Université de Montréal

Essais sur la Determination du Niveau des Prix et sur les Petites Economies Ouvertes Avec des Contraintes d'Endettement

par

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Thèse présentée à la Faculté des études supérieures
en vue de l'obtention du grade de Philosophiæ Doctor (Ph.D)
en sciences économiques

Octobre, 2006

Université de Montréal
Faculté des études supérieures

Cette thèse intitulée:
Essais sur la Determination du Niveau des Prix et
sur les Petites Economies Ouvertes Avec des Contraintes d'Endettement

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Résumé en français

Cette thèse de doctorat consiste en trois essais traitant de différents sujets dans le domaine de l'économie monétaire et de la macroéconomie ouverte. Trois brefs résumés de ces articles sont présentés ci-après.

Chapitre 1

Dans le premier chapitre ("*The Backing of Government Debt and the Price Level*"), j'étudie l'interdépendance existant entre les politiques fiscale et monétaire, et leurs rôles joints dans la détermination du niveau des prix. Le gouvernement est caractérisé par une règle de politique fiscale à long terme, dont une fraction δ de la dette courante a comme contrepartie la valeur présente escomptée des surplus primaires courants et futurs. Le reste de la dette doit être financé par des recettes de seigniorage. Avec cette règle de politique le niveau des prix ne dépend pas seulement du stock de monnaie, mais aussi de la proportion de la dette qui est financée par la création de monnaie. Des estimations empiriques du paramètre δ, qui caractérise l'interdépendance entre les autorités fiscale et monétaire, sont obtenues pour les pays de l'OCDE. Les résultats indiquent que la dette n'a pas d'importance décisive dans la détermination du niveau des prix dans ces économies. De plus, d'après les résultats, ces économies semblent avoir des banques centrales indépendantes Les estimations de δ sont positivement, mais faiblement, corrélées avec des mesures d'indépendance institutionnelle des banques centrales.

Mots-clés : régime Ricardien, règles de politiques, indépendance des banques centrales.

Chapitre 2

Dans le deuxième chapitre ("*Endogenous Borrowing Constraints and Consumption Volatility in a Small Open Economy*"), je démontre l'évidence empirique de la volatilité relative de la consommation par rapport à celle de l'output dans un échantillon de 41 pays. Je montre que cette volatilité est plus grande dans les économies émergentes en comparaison avec les pays plus développés. Une explication possible est

que les économies émergentes font face à des contraintes d'endettement qui limitent l'utilisation des marchés internationaux de capitaux par une petite économie ouverte qui cherche à lisser sa consommation face à des chocs défavorables. Avec un modèle d'équilibre général stochastique simple, j'étudie les implications d'une contrainte d'endettement endogène *à la* Eaton and Gersovitz (1981) sur la volatilité de la consommation dans une petite économie ouverte. Le modèle est calibré pour les donnés du Brésil pour la période 1980-2001, et les résultats suggèrent qu'il est capable d'expliquer plus que la moitié de la différence de volatilité relative de la consommation entre les économies émergentes et développées.

Mots-clés : dette souveraine, volatilité de la consommation, petite économie ouverte.

Chapitre 3

Dans le troisième chapitre ("*IMF-Supported Adjustment Programs : Welfare Implications and the Catalytic Effect*"), j'étudie le gain de bien-être associé aux programmes d'ajustement du Fond Monétaire International (FMI). Le modèle utilise une contrainte d'endettement similaire à celle discutée dans le contexte du chapitre 2 ci-dessus. La décision de signer un programme du FMI est endogène. Le coût de signer un accord ave le Fond est donné par la *conditionnalité* des prêts du FMI (*IMF conditionality*) - pour emprunter de l'argent du FMI, le pays doit accepter des limites imposées sur sa consommation de biens publiques. Le bénéfice vient de la possibilité d'avoir des fonds additionnels du FMI (à un taux d'intérêt plus faible) et/ou de "l'effet catalytique" sur des prêts privés, ce qui peut faciliter la lissage de la consommation. Des simulations du modèle sous deux contextes institutionnels différents – avec et sans le FMI- sont comparées. Les résultats indiquent que lorsque la conditionnalité force le pays à épargner plus, à un coût qui ne l'empêche pas de signer un programme avec le FMI, cela réduit la probabilité de défaut, permettant les prêteurs privés de relaxer leurs contraintes de crédit envers le pays. D'après une calibration du modèle pour les donnés du Brésil, le gain de bien-être associé aux programmes du IMF est relativement faible.

Mots-clés : FMI, effet catalytique, analyse de bien-être.

English Summary

This Ph.D. thesis consists of three essays in which different issues in monetary economics and open macroeconomics are examined. The papers are summarized below.

Chapter 1

In "*The Backing of Government Debt and the Price Level*," the interdependence between fiscal and monetary policies is studied, specially their joint role in the determination of the price level. The government is characterized by a long-run fiscal policy rule whereby a given fraction of the outstanding debt, say δ, is backed by the present discounted value of current and future primary surpluses. The remaining debt is backed by seigniorage revenue. The parameter δ characterizes the interdependence between fiscal and monetary authorities. It is shown that in a standard monetary economy, this policy rule implies that the price level depends not only on the money stock, but also on the proportion of debt that is backed with money. Empirical estimates of δ are obtained for OECD countries using data on nominal consumption, monetary base, and debt. Results indicate that debt plays only a minor role in the determination of the price level in these economies, which tend to have independent central banks. Estimates of δ are weakly correlated with institutional measures of central bank independence.

Key Words: Ricardian/Non-Ricardian regimes, policy rules, central bank independence

Chapter 2

In "*Endogenous Borrowing Constraints and Consumption Volatility in a Small Open Economy*," it is presented empirical evidence that consumption volatility relative to output volatility is consistently higher in emerging economies than in developed economies. One natural explanation is that, emerging economies are more likely to face borrowing constraints and, consequently, find it more difficult to use international capital markets to smooth consumption. This chapter investigates how much this mechanism alone can account for the relative consumption volatility differential between emerging

and developed economies. The theoretical approach relies on a standard dynamic general equilibrium model of a small open endowment economy that is subject to an endogenous borrowing constraint. The borrowing constraint makes the small economy exactly indifferent between two options: *i*) repaying its external debt or *ii*) defaulting and having to live in financial autarky in the future. The model for the constrained economy is calibrated to match Brazilian data during the period 1980-2001. The findings suggest that the model is capable of accounting for more than half of the observed relative consumption volatility differential.

Key Words: sovereign debt, consumption volatility, business cycles, small open economy

Chapter 3

The welfare implications of adjustment programs supported by the International Monetary Fund (IMF) are studied in "*IMF-Supported Adjustment Programs: Welfare Implications and the Catalytic Effect*." The model features an endogenous borrowing constraint set up by international lenders who will never lend more than a debt ceiling that forces the borrowing economy always choose repayment over default. The decision about joining an IMF program is endogenous. The immediate potential welfare cost of joining a program is driven by IMF conditionality - in order to be able to borrow from the IMF, the country has to submit to limits on the consumption of public goods. The benefits come from the additional borrowing both from the IMF (at a lower interest rate) and /or through a "catalytic effect" on private loans, which facilitates consumption smoothing over time. Simulations of the dynamic model in two institutional environments -- with and without the IMF -- are compared. Results indicate that when conditionality forces the country to save more, at a cost that does not prevent it from signing an IMF program, then the resulting lower probability of default can induce private lenders to relax their borrowing constraint. Based on a calibration of the model for the Brazilian economy, the overall welfare gains associated with IMF programs are relatively small.

Key Words: IMF, catalytic effect, emerging economies, welfare analysis.

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Dédicace

À Denise…

mon inspiration,

ma raison d'être,

celle que j'aime de tout mon cœur.

Remerciements

Je tiens à remercier les professeurs Francisco Ruge-Murcia et Rui Castro, mes directeurs de recherche, pour leur disponibilité, toujours appréciée, ainsi que pour leur guidance à travers le chemin, parfois sinueux, de la recherche.

Deuxièmement, je dois remercier le Ministère de l'Éducation du Brésil, la Banque du Canada et le Centre Interuniversitaire de Recherche en Économie Quantitative (CIREQ) pour leur contribution financière durant de cette période d'études au doctorat.

Finalement, un remerciement tout spécial à mes parents, Carlos et Fátima, qui ont mis tous leurs efforts pour me permettre une bonne éducation, et à Denise, qui a accepté la décision d'échanger la stabilité de notre vie au Brésil pour un retour à la vie étudiante.

Introduction

Cette thèse de doctorat est composée de trois chapitres examinant différents sujets en économie monétaire et macroéconomie ouverte. Dans le premier chapitre (*The Backing of Government Debt and the Price Level*), j'étudie l'interdépendance entre les politiques fiscale et monétaire, notamment leur rôle joint dans la détermination du niveau des prix, avec un modèle d'équilibre général pour une économie monétaire. Le modèle considère un gouvernement caractérisé par une règle de politique fiscal à long terme selon laquelle une fraction δ de la dette courante a comme contrepartie la valeur présente escomptée des flous de surplus primaires, courants et futures. La partie qui reste doit être financée par les recettes de *seigniorage*. Le paramètre δ est interprété comme un indice du dégré d'interdépendance entre les autorités fiscale et monétaire. Dans le modèle, le niveau des prix est déterminé par l'équilibre du marché monétaire. Avec la règle de politique proposée dans le modèle, je démontre que le niveau des prix ne dépend non seulement du stock de monnaie, mais aussi de la proportion de la dette ayant comme contrepartie la création de monnaie. Une fois caractérisée la solution du modèle, particulièrement l'équation d'équilibre pour le niveau des prix, des estimations empiriques du paramètre δ ont étés obtenues pour les pays de l'OCDE, en utilisant des techiniques de cointegration. Les résultats indiquent que la dette joue un rôle mineur dans la détermination du niveau des prix dans ces économies, où les banques centrales sont plus indépendantes. Les estimations du paramètre δ sont positivement, mais faiblement, corrélées avec des mesures d'indépendance institutionnelle des banques centrales.

Dans le chapitre 2 (*Endogenous Borrowing Constraints and Consumption Volatility in a Small Open Economy*), je démontre que la volatilité relative de la consommation par rapport à celle de la production est plus élevée dans les économies émergentes que dans les petites économies développées. Une explication possible est que les économies émergentes ont plus de probabilité de faire face à des contraintes d'endettement et, par conséquent, ont plus de difficulté à utiliser le marché international des capitaux pour lisser leur consommation. J'étudie l'importance quantitative de ce mécanisme, à lui seule, pour expliquer la différence de volatilité relative de la consommation entre les économies émergentes et développées. L'approche théorique est basée sur un modèle d'équilibre général dynamique appliqué à une petite économie ouverte assujettie à une contrainte d'endettement. Cette contrainte est définie de sorte que l'économie est indifférente entre deux options: (i) repayer sa dette, ou (ii) faire un défaut et être obligée de vivre en autarchie financière dans l'avenir. Le modèle pour l'économie contrainte a été calibré pour les données brésiliennes pendant la période 1980–2001. Les résultats suggèrent que le modèle explique plus que la moitié de la différence de volatilité relative de la consommation observée entre les pays émergents et les petites économies développées.

Dans le chapitre 3 (*IMF-Supported Adjustment Programs: Welfare Implications and the Cat-*

alytic Effect), j'étudie les implications des programmes d'ajustement du Fond Monétaire International (FMI) sur le bien-être. Le modèle considère une contrainte d'endettement endogène, similaire à celle mentionnée au paragraphe précèdent. La decision de signer un programme du FMI est aussi endogène. En termes de bien-être, le coût potentiel immédiat d'entrer dans un programme du FMI est donné par les clauses de *conditionalité* – pour être éligible à un prêt du FMI,le pays doit limiter sa consommation de biens publiques. Les bénéfices sont dérivés des prêts du FMI à des taux d'intérêts plus faibles, et/ou d'un "effet catalytique" sur les prêts privés. Ces prêts additionnels permettent un lissage plus facile de la consommation au travers le temps. Des simulations du modèle dynamique dans deux contextes institutionnels – avec et sans le FMI – sont comparés. Lorsque la *conditionnalité* force le pays à épargner plus, à un coût qui ne l'empêche tout de même pas de signer un programme avec le FMI, cela réduit la probabilité de défaut, permettant les prêteurs privés de relaxer leurs contraintes de crédit envers le pays. D'après la calibration du modèle pour l'économie du Brésil, les gains de bien-être associés aux programmes d'ajustement du FMI ne sont pas très importantes.

