left(\left(\frac{P_t^0}{P_t} \right)^{1-\epsilon_g} + \left(\frac{P_t^1}{P_t} \right)^{1-\epsilon_g} \right) \tag{2.23}$$

To the extent that the dispersion index is concave and symmetric, its maximum is attained when equal quantities of each of the goods are considered. However, the relationship between prices is given by:

$$P_t^1 = \frac{P_t^0}{\pi_t} \tag{2.24}$$

This equation states that inflation erodes the prices that have been set last period. In consequence, the inflation induces more dispersion in relative prices. Equal quantities of each good will be chosen if there is no variation in relative prices. This means that when there is no inflation, i.e. gross inflation is one, the relative price distortion S_t is equal to one.

2.2.6 Monetary Policy

Monetary policy targets a long-run inflation rate that is constant and equal to the optimal steady-state level of inflation, π. This monetary policy is implemented by an interest rate targeting rule *à la* Taylor. The choice of the interest rate rule versus the money growth rule, is implied by the Woodfordian nature of this economy where no role is reserved for money balances. Woodford (2003) describes a popular class of New

Wicksellian models in which monetary policy is characterized by an interest rate rule, and the money market and financial institutions are typically not modeled. Contrary to the optimization behavior of consumers and producers, the central bank follows this instrumental rule for the determination of the interest rate. This rule relates the rate of interest to the output gap and to the inflation gap.

Orphanides (2000) argues that a Taylor rule that reacts to output growth may be more stabilizing than a rule that responds to the output gap. Inclusion of the output growth variable instead of the output gap can explain the hypothesis that misperceiving the growth during the productivity slowdown in industrialized countries might have caused much of the inflation of the past decades. Other models, including Galì and Rabanal (2004), Liu and Phaneuf (2007), and Smets and Wouters (2007) also consider Taylor rules with output growth rate as a better measure for the conduct of monetary policy. EHL (2000) show that as long as wages are rigid, monetary policy should target an appropriately chosen weighted average of price and wage inflation in the determination of optimal policies. An equally important observation from the data is the serial correlation in the interest rate for the US data. The Federal Reserve shows a tendency to smooth interest rate to capture the serial correlation presented in the data. Mishkin *et al.* (2006) explain that the target level of inflation can also be a mild deflation, as long as the deflation occurs as a result of productivity improvement.

I consider the following Taylor rule, capturing all the above mentioned factors, namely output growth instead of output gap, both price and wage targeting, and smoothing effect:

$$\frac{i_t}{i} = (\frac{i_{t-1}}{i})^{\rho_r}((\frac{\pi_t}{\pi})^{\rho_\pi}(\frac{\pi_t^w}{\pi^w})^{\rho_w}(\frac{g_t}{g})^{\rho_g})^{1-\rho_r}\exp(\varepsilon_t^i) \tag{2.25}$$

where variables without time subscripts denote deterministic steady-state values, target price inflation π, long-run wage inflation π^w, and steady-state long-run output growth, g. ρ_π, ρ_w, ρ_g, are respective coefficients of the price inflation, wage inflation, and output growth. Their respective values stress their importance for stabilization aspects of the monetary policy. ρ_r is the coefficient of smoothing effect for the interest rate and ε_t^i is a white noise shock with constant variance σ_i^2 and zero mean. All calibration is given in Appendix A, Table 2.1.

2.2.7 Equilibrium

The equilibrium consists of allocations and prices where households, labor broker, intermediate firms and final goods firm are all optimizing, the monetary policy rule is satisfied, and all markets clear. The aggregate resource constraints that imply that consumption cannot exceed production in the economy are given in the following equations:

$$C_t^i \leq Y_t^i \tag{2.26}$$

$$Y_t^i = \frac{C_t}{2}\left(\frac{P_t^i}{P_t}\right)^{-\epsilon_g} \tag{2.27}$$

As technology is common to all firms:

$$\sum_{i=0}^{1} Y_t^i = A_t \sum_{i=0}^{1} n_t^i \tag{2.28}$$

and the aggregation gives the total production function of the economy, even if outputs are imperfect substitutes:

$$Y_t = A_t n_t \tag{2.29}$$

The relationship between labor supply n_t^s and employment n_t is given by:

$$n_t^s = \sum_{i=0}^{1} n_t^i = \frac{n_t}{2}\left(\left(\frac{w_t^0}{w_t}\right)^{-\epsilon_l} + \left(\frac{w_t^1}{w_t}\right)^{-\epsilon_l}\right) \tag{2.30}$$

If wages for both types of agent are the same, the relative wage distortion is eliminated, and in consequence the labor supply and employment will be equal. However the presence of inflation induces a wedge between labor supply and employment.

2.3 Steady-State Analysis

The starting point to derive the optimal rate of inflation is the optimal inflation rate at the steady-state of the model. This inflation rate is easy to compute analytically and minimizes the steady-state distortions in the economy (see Appendix B.3 for detailed steady-state derivations).

The technology and preferences are restricted in such a way that a steady-state path exists and that is consistent with the private agents' efficiency conditions (see Appendix B.1 for the equilibrium conditions of the economy). The variables are normalized by the price level. The resulting variables are in real terms. Stationarity is then induced by dividing all real variables by the output growth.

In the steady-state, all normalized real variables are constant and nominal variables are growing at a constant rate, that of the steady-state rate of inflation. Even if Pareto optimality is not attainable, monetary policy, by affecting the rate of inflation, has an impact on the distortions, and leads the economy as close as possible to its optimal allocation of resources. Given a convex welfare cost of the distortions in inflation rates of prices and wages, the optimal inflation rate balances these costs at the margin. The presence of real output growth turns out to increase the welfare cost of inflation.

2.3.1 Steady-State Distortions

I describe the steady-state distortions in this economy, as a function of steady-state inflation. The distortions are summarized in four equations which are functions of inflation as follows: relative wage and price dispersion distortions and price and wage mark-up distortions.

Relative Price Dispersion Distortion

The staggered nature of the price contracts leads to price dispersion and makes the economy operate inside its production possibility frontier. Due to the presence of trend inflation in the steady-state, this distortion is not eliminated. Inflation even increases price dispersion and generates strong distortions in the economy, leading to a deviation from the equality of consumption and employment. This steady-state distortion is denoted by S:

$$S \equiv \frac{An}{C} = \left(\frac{1}{2}\right)^{\frac{-1}{\epsilon_{g-1}}} \left(\frac{1 + \pi^{-\epsilon_g}}{\left(1 + \pi^{1-\epsilon_g}\right)^{\frac{-\epsilon_g}{1-\epsilon_g}}} \right) \tag{2.31}$$

The price dispersion is a convex cost function in the level of inflation. When inflation is zero (i.e. gross inflation is one), the distortion index is equal to one and the relative price distortion is eliminated.

Price Mark-Up Distortion

The second distortion is associated with the imperfect competitive nature of the market for goods. With monopoly power, firms set prices above marginal costs. Furthermore, inflation increases the wedge between the price and the marginal cost of production. The marginal cost value varies with the level of inflation. It reflects real unit labor costs and real wages. Thus, the price mark-up is simply the inverse of real marginal cost as follows:

$$\mu^g \equiv \frac{1}{\frac{w}{AP}} = \left(\frac{\epsilon_g}{\epsilon_{g-1}}\right) \left(\frac{2}{1 + \pi^{\epsilon_g - 1}}\right)^{\frac{1}{\varepsilon_{g-1}}} \left(\frac{1 + \beta\pi^{\epsilon_g}}{1 + \beta\pi^{\epsilon_g - 1}}\right) \tag{2.32}$$

This equation states that the mark-up is affected by the level of inflation. The minimum level of mark-up is equal to $\frac{\epsilon_g}{\epsilon_{g-1}}$ and is only attained when the inflation is zero. However, as the demands are elastic, i.e. $\epsilon_g > 1$, this minimum value always exceeds unity. With steady-state trend inflation, the average mark-up is larger and the monopolistic distortion increases. However, the final effect of inflation on the mark-up depends on the effect of inflation on the mark-ups charged by the two types of firms. Those who reset their prices this period will set higher prices relative to their current marginal costs to offset the erosion of relative prices that trend inflation might create. On the other hand, higher trend inflation erodes the relative prices that were set by firms in past periods. The relative strength of these two countervailing effects determines the marginal impact of trend inflation on mark-up and monopolistic power of firms.[2] Any increase in the level of mark-up would decrease the steady-state output.

Relative Wage Dispersion Distortion

The staggered nature of the labor market leads to relative wage dispersion distortion. This distortion arises because different cohorts of households set different wages in different periods. Each cohort sets the wage at the beginning of each two periods, and does not revise it before the end of the contract. The dispersion index is given by:

$$S^l = \left(\frac{1}{2}\right)^{\frac{-1}{\epsilon_l - 1}} \left(\frac{1 + \pi^{w^{-\epsilon_l}}}{\left(1 + \pi^{w^{1-\epsilon_l}}\right)^{\frac{-\epsilon_l}{1-\epsilon_l}}} \right) \tag{2.33}$$

This relative wage dispersion S^l is at its minimum level if wage inflation is zero, i.e. its gross value is equal to one.

Wage Mark-Up Distortion

The last distortion is due to the mark-up of wages over marginal costs in the labor market. Households, when they adjust their wages, set a higher mark-up to protect themselves from the real wage erosion caused by inflation. The wage mark-up varies with wage inflation in the steady-state and is given by:

$$\mu^w = \frac{w}{\chi}\frac{1}{\lambda}P = \left(\frac{\epsilon_l}{\epsilon_l - 1}\right) \chi \left(\frac{2}{1 + \pi^{w^{\epsilon_l - 1}}}\right)^{\frac{1}{\epsilon_l - 1}} \left(\frac{1 + \beta \pi^{w^{\epsilon_l}}}{1 + \beta \pi^{w^{\epsilon_l - 1}}}\right) \tag{2.34}$$

Even with wage inflation equal to zero, this distortion would not be eliminated. Furthermore, this distortion would exceed unity because labor demand is elastic, $\epsilon_l > 1$, and the disutility of working, χ, has a positive value.

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[2] Ascari (2005) finds that trend inflation affects the average mark-up nonlinearly.

2.3.2 Calibration

I calibrate the parameters of the model, in a realistic range taken from the existing literature, to match certain features of the US economy. The numerical values used to conduct simulations are summarized in Table 2.1, Appendix A. The time period is considered as being a quarter. The subjective discount factor is equal to 0.995, as in King, Plosser and Rebelo (1988). This value implies an annual real interest rate of 2% in line with the US interest rate experience of the last decade. Quarterly real output growth rate per capita is considered to be equal to 0.5%. This value gives an annual real output growth rate of 2% and reflects the experience of industrial countries during the last decade for the level of per capita output growth. The elasticity of substitution in goods markets ϵ_g is equal to 8. This implies a gross level of mark-up equal to 1.142 and implies that prices will be 11.42% higher than marginal costs. Basu (1994) and Huang, Liu and Phaneuf (2004) provide microeconomic evidence for this value of mark-up in the goods markets. Basu and Fernald (2002) and King, Khan and Wolman (2003) suggest that this mark-up is about 1.12, implying an elasticity of substitution equal to 10. However Hall (1988) argues that elasticity of substitution is lower, equal to 7, inducing a higher level for mark-up. Rothenberg and Woodford (1997) consider a value of 7.8 for the demand elasticity in goods markets. Thus, the assigned value of 8 for the demand elasticity in this paper is in the range considered by the literature.

For the labor market, I calibrate the value of the elasticity of substitution between different types of labor skills equal to 6, ϵ_l based on previous studies (Ambler, Guay and Phaneuf (2003)). This value gives a level of mark-up equal to 1.2, meaning that prices should be 12% higher than marginal costs. The parameter χ, measuring the weight on leisure in the utility function, is such that the representative household devotes approximately one third of its time to work in the steady-state. The resulting value for χ is 2.1875. This value gives the trade-off between the additional amounts of income and utility loss in leisure, if households decide to marginally increase their labor supplies.

The coefficients of the Taylor rule are all within the range of empirical estimates

(Galí and Clarida *et al.* (1999)). The following values are assigned to this rule: $\rho_\pi = 1.5$, $\rho_g = 0.5$, $\rho_{\pi^w} = 2$, and $\rho^r = 0.5$ for the smoothing effect of the interest rate. Furthermore, the Taylor principle holds, meaning that the central bank increases its interest rate more than one for one with higher inflation; $\rho_\pi > 1$. Following EHL (2000), as wage inflation is more important than price inflation, a higher weight on its coefficient ρ_{π^w} should be considered.

2.3.3 Results

I begin the analysis of the steady-state optimal rate of inflation in a baseline model that abstracts from real output growth. This model is considered as model (i), with the assigned values for the elasticities of substitution: $\epsilon_l = 6$, $\epsilon_g = 8$. This model allows me to compare my results with those from previous studies in the literature on staggered contracts.

Then, in model (ii) I add the quarterly real output growth of $g = 0.5\%$ into the baseline model to study the optimal rate of inflation with the same values of elasticity. Figure 2.1 describes model (i), where Figure 2.2 describes model (ii) with different values for elasticities. The horizontal axes are the quarterly inflation rate and the vertical axes derive the steady-state values for wage and price dispersion distortions.

The main results follow. Model (i) finds that a slightly positive quarterly inflation rate of 0.025% is the optimal rate. This is in line with the previous findings of optimal inflation rate with staggered contracts; a slightly positive inflation rate reduces the mark-ups of prices over the marginal costs. (Wolman (2001), King *et al.* (2003), and Amano *et al.* (2007)).

In model (ii), the real output growth leads to a wedge between price and wage inflations. Any changes in the price level lead to a relative price distortion. Price dispersion distortion is then eliminated at the zero steady-state (net) price inflation rate. This is intuitive as zero price inflation induces all nominal prices to be equal. However, zero price inflation will not eliminate the wage dispersion distortion. This is due to the fact that wage inflation is increasing with real output growth as given by the linear relationship between two inflations:

$$\log \pi_t^w = \log \pi_t + \log g_t$$

Wage dispersion distortion is eliminated at zero wage inflation rate. In terms of price inflation, this is equal to a price deflation rate of 2% on an annual basis to compensate for the effect of real output growth in this economy.

With staggered price-setting as well as monopolistic competition, the price mark-up exceeds unity. The minimum price mark-up distortion in model (ii) is equal to 1.14 . This distortion is calculated by considering the calibrated elasticities in the labor market equal to 6 ($\epsilon_l = 6$), and in the goods market equal to 8 ($\epsilon_g = 8$). The minimum price mark-up is attained with a slightly positive quarterly inflation rate equal of 0.28% (see Table 2.3). This is equal to an annual price inflation rate of 1.12%, i.e. a mild level of price inflation decreases the mark-up of prices over the marginal costs.

The minimum value for the wage mark-up distortion in model (ii) is equal to 1.21. This value is attained with a slightly positive annual wage inflation. However, due to the wedge between price and wage inflations, the price inflation that minimizes the wage mark-up distortion turns out to be slightly negative, with a quarterly measure of -0.16% or an annual value of -0.64% (see Table 2.4).

The results indicate that there is no single inflation rate that eliminates simultaneously all distortions in this environment. The monetary policy chooses a level of inflation to trade-off these distortions at the margin. For the same length of price and wage contracts of two periods, the labor market is more distorted, i.e. its minimum mark-up is 6% higher than that of the goods market. In this case, the optimal level of inflation is closer to the inflation rate that reduces the labor market distortions.

This result is close in spirit to that found by EHL (2000) in a dynamic model, where the objective of monetary policy is to reduce the greatest distortion of the economy, i.e. wage distortion. In a static model also close in spirit to this paper, Amano *et al.* (2007) report that the optimal price inflation rate is the one that reduces the mark-up distortion in the labor market.

The next section derives the optimal rate of price inflation in the steady-state of the model. The intuition for this optimal rate of price inflation is the one that does a trade-off between (i) a zero price inflation rate to eliminate the price dispersion, (ii) a positive price inflation rate to reduce the price mark-up distortion, (iii) a negative price inflation rate to reduce the wage mark-up distortion (a slightly positive wage inflation rate), and (iv) a negative price inflation rate equal to the rate of output growth that eliminates the wage dispersion distortion in the economy (or zero wage inflation rate).

The optimal rate of inflation that reduces the four above-mentioned distortion appears to be slightly negative. This result argues in favor of a Friedman type of rule with a value originating from the combination of imperfect markets, nominal staggered contracts, and the real output growth in the steady-state of this economy. It is to be noted that the model abstracts from the money demand function that led Friedman (1969) to conclude on the optimality of the deflation rate.

2.3.4 Steady-State Welfare

What average level of inflation should a central bank target? In order to answer this question one must study steady-state welfare as a function of inflation.

$$\max_{\pi} \ U(c^{ss}(\pi), l^{ss}(\pi)) \tag{2.35}$$

where $c^{ss}(\pi)$, $l^{ss}(\pi)$ are the steady-state levels of consumption and leisure. Using these expressions for steady-state consumption and leisure, one can analytically characterize the optimal steady-state inflation rate.

The optimal steady-state rate of inflation in model (ii) is negative and equal to -0.18% on a quarterly basis. This deflation rate is smaller than the one that minimizes solely the wage mark-up distortion and is equal to -0.16% (see Table 2.4) on a quarterly basis. However, this rate is bigger than the one that eliminates the wage dispersion and is equal to -0.5% on a quarterly basis. The deflation rate derived from Friedman's rule in this environment is calculated to be -0.82% on a quarterly basis. The optimal deflation is also bigger (or less negative) than Friedman's rule deflation rate. These results indicate that monetary policy cannot eliminate all distortions with the same inflation rate. The optimal rate of inflation trade-offs the costs of price and wage dispersions with market imperfections in the economy and reveals to be closer to the rate that reduces the mark-up friction in the labor market. This indicates that in this model, labor market real frictions in the form of monopolistic competitions are more important than the nominal frictions due to the staggered nature of wage contracts. For the same length of the staggered contracts, the labor market is more distorted than the goods market, e.g. in the baseline model mark-up distortion is higher than in the goods market (see Tables 2.3 and 2.4). Table 2.2 reports different values for welfare functions at different rates of inflation, corresponding to different values of elasticities.