Chapitre 1

The Backing of Government Debt and the Price Level

1 The Backing of Government Debt and the Price Level

1.1 Introduction

This paper studies the interdependence between fiscal and monetary policies, and their joint role in the determination of the aggregate price level. In general, fiscal and monetary policies are linked through the consolidated government budget constraint. A combination of taxes, new debt issue, and seigniorage revenue must finance government expenditures in every period. Or, expressed in terms of the intertemporal budget constraint, outstanding debt must be backed by a combination of the present discounted value of current and future primary surpluses and seigniorage revenues.

More precisely, this paper examines the proposition that how debt is backed affects the manner in which the aggregate price level is determined. The theoretical analysis is carried out in a standard competitive monetary economy. The government is characterized by a long-run fiscal policy rule whereby a given fraction of the outstanding debt, say δ, is backed by the present discounted value of current and future primary surpluses. The remaining debt is backed by seigniorage revenue. The parameter δ is structural and summarizes the degree of interdependence between fiscal and monetary authorities in a given institutional setup. It is shown that in a standard monetary economy, this policy rule implies that the price level depends not only on the money stock, but also on the proportion of debt that is backed with money.

We draw on earlier research by Aiyagari and Gertler (1985) and extend their work in at least three directions. First, we derive results using only the long-run fiscal policy rule without having to specify a particular period-by-period rule. This long-run rule is compatible with the time-stationary rule in Aiyagari and Gertler, but also with other (perhaps not time-stationary) period-by-period rules. Second, we characterize the determination of the price level at all times, rather than only at the steady state. Finally, we propose a simple empirical strategy to construct an estimate of the δ parameter.

In order to understand the importance of the empirical analysis, note that in this model there is a continuum of fiscal regimes indexed by δ. There are two polar cases. First, in the case where $\delta = 1$, the fiscal authority backs fully all government debt. Fiscal policy accommodates monetary policy in the following sense: whenever the monetary authority sells government bonds in the open market, the fiscal authority increases current or future taxes, and/or reduces current or future expenditures, to back the principal and interest payments on the newly issued debt. The monetary authority never responds to the increase in the stock of government debt associated with a budget deficit. Sargent (1982) and Aiyagari and Gertler (1985) refer to this case as a Ricardian regime.

Second, in the case where $\delta = 0$, the monetary authority backs fully all government debt. In particular, the monetary authority accommodates the fiscal authority whenever a budget deficit is financed with debt. This accommodation takes the form of an increase in current or future seigniorage revenues to back the principal and interest payments on the newly issued debt. The fiscal authority is insensitive to monetary policy in that neither taxes nor expenditure react (today or in the future) to changes in stock of outstanding government debt. Sargent, and Aiyagari and Gertler refer to this case as a polar Non-Ricardian regime.

Aiyagari and Gertler correctly argue that one cannot distinguish between Ricardian and Non-Ricardian regimes on the basis of long-run correlations between nominal interest rates and money growth. The reason is that there exists monetary policy rules for which the Non-Ricardian regimes ($0 \leq \delta < 1$) generate the same correlation as the Ricardian regime ($\delta = 1$). However, we show that under certain conditions, the dynamics of money, debt, and private consumption allow the direct estimation of δ and standard statistical inference can be used to draw conclusions regarding the regime that better describes policy in a given economy. The estimation strategy is based on now standard results in unit-root econometrics that were not well developed at the time Aiyagari and Gertler wrote their contribution.

Using data from a sample of developed economies, we construct country-specific estimates of δ. Although we find some heterogeneity, the null hypothesis that δ equals 1 cannot be rejected at standard levels for most countries in the sample. This finding suggest that a Ricardian regime is a reasonable approximation for these countries, and implies that (*i*) the fiscal authority backs all outstanding debt, and (*ii*) debt plays only a minor role in the determination of the price level.

Additional empirical implications of the model are also examined. First, estimates of δ are compared with measures of central bank independence proposed in the literature. Results indicate a positive correlation between δ and the indices proposed Alesina and Summers (1993) and Cukierman (1992). Intuitively, the more independent the monetary authority, the larger the proportion of debt that is backed by the fiscal authority. Second, results show a negative correlation between δ and seigniorage revenue as proportion of Gross Domestic Product (GDP) and of government spending. This finding does not imply a causal relationship, but it accords with the idea that countries that back a larger proportion of their government debt with seigniorage would require larger average seigniorage revenues. Third, impulse-response analysis is used to examine the effect of a government debt innovation on the future path of the primary surplus. Results indicate that a positive debt innovation leads to a long-run increase in the primary surplus, as predicted by the model when $\delta = 1$.

In Sargent and Wallace (1981), the interaction between fiscal and monetary authorities takes the form of a coordination game. The central bank could move first, determine how much seigniorage revenue can be raised, and force the fiscal authority to follow a policy that satisfies the government's consolidated intertemporal budget constraint. Then, a central bank that is committed to price stability could indeed deliver price stability regardless of fiscal policy. Alternatively, the fiscal authority could move first by defining the path of the primary surplus. Since higher seigniorage revenues would be necessary to avoid explosive debt paths, fiscal policy would have an effect on the price level. Given a predetermined path for the primary surplus, "tight" money today triggers higher interest rates, increases interests rate payments on the government's debt, and requires "loose" money later. Rational agents anticipate the future increase in money creation and bid the price level up today. This is Sargent and Wallace's unpleasant monetarist arithmetic. Our results imply that, for the countries in the sample, the central bank is the first mover. That is, the monetary authority sets its policy in advance and imposes discipline on the fiscal authority.

Our work is related to, but conceptually different from, the literature on the Fiscal Theory of the Price Level (FTPL) [see, for example, Woodford (1995) and Cochrane (1998, 2001)]. Under the FTPL, the price level is determined by the intertemporal budget constraint as the quotient between the nominal value of the interest bearing debt and the present value of the surplus, that might include seignorage revenues. The underlying assumption is that the government's actions are not constrained by budgetary issues. Consequently, the intertemporal budget constraint holds as an equilibrium condition, rather than as a constraint, and only for equilibrium prices. Any change in fiscal policy must impact the price level, regardless of how committed the monetary authority is to price stability. Both our model and the FTPL predict a relationship between the price level and fiscal variables. However, we assume that the intertemporal budget constraint is always satisfied for any arbitrary sequence of prices, whereas the FTPL assumes it is an equilibrium condition. This modeling difference means that our econometric should not be interpreted as a formal test of the FTPL.

The paper is organized as follows. Section 2 presents the theoretical model. Section 3 outlines the estimation strategy and reports empirical results. Section 4 concludes.

1.2 The Model

1.2.1 Private Sector

The economy is populated by identical, infinitely-lived consumers with perfect foresight.[1] The objective of the representative consumer is:

$$\max_{\{c_t,n_t,m_t,b_t,k_t\}} \sum_{t=0}^{\infty} \beta^t u\left(c_t, m_t/p_t, 1-n_t\right), \tag{1}$$

where $\beta \in (0,1)$ is the subjective discount factor and u is strictly increasing in all arguments, strictly concave, twice continuously differentiable, and satisfies the Inada conditions.

In each period, consumers choose consumption (c_t), labor (n_t), and next-period holdings of

[1] The assumption of perfect foresight is not crucial for the theoretical results, but it is analytically convenient. Aiyagari and Gertler (1985) allow uncertainty but focus on a steady state with constant asset prices. Leeper (1991) permits shocks to the fiscal and monetary policy rules, but output, consumption, and government expenditure are deterministic.

capital (k_t), money (m_t) and nominal one-period government debt (b_t). The variable p_t is the aggregate price level. The time endowment is normalized to one. The population size is constant and normalized to one. Capital and labor services are rented each period to a representative competitive firm that produces output according to a standard neoclassical production function.

The inclusion of real balances (m_t/p_t) as an argument of the utility function reflects the convenience of using money in carrying out transactions. Feenstra (1986) shows the equivalence between including real balances in the utility function, assuming liquidity costs that appear in the budget constraint, and introducing a cash-in-advance constraint. In this sense, the approach followed here to motivate money demand is not restrictive. Since our model is concerned with the composition of government liabilities, we follow Woodford (1995) in interpreting m_t as the consumer's holdings of the monetary base.

Because it is analytically very tractable and it allows us to exploit the linearity of the government's budget constraint, we assume that the instantaneous utility function is logarithmic and separable:[2]

$$u\left(c_t, m_t/p_t, 1-n_t\right) = \ln(c_t) + \gamma \ln(m_t/p_t) + \theta \ln(1-n_t),.$$

where γ and θ are positive constants that measure the relative importance of real money holdings and leisure in utility.

The consumer's optimization problem is subject to a no-Ponzi-game condition and to the sequence of budget constraints (expressed in real terms):

$$c_t + \frac{m_t}{p_t} + \frac{b_t}{p_t} + k_t = w_t n_t + r_t k_{t-1} + \frac{m_{t-1}}{\pi_t p_{t-1}} + i_{t-1}\frac{b_{t-1}}{\pi_t p_{t-1}} - \tau_t, \tag{2}$$

for all t, where τ_t is a lump-sum tax, $\pi_t = p_t/p_{t-1}$ is the gross inflation rate, i_{t-1} is the gross nominal interest rate on government debt which is set in period $t-1$ and paid in period t, w_t is the wage rate, and r_t is the gross return on capital between periods $t-1$ and t. In equilibrium, the absence of arbitrage profits will require r_t to equal the real gross interest rate i_{t-1}/π_t.

First-order necessary conditions for the representative consumer's problem include:

$$1/c_t = \beta(i_t/\pi_{t+1})(1/c_{t+1}), \tag{3}$$

$$m_t/p_t = \gamma c_t i_t/(i_t - 1), \tag{4}$$

Equation (3) is an Euler equation for consumption and equation (4) defines money demand as a function of consumption and the return on money. We will see below that only these two conditions are necessary to derive the model's implications for the aggregate price level, without reference to the remaining first-order conditions.

[2] All results of the paper follow through if agents derive utility from government expenditures, as long as they enter separably in the utility function.

1.2.2 Government

In every period, the government spends an exogenous amount of resources G_t. Government expenditures may be financed by levying lump-sum taxes (τ_t), by issuing money (M_t), and by increasing public debt (B_t). The government is subject to a no-Ponzi-game condition and to a dynamic budget constraint (expressed in real terms):

$$G_t + (i_{t-1} - 1)\frac{B_{t-1}}{p_t} = \tau_t + \frac{(M_t - M_{t-1})}{p_t} + \frac{(B_t - B_{t-1})}{p_t}. \tag{5}$$

Forward iteration on (5) and the government's no-Ponzi condition imply an intertemporal budget constraint:

$$\begin{aligned} i_{t-1}\frac{B_{t-1}}{p_t} &= \sum_{j=0}^{\infty}\frac{\tau_{t+j}}{R_t^{(j)}} + \sum_{j=0}^{\infty}\frac{M_{t+j} - M_{t+j-1}}{p_{t+j}R_t^{(j)}} - \sum_{j=0}^{\infty}\frac{G_{t+j}}{R_t^{(j)}}, \\ &= \mathcal{T}_t + \mathcal{S}_t - \mathcal{G}_t, \end{aligned}$$

where $R_t^{(j)} = \prod_{h=1}^{j} r_{t+h}$ is the j-periods-ahead market discount factor, and $\mathcal{T}_t$, $\mathcal{S}_t$ and $\mathcal{G}_t$ are the present value of tax receipts, seigniorage revenue, and government expenditure, respectively. Without loss of generality, we assume that the government's present value budget constraint holds with equality.[3]

The government is assumed to follow a "long-run" fiscal policy rule whereby it commits itself to raise large enough primary surpluses (in present value terms) to back a constant fraction of the currently outstanding debt. More formally:

Definition (The δ-backing Fiscal Policy): *Given a sequence of prices $\{i_{t+j-1}, p_{t+j}\}_{j=0}^{\infty}$ and an initial stock of nominal debt B_{t-1}, a δ-backing fiscal policy is a sequence $\{G_{t+j}, \tau_{t+j}, B_{t+j}\}_{j=0}^{\infty}$ such that, for all t:*

$$\mathcal{T}_t - \mathcal{G}_t = \delta i_{t-1}\frac{B_{t-1}}{p_t}, \tag{6}$$

where $\delta \in [0, 1]$.

Put simply, this fiscal policy rule means that a constant fraction (δ) of the outstanding government debt, including interest payments, is backed by the present discounted value of current and future primary surpluses. Since the government's intertemporal budget constraint is always satisfied, it follows that:

$$\mathcal{S}_t = (1 - \delta)i_{t-1}\frac{B_{t-1}}{p_t}. \tag{7}$$

[3] Note that we impose a no-Ponzi game condition on total government liabilities. Under the assumption that the government does not waste revenues, this amounts to

$$\lim_{j\to\infty} (M_{t+j} + B_{t+j})/p_{t+j}R_t^{(j)} = 0.$$

Hence, the policy (6) also implies that a fraction $(1-\delta)$ of the currently outstanding debt is backed by the present discounted value of current and future seigniorage revenue.

The set of possible fiscal regimes is indexed by the fraction δ of the outstanding debt that is backed by the primary surplus. Because $\delta \in [0,1]$, this set is a continuum limited by the following two polar cases:

(i) In the case where $\delta = 1$, the fiscal authority backs fully all outstanding debt. It commits itself to adjust the stream of future primary surpluses in order to match the current value of the government's bond obligations. There is complete accommodation of the fiscal policy to any open market sale by the monetary authority. Whenever the monetary authority sells government bonds in the open market, the fiscal authority increases current or future taxes (and/or reduces current or future expenditures) to back the principal and interest payments on the newly issued debt. On the other hand, the monetary authority never responds to the increase in the stock of government debt associated with a budget deficit. Sargent (1982) and Aiyagari and Gertler (1985) refer to this case as a Ricardian regime. Because of the apparent leading role played by the monetary authority, Leeper (1991) refers to this case as one of active monetary/passive fiscal policy.

(ii) In the case where $\delta = 0$, all outstanding debt is backed by the monetary authority in the form of current and future seigniorage revenues. The monetary authority fully accommodates the fiscal authority whenever a budget deficit is financed with debt. This accommodation takes the form of an increase in current or future seigniorage revenues to back the principal and interest payments on the newly issued debt. The fiscal authority is insensitive to monetary policy in the sense that neither taxes nor expenditure react (now or in the future) to changes in the stock of outstanding government debt. Sargent, and Aiyagari and Gertler refer to this case as a polar Non-Ricardian regime. Leeper refers to it as one of passive monetary/active fiscal policy.

The long-run rule (6) is consistent with multiple period-by-period fiscal policy rules. As an example, consider the following version of the rule used by Aiyagari and Gertler (1985):

$$p_t(\tau_t - G_t) = \delta\left[(i_{t-1} - 1)\, B_{t-1} - (B_t - B_{t-1})\right]. \tag{8}$$

Under (8), the nominal primary surplus is adjusted in every period (increasing τ_t or reducing G_t) in the exact amount needed to finance a fixed fraction δ of the interest on the outstanding debt (B_{t-1}) net of an adjustment for debt growth. To see that this stationary policy satisfies (6), simply iterate forward on (8) and use the government's no-Ponzi-game condition. In principle, there might be other period-by-period policy rules (perhaps not time-stationary) that are consistent with the rule (6). An advantage of our approach is that we are able to determine the price level and construct empirical estimates of δ using the long-run policy rule (6) without having to assume that a particular policy like (8) is satisfied in every period, for every country in the sample.

The parameter δ characterizes the degree of interdependence between fiscal and monetary authorities. This parameter should not be interpreted narrowly, as capturing a publicly announced policy commitment, or a commitment formally written in a country's budget, constitution, or central bank organic law. Instead, δ is a value that arises from the interaction of the fiscal and monetary authorities given a stable institutional setup. This interpretation is reinforced by the observation that the price level is derived here using a long-run fiscal policy rule without any reference to particular period-by-period fiscal or monetary policy rules.

Our specification of government behaviour follows earlier literature that describes monetary and/or fiscal policies in terms of explicit rules. See, among others, Taylor (1993) and Clarida, Galí, and Gertler (2000) for monetary policy rules; and Sargent and Wallace (1981), Aiyagari and Gertler (1985), Leeper (1991), and Bohn (1998) for fiscal policy rules. Leeper and Bohn point out that fiscal rules relating taxes to debt can be consistent with an optimizing government that minimizes the cost of tax collection by smoothing marginal tax rates over time [see Barro (1979)]. We view the δ-backing rule as a fairly unrestrictive way to parameterize government behaviour that is convenient both analytically and empirically. It captures in a reduced-form way the idea that in response to different institutional settings, the monetary authority will face different obligations regarding fiscal policy. Whether this rule satisfies some optimality criterion, or whether it is a realistic description of government behaviour beyond that just mentioned is an open question to be addressed in future research.

1.2.3 Equilibrium

The competitive equilibrium for this economy may be defined in an entirely standard way. Specifically, it corresponds to a price system, allocations for the representative consumer and the representative firm, and a government policy, such that (*i*) the representative consumer and the representative firm optimize given the government policy and the price system, (*ii*) the government policy is budget-feasible given the price system and the choices of consumers and firms, and (*iii*) markets clear.

In this model, the price level is determined by the clearing of the money market

$$M_t = m_t. \tag{9}$$

Money supply is determined by the combination of the fiscal rule and the government's intertemporal budget constraint [eq. (7)], while money demand is given by the consumer's intratemporal condition relating money and consumption [eq. (4)]. From equation (7), money supply can be written after some manipulations as

$$\frac{M_t}{p_t} = \frac{i_t}{i_t - 1}\left[(1-\delta)i_{t-1}\frac{B_{t-1}}{p_t} + \frac{M_{t-1}}{p_t} - \sum_{j=1}^{\infty}\left(\frac{M_{t+j}}{p_{t+j}R_t^{(j)}}\frac{i_{t+j}-1}{i_{t+j}}\right)\right]. \tag{10}$$

Using the equilibrium condition (9) and money demand (4) in (10) yields

$$\gamma c_t = (1-\delta) i_{t-1} \frac{B_{t-1}}{p_t} + \frac{M_{t-1}}{p_t} - \sum_{j=1}^{\infty} \left(\frac{m_{t+j}}{p_{t+j} R_t^{(j)}} \frac{i_{t+j}-1}{i_{t+j}} \right).$$

Exploiting the recursive nature of the Euler equation [eq. (3)] to find an expression for the infinite sum, $\sum_{j=1}^{\infty}(m_{t+j}/p_{t+j}R_t^{(j)})((i_{t+j}-1)/i_{t+j})$, in terms of current consumption, and after some algebra:

$$p_t = \frac{(1-\beta)(M_{t-1} + (1-\delta) i_{t-1} B_{t-1})}{\gamma c_t}. \tag{11}$$

This equation describes the aggregate price level as a function of consumption and of the beginning-of-period stocks of money and debt. Aiyagari and Gertler obtain an expression for the price level similar to the one above, but assuming a specific period-by-period rule and focusing on a stationary solution with constant asset prices.

As an alternative, one can use the fact that $M_{t-1} + (1-\delta) i_{t-1} B_{t-1} = M_t + (1-\delta) B_t$,[4] to write the price level in terms of the end-of-period stocks of money and debt:

$$p_t = \frac{(1-\beta)[M_t + (1-\delta) B_t]}{\gamma c_t}. \tag{12}$$

Note that equations (11) and (12) are equivalent, but the empirical analysis of (12) would not require data on the gross nominal interest rate. Regardless of whether one focuses on (11) or (12), this model implies that the price level depends not only on the money stock, but also on the proportion of the outstanding debt that is backed by money. In this sense, the proportion of the outstanding debt that is backed by money behaves like money itself.

Notice that the derivation of the price level does not involve the production side of the economy. In particular, it does not involve the consumer's first-order conditions for their choice of capital and labor, the firm's first-order conditions, or the market clearing in goods and factors markets. Since this model displays the property of money superneutrality, the production side of the economy is solved in a completely independent set of equations that do not include nominal variables.[5] The consumption level, c_t, that appears in the denominator of (12) is determined in that subsystem as well. Thus, the aggregate price level is the outcome of monetary policy (reflected in the sequence

[4] The proof goes as follows. Write equation (7) as:

$$\begin{aligned} (M_t - M_{t-1})/p_t - (1-\delta) i_{t-1} B_{t-1}/p_t &= -S_{t+1}/r_{t+1}, \\ &= -(1-\delta) i_t B_t / p_{t+1} r_{t+1}, \\ &= -(1-\delta) B_t / p_t, \end{aligned}$$

where the last line follows from multiplying and dividing the right-hand side by p_t, and using the definitions of gross inflation and gross real interest rate.

[5] In general, the Sidrauski model can exhibit nonsuperneutrality outside the steady state. Fischer (1979) shows that for the CRRA utility function, the rate of capital accumulation is positively related to the rate of money growth, except for the case of log-separable utility used here.

of M_t) and how government debt is backed (summarized by the parameter δ).[6]

In order to develop further the reader's intuition, consider a long run situation where all real variables are constant. By dividing and multiplying the right-hand side of (12) by y, we obtain

$$p_t = \frac{M_t V}{y} + \frac{(1-\delta)B_t V}{y},$$

where $V \equiv (1-\beta)y/(\gamma c)$ can be interpreted as a measure of velocity of the broad monetary aggregate, $M_t + (1-\delta)B_t$, that consists of the sum of money and the monetized debt (*i.e.*, the proportion of debt that is backed by seigniorage). Note that only for the special case where $\delta = 1$, can the constant V be interpreted as money-velocity and the Quantity Theory of Money holds. More generally, for any $\delta \in [0,1)$, the stock of debt plays a role in the determination of the price level. This point was made before by Aiyagari and Gertler.

Government debt also plays a crucial role in the determination of the price level under the Fiscal Theory of the Price Level (FTPL). The FTPL assumes that the government does not have to satisfy its intertemporal budget constraint for all possible paths of the price level. A particular path for the price level that does not satisfy the intertemporal budget constraint could be automatically excluded as an equilibrium by the government because it would not satisfy market clearing nor the consumer's optimality conditions. As a result of this assumption, the aggregate price level is determined as the quotient between the nominal value of interest-bearing debt and the present value of the all government revenues (including seignorage) regardless of whether the government debt is, or will be, monetized. In contrast, in our model, the no-Ponzi-game condition on the government's behaviour implies an intertemporal budget constraint that is satisfied for all price sequences and the equilibrium sequence is determined by the clearing of the money market.

This conceptual difference between the FTPL and our model has both theoretical and empirical implications. At the theoretical level, it implies that, under the FTPL, the stock of debt affects the price level even if it is never monetized while, in this model, only the proportion of debt that is monetized (now or in the future) will affect the price level. The effect of debt on the price level increases linearly with $(1-\delta)$, that is, with the proportion of debt that is backed by current or future seignorage revenues. When $\delta = 1$ and given a path of government expenditure, savings in the form of government debt will be used to pay future lump-sum taxes. Consequently, debt has no effect on the current demand for goods or money and Ricardian equivalence holds. When $\delta \in [0,1)$, a proportion of debt does not require future lump-sum tax increases but implies an increase in current and/or future seigniorage revenue. Anticipating future inflation, forward-looking agents reduce their current money demand and bid the price level up today.