The net quarterly real interest rate in model (i) is equal to 0.5%, and in model (ii) is equal to 0.82%. In both cases, the ability of the central bank to use the nominal interest rate for stabilization purposes is not constrained, and the zero bounds on nominal interest rate are respected. The welfare costs of trend inflation and real output growth are then calculated by means of the compensation variations. Going from optimal 0.18% quarterly deflation to zero inflation and to 0.5% quarterly inflation reduces the steady-state consumption by 1.014%. Somewhat surprisingly, real output growth increases the welfare cost of inflation. The loss in the utility due to inflation (going from 0 to 0.5% quarterly inflation) appears to be 9% higher in the growing economy of model (ii) than in model (i) without growth. This result is explained through the impact of growth in creating an extra friction in both markets, due to the wedge between price and wage inflations. In the growing economy, real wages are not only affected by inflation, but also by the real output growth of the economy. In this case, wage setters choose a higher markup when they have the opportunity to revise the relative wages for the duration of their contracts. The higher markup in the labor market increases the value of wage inflation to reduce this distortion. The cost of inflation in this environment with growth increases as a consequence. The loss of utility is then translated in a consumption equivalent measure of welfare loss. This means that the percentage changes in consumption make households indifferent between the economy with zero inflation and that with 2% inflation. The consumption loss due to inflation in the growing economy is 0.119% of the steady-state consumption, while in model (i) this loss is only 0.1099% of the steady-state consumption.

Figure 2.3 shows the welfare as function of steady-state inflation rate. The inflation rate is considered as the gross quarterly rate on the horizontal axis, where the distortions are on the vertical axis and are measured in steady-state values.

2.3.5 Sensitivity Analysis

Given the uncertainty around parameter values, I examine the sensitivity of my results to alternative calibrations and various structural features of the model. These are changes in the elasticities or monopoly powers on the optimal rate of inflation. These results are presented in Tables 2.2, 2.3, and 2.4.

First, I consider the effects of an increase in elasticity of demand in the goods market. I assign the value suggested by King, Khan and Wolman (2003) for this elasticity, $\epsilon_g = 10$. The mark-up is reduced from the baseline model from 1.14 to 1.11. As the mark-up is reduced, the optimal price inflation that minimizes this mark-up distortion is also reduced from 0.28% to 0.2% on a quarterly basis. When the demand elasticity decreases from 8 to 6, the value of elasticity suggested by Hall (1988), mark-up of prices over the marginal cost is higher than in the baseline model and its value is equal to 1.33 (see Table 2.3).

The wage mark-up distortion is not affected by the changes in the goods markets' elasticity. Also, changes in the labor elasticities do not affect the price mark-up distortions. The more elastic the labor market is, the less distorted by wage mark-up it will be, and the lower the value of the optimal deflation rate to minimize the distortions.

It can be seen that when elasticity in the labor market increases from 4 to 6, the wage mark-up distortion diminishes by 9%. An increase in the elasticity of the labor market from 6 to 8 decreases the distortion by 5.7%. Looking at the optimal deflation rate, it shows that this rate decreases from -0.14% to -0.17% between elasticities of 4 to 8 (see Table 2.4).

It can be seen from Table 2.2 that the steady-state welfare function is also affected by the demand elasticities. The more elastic markets are, the less distorted they will be by real and nominal frictions. In consequence, these markets call for a smaller (in absolute value) inflation rate to reduce their distortions.

2.4 Dynamic Economy

The dynamics of the model under two sources of aggregate uncertainty is briefly discussed. These are real output growth and contractionary monetary policy shocks. The model is solved numerically up to a second-order approximation of the equilibrium conditions around its deterministic steady-state. I use the program DYNARE (Juillard (2004)) for a simulation that allows the shocks to affect the first and the second unconditional moments of variables. The shocks are given in equations 2.13 and 2.25.

2.4.1 Results

Figures 2.4 and 2.5 show the impulse responses of endogenous variables after monetary and real shocks. A contractionary monetary policy shock causes a monetary tightening that decreases demand and price and wage inflations. As a result of an increase in the interest rate, real output growth, real wage growth, the wage dispersion index and the utility function all decrease. However, the price dispersion index increases on impact by a very small amount and the effect fades out after a period. A positive real output growth shock (a permanent productivity shock) improves the economic environment and leads to an increase in the interest rate, labor demand, output and wages. The price inflation, however, decreases after this shock. Again, the growth rate of real variables such as consumption, output, and real wage, are all determined in the long-run by the growth rate of the economy, i.e. real output growth.

The simulation results reveal that a central bank that targets a small price deflation rate or the optimal steady-state price deflation, can achieve the goal of wage stability. This is an important finding as wage inflation combined with growth is costly for the economy. The mean of variables is affected by shocks. When the target level of inflation is the optimal steady-state rate of inflation, in the calibrated model, the mean of wage inflation gets close to zero and monetary policy can stabilize wages. The stochastic mean of variables in model (i) without growth and in model (ii) with growth are given in Tables 2.5 to 2.9. The period utility (the welfare measure here) is still higher in a model with both optimal deflation and growth.

Two simple exercises are then considered. The first one shows that the optimal value of inflation depends on the size of the shocks. The second one studies how the optimal level of inflation depends on the Taylor rule coefficients. The simulation results indicate that (i) when the size of shocks increases, or ii) when monetary policy is less aggressive and the Taylor rule coefficients are smaller, the optimal inflation rate that gives the same level of period utility as before these changes is more negative or smaller. However, the monetary policy cannot reduce the deflation rate more than the limit on the zero bound of nominal interest rate. This means that the ability of the monetary policy to respond to shocks is limited in this model. In this exercise, the following values for the coefficients are considered: $\rho_\pi = 1.2$, $\rho_{\pi^w} = 1.5$, and $\rho_g = 0.2$.

2.5 Conclusion

This chapter studied the impact of real output growth in a New Keynesian model and derived the optimal rate of inflation in this economy. Under a wide range of parameter values, a small price deflation rate turns up to be the optimal rate, the one that minimizes distortions of this economy. Four types of distortions are presented as caused by price and wage rigidities and the imperfect nature of markets. In consequence, the

Pareto optimal level of output is not attainable. The optimal deflation rate is closer to the deflation that minimizes the real distortions of the labor markets. The optimal deflation depends on the structure of the economy, i.e. the demand elasticities. When the labor market is more elastic, the optimal deflation that reduces these distortions is smaller or more negative. However, the labor market elasticities do not affect the behavior of price setters. The price setters are sensitive to the elasticity of substitution in the goods markets. Then, when the goods market is more elastic, the optimal deflation that reduces distortions is smaller or more negative. In the same vein, the goods market's elasticities do not affect the behavior of wage setters.

The results reveal that the labor market is more distorted than the goods market. This gives incentive to the monetary policy to put more emphasis on reducing the distortions of this market. One suggestion made in this paper is to do so through the stabilization of wage inflation. In the dynamic part, this is done through targeting the optimal price deflation rate. The mean of variables is affected by shocks and on average, the mean of wage inflation is very close to zero and the central bank can stabilize wage inflation.

The impulse response analysis affirms that after permanent technology improvement: (i) the interest rate increases, (ii) price inflation falls, (iii) wage inflation increases, (iv) output and real wage growth, as well as price and wage dispersion index all increase on impact. Furthermore, the contractionary monetary policy leads to (i) a decrease in price and wage inflations, (ii) a decrease in output and wage growth, (iii) a decrease in wage dispersion index and period utility, and (iv) an increase in price dispersion index. The impulse responses are robust to a wide range of values for policy parameters and calibration values. The results favor the old view in the monetary policy literature that a slight level of deflation is optimal. Welfare analysis also finds that adding real output growth increases the welfare costs of inflation.

In future analysis, the optimal rules or the optimal coefficients of the Taylor rule to any changes in inflation and output growth should be derived. It would be interesting to back up the theoretical model with empirical evidence of optimal monetary policy in industrialized versus developing countries. Finally, considering a non-allocative labor market is a promising path for further investigations.

APPENDIX A

TABLES

Table 2.1 Model Calibration

Parameter	Value
Preferences	
β	0.995
χ	2.1875
Labor Market	
ϵ_l	6
Goods Market	
ϵ_g	8
Time period	1/4
Taylor Rule Coefficients	
ρ_π	1.5
ρ_{π^ω}	2.0
ρ_g	0.5
ρ: persistence of technology	0.5
ρ^r: smoothing effect	0.5
Stochastic Processes	
σ_{ε_i}: monetary shock	0.01
σ_{ε_g}: technology shock	0.01

Table 2.2 Sensitivity Analysis of Steady-State Welfare to Steady-State Quarterly Inflation

Parameters	$\varepsilon_l = 4, \varepsilon_g = 6$	$\varepsilon_l = 6, \varepsilon_g = 8$	$\varepsilon_l = 8, \varepsilon_g = 10$
Welfare	0.3097	0.3597	0.3783
Optimal Inflation	−0.15%	−0.18%	−0.2%

Table 2.3 Sensitivity Analysis of Price Markup Distortion to Steady-State Quarterly Inflation

Parameters	$\varepsilon_l = 6, \varepsilon_g = 6$	$\varepsilon_l = 6, \varepsilon_g = 8$	$\varepsilon_l = 6, \varepsilon_g = 10$
Distortions	1.33	1.14	1.11
Optimal Inflation	0.4%	0.28%	0.2%

Table 2.4 Sensitivity Analysis of Wage Markup Distortion to Steady-State Quarterly Inflation

Parameters	$\varepsilon_l = 4, \varepsilon_g = 8$	$\varepsilon_l = 6, \varepsilon_g = 8$	$\varepsilon_l = 8, \varepsilon_g = 8$
Distortions	1.33	1.21	1.14
Optimal Inflation	−0.14%	−0.16%	−0.17%

Table 2.5 Stochastic Means based on Quarterly Calibration in Model (i)

	$\pi = 1.00, g = 1.00$
Variable	Means
i_t	1.005
π_t	1.000
π_t^w	1.000
S_t	1.0001
S^l	1.000
U	−1.8278

Table 2.6 Stochastic Means based on Quarterly Calibration in Model (i)

	$\pi = 1.005,\ g = 1.000$
Variable	Means
i_t	1.01
π_t	1.005
π_t^w	1.005
S_t	1.0001
S^l	1.000
U	−1.8289

Table 2.7 Stochastic Means based on Quarterly Calibration in Model (ii)

	$\pi = 0.9982,\ g = 1.005$
Variable	Means
i_t	1.0082
π_t	0.9982
π_t^w	1.0032
S_t	1.0001
S^l	1.0000
U	−1.8185

Table 2.8 Stochastic Means based on Quarterly Calibration in Model (ii)

	$\pi = 1,\ g = 1.005$
Variable	Means
i_t	1.01
π_t	1.000
π_t^w	1.005
S_t	1.0001
S^l	1.0000
U	-1.8189

Table 2.9 Stochastic Means based on Quarterly Calibration in Model (ii)

	$\pi = 1.005,\ g = 1.005$
Variable	Means
i_t	1.015
π_t	1.005
π_t^w	1.01
S_t	1.0001
S^l	1.0001
U	-1.82

APPENDIX B

EQUILIBRIUM CONDITIONS

B.1 The First Order Conditions of Households:

(C_t) :

$$\frac{1}{C_t} = \beta(1+r_t)E_t\frac{1}{C_{t+1}} \tag{B.1}$$

For the household that can choose its wage at time t, (w_t^0):

$$-\chi\frac{\partial n_t^0}{\partial w_t^0} + \lambda_t\frac{n_t^0}{P_t} + \lambda_t\frac{w_t^0}{P_t}\frac{\partial n_t^0}{\partial w_t^0}$$

$$-\beta\chi E_t\frac{\partial n_{t+1}^0}{\partial w_t^0} + \beta E_t\lambda_{t+1}\frac{n_{t+1}^0}{P_{t+1}} + \beta E_t\lambda_{t+1}\frac{w_t^0}{P_{t+1}}\frac{\partial n_{t+1}^0}{\partial w_t^0} = 0$$

with ϵ_l as the elasticity of substitution between differentiated labor skill, greater than one;

$$\left(\chi\epsilon_l + \lambda_t\frac{w_t^0}{P_t}(1-\epsilon_l)\right)\left(\frac{w_t^0}{w_t}\right)^{-\epsilon_l} n_t$$

$$+\beta E_t\left(\chi\epsilon_l + \lambda_{t+1}\frac{w_t^0}{P_{t+1}}(1-\epsilon_l)\right)\left(\frac{w_t^0}{w_{t+1}}\right)^{-\epsilon_l} n_{t+1} = 0$$

this implies:

$$\left(\chi\epsilon_l + \lambda_t\frac{w_t^0}{w_t}\frac{w_t}{p_t}(1-\epsilon_l)\right)\left(\frac{w_t^0}{w_t}\right)^{-\epsilon_l} n_t$$

$$+\beta E_t\left(\chi\epsilon_l + \lambda_{t+1}\frac{w_t^0}{w_t}\frac{w_t}{w_{t+1}}\frac{w_{t+1}}{p_{t+1}}(1-\epsilon_l)\right)\left(\frac{w_t^0}{w_t}\frac{w_t}{w_{t+1}}\right)^{-\epsilon_l} n_{t+1} = 0$$

this gives:

$$\left(\chi\epsilon_l + \lambda_t\frac{w_t^0}{w_t}\frac{w_t}{P_t}(1-\epsilon_l)\right)n_t +$$

$$\beta E_t\left(\chi\epsilon_l+\lambda_{t+1}\frac{w_t^0}{w_t}\frac{w_t}{w_{t+1}}\frac{w_{t+1}}{P_{t+1}}(1-\epsilon_l)\right)\left(\frac{w_t}{w_{t+1}}\right)^{-\epsilon_l}n_{t+1}=0 \tag{B.2}$$

The first order conditions of the firms are:

$$n_t^0:-\frac{w_t}{P_t}+A_t\Psi_t=0 \tag{B.3}$$

$$n_{t+1}^0:\beta E_t\frac{\lambda_{t+1}}{\lambda_t}\left(-\frac{w_{t+1}}{P_{t+1}}+A_{t+1}\Psi_{t+1}\right)=0 \tag{B.4}$$

$$P_t^0:\frac{1}{P_t^0}Y_t^0+\frac{P_t^0}{Y_t^0}\frac{\partial Y_t^0}{\partial P_t^0}\frac{Y_t^0}{P_t}-\Psi_t\frac{\partial Y_t^0}{\partial P_t^0}\frac{P_t^0}{Y_t^0}\frac{Y_t^0}{P_t^0}$$
$$+\beta E_t\frac{\lambda_{t+1}}{\lambda_t}\left(\frac{Y_{t+1}^0}{P_{t+1}}+\frac{Y_{t+1}^0}{P_{t+1}}\frac{\partial Y_{t+1}^0}{\partial P_t^0}\frac{P_t^0}{Y_{t+1}^0}-\Psi_{t+1}\frac{\partial Y_{t+1}^0}{\partial P_t^0}\frac{P_t^0}{Y_{t+1}^0}\frac{Y_{t+1}^0}{P_t^0}\right)=0$$

and in terms of elasticities:

$$\begin{aligned}0 &= \frac{Y_t^0}{P_t}(1-\epsilon_g)+\epsilon_g\Psi_t\frac{Y_t^0}{P_t^0}+\\ &\quad \beta E_t\frac{\lambda_{t+1}}{\lambda_t}\left\{\frac{Y_{t+1}^0}{P_{t+1}}(1-\epsilon_g)+\epsilon_g\Psi_{t+1}\frac{Y_{t+1}^0}{P_t^0}\right\}\end{aligned} \tag{B.5}$$

B.2 Key Equations

Let gather the complete system of eight equations that characterizes the model's equilibrium conditions in eight unknown stationary variables: C_t, $\frac{w_t^0}{w_t}$, $\frac{w_t^1}{w_t}$, $\frac{P_t^0}{P_t}$, $\frac{P_t^1}{P_t}$,[1] n_t, n_t^s, π_t^w. The conditions are:

$$\frac{1}{C_t}=\beta(1+r_t)E_t\frac{1}{C_{t+1}} \tag{B.6}$$

$$\frac{w_t^0}{w_t}=\frac{\epsilon_l}{\epsilon_l-1}\varkappa\left(\frac{n_t+\beta E_t\pi_{t+1}^{\omega^{\varepsilon_l}}n_{t+1}}{\frac{w_t}{P_t}\frac{n_t}{C_t}+\beta E_t\pi_{t+1}^{\omega^{\varepsilon_l-1}}\frac{n_{t+1}}{C_{t+1}}\frac{w_{t+1}}{P_{t+1}}}\right) \tag{B.7}$$

$$\frac{w_t^1}{w_t}=\frac{\epsilon_l}{\epsilon_l-1}\varkappa\left(\frac{n_{t-1}+\beta\pi_t^{\omega^{\varepsilon_l}}n_t}{\frac{w_{t-1}}{P_{t-1}}\frac{n_{t-1}}{C_{t-1}}+\beta\pi_t^{\omega^{\varepsilon_l-1}}\frac{n_t}{C_t}\frac{w_t}{P_t}}\right) \tag{B.8}$$

$$\frac{P_t^0}{P_t}=\frac{\epsilon_g}{\epsilon_g-1}\left(\frac{\frac{w_t}{A_tP_t}+\beta E_t\frac{w_{t+1}}{A_{t+1}P_{t+1}}\pi_{t+1}^{\epsilon_g}}{1+\beta E_t\pi_{t+1}^{\varepsilon_g-1}}\right) \tag{B.9}$$

$$\frac{P_{t-1}^0}{P_{t-1}}=\frac{\epsilon_g}{\epsilon_g-1}\left(\frac{\frac{w_{t-1}}{A_{t-1}P_{t-1}}+\beta\frac{w_t}{A_tP_t}\pi_t^{\epsilon_g}}{1+\beta\pi_t^{\varepsilon_g-1}}\right) \tag{B.10}$$

[1] (P_t^1/P_t) denotes relative prices for those firms who revise their prices in the past period.

$$A_t n_t = \frac{C_t}{2}\left((\frac{P_t^0}{P_t})^{\epsilon_g} + (\frac{P_t^1}{P_t})^{\epsilon_g} \right) \tag{B.11}$$

$$n_t^s = \frac{n_t}{2}\left((\frac{w_t^0}{w_t})^{-\epsilon_l} + (\frac{w_t^1}{w_t})^{-\epsilon_l} \right) \tag{B.12}$$

$$\pi_t^{\omega} = \pi_t g \tag{B.13}$$

B.3 Steady-State Derivations

The system can be solved analytically. With zero inflation rate and no real growth, the steady-state is given by:

$$\left(\frac{w^0}{w}\right) = \left(\frac{w^1}{w}\right) = \left(\frac{P^0}{P}\right) = 1$$

I get the following three equations:

$$\left(\frac{w}{AP}\right) = \left(\frac{\epsilon_l}{\epsilon_l - 1}\right)\left(\frac{C}{A}\right)\chi \tag{B.14}$$

$$1 = \left(\frac{\epsilon_g}{\epsilon_g - 1}\right)\left(\frac{w}{AP}\right) \tag{B.15}$$

$$n = \left(\frac{C}{A}\right) \tag{B.16}$$

Then:

$$2 = \left(\frac{P^0}{P}\right)^{(1-\epsilon_g)} + \left(\frac{P^0}{P\pi}\right)^{(1-\epsilon_g)}$$

so:

$$\left(\frac{P^0}{P}\right) = \left(\frac{2}{1+\pi^{(\epsilon_g - 1)}}\right)^{\frac{1}{1-\epsilon_g}} \tag{B.17}$$

As inflation is higher, firms set a price which is higher with respect to the overall price level, knowing that their relative price is going to be eroded in the second period due to inflation. This is called the front end loading effects in this literature (Wolman, (2001)).