[6] Results are also robust to allowing distortionary taxation on capital and labor. The reason is that the Euler equation (3) and the intratemporal condition (4) are unchanged when the model is generalized in this manner. All that is required to make our results go through is to redefine $\mathcal{T}_t$ as the present discounted value of all lump-sum and distortionary taxes on capital and labor income.

At the empirical level, we show in the next section that, under certain conditions, the long-run dynamics of money, debt, and private consumption permit the econometric estimation of δ in our model. Statistical inference can then be used to draw conclusions regarding the policy regime (whether Ricardian or not) in a given economy. However, since we assume that the intertemporal budget constraint is always satisfied, our econometric results have no direct bearing on the impossibility result in Cochrane (1998), whereby the FTPL cannot be falsified empirically because only equilibrium prices are observable.

1.3 Empirical Analysis

1.3.1 Econometric Strategy

This section describes a simple econometric strategy to obtain estimates of the parameter that measures the degree of interdependence between fiscal and monetary policies, δ. Rewrite equation (12) as:

$$M_t = \frac{\gamma}{(1-\beta)} C_t - (1-\delta)B_t, \tag{13}$$

where $C_t \equiv p_t c_t$ denotes nominal private consumption. Consider the empirical counterpart to this relation:

$$M_t = \alpha + \rho_1 C_t + \rho_2 B_t + e_t, \tag{14}$$

where α is an intercept, ρ_j for $j = 1, 2$ are constant coefficients, and e_t is a disturbance term that captures specification error. In terms of the structural parameters of the model, $\rho_1 = \gamma/(1-\beta)$, and $\rho_2 = -(1-\delta)$. Notice that although not all structural parameters could be identified from the Ordinary Least Squares (OLS) projection of M_t on C_t and B_t, δ would be identified from the coefficient on the stock of debt. In principle, because all three variables are endogenous in this model, the OLS regression would yield biased and inconsistent estimates if the variables were covariance-stationary. However, if M_t, C_t, and B_t are $I(1)$ variables (integrated of order one), and equation (14) is a cointegrating relationship, then the same regression would yield superconsistent parameter estimates [see Phillips and Durlauf (1986)].[7]

Our approach is not the only one that could deliver estimates of the parameter δ. We can think of at least two other strategies. First, one could consider estimating δ directly from the fiscal rule (6). An advantage of this strategy is that it would deliver a "theory-free" estimate without the need to model the consumer's behaviour or make assumptions about functional forms. However, this strategy requires the computation of the present discounted values $\mathcal{T}_t$ and $\mathcal{G}_t$ that involve infinite future values for taxes and government expenditure. Since we only have access to a finite number

[7] In principle, the reduced-form (14) may be written with either M_t, C_t, or B_t on the left-hand side. In adopting the formulation above, we are normalizing the coefficient of M_t in the cointegrating vector to unity. Provided M_t belongs to the cointegrating relation, results are robust to this normalization. The reason we choose to write the reduced-form in this manner is that its estimation delivers δ directly without the need to use, for example, the Delta method to compute its standard error.

of observations, the implementation of this approach would necessarily involve truncation and the loss of many degrees of freedom.

Second, one could follow the literature and construct inferences about government behaviour on the basis of particular period-by-period rules [see, for example, Bohn (1998)]. This strategy would overcome the problem created by the computation of infinite summations. However, it seems unlikely that the same period-by-period rule describes government behaviour in a cross-section of countries with different institutional arrangements. Instead, the approach here makes the hypothesis of similar consumer's preferences across countries (at least in terms of functional form if not of preference parameters) but avoids imposing a period-by-period common institutional design for governments in different countries.

Notice that we are able to identify δ, even if the theoretical model only assumes a long-run fiscal policy rule and allows any period-by-period rule that satisfies (6). The reason is that current money supply is derived directly from the implication of the long-run fiscal rule and the government's intertemporal budget constraint. We then use the money market equilibrium and the agents' first-order conditions to derive the price level. Thus, there is a sense in which we estimate the long-run rule directly but use the restrictions from economic theory to solve out the infinite sum.[8] Hence, by developing a fully-specified model, we can construct econometric inferences about the policy regime, even if we do not know the particular period-by-period rule followed by a given government in a given country.

1.3.2 Data

The empirical analysis is based on annual, per-capita data on nominal monetary base, nominal government debt, and nominal private consumption from 14 industrialized countries. All series come from the International Financial Statistics (IFS) database compiled by the International Monetary Fund. The only exceptions are government debt for the United States and Canada.

The data on monetary base corresponds to IFS series 14 (Reserve Money).[9] For Canada, government debt corresponds to the series D469409 (Net Federal Government Debt) in the CANSIM database of Statistics Canada. For the United States, government debt is the series Gross Federal Debt Held by the Public from the U.S. Department of Commerce and available from the web site of the Federal Reserve Bank of St. Louis (*www.stls.frb.org*). For all other countries, government debt corresponds to the IFS series 88a (Government Debt on National Currency) or, when this was not available, the series 88b (Government Domestic Debt). Private consumption corresponds

[8] Recall that we used the money market equilibrium to substitute M's (money supply) with m's (money demand) in (10). Then, we used the agents' intratemporal condition (4) to express the infinite sum in terms of future consumption and, finally, we used consumption smoothing to write the infinite consumption sum in terms of current consumption alone.

[9] Whenever Reserve Money was not reported, we used the sum of series 14a, 14c and 14d. These series are the disaggregated liabilities of the monetary authority.

to the series 96F (Household Consumption Expenditures or Private Consumption). Population is the mid-year estimate of the total population by the United Nation's *Monthly Bulletin of Statistics* and labeled as series 99Z..ZF in the IFS.

The countries in the sample were not randomly selected. Instead, we included in the sample all member countries of the Organization for Economic Cooperation and Development (OECD) for which reasonably long time series of the variables were available. An advantage of using data from OECD countries is that they are market economies with relatively few good prices under direct or indirect government control.[10]

The countries in the sample (with the sample period in parenthesis) are: Austria (1970 to 1997), Belgium (1953 to 1997), Canada (1948 to 1999), Finland (1950 to 1997), France (1950 to 1998), Germany (1950 to 1990), Italy (1962 to 1998), the Netherlands (1951 to 1998), Norway (1971 to 1997), Spain (1962 to 1998), Sweden (1950 to 1999), Switzerland (1960 to 1999), United Kingdom (1970 to 1997) and United States (1951 to 1999). In addition to data availability, the sample period for some countries was limited by substantial institutional changes. In particular, sample for Germany ends before the reunification and the samples for member countries of the European Monetary Union end before the introduction of the Euro in January 1999.

1.3.3 Results

The econometric strategy outlined above to estimate the structural parameters of the model is valid only if M_t, C_t, and B_t are $I(1)$ variables and the OLS regression (14) is not spurious, that is, if (14) forms a cointegrating relation. Unit root and cointegration tests are used to assess both conditions.

Table 1.1 report results of Augmented Dickey-Fuller (ADF) unit-root tests. The estimated alternative is a covariance-stationary autoregression with both a constant and a deterministic trend. For all ADF tests, the level of augmentation, (*i.e.,* the number of lagged first differences included in the OLS regression) was based on the Modified Information Criterion (MIC) proposed by Ng and Perron (2001).[11] In all cases, the null hypothesis of a unit root with drift cannot be rejected against the alternative of a deterministic trend at the 5 per cent significance level. The only exceptions are the per-capita nominal government debts of Norway and Italy. However, in the case of Norway the hypothesis cannot be rejected at the 1 per cent level, and in both cases the hypothesis cannot be rejected when we apply recursive t-tests to select the level of augmentation.

The null hypothesis of no cointegration is tested using the residual-based method proposed by Engle and Granger (1987) and Phillips and Ouliaris (1990). Gonzalo and Lee (1998) show that

[10] In preliminary work, we considered using data from developing countries. Unfortunately, their government debt series are usually too short and/or unreliable to allow a meaningful analysis, and a substantial proportion of goods and services have or have had their prices subject to government control. For example, Argentina, Brazil, and Israel used widespread price and wage controls during inflation stabilization programs in the 1980s.

[11] In order to assess the robustness of the results to the lag-selection method, we also applied recursive t-tests with similar conclusions to the ones reported. Two exceptions are noted below.

this test is more robust than Johansen's trace test to certain departures from unit root behaviour like long memory and stochastic unit roots. The residual-based test requires running OLS on the relation of interest and then testing the hypothesis that the regression residuals have a unit root. Nonstationarity of the residuals constitutes evidence against cointegration. These test results are reported in the last column of Table 1.1. The null hypothesis is rejected at the 5 per cent level for Austria, Canada, Spain and Sweden, and at the 10 per cent level for Belgium, Finland and the United States. For France, Italy, Norway and the United Kingdom, the null cannot be rejected at the 10 per cent level but the result is marginal in that the p-values are close the 0.10. Without ambiguity, the null cannot be rejected for the Netherlands and Switzerland. Because, M_t, B_t, and C_t were found to be $I(1)$ for both countries, the absence of cointegration is interpreted as a rejection of the theoretical model for these two countries.

Table 1.1
Unit Root and Cointegration Tests Results

Country	ADF Unit Root Test M_t	B_t	C_t	Residual-Based Cointegration Test
Austria	−2.20	−1.53	−1.25	−5.52*
Belgium	−1.45	−1.45	−2.67	−3.56†
Canada	−0.59	−1.68	−1.93	−4.82*
Finland	−2.15	1.21	−2.22	−3.71†
France	−3.16	−2.15	−2.37	−3.41
Germany	−2.40	−2.24	−1.53	−4.50*
Italy	−0.54	−4.73*	−2.38	−3.30
Netherlands	−1.82	−1.85	−1.79	−2.09
Norway	−0.07	−3.66*	−2.45	−3.18
Spain	−1.77	0.20	−1.66	−3.82*
Sweden	−2.13	−1.88	−1.11	−4.96*
Switzerland	−1.49	−1.64	−2.99	−2.07
United Kingdom	−1.10	−3.29†	−1.68	−3.02
United States	2.28	−2.64	−0.24	−3.76†

Note: the superscripts * and † denote the rejection of the null hypothesis at the 5 per cent and 10 per cent significance levels, respectively.

The above results are important because they allow us to describe empirically the money market equilibrium as a cointegrating relation. This means that even if the individual series can be represented as nonstationary processes, the behavioral rules and constraints of the model economy imply that a precise combination of these variables should be stationary. Hence, a simple Least

Squares regression yields a superconsistent estimate of the parameter that characterizes the interdependence between fiscal and monetary policies.[12] Because not all conditions outlined above are met for all countries in the sample, the analysis that follows focuses only on 12 of the 14 countries in the original sample, namely Austria, Belgium, Canada, Finland, France, Germany, Italy, Norway, Spain, Sweden, the United Kingdom, and the United States.

For the estimation of the cointegrating vector, we employ the DOLS method proposed by Stock and Watson (1993). This method is asymptotically equivalent to maximum likelihood but exploits the functional relationship predicted by the model. This approach involves running the OLS regression:

$$M_t = \alpha + \rho_1 C_t + \rho_2 B_t + \sum_{s=-k}^{k} \xi_{1,s} \Delta C_{t-s} + \sum_{s=-k}^{k} \xi_{2,s} \Delta B_{t-s} + e_t, \tag{15}$$

where $\xi_{j,s}$ for $j = 1, 2$ and $s = -k, -k+1, \ldots, k-1, k$ are constant coefficients. The appropriate number of leads and lags was selected by the sequential application of recursive F-tests.[13]

Table 1.2
Estimates of Structural Parameters

Country	$\hat{\rho}_1$		$\hat{\delta}$	
	Estimate	s.e.	Estimate	s.e.
Austria	0.197*	(0.012)	0.944*	(0.011)
Belgium	0.145*	(0.061)	0.959*	(0.019)
Canada	0.128*	(0.059)	0.956*	(0.043)
Finland	0.292*	(0.101)	0.997*	(0.338)
France	0.163*	(0.020)	0.939*	(0.048)
Germany	0.179*	(0.031)	0.928*	(0.060)
Italy	0.360	(0.283)	0.903*	(0.106)
Norway	0.089	(0.101)	0.946*	(0.298)
Spain	0.467	(0.652)	0.905*	(0.536)
Sweden	0.268*	(0.064)	0.952*	(0.062)
United Kingdom	0.046*	(0.008)	0.994*	(0.019)
United States	0.033	(0.046)	1.073*	(0.049)

Notes: s.e. is the (rescaled) standard error. The superscript * denotes the rejection of the null hypothesis that the true coefficient is zero at the 5 % significance level.

[12] Elliot (1998) shows that even if the model variables have roots near but not exactly equal to one, the point estimates of the cointegrating vector are consistent. However, hypothesis tests regarding the coefficients that do not have an exact unit root can be subject to size distortions.

[13] Results using the Bayesian Information Criteria (BIC) are similar to the ones reported and are available from the corresponding author upon request.

Table 1.2 presents estimates of the structural parameters and their rescaled standard errors. Standard errors are rescaled to take into account the serial correlation of the residuals that remains after adding the k leads and lags [see, Hayashi (2000, pp. 654-657)]. In all cases the coefficient on nominal consumption, $\rho_1 = \gamma/(1-\beta)$ is positive and (except for Italy and Norway) statistically different from zero. However, the weight of real balances in the utility function (γ) and the subjective discount rate (β) are not separately identified.[14]

An estimate of δ is identified from the reduced-form parameter $\rho_2 = -(1-\delta)$. This estimate is reported in Column 3. In all cases, this parameter is positive, statistically different from zero, and (except for Austria and Belgium) not statistically different from one at the 5 per cent level.[15] Recall that δ is the proportion of current government debt that is backed by the present discounted value of current and future primary surpluses. Hence the finding that δ is close to 1 means that outstanding debt in developed economies is essentially backed by the fiscal authority. Backing takes the form of a commitment to adjust the stream of future primary surpluses to match the current value of its bond obligations. In the long-run, there is complete accommodation of fiscal policy to the open market operations by the monetary authority. For example, when the monetary authority sells government bonds, the fiscal authority increases current or future taxes, and/or reduces current or future expenditures, to back the principal and interest payments on the newly issued debt.

This finding suggests that the interdependence between fiscal and monetary authorities in developed economies is well described by what Sargent (1982) and Aiyagari and Gertler (1985) refer to as a Ricardian regime or, in the language of Leeper (1991), an active monetary/passive fiscal policy regime. In this regime, the fiscal authority backs all outstanding debt, debt plays only a minor role in the determination of the price level, and the Quantity Theory of Money holds as a long-run proposition.

In terms of Sargent and Wallace's (1981) coordination game between monetary and fiscal authorities, our results imply that, for the countries in the sample, the central bank is the first mover. That is, the monetary authority sets its policy in advance and imposes discipline on the fiscal authority. By discipline, we mean that the fiscal authority has to select a sequence of primary surpluses and debt that is consistent with the sequence of M_t supplied by the monetary authority, and that insures that the intertemporal budget constraint is always satisfied. In turn, this implies that the unpleasant monetarist arithmetic might not be empirically relevant for developed economies

[14] All regressions include an intercept term (not reported). The theoretical model predicts that the intercept should be zero [see eq. (13)]. However, for most countries in the sample, the intercept was found to be statistically different from zero. Strictly speaking, this constitutes a rejection of the theory. A more constructive interpretation of this result is that the theoretical relation holds *up to* a constant term.

[15] The theoretical model implies that δ is bounded between zero and one. Rather than incorporating a nonlinear restriction in a linear estimation framework, we follow the simpler approach of first estimating the cointegrating vector and then verifying whether $\hat{\delta}$ falls in the $[0,1]$ range. This is the case for all countries, except the U.S. For the U.S., $\hat{\delta}$ is slightly larger than one, but the hypothesis that its true value is one cannot be rejected at the 5 per cent level.

and that "tough" central banks can fight inflation with tight money.

Our empirical results are consistent with findings in Fischer, Sahay, and Vegh (2002). These authors use annual panel data from 133 market economies and report that the expected negative relationship between fiscal balance and inflation is not verified for low-inflation, mostly developed, countries. A possible explanation of their finding is that in a Ricardian regime, government debt plays no role in the determination of the price level. This point is related to Sargent's (1982) observation that "one cannot necessarily prove that current deficits are not inflationary by running time-series regressions and finding a negligible effect." The reason is that the question of whether budget deficits are inflationary is intimately related to the policy regime and institutional arrangements.

1.3.4 Additional Implications

We now examine some additional empirical implications of the model. First, we compare $\hat{\delta}$ with measures of central bank independence and seigniorage revenue computed by other researchers. The comparison with indices of central bank independence is motivated by the idea that δ summarizes the interaction between fiscal and monetary authorities in a given institutional setup. By institutional setup we mean not only the legal characteristics of the central bank's organic law, but also to the informal policy decision-making in practice. Hence, δ captures both formal and informal behavioral elements. The comparison with seigniorage is not meant to capture a causal relationship. However, it is plausible that countries where a smaller proportion of government debt is backed with the primary surplus, would feature larger average seigniorage revenues as a proportion of GDP and of government spending, for a given level of the public debt.

Second, we derive the joint implications of $\hat{\delta}$ and the long-run policy rule regarding the response of the primary surplus to an innovation in government debt. We then use a Vector Autoregression to examine whether these implications are broadly consistent with the data.

Figures 1.1 and 1.2 plot the relation between $\hat{\delta}$ and measures of central bank independence. The measure in Figure 1.1 is the index computed by Alesina and Summers (1993) as the arithmetic average of the indices constructed by Bade and Parkin (1982) and by Grilli, Masciandaro, and Tabellini (1991). The measure in Figure 1.2 is the index constructed by Cukierman (1992). These indices measure central bank independence by focusing primarily on legal characteristics like the terms of office of the central bank director(s), restrictions on public sector borrowing from the central bank, conflict resolution between the central bank and the executive branch, etc.

In both figures, we observe a positive relation between the empirical measure of interdependence between fiscal and monetary policies ($\hat{\delta}$) and the indices of central bank independence. In general, the larger the independence of the monetary authority, the larger the proportion of government debt that is backed by the fiscal authority. This relationship can be quantified by means of correlation coefficients and OLS regressions. The correlations between $\hat{\delta}$ and the indices in Figures 1 and 2 are 0.45 and 0.23, respectively.

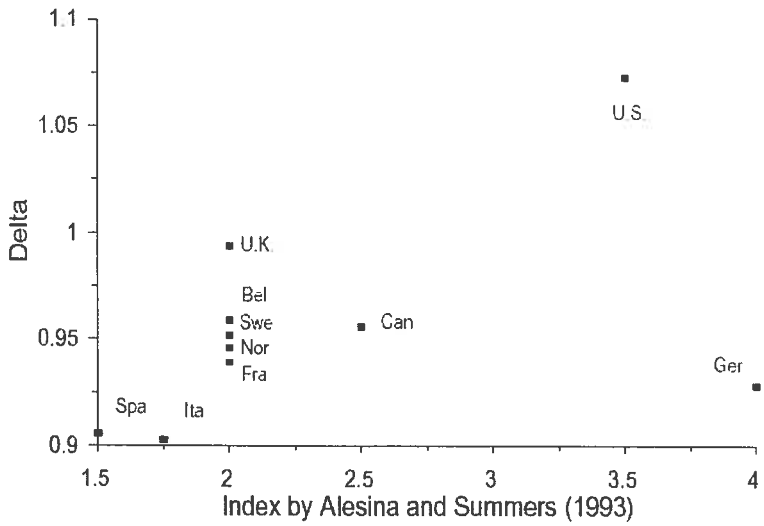

Fig 1.1 - Relationship between δ and Central Bank Independence (I)

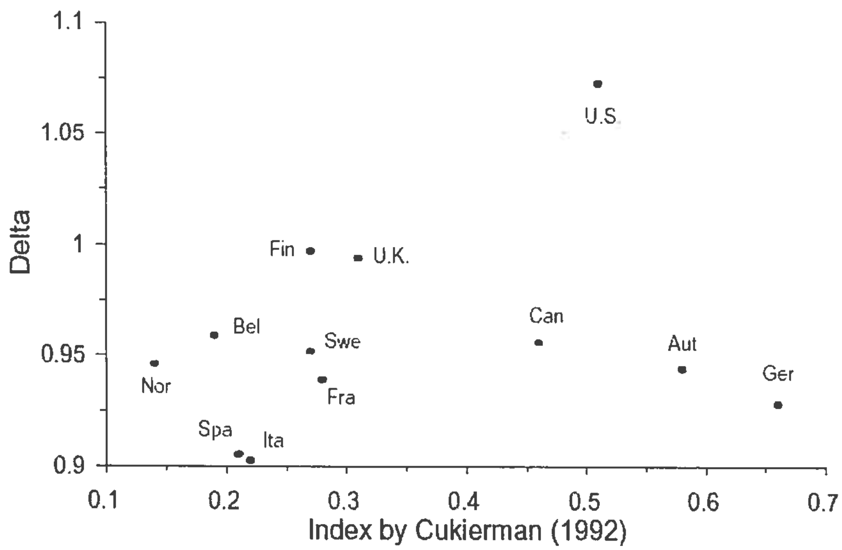

Fig 1.2 - Relationship between δ and Central Bank Independence (II)

Results from regressions of $\hat{\delta}$ on each index of central bank independence are reported in Table 1.3. First, consider results in Columns 1 and 3, where the regressors are an intercept term and the independence index. In all cases, the coefficient on the index is positive but not statistically different from zero at standard levels, and the R^2's are generally low. Second, consider results in Columns 2 and 4, where the set of regressors is expanded to include the independence index squared. In all cases, the coefficients on the index (index squared) are positive (negative), and the R^2's are considerably larger than in the linear projections. These results indicate a nonlinear, concave relation between $\hat{\delta}$ and central bank independence.

Table 1.3
Relationship between $\hat{\delta}$ and Central Bank Independence

	Measure of Independence			
	Alesina and Summers'		Cukierman's	
Intercept	0.89*	0.48*	0.94*	0.81
	(0.06)	(0.20)	(0.03)	(0.09)
Index	0.03	0.35*	0.06	0.83
	(0.03)	(0.15)	(0.09)	(0.49)
Index^2	–	−0.06*	–	−0.96
		(0.03)		(0.54)
R^2	0.21	0.52	0.05	0.25

Notes: the figures in parenthesis are robust standard errors. The superscript * denotes the rejection of the null hypothesis that the true coefficient is zero at the 5 per cent significance level.

A possible explanation of this result is that at lower levels of central bank independence (as measured by the standard indices), the interaction between fiscal and monetary authorities is largely determined by formal considerations (*e.g.,* the central bank's organic law). Thus, our estimate of δ and indices of formal central bank independence are closely related. However, at higher levels of central bank independence, informal elements might play an important role in policy making and the relation between our estimate of δ and these indices is not as tight.

Consider now the relation between $\hat{\delta}$ and seigniorage revenue as a proportion of GDP and of government expenditures. These relations are plotted in Figures 1.3 and 1.4, respectively. The seigniorage measures are the annual averages between 1971 and 1990 reported by Click (1998, p. 155). In both cases there is a negative (possibly nonlinear) relation between $\hat{\delta}$ and seigniorage. The correlation coefficients are, respectively, −0.61 and −0.53.