Given $\left(\frac{P^0}{P}\right)$, the average real wage is:

$$\left(\frac{w}{AP}\right) = \left(\frac{P^0}{P}\right)\left(\frac{\epsilon_g - 1}{\epsilon_g}\right)\left(\frac{1+\beta\pi^{(\epsilon_g - 1)}}{1+\beta\pi^{\epsilon_g}}\right)$$

and:

$$2 = \left(\frac{w^0}{w}\right)^{(1-\epsilon_l)} + \left(\frac{w^0}{w\pi^{\omega}}\right)^{(1-\epsilon_l)}$$

$$\left(\frac{w^0}{w}\right) = \left(\frac{2}{1+\pi^{\omega^{(\epsilon_l-1)}}}\right)^{\frac{1}{1-\epsilon_l}} \tag{B.18}$$

Again, this equation should be an increasing function of wage inflation π^w. Wage setters set a high initial value for wages since they know that their real values will be eroded by wage inflation in the following period.

The entire simplified system of equation, at the steady-state, is given by the following six equations:

$$\left(\frac{P^0}{P}\right) = \left(\frac{2}{1+\pi^{(\epsilon_g-1)}}\right)^{\frac{1}{1-\epsilon_g}} \tag{B.19}$$

$$\left(\frac{w^0}{w}\right) = \left(\frac{2}{1+\pi^{w^{(\epsilon_l-1)}}}\right)^{\frac{1}{1-\epsilon_l}} \tag{B.20}$$

$$\left(\frac{w}{AP}\right) = \left(\frac{P^0}{P}\right)\left(\frac{\epsilon_g-1}{\epsilon_g}\right)\left(\frac{1+\beta\pi^{\epsilon_g-1}}{1+\beta\pi^{\epsilon_g}}\right) \tag{B.21}$$

$$\left(\frac{C}{A}\right) = \left(\frac{w^0}{w}\right)\left(\frac{w}{AP}\right)\left(\frac{\epsilon_l-1}{\epsilon_l}\right)\left(\frac{1}{\chi}\right)\left(\frac{1+\beta\pi^{w^{\epsilon_l-1}}}{1+\beta\pi^{w^{\epsilon_l}}}\right) \tag{B.22}$$

$$n = \frac{1}{2}\left(\frac{C}{A}\right)\left(\left(\frac{P^0}{P}\right)^{-\epsilon_g}(1+\pi^{\epsilon_g})\right) \tag{B.23}$$

$$n^s = \frac{n}{2}\left(\left(\frac{w^0}{w}\right)^{-\epsilon_l}\left(1+\pi^{w^{\epsilon_l}}\right)\right) \tag{B.24}$$

APPENDIX C

FIGURES

Figure 2.1 Model (i): zero growth

Figure 2.2 Model (ii): 0.5% quarterly growth, and different values for elasticity in the labor and goods markets

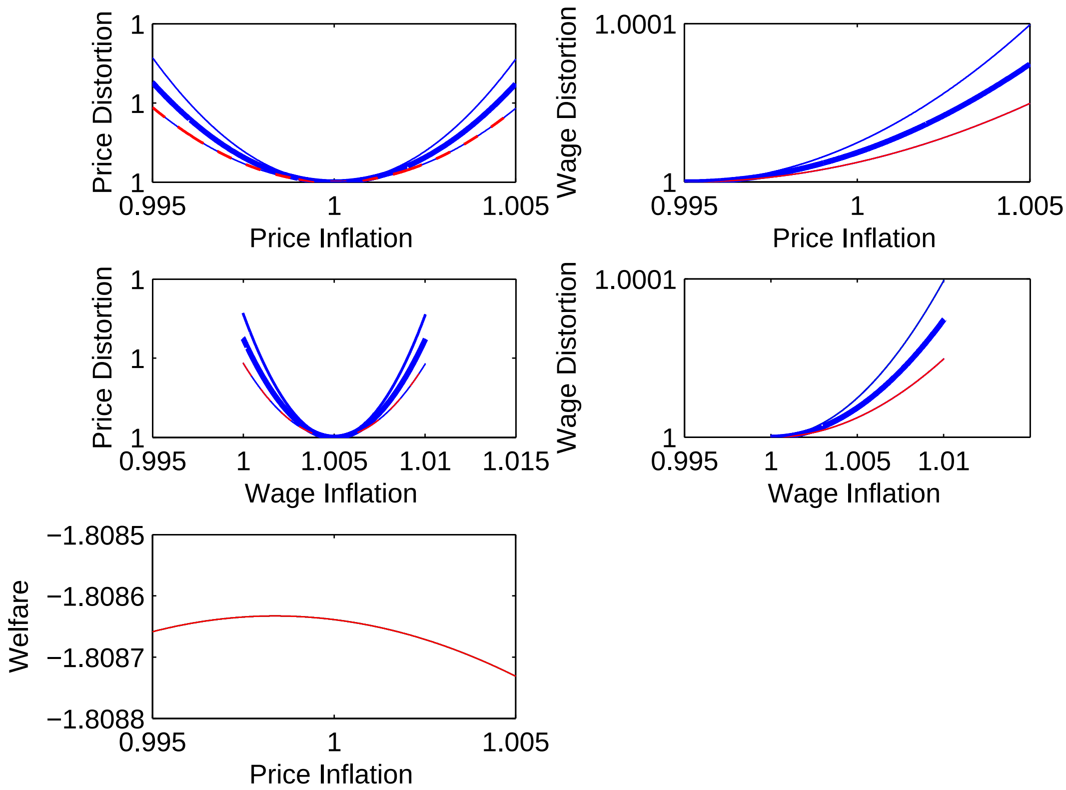


Figure 2.3 Prices and wages mark-up distortions

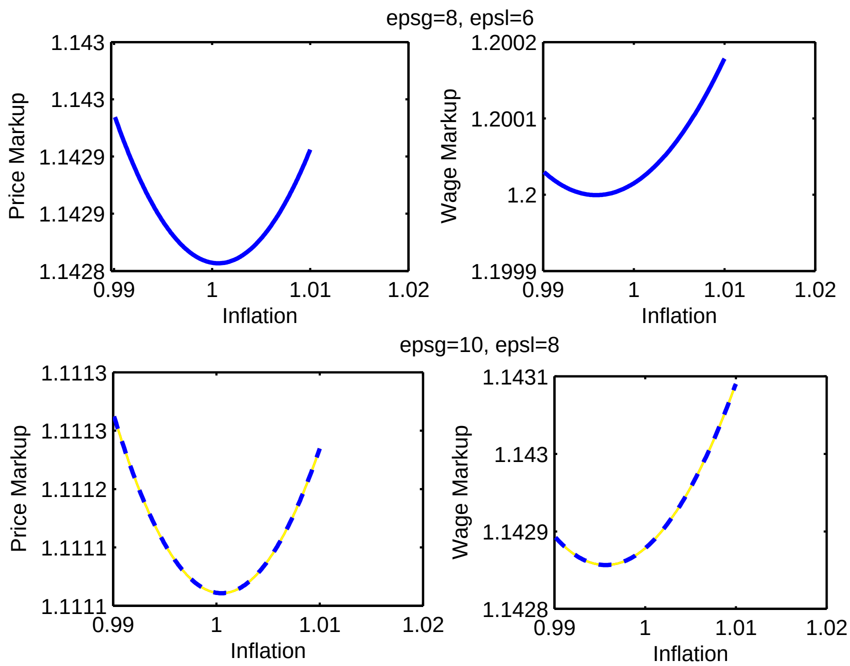


Figure 2.4 One percent contractionary monetary policy shock, Taylor rule with price and wage inflations, output growth and smoothing effect

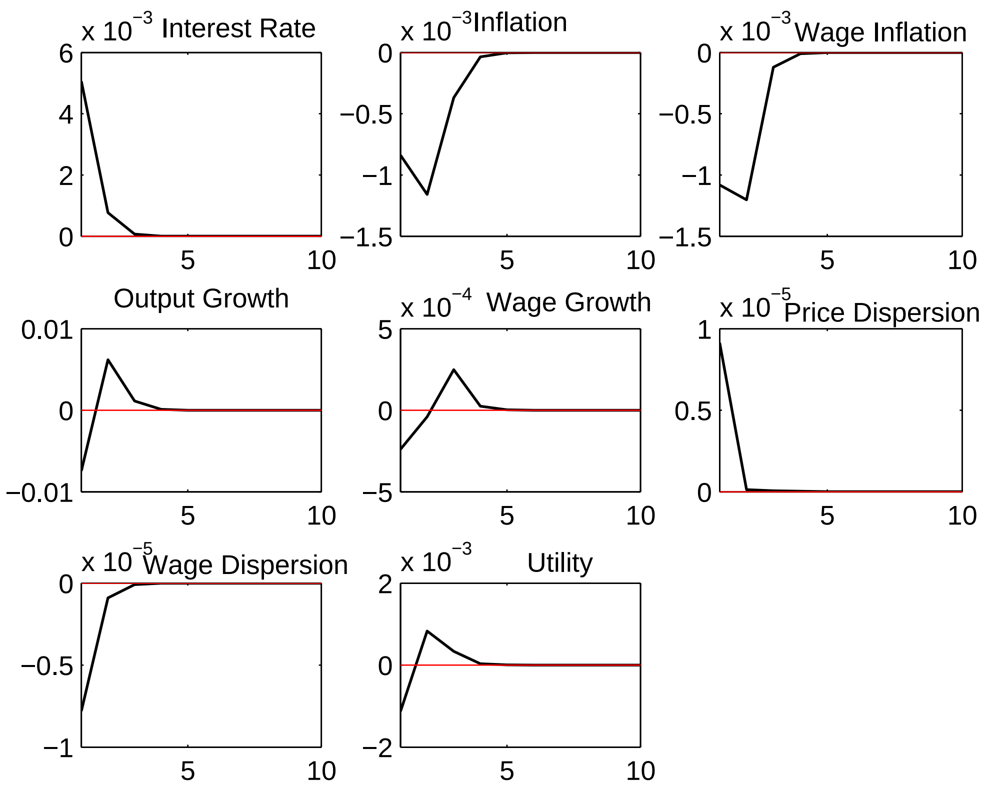
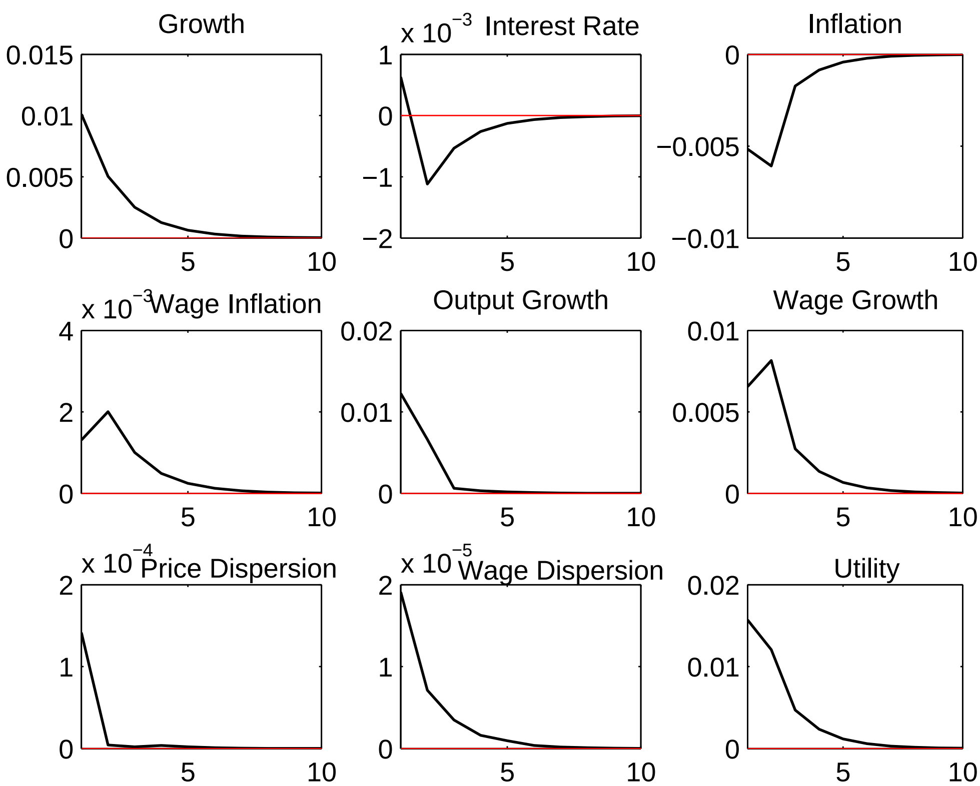


Figure 2.5 One percent positive output growth shock



CHAPTER III

TO FIX OR TO FLOAT? A THEORETICAL ASSESSMENT

Abstract

This essay takes a new look at choice of optimal exchange regime for developing countries. It does so through the development of a small open economy model with nominal flexibility and real rigidity, i.e. international financial market segmentation. This kind of real rigidity, because it leads to heterogeneity among agents, has important implications for the choice of exchange regime in these economies. The simulation exercises reveal that agents who are excluded from the foreign exchange market (non-traders) marginally prefer flexible exchange rates, while those who have access to the foreign exchange market (traders) are better off with fixed rates. Flexible rates yield a potential Pareto improvement if traders represent a very small fraction of the total population. Plausible weights on the two groups in a utilitarian social welfare function give a higher level of social welfare under fixed rates.
Keywords: Exchange Rate Regime, Monetary Policy.

3.1 Introduction

In this chapter, I address the issue of optimal exchange rate regimes for emerging market economies in an environment with flexible prices and real rigidities. Agents are divided into two groups in terms of their access to international financial markets; i.e. traders versus non-traders. I find that this kind of real rigidity, backed by empirical observations in emerging economies where financial markets are not well developed, has important implications for the choice of the exchange rate regime for these economies. My findings reveal that as long as the weight of non-traders is not more than 90% of the total population, financial market segmentation favors a fixed regime for these economies. This is obtained by considering a weighted average welfare function in consumption of both groups. The result stands even if both types of agents are not individually better off under a fixed regime. The optimal exchange rate choice is the one chosen by traders. When shocks are monetary, traders who have access to international financial markets accommodate these shocks easily. Non-traders who do not have access to the financial market cannot benefit from this exchange regime. For this group, a flexible exchange rate can stabilize real money balances, thanks to an increase in the price level caused by a positive monetary shock. As nominal balances and prices both increase, real balances are left less affected and this leads to a reduced variability of consumption for this group.

These results confirm that in an environment of price flexibility in which agents are divided by their borrowing capacities and hence cannot smooth their consumption, an optimal exchange rate offsets their incapacity to react optimally to the shocks. The gain for traders of being in a fixed regime is higher than the loss for non-traders of being in such a regime. This is the case no matter the nature of shocks, as long as the whole population is not non-trader.

The results in this paper are related to the debate on the choice of an optimal exchange regime in emerging markets. Developing countries face a combination of monetary and real shocks that makes it difficult to determine the real source of shocks. The financial structures of these economies are also weak and this has an important implication for the study of their exchange regimes. The ratio of banking deposits to GDP, as a measure of financial depth, is much less in these countries than it is in industrial ones $(20 - 40\%)$.[1]

The model is explained as follows. Households are heterogenous in terms of their access to international financial markets. They are divided into two cohorts (traders and non-traders) and have different spending rates; non-traders who are borrowing constrained in each period consume less and have fewer possibilities of consumption

[1]See Lahiri, Singh, et Vegh (2007).

smoothing. More specifically, only a fraction of agents - traders - uses the financial market. The bond, denominated in dollars, is circulating in the market and acts as an insurance to smooth traders' consumption over time. Due to missing insurance markets and lack of access to the financial market for non-traders, in addition to the possibility of being borrowing constrained in future periods, there is a possibility of heterogeneity among agents of this group. The paper eliminates this possibility by considering that households in this cohort have the same distribution of wealth, do not save, and are only subject to aggregate shocks, i.e. real and monetary.

The focus of this work is on the welfare implications of two regimes under shocks, flexible versus fixed. I calibrate the model to reproduce the high level of interest rates in Argentina during the last three decades. I try to understand how inclusion of international financial market frictions affects the choice of the exchange regime for a borrowing constrained economy. The second order approximation of the unconditional utility and then conditional welfare of agents under the above-mentioned shocks provides insights about welfare under the two exchange regimes.

My results are related to the findings of Lahiri, Singh, and Vegh (2007). In a recent paper, these authors show analytically how types of friction might alter the choice of the optimal exchange regime. They conclude that the type of friction is as important as the type of shock in the determination of the optimal exchange regime. While my paper is closest in spirit to Lahiri *et al.* (2007) for market segmentation, I use simulation method to choose the optimal exchange regime. The issue of the optimal exchange rate regime is an old question in international finance. More than half a century after Milton Friedman's (1953) case for a flexible exchange rate, the debate on optimal exchange rate regimes is still controversial. Friedman argued that when prices are sticky, a floating rate leads to an adjustment in relative prices and is a better insulation mechanism from foreign shocks. However, Mundell (1961) argued that in a world with capital mobility, the optimal choice of exchange regime depends on the type of shocks; real shocks call for a floating exchange rate, whereas monetary shocks call for a fixed exchange rate regime. Helpman and Razin (1979) argued that optimality of an exchange regime requires a utility-maximizing framework analysis. They concluded that there is a welfare equivalence between a fixed and a flexible exchange rate for an economy with perfect capital mobility where agents are subject to cash-in-advance constraints.

More recently, Obstfeld and Rogoff (1995) bring microfoundation analysis to theoretical studies of international macroeconomics under the New Open Economy Macroeconomics (NOEM). Devereux and Engel (2003) reexamine the case for optimal exchange rates in a sticky price model and show that results are sensitive to whether prices are denominated in the producer's or consumer's currency. Edwards and Yeyati (2005) find that countries with flexible exchange rate regimes grow faster than countries with fixed exchange rates. In the same vein, Edwards and Magendzo (2006) confirm that volatility of variables is significantly higher in dollarized - a kind of fixed exchange rate regime - than in non-dollarized economies.

However, those in favor of fixed regimes such as Dornbusch (2001), emphasize that the effects of fixed exchange rates on the real activities of emerging markets operate through two channels: investment and trade. First, fixed regimes, because of lower interest rates, encourage investment. Second, fixed regimes, by eliminating currency risks, encourage trade. Calvo and Reinhart (2002) explain that emerging countries which say they allow their exchange rate to float, mostly do not. These authors call this observation "fear of floating". Calvo (2005) explains that dollarization is the only viable exchange regime choice for Latin America. His argument is based on the weak structure of financial markets in these economies. The exchange-rate based stabilization literature also stresses that exchange-rate anchors are credibility enhancers for those economies. Arellano and Heathcote (2007) develop a model of credibility in which dollarization reduces the likelihood of default and increases the ability to access international financial markets. Ambler (2006) constructs a model with nominal wage rigidities which confirms the superiority of the fixed regime, when monetary shocks dominate real ones.

Historical evidence suggests a general cyclical pattern for the choice of one regime rather than another since the end of World War II. The first period is that of the gold standard or Bretton Woods era (1945 -1973), during which the US was obliged to pay gold at 35 dollars an ounce to its official foreign creditors, and which saw other countries peg their currencies to the dollar. The gold system collapsed due to its rigidity after the oil shock of 1973.

The early 1990s witnessed, again, a period of super-fixed regime (e.g. currency board or dollarization) revival. This switch was motivated by evidence that fixed regimes were accompanied by a reduction in inflation variability, at least in emerging economies.[2] Some economists believe that the early twenty first century is experiencing a renewal of the Bretton Woods era (Bretton Woods II). All these empirical observations lead one to conclude that the choice of an exchange regime depends on macroeconomic priorities. According to the International Monetary Fund (2003), countries are now grouped into four types of exchange rate arrangements: peg, limited flexibility, managed floating and, freely-floating. While the IMF explains that countries should opt for more flexible regimes, classified as hybrid systems (e.g. crawling pegs, crawling bands, fixed but adjustable regimes with frequent sterilized interventions of central banks), the floating countries are still "floating with life-jackets".

The rest of the chapter is organized as follows. The next section sets out the model economy. The third section discusses its calibration and the solution method. The fourth section discusses the results. The fifth section concludes.

3.2 Model Economy

The model is a simple small open endowment economy in the spirit of Alvarez, Lucas, and Weber (2001). The asymmetry of endowment with the rest of the world gives an incentive to trade. Purchasing power parity holds within the goods market and the economy is perfectly integrated with world goods markets. The world currency

[2]Panama and El Salvador dollarized, whereas Argentina had a fixed system of currency board.

price of the consumption good is fixed at one.

There are two types of agents: those who do not have access to international financial markets in each period, non-traders, and those who have access to these markets and can buy one-period foreign bonds, traders. On the aggregate level, foreign bonds become the country's debt to international financial markets. Individuals are either trader or non-trader and remain so forever.

Each agent receives a random endowment of the consumption good in each period. The total endowment y_t is an independently and identically distributed random variable. Positive endowment shocks are an abstraction for technological improvement.

Money is introduced into the model via a cash-in-advance (CIA) constraint. Both types of agents carry cash from one period to another for their purchasing needs. Financial markets open and close before goods markets and only cash accumulated in the last period can be used for consumption purposes. Then, following Alvarez *et al.* (2001), a proportion of the current period's sales receipts, i.e. d_t, is also consumed in each period in addition to the cash carried over from the last period M_{t-1}. d_t is an independently and identically distributed random variable that can be interpreted as the velocity of money.[3] Alvarez *et al.* (2001) explain that uncertainty regarding d_t is similar to that regarding the total volume of sales at the time that the agents access cash. They suggest that one can also consider d_t as a mix of cash or credit transaction that fluctuates across periods.

The assumption of random variability of d_t is the same as the random variability of velocity of money that is a contribution of Svensson (1985) to the basic cash-in-advance model of Lucas and Stockey (1987). Svensson (1985) assumes that consumers have to choose how much cash to hold before the current state of the world is revealed. Consumers then hold money for precautionary purposes. There is an obvious positive

[3]Lahiri *et al.* (2007) explain that d_t could be interpretated as the velocity of money, as it is the amount of sales used for the purpose of consumption at the curent period.

relationship between the uncertainty and the amount of precautionary balances. However, consumers have to trade the benefits of higher money balances against the costs; i.e. loss of interest. As a result, the velocity of money holding becomes time-varying and interest rate dependent.

The above mentioned mechanism is reinforced in this paper when only a fraction of agents have access to international financial market to smooth their consumption when faced with shocks.

The economy is faced by two types of uncertainty. A real shock that determines the endowment y_t in each period and a monetary shock that is the fraction of the proceed from current sales that can be carried into the goods market, d_t.

3.2.1 Households

Non-traders

Consider first the problem of non-traders. This group holds money but does not participate in international financial markets. Non-traders use cash accumulated in the previous period to purchase goods in the current period. They also use a random part of their current sales receipts d_t to purchase goods. Preferences are given by a logarithmic utility function. Households are infinitely-lived and maximize the following utility function:

$$Max\ U\left(C_t^{NT}\right) = E_0 \sum_{t=0}^{\infty} \beta^t log(C_t^{NT}) \tag{3.1}$$

Their maximization is subject to the following nominal budget and cash-in-advance constraints:

$$M_{t+1}^{NT} + P_t C_t^{NT} = M_t^{NT} + (1-\alpha) P_t y_t + (1-\alpha) T_t \tag{3.2}$$

$$P_t C_t^{NT} = M_t^{NT} + (1-\alpha) d_t P_t y_t \tag{3.3}$$

where $\beta \in (0,1)$ is the discount factor, C_t^{NT} is the consumption of non-traders, M_t^{NT} is the holding of money for this group, $1-\alpha$ is the share of non-traders from the total population, P_t is the price level, y_t is the total random endowment in each period, T_t is the lump-sum transfer of the government to this group, and d_t is the monetary shock. Given these two constraints, the amount of money holding at the end of current period to be used at the beginning of the next period is given by:

$$M_{t+1}^{NT} = (1-\alpha)(1-d_t)P_t y_t + (1-\alpha)T_t \tag{3.4}$$

This equation is a variant of the quantity theory of money for the non-traders, where d_t acts as the velocity of money holding. It is also important to note that the cash-in-advance constraint binds in equilibrium.[4] This is a standard assumption in the literature (see Alvarez, Atkeson, and Kehoe (2002), and Alvarez *et al.* (2001)).

Traders

Traders have access to international financial markets and can buy bonds. In any period their assets are in the form of money balances and bonds carried over from the previous period. Their maximization problem is given by:

$$Max\ U\left(C_t^T\right) = E_0 \sum_{t=0}^{\infty} \beta^t log(C_t^T) \tag{3.5}$$

under the following budget and cash-in-advance constraints:

$$M_{t+1}^T + P_t C_t^T + \frac{S_t B_{t+1}^*}{R^* \kappa_t} = M_t^T + \alpha P_t y_t + S_t B_t^* + \alpha T_t \tag{3.6}$$

$$P_t C_t^T = M_t^T + \alpha d_t P_t y_t \tag{3.7}$$

where α is their share in the total population, C_t^T is the consumption of the trader, M_t^T denotes their money balances, S_t is the nominal exchange rate, B_t^* is the holding of foreign nominal bonds denominated in units of foreign currency, R^* is the exogenous and constant gross nominal foreign interest rate, κ_t is the risk premium that reflects

[4]Lahiri *et al.* (2007) provide proofs that this is indeed true for all t.

departures from uncovered interest parity, y_t is the total current revenue, αT_t denotes the share of nominal lump-sum transfers from the government, i.e. negative taxes, and finally $\alpha d_t P_t y_t$ is a part of the sales for consumption purposes of traders from the current sales. Adding a risk premium term κ_t to the interest rate parity is crucial here to confirm the departure from the interest rate parity on the one hand, and to ensure that the economy's steady state equilibrium is unique on the other. In fact, if one does not consider a risk premium term for the interest rate, holding of the traded international bond follows a unit root. This unit root implies that deviations from the steady state of the economy, even after small temporary shocks, will have permanent effects on variables.[5]

By combining these two equations for budget constraint and cash-in-advance, one can arrive at the following equation that explains the amount of money to be used at the beginning of the next period by traders:

$$M_{t+1}^{T} = \alpha(1-d_t)P_t y_t + S_t B_t^* R^* \kappa_t - S_t B_{t+1}^* + \alpha T_t \tag{3.8}$$

It can be easily seen that the bigger the monetary shock in this period, the less the amount of money that is left for the next period will be. An increase in the sales' receipts will be absorbed and consumed in the same period.

3.2.2 International Financial Markets

Traders in the economy can borrow from international financial markets. For a net borrower emerging market economy, the risk premium is positively related to a share of the economy's net foreign asset position relative to output, i.e. y_t. This is to say that risk premium increases with the economy's level of indebtedness. Following Senhadji

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[5] See Schmitt-Grohé and Uribe (2003) who discuss alternative ways of specifying models of small open economies in order to avoid the hysteresis problem.

(2003) the risk premium κ_t can be written as:

$$\kappa_t = \exp\left(\frac{\varphi S_t B_{t-1}^*}{P_t y_t}\right) \tag{3.9}$$

where φ is the sensitivity of the risk premium to the debt. The higher the value of φ is, the higher the sensitivity of the interest rate to foreign debt.

The following equation gives the relationship between the domestic and foreign interest rate:

$$R_t = \kappa_t R^* \tag{3.10}$$

The no-Ponzi-game on the holding of foreign bonds ensures that the path of asset holding is not exploding:

$$\lim_{T\to\infty}(\Pi_{t=0}^{T}\frac{1}{R^*\kappa_t})B_T^* = 0 \tag{3.11}$$

3.2.3 Goods Market

Purchasing power parity is assumed to hold in the goods market:

$$P_t = P_t^* S_t \tag{3.12}$$

and the price of foreign currency is normalized to one:

$$P_t^* = 1 \tag{3.13}$$

This implies that the price is also equal to the exchange rate:

$$P_t = S_t \tag{3.14}$$

3.2.4 Monetary Policy

The paper considers the problem of monetary policy in a fixed and in a flexible regime separately. Under a fixed exchange rate regime, the exchange rate is exogenous and the money supply is endogenous. The central bank intervenes in the market for foreign currency to support the fixed rate. The foreign exchange market intervention is then not sterilized. This means that changes in foreign exchange reserves have an effect on the monetary base. The problem of the monetary policy in the fixed regime is written as:

$$S_t = S \tag{3.15}$$

Under a flexible exchange rate regime, the exchange market itself determines the value of the exchange rate. This means that the exchange rate is endogenous and that the money supply is determined exogenously. The problem of the monetary policy is then given by:

$$M_t = M \tag{3.16}$$

3.2.5 Government

The government issues domestic money, and makes lump-sum transfers to the agents, both traders and non-traders. Thus the government's budget constraint is given by:

$$M_{t+1} - M_t = T_t \tag{3.17}$$

where equilibrium in the money market requires that:

$$M_t = M_t^T + M_t^{NT} \tag{3.18}$$

3.2.6 Current Account

The economy's current account is given by adding together the budget constraints of both types of households and the government:

$$P_t y_t + S_t B_t^* = P_t C_t^{NT} + P_t C_t^T + \frac{S_t B_{t+1}^*}{R^* \kappa_t} \tag{3.19}$$

3.2.7 Shocks

There are two sources of uncertainty in this economy, one monetary and one real. First, the current period's sales receipts, i.e. d_t is random and is defined in a log autoregressive process, i.e. AR(1) as follows:

$$\log(d_t) = \rho_d \log(d_{t-1}) + \varepsilon_{dt},\ 0 < \rho_d < 1 \tag{3.20}$$

The second source of uncertainty is the endowment shock. A positive endowment shock acts as a productivity improvement for the economy. The log of endowment follows an autoregressive process as follows:

$$\log(y_t) = \rho_y \log(y_{t-1}) + \varepsilon_{yt},\ 0 < \rho_y < 1 \tag{3.21}$$

The innovations ε_{dt} and ε_{yt} are independent, white noise shocks, and with constant variances.

3.3 Calibration and Simulation

3.3.1 Calibration

The model is solved numerically by using a second-order approximation of its equilibrium conditions.[6] As explained by Kim and Kim (2003), the use of second order approximations is crucial for welfare analysis, as they give more accurate results and avoid the possibility of spurious welfare reversals.

The calibration used to conduct stochastic simulations is summarized in Table 1. They are taken from the business cycle literature in emerging economies, such as the study of the microfoundation of the Argentinian economy by Neumeyer and Perri (2004), as well as Kydland and Zarazaga (1997), and Arellano *et al.* (2007). However, as the model economy is admittedly simplistic for its results to be directly related to

[6] The model is solved with the help of the Dynare program (Juillard, (2004)).

the Argentinian economy, I produce a benchmark economy with parameters aiming to match those features of the data that these parameters are most likely to affect. I then conduct a sensitivity analysis to test the robustness of these results to any changes in these parameter values.

The following parameters of the model are calibrated: discount factor, international nominal interest rates which are also equal to the real interest rate as the world inflation is considered to be zero, the relative sizes and persistence of stochastic processes, i.e. endowment and monetary shocks.

Note that a period in the model is assumed to be a quarter. The calibrations aim to reproduce the high level of mean spread between the Argentinian interest rate with the rest of the world. This spread in interest rates between pesos and dollars for loans within Argentina and for the period of 1983 to 2001, is estimated around 10% (see Neumeyer *et al.* (2004)). The parameter β or the subjective discount factor is set to 0.966[7] to give on average an annual interest rate of 14.0%, as shown by the same data-base from Neumeyer *et al.* (2004). The international interest rate is set equal to an annual rate of 2%, as the average of the interest rate for industrial economies during the same period as for Argentina (1983-2001). The risk premium κ_t is then calculated at the steady-state of the model from equation (3.9). The persistence of the endowment shock ρ_y is the same as the persistence of the productivity process, i.e. the autocorrelation estimated for an $AR(1)$ technology process, estimated for Argentina by Neumeyer *et al.* (2004), and is equal to 0.95. The persistence of the velocity shock ρ_d, estimated by the same authors, is then equal to 0.81. The steady-state level of debt, which is equal to the holding of foreign assets by traders, is set to zero in the baseline model. The sensitivity of the risk premium to the debt φ is then calculated based on the value for κ_t.

In the baseline model, I first simulate the model with symmetric and small shocks, with the relative size of standard deviations equal to one percent, where σ_d is the

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[7]Arellano *et al.* (2007) considers even a small discount factor $\beta = 0.953$ that leads to a higher level of interest rate.

monetary shock and σ_y is the real endowment shock. Then, through sensitivity analysis, I vary the size of shocks. I use data in Neumeyer *et al.* (2004) and Kydland *et al.* (1997), to set the standard deviations of shocks within a plausible range of value, to reflect the data for Argentina. These shocks are equal to $\sigma_d = 11.3\%$, and $\sigma_y = 4.22\%$. The relative variability of velocities for the demand for money M2 in Argentina for the period of 1970–1996 is estimated to be in a range of 7% to 16%. I then inverse the size of these shocks to see if the optimal choice of exchange regime will vary when the real shocks dominate the monetary shocks. This means that I consider a scenario in which $\sigma_y = 11.3\%$, and $\sigma_d = 4.22\%$.