Although these results are suggestive, they must be interpreted with caution for two reasons. First, the number of countries in the sample is relatively small and, consequently, outliers can have a large effect on the computed correlations. For example, when one excludes the United States from the sample, the correlations between $\hat{\delta}$ and the legal-based indices drop to 0.05 (Alesina and Summers) and −0.02 (Cukierman). Second, a F-test of the restriction that δ is the same in all countries in the sample yields a statistic of 0.003. Comparing this statistic with the 5 per cent critical value of the F distribution with (11, 259) degrees of freedom indicates that the restriction cannot be rejected. This means that the interaction between fiscal and monetary authorities in the sample countries is relatively similar, perhaps because institutional differences across these countries are comparatively small.

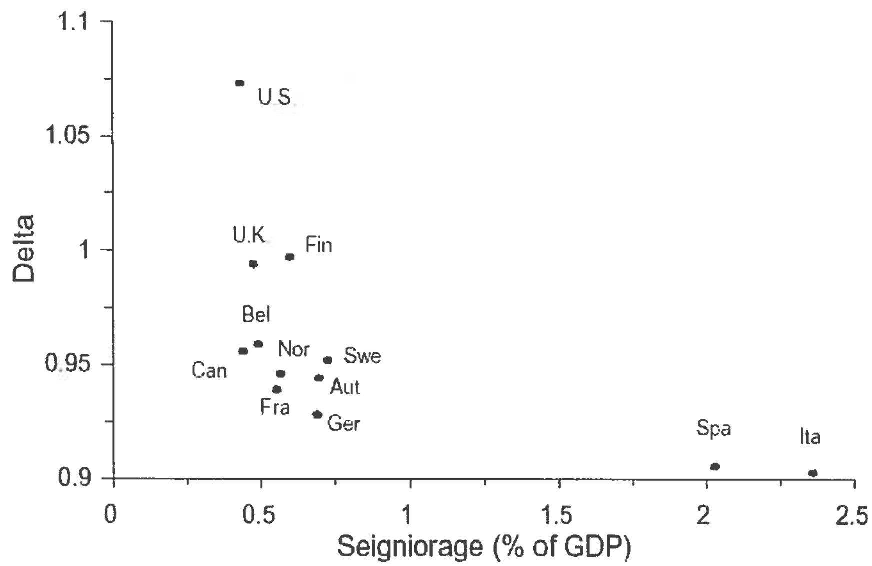

Fig 1.3 - Relationship between δ and seigniorage (I)

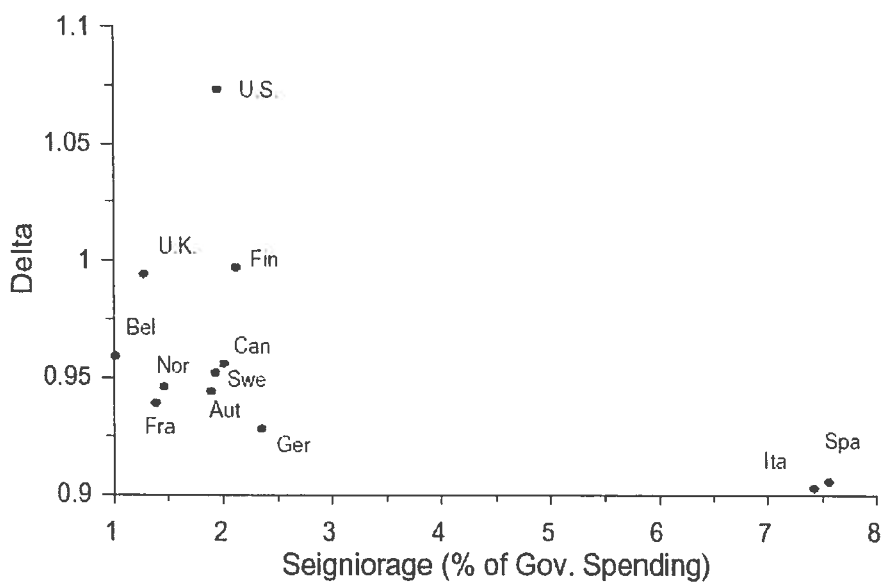

Fig 1.4 - Relationship between δ and Seigniorage (II)

The assumed long-run policy rule in conjunction with the finding that $\hat{\delta}$ is approximately equal to one imply that innovations in government debt should provoke a positive long-run response in the primary surplus. In order to assess this implication, we construct a parsimonious Vector Autoregression of order 1 with government debt and the primary surplus as per cent of GDP for each country in the sample. The data on the primary surplus was also taken from the IFS database of the International Monetary Fund.[16]

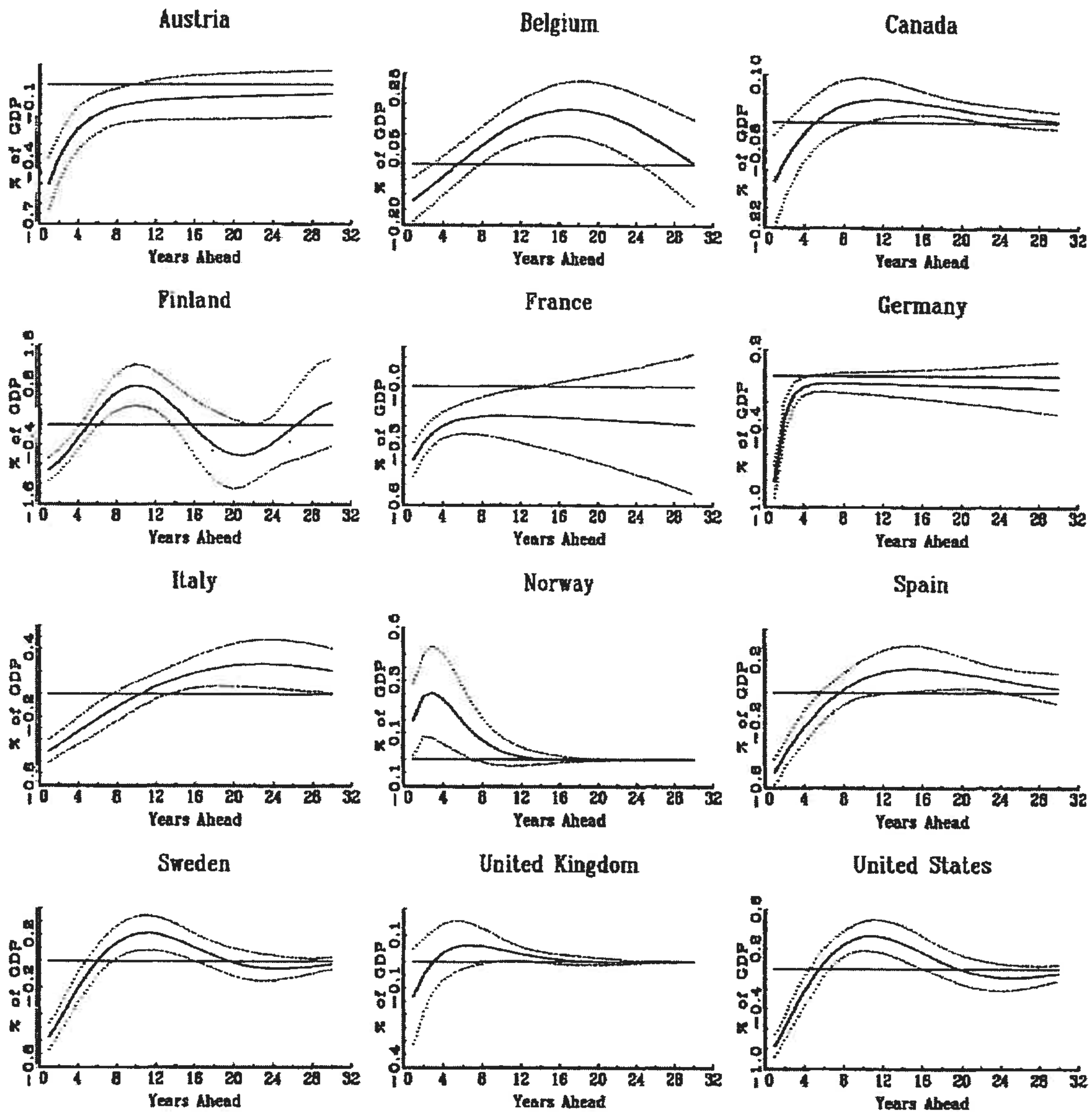

Fig 1.5 - Response of Primary Surplus to a Debt Innovation.

[16]For the United States, the primary surplus is available only since 1959. Consequently, the US sample for this VAR is slightly shorter than the one used to obtain previous empirical results. For all countries, the surplus measure includes interests payments on debt. This biases the results against the finding that an increase in current government debt means future increases in the primary surplus. The reason is that an increase in current debt also entails an increase in future interest payments and a proportional decrease in the government's surplus as recorded by the IFS.

The responses of the primary surplus following an innovation in government debt of 1 per cent of GDP are plotted in Figures 1.5. The dotted lines are asymptotic 95 per cent confidence intervals. The initial response of the primary surplus is usually negative and statistically different from zero. Thereafter, the primary surplus increases over time and becomes positive after 5 to 10 years following the debt shock. In most cases, this positive response becomes statistically different from zero at some point in the 10 to 20 year horizon. This result is consistent with view that the fiscal authority increases future taxes and/or reduces future expenditures to back newly issued debt. Exceptions are Austria, France, and Germany, where the point estimate of the impulse response is still negative (though not statistically significant) after 30 years, and Norway, for which the response is always positive. These results are in line with previous work by Bohn (1998) and Canzoneri, Cumby, and Diba (2001). Bohn finds for the United States that an increase in government debt by $100 leads to an increase in the primary surplus by $5.40 in the following year. Canzoneri, Cumby, and Diba (2001) use impulse-response analysis to examine the response of U.S. government debt to a positive innovation in the primary surplus (including seigniorage revenue) and report a negative, persistent, and statistically significant debt response that is explained as the government's paying off some of its previously accumulated debt.

1.4 Conclusions

This paper uses a simple infinite-horizon monetary economy to study how fiscal and monetary policy interact to determine the aggregate price level. The government behaviour is summarized by a long-run fiscal policy rule, where a fraction of the outstanding debt is backed by the present discounted value of current and future primary surpluses. The remaining debt is backed by the present discounted value of current and future seigniorage revenue. Economies may thus be indexed by the fraction of the debt backed by the fiscal authority. Only in the polar Ricardian regime, where the debt is fully backed by fiscal policy, the price level is determined by the stock of money alone. More generally, the proportion of debt backed by money behaves like money itself for the purpose of determining the price level.

Simple unit root econometrics techniques can be employed to identify the parameter that indexes the policy regimes from the long-run dynamics of nominal money stock, consumption, and government debt. Results from OECD economies suggest that a Ricardian regime is a reasonable approximation for these countries. This finding implies that (*i*) the fiscal authority backs all outstanding debt, and (*ii*) debt plays only a minor role in the determination of the price level. Consistency checks based on impulse-response analysis are roughly in agreement with the main empirical results.

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Chapitre 2

Endogenous Borrowing Constraints and Consumption Volatility in a Small open Economy

2 Endogenous Borrowing Constraints and Consumption Volatility in a Small open Economy

2.1 Introduction

The purpose of this paper is to study the differences in consumption volatility observed in the data from emerging and developed small open economies. As a general rule, empirical evidence from business cycle statistics across countries suggests that economic activity is more volatile in emerging economies than in developed ones. In particular, the data show that output volatility is higher in the former than in the latter. Considering that output volatility may be interpreted as the underlying volatility of the economy, it is not a surprise that most macroeconomic variables, including private consumption, also tend to be more volatile in emerging economies. However, and more importantly for the purposes of this paper, standard business cycle statistics show that, even if one controls for the output volatility, the (relative) volatility of consumption is still higher in emerging economies than in small open developed economies.

Section 2 of this paper presents empirical evidence of consumption and output volatilities for two groups of small open economies. For a sample of 24 emerging economies, and 17 small open developed economies, the volatility of consumption relative to output volatility is, on average, 30% higher in the emerging economies' subsample. These findings are robust to the sample period as well as to the data frequency, and confirm the results implied by studies containing business cycle statistics for developed economies [Cooley and Prescott (1995), for the United States; Mendoza (1991), for Canada; Correia, Neves, and Rebelo (1995), for Portugal] and emerging economies [Mendoza (2001), for Mexico; Neumeyer and Perri (2004), and Aguiar and Gopinath (2004), for Argentina].