3.3.2 Simulation

To simulate the model, the first order conditions of both types of agents are added to the equilibrium conditions of the economy, to the current account, to the monetary policy, to the budget constraints, and finally to the cash-in-advance constraints. In the fixed regime, the exchange rate is fixed and acts as an exogenous variable. In the flexible model, the path of the money supply is fixed and considered as an exogenous variable. The model is then simulated with a fixed and a flexible regime, under shocks to endowments y_t, i.e. real, and to the current period sales receipts d_t, i.e. nominal monetary shock. The complete set of first-order equations and equilibrium conditions is given in Appendix A. The steady-state solution of the model is in Appendix B.

3.4 Results

In order to assess the role of financial market frictions for the choice of the optimal exchange regime, different analyses are considered. The first is the steady-states analysis. Second, the baseline results are given for a model with one percent standard deviation symmetric shocks. Third, the impulse response functions of the model are presented. Fourth, sensitivity analysis provides insights for the choice of one regime over the other.

3.4.1 Steady-State Analysis

Table 2 reports the steady-state results. The steady-state of both regimes is equivalent. This is intuitive: absent shocks, both regimes lead to the same allocation of resources.

3.4.2 Baseline Model

Tables 3.3, 3.4, 3.5, and 3.6 report the results for the baseline model: second moments of variables, period utilities, and welfare evaluation.

Non-traders have a greater variability of their consumption in the fixed regime, relative to traders. This is intuitive, as these agents cannot access the financial market to absorb the shocks. However, their consumption variability is less under the flexible regime and even less relative to traders' consumption. This is explained by the fact that any changes in the exchange rate impacts those who participate in the financial markets more, i.e. traders. Contrary to the international financial literature, the results here are a consequence of the structure of the market and do not depend on the shocks.

While the period utility for non-traders is the same across the two regimes, equal to -0.6932, the period utility of traders is higher under a fixed regime. The stochastic mean of consumption of non-traders are also the same across both regimes, while that of traders is higher under a fixed regime. However, the consumption of traders is less volatile under a fixed regime and that of non-traders is less volatile under a flexible exchange regime. These results confirm that for the small symmetrical shocks, the non-traders are indifferent between both regime, while the traders unambiguously prefer the fixed regime.

To understand the intuition behind these results, it is helpful to note that while both types of agents face the same small and symmetrical shocks, their ability to absorb them is asymmetric. In particular, trading households have an extra instrument - foreign bonds - which allows them to smooth their consumption in response to shocks. Non-traders do not participate in the financial market and cannot smooth their consumption after shocks. This is reflected in their higher variabilities of consumption compared to traders, certainly in the fixed regime. They consume their endowments, certainly when it is not for the presence of cash-in-advance constraint. Whenever they receive higher endowment and/or an increase in access to the sales' receipt from the current period's sale, they increase their consumptions. The velocity shock changes the nominal balances of this group that are available for consumption. When exchange rate is fixed and PPP holds, any changes in nominal balances have a direct impact on real balances of these groups.

A positive real shock increases consumption through two channels. First, an increase in output appreciates the currency. Second, an increase in output raises the current sales revenue and in consequence the cash for consumption. When the exchange rate can vary, the optimal monetary policy calls for an expansion in money growth for these groups. This will depreciate their currencies and leave their real balances unchanged. These mechanisms explain why consumption of non-traders is less variable under a flexible regime. However, for traders who access the financial market, consumption and real balances are less variable under a fixed regime. The present simulation exercise concludes that faced with symmetrical shocks, financial market segmentation favors the consumption stabilization of those participating in the financial market, i.e. traders.

Later on in this paper, I analyze the effects of asymmetrical shocks on the choice of the optimal exchange regime.

3.4.3 Impulse Response Analysis

To qualitatively compare the dynamics of this model with existing literature on optimal exchange policies, I look at the impulse responses after real and monetary shocks. The real shock is a shock to endowment, whereas monetary shock is an increase in the receipt from the current sales. Figures 3.1 to 3.4 illustrate the response of aggregates: consumption, real money balances, weighted period utilities and conditional welfare in both regimes and under both shocks. The y-intercepts in these figures indicate the level deviations of variables from their steady state values. Due to the fact that shocks are written in logs, the deviation can also be treated as the percentage of changes from the steady-state values.

Two main observations can be summarized as follows. First, financial market segmentation alone accounts for the persistence of real variables. Second, variables are not persistent after monetary shocks.

The consequence of a positive endowment shock in the fixed regime is traced in Figure 3.1. Consumption for both groups increases after a positive real shock. However, the impact is more persistent for traders, since thanks to their access to financial markets they have an extra instrument for consumption smoothing.

Figure 3.3 shows the impact of a positive endowment shock in a flexible regime. A positive endowment shock increases the consumption of both groups, but the consumption increase turns out to be persistent for traders.

Figures 3.2 and 3.4 show the impact of a positive monetary shock, i.e. an increase in sales' receipt for a fixed and a flexible regime. An increase in the current sales' receipts boosts the current consumption for both groups. From equations (3.4) and (3.8), it can be seen that the higher the monetary shock, the greater the consumption and the less money left at the end of the period. When all increases in receipts are consumed at the current period, the money holding will decrease.

I then look at some of the quantitative features of the simulated model. The objective of the computational experiment in this paper is to evaluate the role played by financial market segmentation for the choice of an optimal exchange rate in emerging markets. However, the simulated model should behave in the range of plausible values for the business cycle properties of the calibrated economy. To this end, I look at some of the relative volatility statistics and comovements of the variables in the simulated model and compare them with the data. They are presented in Table 3.6 for both regimes.

In the baseline model, the relative volatility of consumption (average for both groups) to output for the fixed regime is 1.0001. For the flexible regime, this is even less and is equal to 0.999. These values are about half of those found in data for Argentina for the past decades.[8] The relative variability of consumption for non-traders is higher in the fixed regime than it is for traders. Consumption is procyclical in both regimes. However, the cross-correlation of output and total consumption is smaller than that in data, for both exchange regimes. These cross-correlations are higher in the fixed regime, 0.73, versus the flexible one, 0.68. Another result that is confirmed by empirical observations for emerging markets is the countercyclicality of the interest rate in both regimes (see Table 3.6).[9]

3.4.4 Welfare Analysis

Unconditional Welfare

I compare the unconditional welfare function W of both regimes with each other, where α is the share of traders in the total population. This function is given by:

$$W = E\sum_{t=0}^{\infty}\beta^t U(C_t^{NT}, C_t^T) = \frac{1}{1-\beta}E((1-\alpha)U(C_t^{NT}) + \alpha U(C_t^T)) \tag{3.22}$$

I first posit that this share is 0.5, meaning that an equal weight from the total population for both types of agents is considered. The results are given in Table 3.5. The unconditional welfare in this case is the same across both regimes, i.e. -0.0236. However, the period utility is higher in a fixed regime, i.e. 0.6931 versus 0.6940. The average period utility is also less volatile in a fixed regime, 0.0233 versus 0.040. These results explain that the gain for the traders of being in an optimal fixed regime outweighed

[8]See Kydland *et al.* (1997).

[9]See Neumeyer *et al.* (2004).

the loss for the non-traders of being in a sub-optimal fixed exchange regime. I translate this utility gain or loss into a measure of consumption units for both groups. In other words, the welfare gain is the amount of consumption that should be added to the steady-state consumption of non-traders in the fixed regime to leave them as well off as if they were in the flexible regime. For this group, this amount is 0.08% of their steady-state consumption.

Then in the sensitivity analysis I study the impact of different values for α on the choice of the optimal exchange regime.

Conditional Welfare Analysis

In this section, I compare the conditional welfare or the life-time weighted utility of agents under shocks, for both regimes and with each other. This can be written as maximizing the following lifetime utility function as follows:

$$W_t = E_t \sum_{t=0}^{\infty} \beta^t U(C_t^{NT}, C_t^T) = E_t \sum_{t=0}^{\infty} \beta^t \left((1-\alpha)U(C_t^{NT}) + \alpha U(C_t^T)\right) \tag{3.23}$$

The results in Table 3.5 indicate that the conditional welfare is 0.13% higher under the fixed regime.

3.4.5 Sensitivity Analysis

Throughout the paper, the response of the variables to small and symmetrical shocks has been considered. However, emerging economies are volatile and empirical observations confirm that the variability of nominal shocks mostly dominates that of the real shocks. For this reason, I first run a sensitivity analysis by choosing more realistic values for shocks as in Neumeyer *et al.* (2004), where the standard deviation of monetary shock dominates that of real shock, i.e. $\sigma^d = 11.3\%$, $\sigma^y = 4.2\%$. The results are given in Tables 3.7, 3.8 and 3.9.

These results reveal that with an equal share for both types of agents from the total population, the optimal exchange rate is still the fixed regime. Non-traders gain a little bit from the flexible regime; -0.6987 versus -0.7002, but the traders unambiguously prefer the fixed exchange regime and their preference dominates the weighted utility function. The intuition for this result is as follows. With price flexibility, non-traders prefer a flexible regime in presence of monetary shocks. The exchange rate change acts as a mechanism to absorb the fluctuation in their real money balances after a monetary shock. However, traders prefer the fixed regime as a form of insurance in the financial market.

I then consider what would happen to the optimal choice of an exchange rate regime if the real shock dominates the monetary shock. For the sake of simulation, I inverse the size of the shocks from the previous exercise, i.e. $\sigma^y = 11.3\%$, $\sigma^d = 4.2\%$. The simulation results are given in Tables 3.10, 3.11, and 3.12. In this case, both groups prefer the fixed exchange regime, even if the gain for traders is greater than for non-traders. The intuition is as follows. As the economy is an endowment one, any changes in the total endowment have a direct impact on the consumption of both groups. In presence of real shocks, the ability to cope with shocks through the exchange rate itself is reduced and the fixed exchange rate offers a security to both groups. The consumption of both groups is less volatile under the fixed regime. The stochastic mean of consumption for non-traders is higher in the flexible regime. However, once the shocks are considered, the period utility of this group is higher under the fixed regime, where the volatilities are less.

In the third stage, I run a sensitivity analysis to see what happens if the share of non-traders from the total population increases. For this purpose, I increase the share of non-traders to 90%, i.e. $\alpha = 0.1$. The results are given in Tables 3.13, 3.14, and 3.15 and confirm that the choice of the optimal exchange rate, when the weighted average utility is considered, is the fixed regime.

However, when almost all of the population are non-traders, i.e. when their share increases to more than 90% or $\alpha < 0.1$, the preference of non-traders dominate the overall welfare criterion. The results are given in Tables 3.16, 3.17, and 3.18. In this case, the weighted average utility function favors a flexible regime. The result is intuitive as a small fraction of the population cannot help maintain the fixity of the exchange rate for the whole economy by accepting all the monetary changes in the financial market. This result is independent from the nature and the size of the shocks; the flexible exchange regime is the optimal regime.

3.5 Conclusion

In this paper, I compared the welfare implications of fixed versus flexible exchange regimes. The analysis was conducted within a simple small open economy model of endowment, with a cash-in-advance constraint, flexible prices, and real rigidity in terms of limited access to the international financial market. The model is then calibrated to the Argentinean economy and is driven by two positive shocks: one real and one monetary. The simulated model does relatively well in terms of business cycle properties of variables. Different experiments are considered to choose the optimal exchange regime.

The results reveal that in an environment of price flexibility and real rigidity, i.e. financial market segmentation, the fixed exchange regime welfare dominates the choice of regime. This is true whether the shocks are real or monetary, as long as the non-traders are not the whole population and this group has a realistic share of the total population as in the data.

On an individual level, faced with monetary shocks, traders prefer the fixed regime and non-traders prefer the flexible regime. The effects of monetary instability are better absorbed under fixed exchange rates. However, confronted with real positive shocks, the fixed regime leads to an increase in consumption and in the sales' receipts of the current period, and becomes the optimal choice for both groups. When almost all the population is composed of non-traders, i.e. more than 90% of the population, their choice dominates the whole economy and the flexible regime becomes the optimal choice. These results have an important implication for policymakers in emerging markets. An optimal monetary policy should, in order to increase the average level of welfare in the economy, target the stabilization of those not participating in the financial market.

There are several directions in which this study can be extended. First, one could include a production structure to the model and see the implication for policy analysis. Second, one can add nominal frictions to the model, i.e. price and wage staggered contracts. One way of adding nominal friction is to depart from purchasing power parity and price flexibility through a local currency pricing for exported goods. Finally, another extension would be to add two sectors to the model, tradable and non-tradable, thereby introducing a role for inflation stabilization in the design of monetary policy.

APPENDIX A

TABLES

Table 3.1 Model Calibration

Parameter	Definition	Value
β	Subjective discount factor	0.966
ρ_d	Persistent of velocity shock	0.81
ρ_y	Persistent of endowment shock	0.95
ε_d	Standard deviation of velocity shock in the baseline model	1%
ε_y	Standard deviation of real shock	1%
ε_d	Standard deviation of velocity shock	11.3%
ε_y	Standard deviation of real shock	4.22%
M	Long run money supply	1
R^*	Gross foreign interest rate	1.005
t	Time horizon	1/4

Table 3.2 Steady-State Values

Variables		
	Fixed Regime	**Flexible Regime**
	Deterministic Steady-State	Deterministic Steady-State
C_t^{NT}	0.5	0.5
C_t^{T}	0.5	0.5
M_t^{NT}	0.5	0.5
M_t^{T}	0.5	0.5
r_t	1.0352	1.0352
y_t	1	1
$E(U(C_t^{NT}))$	-0.693147	-0.693147
$E(U(C_t^{T}))$	-0.693147	-0.693147
$E(U(C_t))$	-0.693147	-0.693147
W	-0.023567	-0.023567
W_t	-20.3867	-20.3867

C_t is the consumption index of the representative agent.

1 and 3) From Kydland et Zarazaga (1997)

2) From Neumeyer and Perri (2004)

Table 3.3 Second Moments for Symmetric Shocks in Baseline Model

Variables	Symmetric Shocks: a=0.5, σ_y=1%, σ_d=1%	
	Fixed Regime	**Flexible Regime**
Standard Deviation		
$\sigma_{C_t^{NT}}$	0.0126	0.0123
$\sigma_{C_t^T}$	0.0124	0.0145
$\sigma_{M_t^{NT}}$	0.0143	0.0134
$\sigma_{M_t^T}$	0.0138	0.0143
Stochastic Means		
C_t^{NT}	0.5001	0.5001
C_t^T	0.5003	0.4994

Table 3.4 Period Utilities for Symmetric Shocks in Baseline Model

Variables	Symmetric Shocks: a=0.5, σ_y=1%, σ_d=1%	
	Fixed Regime	**Flexible Regime**
$EU(C_t^{NT})$	-0.6932	-0.6932
$EU(C_t^T)$	-0.6931	-0.6947

Table 3.5 Welfare Evaluation for Symmetric Shocks in Baseline Model

Variables	Weighted Average Utility a=0.5, σ_y=1%, σ_d=1%	
	Fixed Regime	**Flexible Regime**
σ_{u_C}	0.0233	0.0233
EU_c	-0.6931	-0.6940
W	-0.0236	-0.0236
W_t	-20.3842	-20.4111

Table 3.6 Business Cycles in the Baseline Model

Variables	Simulated Model for a=0.5, σ_y=1%, σ_d=1%		
	Fixed Regime	**Flexible Regime**	**Argentine Data**
$\sigma(\frac{C_t}{y_t})$	1	0.999	1.99[1]
$\rho(r_t, y_t)$	-0.42	-0.34	-0.63[2]
$\sigma(\frac{C_t^{NT}}{C_t^T})$	1.016	0.840	NA
$\rho(C_t, y_t)$	0.739	0.683	0.96[3]

Table 3.7 Second Moments for Asymmetric Shocks, Dominance of Monetary Shock

Variables	Asymmetric Shocks: a=0.5, σ_y=4.22%*, σ_d=11.3%*	
	Fixed Regime	**Flexible Regime**
Standard Deviation		
$\sigma_{C_t^{NT}}$	0.0766	0.0764
$\sigma_{C_t^T}$	0.0761	0.0898
$\sigma_{M_t^{NT}}$	0.1078	0.0971
$\sigma_{M_t^T}$	0.1014	0.0865
Stochastic Means		
C_t^{NT}	0.5023	0.5031
C_t^T	0.5049	0.4589

$*$ These values are based on Neumeyer *et al.* (2004), and also based on Lahiri *et al.* (2007).

Table 3.8 Period Utilities, Dominance of Monetary Shock

Variables	Asymmetric Shocks: a=0.5, σ_y=4.22%, σ_d=11.3%	
	Fixed Regime	**Flexible Regime**
$EU(C_t^{NT})$	-0.7002	-0.6987
$EU(C_t^{T})$	-0.6949	-0.7916

Table 3.9 Welfare Evaluation, Dominance of Monetary Shock

Variables	Weighted Average Utility: a=0.5, σ_y=4.22%, σ_d=11.3%	
	Fixed Regime	**Flexible Regime**
Standard Deviation		
EU_c	-0.6976	-0.7451
W	-0.0237	-0.0253
W_t	-20.5163	-21.9511

Table 3.10 Second Moments for Asymmetric Shocks, Dominance of Real Shock

Variables	Asymmetric Shocks: a=0.5, σ_y=11.3%, σ_d=4.22%	
	Fixed Regime	**Flexible Regime**
Standard Deviation		
$\sigma_{C_t^{NT}}$	0.1315	0.1352
$\sigma_{C_t^{T}}$	0.1293	0.1495
$\sigma_{M_t^{NT}}$	0.1345	0.1339
$\sigma_{M_t^{T}}$	0.1317	0.1462
Stochastic Means		
C_t^{NT}	0.5168	0.5171
C_t^{T}	0.5338	0.4555

Table 3.11 Period Utilities, Dominance of Real Shock

Variables	Asymmetric Shocks: a=0.5, σ_y=11.3%, σ_d=4.22%	
	Fixed Regime	**Flexible Regime**
$EU(C_t^{NT})$	-0.6941	-0.6954
$EU(C_t^{T})$	-0.6590	-0.8267

Table 3.12 Welfare Evaluation, Dominance of Real Shock

Variables	Weighted Average Utility: a=0.5, σ_y=11.3%, σ_d=4.22%	
	Fixed Regime	**Flexible Regime**
σ_{u_C}	0.2395	0.2416
EU_c	-0.6776	-0.7611
W	-0.0259	-0.023
W_t	-19.8987	-22.3851

Table 3.13 Period Utilities, Symmetric Shocks with Different Share of Non-traders from Total Population

Variables	Weighted Average Utility: a=0.1, σ_y=1%, σ_d=1%	
	Fixed Regime	**Flexible Regime**
σ_{u_C}	0.0250	0.0244
EU_c	-0.3250	-0.3258

Table 3.14 Period Utilities, Dominance of Monetary Shock with Different Share of Non-traders from Total Population

Variables	Weighted Average Utility: a=0.1, σ_y=4.22%, σ_d=11.3%	
	Fixed Regime	**Flexible Regime**
σ_{u_C}	0.1527	0.1439
EU_c	−0.3299	−0.3472

Table 3.15 Period Utilities, Dominance of Real Shock with Different Share of Non-traders from Total Population

Variables	Weighted Average Utility: a=0.1, σ_y=11.3%, σ_d=4.22%	
	Fixed Regime	**Flexible Regime**
σ_{u_C}	0.2595	0.2560
EU_c	−0.3135	−0.4076

Table 3.16 Period Utilities, Symmetric Shocks with Different Share of Non-traders from Total Population

Variables	Weighted Average Utility: a=0.01, σ_y=1%, σ_d=1%	
	Fixed Regime	**Flexible Regime**
σ_{u_C}	0.0258	0.0266
EU_c	−0.0552	−0.0498

Table 3.17 Period Utilities, Dominance of Monetary Shock with Different Share of Non-traders from Total Population

Variables	Weighted Average Utility: a=0.01, σ_y=4.22%, σ_d=11.3%	
	Fixed Regime	**Flexible Regime**
σ_{u_C}	0.1651	0.1527
EU_c	−0.3299	0.5357

Table 3.18 Period Utilities, Dominance of Real Shock Dominance with Different Share of Non-traders from Total Population

Variables	Weighted Average Utility: a=0.01, σ_y=11.3%, σ_d=4.22%	
	Fixed Regime	**Flexible Regime**
σ_{u_C}	0.2595	0.2757
EU_c	−0.3135	0.2561

APPENDIX B

EQUILIBRIUM CONDITIONS

B.1 First Order Conditions

Non-traders choose the path of consumption and real balances to maximize their utilities under budget and cash-in-advance constraints:

$$(C_t^{NT}) : U'\left(C_t^{NT}\right) = \left(\lambda_t^{'} + \gamma_t^{'}\right) \tag{B.1}$$

$$(M_t^{NT}) : \lambda_t^{'} = \beta/\pi_{t+1}(E_t\gamma_{t+1}^{'} + E_t\lambda_{t+1}^{'}) \tag{B.2}$$

Traders optimize their utilities by choosing the path of consumption, money, and bond holdings:

$$(C_t^{T}) : U'\left(C_t^{T}\right) = (\lambda_t + \gamma_t) \tag{B.3}$$

$$(M_t^{T}) : \lambda_t = \beta/\pi_{t+1}(E_t\gamma_{t+1} + E_t\lambda_{t+1}) \tag{B.4}$$

$$(B_t^{*}) : \lambda_t = \beta R_t E_t\lambda_{t+1}/\pi_{t+1} \tag{B.5}$$

B.2 The System of Equations

Here, I give the complete system of equations used to simulate the model. The model's equilibrium can be calculated using the following equations. In the fixed regime, exchange rate is fixed and exogenous and money balance is endogenous; i.e. $S_t = S$.

Prices are equal to exchange rates, and by PPP assumption, the inflation tax is then equal to the devaluation rate e which is constant and exogenous. The set of endogenous variables is as follows: $C_t^{NT}, C_t^T, M_t^{NT}, M_t^T, M_t, B_t^*, \lambda_t, \gamma_t, \lambda_t^{'}, \gamma_t^{'}, \kappa_t, R_t, U_t^{Fixed}$, W_t^{Fixed}, T_t, W^{Fixed}, d_t, y_t.

In case of a flexible exchange rate regime, the exchange rate is endogenous and the money balances are exogenous; $M_t = M$. The set of endogenous variables is as follows: $C_t^{NT}, C_t^T, M_t^{NT}, M_t^T, B_t^*, \lambda_t, \gamma_t, \lambda_t^{'}, \gamma_t^{'}, \kappa_t, R_t, U_t^{Flexible}, W_t^{Flexible}$, $W^{Flexible}$, T_t, d_t, y_t, S_t, P_t.

As long as PPP holds and the foreign prices are normalized to one, $S_t = P_t$, the gross inflation tax is equal to the gross devaluation rate, $e_t = \pi_t$. To induce stationarity in variables, all nominal variables are normalized by the price level: $\pi_t = P_t/P_{t-1}$, $b_t^* = B_t^*/P_t$, $m_t = M_t/P_t$, $m_t^{NT} = M_t^{NT}/P_t$, $m_t^T = M_t^T/P_t$, $tt_t = T_t/P_t$, $s_t = S_t/P_t$.

The following system of equations in stationary variables characterize the model's equilibrium and is considered for simulation for each regime in presence of monetary and endowment shocks.

$$e_t = \frac{S_t}{S_{t-1}} \tag{B.6}$$

$$\pi_t = e_t \tag{B.7}$$

$$\frac{1}{C_t^T} = (\lambda_t + \gamma_t) \tag{B.8}$$

$$\lambda_t = \beta(E_t\lambda_{t+1} + E_t\gamma_{t+1})/\pi_{t+1} \tag{B.9}$$

$$\lambda_t = \beta R_t E_t \lambda_{t+1}/\pi_{t+1} \tag{B.10}$$

$$R_t = R^* \kappa_t \tag{B.11}$$

$$\log \kappa_t = \varphi \exp\left[-(\frac{S_t b_{t-1}^*}{\pi_t y_t})\right] \tag{B.12}$$

$$\frac{1}{C_t^{NT}} = \left(\lambda_t^{'} + \gamma_t^{'}\right) \tag{B.13}$$

$$\lambda_t^{'} = \beta(E_t\lambda_{t+1}^{'} + E_t\gamma_{t+1}^{'})/\pi_{t+1} \tag{B.14}$$

$$C_t^{NT} = m_{t-1}^{NT}/\pi_t + (1-\alpha)d_t y_t \tag{B.15}$$

$$C_t^T = m_{t-1}^T/\pi_t + \alpha d_t y_t \tag{B.16}$$

$$m_t^{NT} = -C_t^{NT} + m_{t-1}^{NT}/\pi_t + (1-\alpha)y_t + (1-\alpha)tt_t \tag{B.17}$$

$$\frac{S_t b_{t-1}^*}{\pi_t} = C_t^T + C_t^{NT} + \frac{S_t b_t^*}{R_t} - y_t \tag{B.18}$$

$$m_t = m_t^T + m_t^{NT} \tag{B.19}$$

$$tt_t = m_t - \frac{m_{t-1}}{\pi_t} \tag{B.20}$$

$$U^{Flexible} = (1-\alpha)\log(C_t^{NT}) + \alpha\log(C_t^T) \tag{B.21}$$

$$U^{Fixed} = (1-\alpha)\log(C_t^{NT}) + \alpha\log(C_t^T) \tag{B.22}$$

$$W^{Flexible} = \frac{1}{1-\beta}U^{Flexible} \tag{B.23}$$

$$W^{Fixed} = \frac{1}{1-\beta}U^{Fixed} \tag{B.24}$$

$$W_t^{Flexible} = \sum_{i=0}^{\infty}\beta^i U^{Flexible} = U^{Flexible} + \beta W_{t+1}^{Flexible} \tag{B.25}$$

$$W_t^{Fixed} = \sum_{i=0}^{\infty}\beta^i U^{Fixed} = U^{Fixed} + \beta W_{t+1}^{Fixed} \tag{B.26}$$

$$\log y_t = \rho^y \log y_{t-1} + \varepsilon_t^y \tag{B.27}$$

$$\log d_t = \rho^d \log d_{t-1} + \varepsilon_t^d \tag{B.28}$$

B.3 Deterministic Steady-State

In the steady-state, all variables are written without time subscripts. Time is considered to be a quarter. λ and λ' are respectively the marginal utility of consumption for traders and non-traders, while γ and $\gamma^{'}$ are the cash-in-advance shadow values. α is the weight of traders from total population. At the steady-state, the real money stock is constant. Therefore the gross rate of inflation is equal to the rate of money growth. As PPP holds and the world price is normalized to 1, the inflation rate is also equal to the devaluation or depreciation rate (depending on whether the economy is governed under a fixed or flexible regime). The steady-state value of exchange rate S and endowment

y are normalized to 1. Then, the steady-state equations are calculated recursively and the values are the same for both regimes.

$$y = 1 \tag{B.29}$$

$$P^* = 1 \tag{B.30}$$

As PPP holds, the domestic price is then equal to nominal exchange rate:

$$P = S \tag{B.31}$$

The foreign interest rate is exogenously given by the experience of the industrialized economies with an annual net interest rate of 2%. The gross quarterly interest rate is then equal to:

$$R^* = 1.005 \tag{B.32}$$

And the Euler equation for bonds implies immediately that:

$$R = \frac{1}{\beta} \tag{B.33}$$

The value for the discount factor has been chosen to match the high level of interest rates in Argentina. The risk premium is the ratio of the interest rates:

$$\kappa = \frac{R}{R^*} \tag{B.34}$$

The equation for the risk premium implies a solution for the sensitivity of risk-premium:

$$\varphi = \frac{\log(\kappa)}{\frac{Sb^*}{y}} \tag{B.35}$$

The long-run real money balances is normalized to one:

$$M = 1 \tag{B.36}$$

The national income identity gives:

$$C^{NT} = (1-\alpha)y \tag{B.37}$$

from cash-in-advance constraint:

$$m^{NT} = C^{NT} - (1-\alpha)(1-d)y \tag{B.38}$$

and from aggregate money holding:

$$m^T = m - m^{NT} \tag{B.39}$$

$$C^T = m^T + (1-\alpha)(1-d)y \tag{B.40}$$

The household's first order conditions for consumptions and money-balances can be used to solve for λ, γ, $\lambda^{'}$, $\gamma^{'}$ as follows:

$$\lambda = \frac{\beta}{C^T} \tag{B.41}$$

$$\gamma = \frac{1}{C^T} - \lambda \tag{B.42}$$

$$\lambda^{'} = \frac{\beta}{C^{NT}} \tag{B.43}$$

$$\gamma^{'} = \frac{1}{C^{NT}} - \lambda^{'} \tag{B.44}$$

APPENDIX C

FIGURES

Figure 3.1 One percent positive real shock in a fixed regime, when NT stands for Non-traders, and T stands for Traders