It has been shown [Neumeyer and Perri (2004); Calvo, Leiderman, and Reinhart (1993)] that the excess volatility of business cycles in emerging economies may have a lot to do with a possible dominant role played by external shocks that affect these economies.[1] However, in the context of a small open economy model, one natural theoretical explanation for the differences in volatility is that, perhaps, the two groups of countries, emerging and developed economies, are subject to different external constraints in terms of their ability to borrow in the international capital markets. The obvious intuition on the relationship between borrowing constraints, including the type of constraint discussed here, and the volatility of consumption, is that they may limit consumption smoothing by risk-averse agents and produce a more volatile consumption path.

[1] Neumeyer and Perri (2004), using Argentina as a benchmark, stress the important role that shocks to the idiosyncratic interest rate (international interest rate plus a country risk factor) may play on the business cycle volatility in emerging economies. Calvo, Leiderman, and Reinhart (1993), on the other hand, suggest that external factors, such as macroeconomic variables in the United States, and capital flows in particular, may be very important to account for macroeconomic developments in Latin America.

If, in fact, emerging markets are different from developed economies in that they have a lower ability to use international credit markets to smooth consumption, then the data should reveal noticeable differences in consumption volatility in those two groups of countries, as seems to be the case.[2] This empirical evidence has one important implication for the use of theoretical models applied to the study of emerging economies. If one wants to explain the high volatility observed in their business cycles, particularly in consumption, then this external borrowing constraint has to be taken into consideration and the typical assumption of unlimited access to perfect world capital markets, which is implausible in this context, must be abandoned. That is precisely the spirit of the theoretical model discussed here.

The paper is concerned with answering the following question: how much of the observed differences in relative consumption volatility in the data from small open emerging and developed economies can be accounted for by a borrowing constraint alone?

More specifically, in order to account for the facts, the paper proposes a dynamic general-equilibrium model featuring two goods (tradable and non-tradable goods) in an endowment economy that is subjected to two kinds of imperfections in international capital markets: (i) the lack of any contingent assets (incomplete markets), and (ii) a financial friction that may restrict international borrowing. The financial friction considered here is an endogenous borrowing constraint in the tradition of Eaton and Gersovitz (1981) [see also Kletzer (1984)], which has been recently discussed in the international macroeconomics literature [Arellano (2004); Aguiar and Gopinath (2004)]. In their paper, Eaton and Gersovitz are motivated by the apparent paradox of why sovereign governments ever choose to repay their debt even when there is no credible enforcement mechanism in the international markets. Although there is some controversy [Bulow and Rogoff (1989)], their answer to the "paradox" is that the threat of financial autarky induces sovereign governments to make repayments on their foreign debt in order to preserve a "reputation collateral" needed for future borrowing [see also Cole and Kehoe (1995, 1998); Cole, Dow, and English (1995); Grossman and Han (1999)]. Borrower countries know that if they default, lenders will be less willing to lend to them in the future. The potential exclusion from future borrowing is a cost to a small open economy populated by risk-averse agents because, in financial autarky, their abil-

[2] The proposition that access to international capital and credit markets is more restricted for emerging economies in comparison to, say, OECD countries does not seem very difficult to accept. Although there is no direct evidence of that, one could mention the lower credit ratings and the higher interest rates paid by emerging economies on their sovereign debt as indirect evidence that they are more likely to be credit constrained than developed economies. Events such as the Asian crisis during the late nineties, the frequent balance-of-payments crises experienced by emerging economies that usually trigger bailouts from the IMF, and their not uncommon decisions to default on their external debt (the most recent being Argentina's default in 2002), in a sense, could also be thought of as indirect evidence that emerging economies are different in their access to international capital markets. Not surprisingly, those events gave enough motivation for a growing literature that deals with the specificities of emerging markets in explaining, among other things, how changes in their access to international credit may affect the domestic economies in various dimensions. This literature includes papers on currency crises [Eichengreen, Rose, and Wyplosz (1995); Kaminsky, Lizondo, and Reinhart (1997); Frenkel and Rose (1996)], balance-of-payments crises [Kaminsky and Reinhart (1999); Calvo and Vegh (1999); Edwards (2001)], and "sudden stops" [Calvo (1998a,b); Calvo and Reinhart (1999)].

ity to smooth consumption over time and over different states of nature is compromised. Default occurs whenever the present value of the (instantaneous) benefits of not paying the due services of the external debt outweighs the (intertemporal) losses in utility that will take place during an autarky state. International lenders, aware of the potential for debt repudiation, will set in motion a defensive rule to receive back the full amount of any conceded loans, including interests at the international interest rate, in all states of nature, and will never lend funds in excess of the level of credit that leaves the borrower country exactly indifferent between defaulting and fully repaying its debt.

Although some aspects of the more volatile economic fluctuations verified in emerging economies have already been studied in the literature on emerging markets' crises, a systematic attempt to explain the differences in relative consumption volatility observed in the data from emerging and developed small open economies, using a non-ad hoc, endogenous borrowing constraint, has not yet been done. Using data for 1994Q1–2000Q2 from some emerging and developed countries, Neumeyer and Perri (2004) present a broader set of facts about business cycle volatility, including information on relative consumption volatility. They find the average relative consumption volatility for their sample of emerging economies to be 78.2% higher than that of Canada, which is in line with the evidence presented in section 2 of this paper. However, their explanation for the facts relies on an exogenous stochastic process for the idiosyncratic international interest rate faced by the small economy. The exogenous positive shocks on the interest rate could be interpreted as a more stringent borrowing constraint that imposes additional costs to smoothing consumption through borrowing in the international capital markets, but the mechanism does not result from optimizing behaviour on the part of lenders or borrowers.

Mendoza (2001) uses an ad hoc borrowing constraint to explain "sudden stops" in capital flows to emerging economies. The constraint takes the form of a collateral, whereby the country must commit a constant (exogenous) proportion of its output before contracting any external credits. Although his model is successful in explaining the abrupt swings in capital inflows to the small emerging economy, it generates an insignificant difference in the relative volatility of consumption between the economies with and without the financial constraint.

Borrowing constraints are a way to ration out the amount of credit available to a particular economy through restriction in quantities. One could also think that, in reality, not only the quantity of credit is to be directly rationed, but the prices (i.e., the idiosyncratic interest rate that the country pays on its debt) must impose additional restrictions on the equilibrium amount of debt. One approach that allows for the interest rate on the external debt to be endogenously determined, along with the level of debt, in a model with the same kind of borrowing constraint used in this paper, is pursued by Arellano (2004) and by Aguiar and Gopinath (2004). They use the same insights that motivated this paper's endogenous borrowing constraint (in their case, to generate a positively sloped "supply of debt"), in a model that allows for default to occur in equilibrium. However, these papers do not discuss how the same model would behave without the financial constraint, nor do they try to explain the potential differences in the relative consumption volatility in constrained and unconstrained economies.

Economists have been trying to understand why emerging economies are so vulnerable to all sorts of crises, from balance-of-payments' crises and sudden stops to banking crises and currency crashes. Although the profession's explanations about the underlying mechanisms of these events have improved over the past two decades, no definitive answer has yet been presented. It is likely that the road map to a more complete understanding of these phenomena includes a clear identification of the particularities, if any, that emerging economies have in comparison with the developed world. In this sense, because it explicitly proposes an explanation to an important aspect of the differences between emerging and developed economies, the paper makes a clear contribution to the literature on emerging economies.

The rest of this paper is organized as follows. Section 2 discusses evidence of the differences in output and consumption volatility in small open economies, divided into "emerging" and "developed" groups. Section 3 presents the theoretical model featuring the endogenous borrowing constraint. Section 4 discusses of the numerical solution of the model, its calibration, and some simulation results. Section 5 concludes.

2.2 Consumption Volatility Across Emerging and Developed Economies

Table 2.1 displays evidence of the higher ratio of consumption volatility to output volatility, at business cycle frequencies, in emerging economies vis-à-vis small open developed countries. The table is constructed from quarterly data on real output and real private consumption (as deflated by the consumer price index),[3] for 24 emerging economies and 17 small open developed economies. The sample of countries is selected according to data availability for a relatively long period (ending in 2001Q4). All data, computed in per capita values at constant 1995 prices, come from the International Monetary Fund's *International Financial Statistics* (IMF/IFS) dataset, with the exception of Brazilian and Argentinian data, which come from national sources.[4] The series were transformed previously to the computation of their second-moment statistics, as follows. First, all the variables were expressed in logarithms. Second, a seasonal adjustment on the log variables was implemented using the multiplicative ratio-to-moving-average method. Finally, a smooth trend was subtracted

[3]Typically, in the real business cycle literature, statistics on consumption exclude the consumption of durable goods (since it behaves closely to investment, being more volatile). We could not yet find the required information to do the same here. Probably, for the same reason, Neumeyer and Perri's (2004) similar empirical exercise considered only total consumption. A potential problem of this procedure would arise if, for instance, durable consumption accounts for a higher proportion of the total consumption in emerging economies than in developed countries.

[4]Argentinian data come from the *Dirección Nacional de Cuentas Nacionales* (DNCN) and Brazilian data are collected from the *Instituto de Pesquisa Economica Aplicada* (IPEA) at <http://www.ipeadata.gov.br> and from the Central Bank of Brazil. Both datasets are consistent with IMF/IFS's data, when they happen to overlap.

using the Hodrick-Prescott filter with a smoothing parameter of 1600 for quarterly data.

Table 2.1

Output and Consumption Volatility: Cross-Country Differences

Emerging Economies					Small Open Developed Economies				
Country	σ_c (%)	σ_y (%)	σ_c / σ_y	Data (Start)	Country	σ_c (%)	σ_y (%)	σ_c / σ_y	Data (Start)
Bulgaria	15.17	12.42	1.221	1994Q1	Austria	2.51	2.05	1.219	1980Q1
Lithuania	6.97	4.20	1.657	1993Q1	Norway	2.38	1.75	1.366	1980Q1
Latvia	6.69	5.09	1.316	1992Q1	UK	1.90	1.56	1.219	1980Q1
Ecuador	6.16	2.45	2.503	1991Q1	Italy	1.50	1.02	1.470	1980Q1
Argentina	5.61	5.34	1.051	1980Q1	Netherlands	1.45	1.14	1.269	1980Q1
Malaysia	5.34	3.52	1.528	1991Q1	Spain	1.42	1.13	1.257	1980Q1
Indonesia	5.22	4.20	1.242	1990Q1	Finland	2.22	2.47	0.898	1980Q1
Turkey	5.14	4.41	1.166	1987Q1	Ireland	1.99	2.01	0.993	1997Q1
Thailand	4.96	4.63	1.071	1993Q1	Sweden	1.86	1.88	0.990	1980Q1
Mexico	4.92	2.66	1.847	1980Q1	Denmark	1.62	1.63	0.992	1987Q1
Brazil	3.86	2.95	1.308	1980Q1	Canada	1.46	2.17	0.671	1980Q1
Croatia	3.52	2.58	1.782	1997Q1	New Zealand	1.38	1.60	0.864	1987Q1
Estonia	3.13	2.74	1.143	1993Q1	Portugal	1.32	1.70	0.780	1988Q1
Slovak Rep.	3.00	1.45	2.061	1993Q1	Australia	1.03	1.46	0.705	1980Q1
Malta	2.81	2.40	1.170	1992Q1	Switzerland	0.99	1.37	0.722	1980Q1
Czech Rep.	2.68	2.45	1.097	1994Q1	France	0.98	1.23	0.905	1980Q1
Hungary	2.64	2.23	1.186	1995Q1	Belgium	0.97	1.37	0.705	1980Q1
South Africa	2.38	1.82	1.310	1980Q1					
Colombia	2.34	2.03	1.153	1994Q1					
Slovenia	2.12	1.11	1.908	1993Q1					
Poland	1.45	1.21	1.203	1995Q1					
Peru	6.33	6.38	0.993	1980Q1					
South Korea	4.59	4.93	0.931	1980Q1					
Phillipines	3.47	3.91	0.888	1981Q1					
Emerging	**4.60**	**3.63**	**1.27**		**Developed**	**1.59**	**1.62**	**0.98**	

From Table 2.1 it seems clear that:

(i) The volatility of the gross domestic product (GDP), denoted as σ_y in Table 2.1, is more than twice as high in emerging economies compared with the developed economies. The averages are 3.6% and 1.6%, respectively.