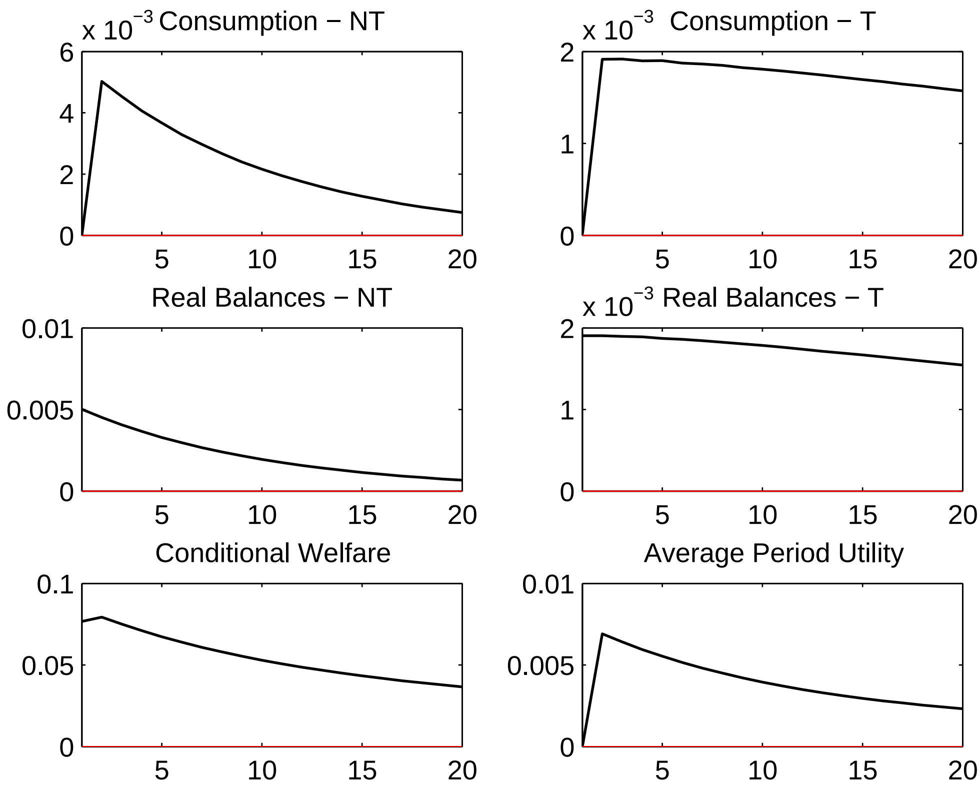


Figure 3.2 One percent positive monetary shock in a fixed regime

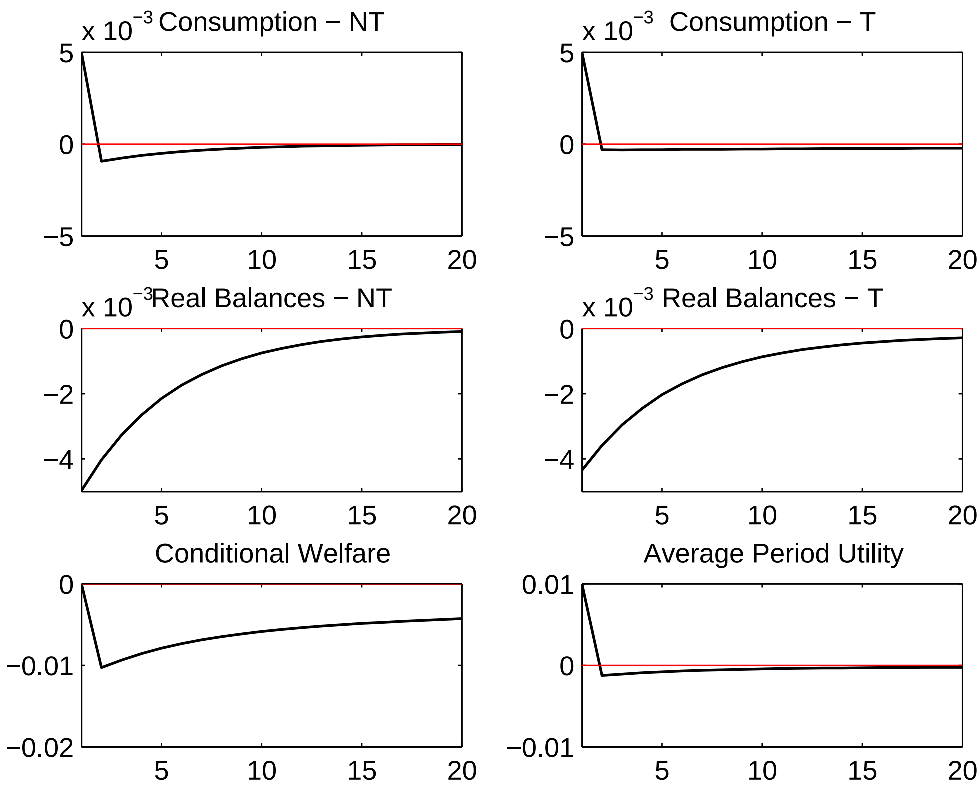


Figure 3.3 One percent positive real shock in a flexible regime

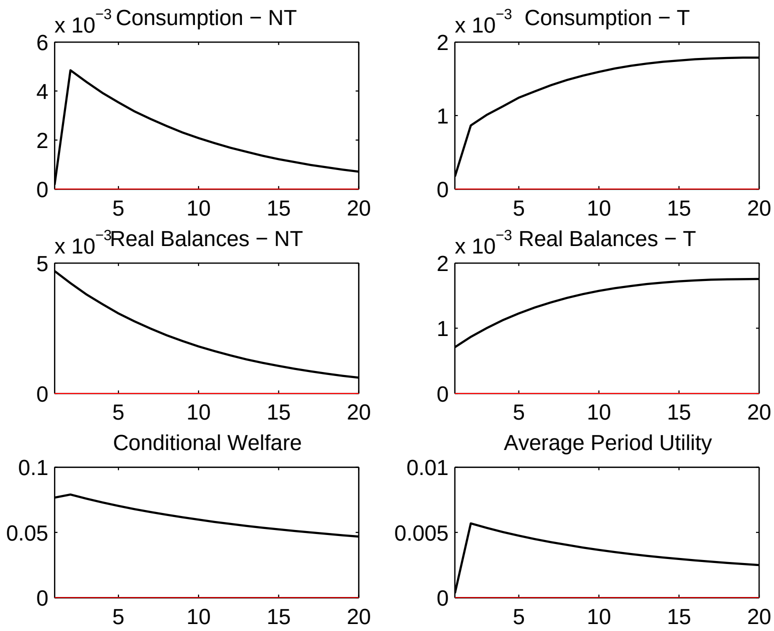
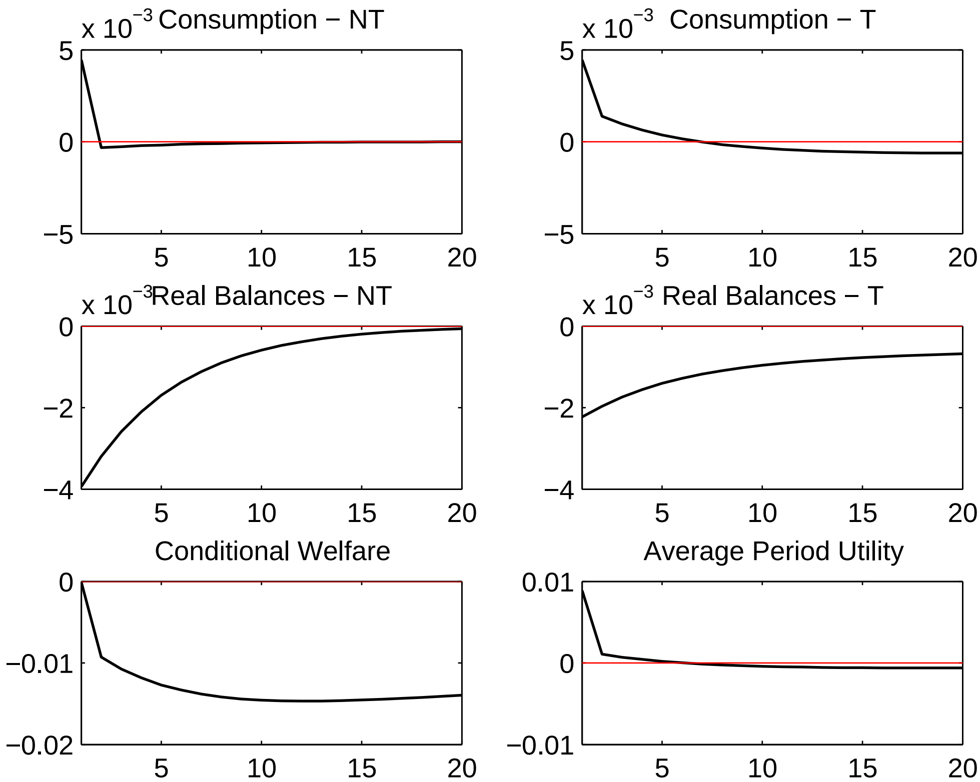


Figure 3.4 One percent positive monetary policy shock in a flexible regime



CONCLUSION

Dans cette thèse, je me suis intéressée à travers trois essais à la question de la politique monétaire efficace et optimale : efficace en termes de prévisions, et optimale en termes de l'impact sur le bien-être des agents économiques.

Dans un premier temps, j'ai développé un outil d'analyse conjoncturel pour les petites économies ouvertes. Cet outil est composé de deux éléments, l'un pour les prévisions de court et l'autre pour celles de long terme, selon que les chocs sont temporaires ou permanents. Contrairement aux méthodes empiriques, je développe tout d'abord un modèle économique structurel.

La méthodologie est novatrice en ce qu'elle permet de combiner les deux approches les plus utilisées dans la littérature des modèles structurels, celui de PGLS (2003) et de KPSW (1991). J'ai ensuite verifié cet outil dans un but normatif afin d'évaluer les politiques économiques canadiennes, dans leur relation à celles des États-Unis. À l'aide des estimations du modèle développé et l'étude des impulsions conjointes pour les deux économies, je trouve que les marchés des biens et les marchés monétaires sont intégrés entre les deux pays, ce qui explique que leurs cycles conjoncturels soient significativement inter-reliés. La croissance de long terme pour les deux pays est le résultat des progrès technologiques et l'appréciation du dollar canadien durant les dernières années a été accompagnée par une diminution d'actifs nette au Canada. Puisque la Banque du Canada suit une politique de cible d'inflation, les résultats renforcent l'idée que les politiques expansionnistes doivent être traitées avec précautions. Les résultats confirment également que la méthodologie mise en œuvre dans ce chapitre semble prometteuse comme outil d'analyse au sein d'une banque centrale.

Dans un deuxième temps, j'ai dérivé le taux d'inflation optimal pour la cible d'inflation, dans un environnement de croissance non nulle et présentant des rigidités de prix et de salaires, comme dans la tradition des modèles néo-Keynesiens.

Les résultats remettent au goût du jour la règle de Friedman (1969), qui veut que la déflation soit la politique optimale. En termes de taille de cette déflation, le taux optimal s'avère plus grand (moins négatif) que le taux d'intérêt réel de l'économie, comme suggéré dans la thèse de Friedman. Ce taux est aussi plus grand que le taux éliminant la dispersion salariale. Ceci reflète la présence de différentes distortions en économie et le fait que le taux d'inflation optimal cherche à minimiser les distortions dûes aux dispersions (prix et salaires), ainsi que celles liées aux concurrences monopolistiques dans cet environnement. Le taux optimal s'avère plus proche du taux minimisant les frictions réelles sur le marché de travail. Le résultat reste valable même en présence d'une analyse de sensibilité et des différents paramètres structurels de l'économie, notamment l'élasticité des substitutions entre les types de travailleurs et entre les types de biens différenciés. Le coût d'inflation dans l'environnement avec croissance s'avère plus élevé, car l'état-stationnaire du modèle connaît plus de distortions.

Ainsi, une banque centrale qui utilise comme instrument le taux d'intérêt par le biais d'une règle de Taylor, devrait choisir cette valeur d'inflation optimale négative comme sa cible d'inflation. Les moyennes stochastiques des variables étant affectées par les chocs à court-terme, la moyenne de l'inflation salariale se fixera autour de zéro et une des distortions nominales du modèle sera minimisée. Une étude récente de Mishkin *et al.* (2006) montre qu'une déflation résultant du progrès technique n'a pas d'effets néfastes sur l'activité économique.

Dans un dernier essai, j'ai étudié le choix de régime de change, pour les économies émergentes. Mes résultats favorisent un régime de change fixe pour ces économies. Ceci est conforme aux idées de certains économistes qui trouvent que le seul régime optimal pour ces économies est la dollarisation. Mes résultats tiennent compte de la structure réelle et de la faiblesse des institutions financières dans ces économies. Les agents, par leur accès aux marchés, sont divisés en deux groupes. Le choix de régime de change n'est pas le même pour ces deux groupes. Les participants aux marchés cherchent la stabilité de change à travers un régime fixe. Quant aux non-participants et en présence de la flexibilité des prix, un régime du taux de change flexible absorbe mieux les fluctuations des balances réelles. Le régime de change optimal est celui qui équilibre les coûts de chaque groupe (participant et non-participant) à la marge. Une fonction de bien-être social avec un poids raisonable pour les deux types d'agents, favorise un régime de change fixe dans cette économie. Ce régime est moins volatile dans ce cas et les gains de bien-être pour les participants aux marchés dépassent les pertes des non-participants.

Les analyses de sensibilités confirment que ces résultats restent valides même en présence de perturbations asymétriques et la domination d'un choc sur l'ensemble des activités économiques. La seule exception est quand la part des participants aux marchés diminue à moins de 10% de la population totale. Dans ce cas, le régime de change optimal devient le choix des non-participants aux marchés, c'est à dire le régime flexible. Ces résultats, indépendants du type de choc, plaident en faveur de la mise en œuvre d'une politique monétaire qui, si elle a pour but d'augmenter le bien-être social, doit viser le bien-être des non-participants et en conséquence sera distortionnaire.

Cette thèse a fourni l'occasion d'une réflexion nouvelle sur les politiques monétaires. Plusieurs extensions à ce travail sont envisageables. La méthodologie proposée en premier chapitre est aisément adaptable pour tenir compte d'autres aspects importants de la conjoncture économique entre le Canada et les États-Unis, notamment la mise en place d'une union monétaire nord-américaine. L'étude de l'interdépendance des politiques fiscales entre les deux pays, ainsi que son influence sur les politiques monétaires est un autre aspect qui mériterait plus de recherches.

Ensuite, une étude empirique de l'efficacité des politiques cibles d'inflation dans les pays avec des perspectives différentes de croissance semble une extension intéressante du deuxième chapitre. L'influence de la politique fiscale sur l'efficacité de la cible d'inflation est une réflexion importante qui devra être menée dans un travail futur. Un autre exercice pertinent sera d'inclure la variable du capital dans le choix de modélisation.

Une extension prometteuse pour le troisième chapitre serait d'inclure le loisir dans la fonction d'utilité des agents, et de voir si cela changerait les décisions intertemporelles de ces derniers, dans un marché financier segmenté et face aux différents chocs. Il pourrait ainsi s'avérer judicieux de combiner les politiques monétaires avec les politiques fiscales pour les pays émergents où il y'a une forte dominance de ces dernières. L'étude des interactions entre les différents types de frictions, notamment celles du marché du travail, semble une autre piste de réflexion.

BIBLIOGRAPHY

Adao, B., Correia, I., et Teles, P. 2001. Gaps and Triangles, *The Review of Economic Studies*, vol. 70, p. 699–713.

Akerlof, G., Dickens, W., et Perry, G. 2000. Near-Rational Wage and Price Setting and the Optimal Rates of Inflation and Unemployment, *Brookings Papers on Economic Activity*, vol. 1, p. 1–44.

Akerlof, G., T. D. et Perry, G. L. 2000. Near-Rational Wage and Price Setting and the Optimal Rates of Inflation and Unemployment, *Brookings Papers on Economic Activity*, vol. 1, p. 31–44.

Alvarez, F., Atkeson, A., et Kehoe, P. 2002. Money, Interest Rates, and Exchange Rates with Endogenously Segmented Asset Markets, *Journal of Political Economy*, vol. 110, p. 73–112.

Alvarez, F., R. Lucas, J., et Weber, W. 2001. Interest Rates and Inflation, *American Economic Review*, vol. 91, p. 219–225.

Amano, R., Ambler, S., et Rebei, N. 2007. The Macroeconomic Effects of Nonzero Trend Inflation, *Journal of Money, Credit and Banking*, vol. 39, p. 1821–1838.

Amano, R., Moran, R., Murchison, S., et Rennison, A. 2007. Trend Inflation, Wage and Price Rigidities, and Welfare, *Working Paper, Bank of Canada*, vol. 42.

Ambler, S. 2000. Comments on: The Economic Consequences of Alternative Exchange Rate and Monetary Policy Regimes in Canada, *Revisiting the Case for Flexible Exchange Rates.* by Tiff Macklem, Patrick Osakwe, Hope Pioro and Lawrence Schembri, Ottawa, Bank of Canada.

——— 2006. Terms of Trade Shocks, Monetary Instabiliy and Exchange Rate Regime Choice, *draft, Université du Québec à Montréal.*

Ambler, S. et Cardia, E. 1998. The Cyclical Behavior of Wages and Profits under Imperfect Competition, *Canadian Journal of Economics*, vol. 31, p. 148–164.

Ambler, S., Dib, A., et Rebei, N. 2004. Optimal Taylor Rules in an Estimated Model of a Small Open Economy, *Working Papers 04-36, Bank of Canada.*

Ambler, S., Phaneuf, L., et Guay, A. 2003. Labor Market Imperfection and the Dynamics of Postwar Business Cycles, *draft, Université du Québec à Montréal.*

Arellano, C. et Heathcote, J. 2007. Dollarization and financial integration, *Staff Report 385, Federal Reserve Bank of Minneapolis.*

Ascari, G. 2005. Staggered Price and Trend Inflation: Some Nuisances, *Review of Economic Dynamics*, vol. 7, p. 642–667.

Bailey, M. 1956. The Welfare Cost of Inflationary Finance, *Journal of Political Economy*, vol. 64, p. 93–110.

Bakhshi, H., Lombart, P., Khan, H., et Rudolf, B. 2003. Endogenous Price Stickiness, Trend Inflation, and the New Keynesian Phillips Curve, *Working Paper 19, Bank of England.*

Ball, L. 2001. Another Look at Long-run Money Demand, *Journal of Monetary Economics*, vol. 47, p. 31–44.

Ball, L. et Romer, D. 1990. Real Rigidities and the Non-Neutrality of Money, *Review of Economic Studies*, vol. 57, p. 183–204.

Basu, S. 1994. Intermediate Goods and Business Cycles: Implications for Productivity and Welfare, *National Bureau of Economic Research, NBER Working Papers*, vol. 4817.

Basu, S. et Fernald, J. 2002. Aggregate Productivity and Aggregate Technology, *European Economic Review*, vol. 46(6), p. 963–991.

Benassy, J. P. 1995. Money and Wage Contracts in an Optimizing Model of the Business Cycle, *Journal of Monetary Economics*, vol. 35, p. 303–315.

Benigno, P. et Woodford, M. 2004. Optimal Stabilization Policy When Wages and Prices are Sticky: The Case of a Distorted Steady States, *Working Paper 10839, National Bureau of Economic Research.*

Beveridge, S. et Nelson, C. 1981. A New Approach to Decomposition of Economic Time Series into Permanent and Transitory Components with Particular Attention to Measurement of the Business Cycle , *Journal of Monetary Economics*, vol. 7, p. 151–174.

Blanchard, O. et Kiyotaki, N. 1987. Monopolistic Competition and the Effects of Aggregate Demand, *The American Economic Review*, vol. 77, p. 647–666.

Blanchard, O. et Quah, D. 1982. Identification in Dynamic Linear Models with Rational Expectations, *NBER technical working paper 024.*

——— 1990. The Dynamic Effects of Aggregate Demand and Supply Disturbance, *National Bureau of Economic Research, NBER Working Papers*, vol. 2737.

Bossaerts, P. 1988. Common Nonstationary Components of Asset Prices, *Journal of Economic Dynamics and Control*, vol. 12, p. 347–364.

Buiter, W. et Panigirtzoglou, N. 2003. Overcoming the Zero Bound on Nominal Interest Rates with Negative Interest on Currency: Gesell's Solution, *Economic Journal*, vol. 113, p. 723–746.

Calvo, G. 1983. Staggered Prices in a Utility - Maximising Framework, *Journal of Monetary Economics*, vol. 12, p. 383–398.

——— 2005. Crises in Emerging Market Economies: A Global Perspective, *National Bureau of Economic Research, Working Paper 11305.*

Calvo, G. et Mishkin, F. 2003. The Mirage of Exchange Rate Regimes for Emerging Markets Countries, *Journal of Economic Perspectives*, vol. 17, p. 99–118.

Calvo, G. et Reinhart, C. 2002. Fear of Floating, *The Quarterly Journal of Economics*, vol. 117, p. 379–408.

Chadha, J. 1997. Shoe Leather Costs Reconsidered, *Working Paper 86, Bank of England.*

Chari, V., Kehoe, P., et McGrattan, E. 2000. Can Sticky Price Models Generate Volatile and Persistent Real Exchange Rates?, *Review of Economic Studies.* Federal Reserve Bank of Minneapolis Staff Report 277.

Cheung, J. et Lai, L. 1993. Business Cycle Analysis Without Much Theory: A Look at Structural VARs, *Tests for Fractional Integration: A Monte-Carlo Integration*, vol. 14, p. 331–345.

Cho, J. 1993. Money and the Business Cycle with One-period Nominal Contracts, *Canadian Journal of Economics*, vol. 12, p. 383–398.

Cho, J. et Cooley, T. 1995. Business Cycles with Nominal Contracts, *Economic Theory*, vol. 6, p. 13–34.

Cho, J., Cooley, T., et Phaneuf, L. 1997. The Welfare Cost of Nominal Wage Contracting, *The Review of Economic Studies*, vol. 64, p. 465–484.

Christiano, L., Eichenbaum, M., et Evans, C. Monetary Policy Shocks: What Have We Learned and to What End?, *National Bureau of Economic Research, NBER Working Papers.*

——— 2001. Nominal Rigidities and the Dynamics Effects of a Shock to Monetary Policy, *Working Paper 8403, National Bureau of Economic Research.*

Clarida, R., Galí, J., et Gertler, M. 2000. Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory, *Quarterly Journal of Economics*, vol. 115, p. 147–180.

Cogley, T. et Nason, J. 1995. Output Dynamics in Real Business Cycle Models, *American Economic Review*, vol. 85, p. 492–511.

Crowder, W., Hoffman, D., et Rasche, R. 1999. Identification, Long-Run Relations, and Fundamental Innovation in a simple Cointegrated System, *Review of Economics and Statistics*, vol. 81, p. 109–121.

Devereux, M. 2000. Monetary Policy, Exchange Rate Flixibility, and Exchange Rate Pass-Through, *National Bureau of Economic Research, Working Paper 11305.* Revisiting the Case for Flexible Exchange Rates, Ottawa, Bank of Canada.

Devereux, M. et Engel, C. 2003. Monetary Policy in the Open Economy Revisited: Price Setting and Exchange Rate Flexibility, *Review of Economic Studies*, vol. 70, p. 765–84.

Devereux, M., Head, A., et Lapham, B. 1996. Exit and Entry, Increasing Returns in Specialization, and Business Cycles, *Journal of Economic Dynamic and Control*, vol. 20, p. 627–656.

Dixit, A. et Stiglitz, J. 1977. Monopolistic Competition and Optimal Product Diversity, *American Economic Review*, vol. 67, p. 297–308.

Dornbusch, R. 2001. A Primer on Emerging Market Crises, *NBER Working Papers 8326, National Bureau of Economic Research.*

Dotsey, M., King, R., et Wolman, A. 1999. State Dependent Pricing and the General Equilibrium Dynamics of Money and Output, *Quarterly Journal of Economics*, vol. 114, p. 655–690.

Edwards, S. et Magendzo, I. 2006. Strict Dollarization and Economic Performance: An Empirical Investigation, *Journal of Money Credit and Banking*, vol. 38, p. 269–282.

Edwards, S. et Yeyati, E. L. 2005. Flexible Exchange Rates as Shock Absorbers, *European Economic Review, Elsevier*, vol. 49, p. 2079–2105.

Eichenbaum, M. et Evans, C. 1992. Liquidity Effects and the Monetary Transmission Mechanism, *American Economic Review*, vol. 82, p. 346–353.

——— 1995. Some Empirical Evidence on the Effects of Shocks to Monetary Policy on Exchange Rates, *Quarterly Journal of Economics*, vol. 110, p. 975–1009.

Elliot, G., Rothenberg, T., et Stock, J. 1996. Efficient Tests for an Autoregressive Unit Root, *Econometrica*, vol. 64, p. 813–36.

Engel, R. et Granger, F. 1987. Efficient Tests for an Autoregressive Unit Root, *Econometrica*, vol. 55, p. 251–276.

Engel, R. et Yoo, B. 1989. Cointegrated Economic Time Series: A Survey with New Results, *Discussion Paper 87-26R (University of California, San Diego, CA).*

Erceg, C., Henderson, D., et Levin, A. 2000. Optimal Monetary Policy with Staggered Wage and Price Contracts, *Journal of Monetary Economics*, vol. 46, p. 281–313.

Friedman, M. 1953. The Case for Flexible Exchange Rates, *In: Essays in Positive Economics, University of Chicago Press, Chicago, IL.*

——— 1969. The Optimum Quantity of Money, *The Optimum Quantity of Money and Other Essays.*

Friedman, M. et Schwartz, N. *A Monetary History of the United States: 1867-1960.* Princeton University Press.

Froot, K. et Rogoff, K. 1995. Perspectives on PPP and Long-run Real Exchange Rates, *Handbook of International Economics*, vol. 3. by G. M. Grossman and K. Rogoff, North Holland, Amsterdam.

Galí, G. et Rabanal, P. 2004. Technology Shocks and Aggregate Fluctuations: How Well Does the RBS Model Fit Postwar U.S. Data?, *National Bureau of Economic Research, NBER Working Papers*, vol. 10636.

Galí, J. 1999. Technology, Employment and the Business Cycle: Do Technology Shocks Explain Aggregate Fluctuations?, *American Economic Review*, vol. 89, p. 249–271.

Galí, J. et Clarida, R. 1994. Sources of Real Exchange-rate Fluctuations: How important are Nominal Shocks?, *Carnegie- Rochester Conference Series on Public Policy*, vol. 41, p. 1–56.

Gonzalo, J. 1994. Five Alternative Methods of Estimating Long-run Equilibrium Relationships, *Journal of Econometrics*, vol. 60, p. 203–233.

Hall, R. 1988. Intertemporal Substitution in Consumption, *Journal of Political Economy*, vol. 88, p. 339–357.

Hamilton, J. 1994. *Time Series Analysis.* Princeton : Princeton University Press.

Hansen, B. et Phillips, O. 1990. Estimation and Inference in Models of Cointegration: A Simulation Study, *Advanced in Econometrics*, vol. 8, p. 225–284.

Hayashi, F. 1982. Tobin's Marginal q and Average q: A Neoclassical Interpretation, *Econometrica*, vol. 50, p. 213–24.

Helpman, E. et Razin, A. 1979. Towards a Consistent Comparison of Alternative Exchange Rate Systems, *Canadian Journal of Economics*, vol. 12, p. 349–409.

Hercowitz, Z. et Sampson, M. 1991. Output Growth, the Real Wage, and Employment Fluctuation, *American Economic Review*, vol. 81, p. 1215–1237.

Huang, K., Liu, Z., et Phaneuf, L. 2004. Why Does the Cyclical Behavior of Real Wages Change Over Time?, *American Economic Review*, vol. 94.

Johansen, S. 1988. Statistical Analysis of Cointegrating Vectors, *Journal of Economic*

Dynamics and Control, vol. 12, p. 231–54.

——— 1995. *Likelihood Based Inference on Cointegration in the Vector Autoregressive Models.* Oxford University Press, Oxford.

Johansen, S. et Juselius, K. 1992. Testing Structural Hypothesis in a Multivariate Cointegration Analysis of the PPP and UIP for UK, *Journal of Econometrics*, vol. 53, p. 211–244.

Juillard, M. 2004. Dynare Manual, Version 3.0, *CEPREMAP.* http://www.cepremap.cnrs.fr/dynare/download/manual/manual.pdf.

Kaminsky, G. et Reinhart, C. 1999. A The Twin Crises : The Causes of Banking and Balance of-Payments Problems, *American Economic Review*, vol. 89, p. 473–500.

Keating, J. 1992. Structural Approaches to Vector Autoregressions, *Federal reserve Bank of St. Louis.*

Khan, A., King, R., et Wolman, A. 2003. Optimal Monetary Policy, *Review of Economic Studies*, vol. 70, p. 825–860.

Kilian, L. 1998. Small-Sample Confidence Intervals for Impulse Response Functions, *Review of Economics and Statistics*, vol. 80, p. 186–201.

Kim, J. et Kim, S. 2003. Spurious Welfare Reversals in International Business Cycle Models, *Journal of International Economics*, vol. 60, p. 471–500.

Kim, J., Kim, S., Schaumburg, E., et Sims, C. 2003. Calculating and Using Second Order Accurate Solutions of Discrete Time Dynamic Models, *manuscript, Princeton Universiy.* http://sims.princeton.edu/yftp/gensys2/Algorithm2.pdf.

King, R., Plosser, C., et Rebelo, S. 1988. Production, Growth and Business Cycles I: The Basic Neoclassical Model, *Journal of Monetary Economics. 21(2-3): 195-232*, vol. 21, p. 195–232.

King, R., Plosser, C., Stock, J., et Watson, M. 1991. Stochastic Trends and Economic Fluctuations, *American Economic Review*, vol. 81, p. 819–840.

King, R. et Wolman, A. 1999. What Should the Monetary Authority Do When Prices are Sticky?, *Monetary Policy Rules*, p. 349–398. J.B. Taylor, editor, Chicago, University of Chicago Press.

Koop, G., Pesaran, M., et Potter, S. 1996. Impulse Response Analysis in Nonlinear Multivariate Models, *Journal of Econometrics*, vol. 74, p. 119–47.

Krugman, P. 1979. A Model of Balance-of-Payments Crises, *Journal of Money, Credit, and Banking*, vol. 11, p. 311–325.

Kwiatkowski, D., Phillips, P., Schmidt, P., et Shin, Y. 1992. Testing the Null Hypothesis of Stationarity Against the Alternative of a Unit Root: How Sure are We that

Economic Time Series Have a Unit Root?, *Journal of Econometrics*, vol. 54, p. 159–178.

Kydland, F. et Zarazaga, C. 1997. Is the Business Cycle of Argentina Different?, *Federal Reserve Bank of Dallas, Economic Review*, vol. 4.

Lahiri, A., Singh, R., et Vegh, C. 2007. Segmented Asset Markets and Optimal Exchange Rate Regimes, *Journal of International Economics*, vol. 72, no. 1, p. 1–21.

Liu, Z. et Phaneuf, L. 2007. Technology Shocks and Labor Market Dynamics: Some Evidence and Theory, *Journal of Monetary Economics*, vol. 54, p. 2534–2553.

Lucas, R. 1982. Interest Rates and Currency Prices in a Two-Country Model, *Journal of Monetary Economics*, vol. 10, p. 335–360.

Lucas, R. et Stokey, N. 1987. Money and Interest in a Cash-in-Advance Economy, *Econometrica*, vol. 55, no. 3, p. 491–513.

Lucas, R. J. 1994. On the Welfare Cost of Inflation, *Working Paper 394, Stanford University Center for Economic Policy Research*.

Lütkepohl, H. 1991. *Introduction to Multiple Time Series Analysis*. Springer-Verlag, New York.

Mark, N. 2001. *International Macroeconomics and Finance*. Blackwell Publishers.

McKinnon, R. 2001. Mundell, the Euro, and Optimum Currency Areas, *Essays in Honor of Robert Mundell*. Thomas Courchene, ed., Queen's University Press, http://www-econ.stanford.edu/faculty/workp/swp00009.pdf.

Mellander, E., Vredin, A., et Warne, A. 1992. Stochastic Trends and Economic Fluctuations in a Small Open Economy, *Journal of Applied Econometrics*, vol. 7, p. 369–394.

Mendoza, E. 2001. The Benefits of Dollarization when Stabilization Policy Lacks Credibility and Financial Markets are Imperfect, *Journal of Money, Credit and Banking*, vol. 33, no. 2, p. 440–474.

Mishkin, F. et Takatoshi, I. 2006. Two Decades of Japanese Monetary Policy and the Deflation Problem, *NBER Chapters in: Monetary Policy under Very Low Inflation in the Pacific Rim*, vol. 15, p. 131–202.

Mundell, R. 1961. A Theory of Optimum Currency Areas, *American Economic Review*, vol. 51, p. 657–665.

Neumeyer, P. et Perri, F. 2004. Business Cycles in Emerging Economis: The Role of Interest Rates, *National Bureau of Economic Research, Working Paper 10387*.

Ng, S. et Perron, P. 2000. Lag-Length Selection and Construction of Unit Root Tests with Good Size and Power, *Department of Economics, Boston College*.

Obstfeld, M. et Rogoff, K. 1995. Exchange Rate Dynamics Redux, *Journal of Political Economy*, vol. 103, p. 624–60.

Ogaki, M. 1992. Engle's Law and Cointegration, *Journal of Political Economy*, vol. 100, p. 1027–46.

Ogaki, M. et Jang, K. 2001. The Effects of Monetary Policy Shocks on Exchange Rates: A Structural Vector Error Correction Model Approach, *Ohio State University, Department of Economics, Working Paper 01-02.*

Ogaki, M. et Park, Y. 1995. The Distortionary Effects of Inflation: An Empirical Investigation, *Ohio State University, Working Papers 01-02.*

Orphanides, A. 2000. Activist Stabilization Policy and Inflation: the Taylor Rule in the 1970s, *Finance and Economics Discussion Series*, vol. 13.

Perron, B. et Moon, H. 2007. An Empirical Analysis of Nonstationarity in a Panel of Interest Rates with Factors, *Journal of Applied Econometrics*, vol. 22, p. 383–400.

Pesaran, M. 1997. The Role of Economic Theory in Modelling the Long-run, *The Economic Journal*, vol. 107, p. 178–191.

Pesaran, M., Garratt, A., Lee, K., et Shin, Y. 1998. *A Structural Cointegrating VAR Approach to Macroeconometric Modelling*, chapitre 5, p. 94–131.

——— 2003. A Long-run Structural Macroeconometric Model of the UK, *Economic letter*, vol. 113, p. 412–455.

Pesaran, M., Pierce, R., et Lee, K. 1993. Persistence, Cointegration and Aggregation: A Disaggregated Analysis of Output Fluctuations in the U.S. Economy, *Journal of Econometrics*, vol. 56, p. 57–88.

Pesaran, M. et Shin, Y. An Autoregressive Distributed Lag Modelling Approach to Cointegration Analysis, *Department of Applied Economics at Cambridge (DAE) Working Paper*, vol. 9514.

——— 1998. Generalized Impulse Response Analysis in Linear Multivariate Models, *Economic Letters*, vol. 58, p. 17–29.

——— 2002. Long-run Structural Modelling, *Econometrics Review*, vol. 21, p. 49–87.

Pesaran, M., Shin, Y., et Smith, R. 2000. Structural Analysis of Vector Error Correction Models with Exogenous I(1) Variables, *Journal of Econometrics*, vol. 97, p. 293–343.

Phillips, P. 1987. *Spectral Regression for Cointegrating Time Series*, p. 413–436. Cambridge University Press.

Pitarakis, J. 1998. On the Exact Moments of Asymptotic Distributions in an Unstable

AR(1) with Dependant Errors, *International Economic Review*, vol. 39.1, p. 71–88.

Podivinsky, J. 1998. Testing Misspecified Cointegrating Relationships, *Economic Letters*, vol. 60, no. 1, p. 1–9.

Rogoff, K. 1996. The Purchasing Power Parity Puzzle, *Journal of Economic Literature*, vol. 34, p. 647–88.

Romer, D. et Romer, C. 1990. Does Monetary Policy Matter? A New Test in the Spirit of Friedman and Schwartz, *National Bureau of Economic Research, NBER Working Papers*, vol. 2966.

——— 1994. What Ends Recessions, *National Bureau of Economic Research, NBER Working Papers*, vol. 9765.

Rotemberg, J. et Woodford, M. 1995. *Dynamic General Equilibrium Model with Imperfectly Competitive Product Market*. T. Cooley, editor, Princeton, Princeton University Press. Frontiers of Business Cycle Research.

Sarno, L. 1961. Toward a New Paradigm in Open Economy Modeling: Where Do We Stand?, *Federal Reserve Bank of St. Louis Review*, p. 21–36. May-June.

Schmitt-Grohé, S. et Uribe, M. 2001. Stabilization Policy and the Cost of Dollarization, *Journal of Money, Credit, and Banking*, vol. 33, p. 482–509.

——— 2003. Closing Small Open Economy Models, *Journal of International Economics*, vol. 61, p. 163–185.

——— 2004a. Solving Dynamic General Equilibrium Models Using a Second-Order Approximation to the Policy Function, *Journal of Economic Dynamic and Control*, vol. 28, p. 755–775.

——— 2004b. Solving Dynamic General Equilibrium Models using a Second-Order Approximation to the Policy Function, *Journal of Economic Dynamics and Control*, vol. 28, p. 755–775.

Senhadji, A. 2003. External Shocks and Debt Accumulation in a Small Open Economy, *Review of Economic Dynamics*, vol. 6, p. 207–239.

Shapiro, M. et Watson, M. 1998. Source of Business Cycle Fluctuations, *National Bureau of Economic Research, NBER Working Papers*, vol. 2582.

Shin, Y. 1994. A Residual-Based Test of the Null of Cointegration against the Alternative of No Cointegration, *Econometric Theory*, vol. 10, no. 1, p. 95–115.

Sidrauski, M. 1967. Rational Choice and Patterns of Growth in a Monetary Economy, *American Economic Review*, vol. 57, p. 634–44.

Sims, C. 1980. Macroeconomics and Reality, *Econometrica*, vol. 48, no. 1, p. 1–48.

Sims, C. et Zha, T. 1996. Bayesian Methods for Dynamic Multivariate Models, *Working Paper 96-13, Federal Reserve Bank of Atlanta*, p. 1–48.

Smets, F. et Wouters, R. 2007. Shocks and Frictions in US Business Cycles: A Bayesian DSGE Approach, *CEPR Discussion Papers 6112*.

Stock, J. 1987. Asymptotic properties of least squares estimators of cointegrating vectors, *Econometrica*, vol. 55, p. 1035–1056.

Stock, J. et Watson, M. 1988. Testing for Common Trends, *Journal of the American Statistical Association*, vol. 83, p. 1097–1107.

Svensson, L. 1985. Money and Asset Prices in a Cash-in-Advance Economy, *University of Chicago Press*, vol. 47, p. 919–44.

——— 1997. Optimal Inflation Targets, Conservative Central Banks, and Linear Inflation Contracts, *American Economic Review*, vol. 87, p. 98–114.

——— 1999. Inflation Targeting as a Monetary Policy Rule, *Journal of Monetary Economics*, vol. 43, p. 607–654.

Taylor, J. B. 1980. Aggregate Dynamics and Staggered Contracts, *Journal of Political Economy*, vol. 88, p. 1–23.

——— 1999. *Staggered Prices and Wage Setting in Macroeconomics*. J. Taylor and M. Woodford, editors, Amsterdam, North Holland. Handbook of Macroeconomics.

Uribe, M. et Yue, V. 2003. Country Spreads and Emerging Countries: Who Drives Whom?, *National Bureau of Economic Research, NBER Working Papers*, vol. 10018.

Vredin, A. et Söderlind, P. 1995. Applied Cointegration Analysis in the Mirror of Macroeconomic Theory, *C.E.P.R. Discussion Papers 1120*.

Walsh, C. 2003. *Monetary Theory and Policy*. The MIT Press, 2 édition.

Wolman, A. 1997. Zero Inflation and the Friedman Rule: A Welfare Comparison, *Federal Reserve Bank of Richmond Economic Quarterly Review*, vol. 83, p. 1–22.

——— 2001. A Primer on Optimal Monetary Policy with Staggered Price Setting, *Federal Reserve Bank of Richmond Economic Quarterly Review*, vol. 87, p. 27–52.

——— 2005. The Optimal Rate of Inflation with Trending Relative Prices, *Manuscript*.

Woodford, M. 2003. *Interest and Prices: Foundations of a theory of Monetary Policy*. Princeton, Princeton University Press.

Woodford, M. et Rothenberg, J. 1997. An Optimized-Based Econometric Model for the Evaluation of Monetary Policy, *NBER, Macroeconomic Annual*, vol. 12, p. 297–

346.

Zellner, A. 1962. An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregations Bias, *Journal of American Statistical Association*, vol. 57, p. 348–68.