(ii) The consumption volatility (σ_c) is also higher in emerging economies. On average, σ_c is almost three times as high in emerging economies. Given the results for the output volatility, this is not a surprise, since σ_y may be interpreted as the underlying volatility of the economy, affecting the volatility of all other variables.

(iii) The relative volatility of consumption tends to be higher than 1 in emerging economies (the only three exceptions are Peru, South Korea, and the Philippines) and lower than 1 in developed economies (six exceptions in the sample). The ratio between the average σ_c and the average σ_y is 30% higher in emerging economies in comparison with developed economies (1.27 against 0.98).

Table 2.2 displays the results of four tests of equality of means for $X = \sigma_c$, σ_y, and σ_c/σ_y, between the two groups of countries. Columns 2 and 3 refer to the test of the null hypothesis $H0 : mean\,(X_{emerging}) = mean\,(X_{developed})$, against the alternative $H1(a) : mean\,(X_{emerging}) \neq mean\,(X_{developed})$, based on the ANOVA F-statistic.[5] Columns 4 and 5 also refer to the test of $H0$ against $H1(a)$, but using a simple t-statistic. Columns 6 and 7 consider t-tests of $H0$ against the alternative hypotheses $H1(b) : mean\,(X_{emerging}) > mean\,(X_{developed})$ and $H1(c) : mean\,(X_{emerging}) < mean\,(X_{developed})$, respectively.

First, consider the test of $H0$ against $H1(a)$. Note that the null hypothesis of equal means can be strongly rejected both according to the ANOVA F-test and the two-tailed t-test for all three variables. Second, regarding the one-tailed t-test of $H0$ against $H1(b)$, the null is also rejected for all variables at standard significance levels. Finally, the null cannot be rejected in the one-tailed t-test of $H0$ against $H1(c)$. The results suggest that the lower absolute and relative volatilities in emerging economies, as shown in Table 1, are statistically significant.

Table 2.2
Test of Equality of Means

		p-value		*p*-value		
X	Anova *F*-test	H1(a)	*t*-test	H1(a)	H1(b)	H1(c)
σ_c	19.8493	0.0001	2.0855	0.0436	0.0218	0.9782
σ_y	12.1626	0.0012	1.9186	0.0624	0.0312	0.9688
σ_c / σ_y	10.8192	0.0021	9.4615	0.0000	0.0000	1.0000

H0 : $mean(X_{emerging}) = mean(X_{developed})$
H1(a): $mean(X_{emerging}) \neq mean(X_{developed})$
H1(b): $mean(X_{emerging}) > mean(X_{developed})$
H1(c): $mean(X_{emerging}) < mean(X_{developed})$

The results shown above are also consistent with those obtained by Neumeyer and Perri (2004). They use basically the same sample period in a comparison between Argentinian and Canadian business cycles' statistics[6] and find similar qualitative results as those in Table 2.1. They also compare Canada with five emerging countries (Argentina, Brazil, Mexico, South Korea, and the Philippines) for the period 1994Q1–2000Q2 and, again, their results are in the same direction.

Table 2.3 displays the volatilities of output and consumption, as well as their ratio, reported in Neumeyer and Perri (2004) and in other selected studies. Note that the reported relative volatility of consumption confirms the higher volatility in small open emerging economies. The information in Tables 2.1, 2.2, and 2.3 seems to indicate that the basic result—a higher relative consumption

[5] This test is based on a single-factor, between-subjects analysis of variance (ANOVA). The basic idea is that if the subgroups have the same mean, then the variability between the sample means (between groups) should be the same as the variability within any subgroup (within group).

[6] Although we both use basically the same data, Newmeyer and Perry adjust the series of total consumption to include government consumption, changes in inventories, and a statistical discrepancy, in order to be consistent with the only available quarterly data for Argentina previous to 1993. Here, I use the information on annual series for Argentina to exclude these items from the total consumption previous to 1993, by assuming that the same proportions observed in annual data are verified in all quarters of a given year.

volatility in emerging economies in comparison with developed economies–is robust to the sample of countries, frequency of the data, and sample period.

Table 2.3
Examples of Output and Consumption Volatility Statistics in the Literature

United States	σ_y (%)	σ_c (%)	σ_c/σ_y	Data
Cooley and Prescott (1995)	1.72	1.27	0.74	1954Q1-1991Q11

Small Open Developed Economies	σ_y (%)	σ_c (%)	σ_c/σ_y	Data
Canada: Mendoza (1991)	2.81	2.46	0.88	1945-1985
Portugal: Correia, Neves, and Rebelo (1995)	3.78	3.17	0.84	1958-1991
Canada: Neumeyer and Perri (2004)	1.17	1.02	0.87	1994Q1-2002Q2

Emerging Economies	σ_y (%)	σ_c (%)	σ_c/σ_y	Data
Mexico: Mendoza (2001)	2.73	3.35	1.23	1980Q1-1997Q4
Average of 5 EE: Neumeyer and Perri (2004)	2.94	4.62	1.57	1994Q1-2002Q2
Argentina: Aguiar and Gopinath (2004)	4.08	4.86	1.19	1983Q1-2000Q2

The next section discuss a possible theoretical explanation for this empirical evidence.

2.3 The Model

In this section, a dynamic general-equilibrium model of a small open economy is presented. The model departs from traditional small open economy models with perfect capital mobility in that it allows for the possibility that the economy can choose optimally between defaulting or repaying its external debt. This feature introduces an endogenous borrowing constraint in the tradition of Eaton and Gersovitz (1981) and Kletzer (1984).

Consider a small open economy, where a central planner seeks to maximize the lifetime utility of a representative agent. The agent enjoys utility from a consumption index, c_t, which is a composite of the consumption of tradable (c_t^T) and non-tradable goods (c_t^N). There is no production and the agent receives an endowment of non-tradable goods (Y^N), assumed constant for simplicity, and an endowment of tradable goods, $Y_t^T = Y^T + z_t$, which randomly fluctuates around the average level, Y^T, according to a stochastic process for the production shock, z_t.

International asset/capital markets are incomplete and no contingent contracts are signed.[7] At

[7] Kehoe and Levine (1993) discuss endogenous borrowing constraints with complete markets. The assumption of incomplete markets seems to better fit the evidence that countries tend to default during recessions. With the insurance given by contingent assets, agents tend to leave the credit contract (that is, to default) during "good times," when they have to make payments, as opposed to the "bad times," when they receive the insurance.

the beginning of every period t, the economy inherits a one-period external debt, d_{t-1}, expressed in units of the tradable good, contracted at $t-1$ at the exogenous foreign interest rate, r, and realizes the levels of the endowments. Denote $S(d_{t-1}, z_t) = \{d_{t-1}, z_t\}$ to be the current state of the economy, at time t. Once $S(d_{t-1}, z_t)$ is known, the central planner decides whether the outstanding debt, including interest services, $(1+r)\, d_{t-1}$, is going to be paid or defaulted. The central planner's decision about the full repayment of the external debt is based on the relative incentives to do so, as follows. The cost of defaulting at time t is to stay out of the international capital markets from t onwards, renouncing the possibility of using international borrowing to smooth consumption.[8] Implicitly, we are assuming that default against one lender is taken as a signal by all other international lenders and that they will not only exclude the defaulting country from borrowing again, but will seize its assets if the country eventually tries to invest any assets in another international financial institution. Given the current state, let V_t^D and V_t^R be the indirect utility of defaulting at t (and having to consume the endowments Y^N and Y_t^T from this time onwards), or of fully repaying the external debt and continuing to be able to borrow abroad. Default at time t is chosen by the country whenever $V_t^D > V_t^R$.

The international capital market consists of lenders who want to receive back the full amount of their loans in all possible states of nature. The directive proposed here is to find a borrowing constraint that, at each date and state, will induce the country to participate in the asset market, instead of defaulting. One could think of the international lenders as a representative international investor, or an outside foreign agency, that has full information about the domestic economy (for instance, its current state and the specification of the borrower/consumer's preferences) and the borrower's optimization problem. The only role played by the foreign agents is to set up and enforce the credit limits. Should the sovereign country default on its external debt, the "agency," or the pool of investors, would exclude it from intertemporal asset trading forever and, as a result, the country would be deprived of the risk-sharing opportunities in the future. Aware of potential debt repudiation, in order to prevent default, the foreign agents will impose a borrowing constraint to the small economy, by not lending any amount of funds that makes the planner choose default over repayment. That is, the external investors will set the credit limit such that the borrower's expected lifetime utility from participating in the asset market is at least as high as that of staying in financial autarky, where the country consumes its exogenous endowment output.

If $\overline{d}$ is the maximal amount of funds that the domestic economy can borrow without triggering the strategy of optimal default (that is, $\overline{d}$ is such that $V_t^D \leq V_t^R$), at every period t, then the domestic economy is constrained to borrow $d_t \leq \overline{d}$. In order to assure repayment in all states of

[8] The assumption that countries that default will stay out of the international capital markets forever is clearly at odds with the evidence that shows many of defaulting countries are able to borrow again after some renegotiation of their debts. In terms of the model presented in this paper, this assumption means, perhaps, a higher penalty for defaulting countries than what actually occurs. The standard and simple way of dealing with this issue [Arellano (2004)] is to introduce an exogenous probability of leaving the default state at each period.

nature, Zhang's (1997) approach is adopted by considering the worst-case scenario for the foreign lenders to define the critical level of borrowing that triggers default, given the state $S(d_{t-1,}z_t)$.

We assume that the lifetime utility of the representative agent is given by:

$$V_0 = \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t), \tag{1}$$

where $u(\cdot)$ is concave, strictly increasing, and twice continuously differentiable; $\beta \in (0,1)$ is the subjective discount factor and c_t is a consumption index, assumed to be a constant elasticity of substitution (CES) aggregator of the consumption of tradables and non-tradables, with elasticity of substitution between c_t^T and c_t^N given by $1/(1+\mu) > 0$, and the weight of tradables in the index equal to $\omega \in [0,1]$:

$$c_t = \left[\omega \left(c_t^T\right)^{-\mu} + (1-\omega)\left(c_t^N\right)^{-\mu}\right]^{-\frac{1}{\mu}}. \tag{2}$$

The economy is subject to two resource constraints, one for each type of good. For the non-tradable good, the constraint means that the economy has to consume the endowment:

$$c_t^N = Y^N. \tag{3}$$

In contrast to Bulow and Rogoff (1989), this paper accepts the notion that default on the external debt precludes a sovereign government not only of borrowing internationally, but also excludes the country from investing its accumulated assets in the international market in the form of bank accounts, treasury bills, stocks, and other state-contingent assets, without the risk of having those assets seized by international financial institutions or governments. This assumption assures a support for a positive external debt in equilibrium.[9] However, as shown by other empirical studies that use the same type of borrowing constraint considered here [Arellano (2004); Aguiar and Gopinath (2004)], for reasonable values of the structural parameters on a dynamic general-equilibrium model applied to a small open economy, the threat of autarky, although capable of producing a positive amount of debt in equilibrium, cannot generate the levels of debt-output ratio observed in actual indebted economies. For this reason, the model imposes an extra penalty to the defaulting country, which could be motivated by "the common view that after default there is a disruption in the countries' ability to engage international trade, and this reduces the value

[9] Bulow and Rogoff (1989, p. 43) have shown that "under fairly general conditions, lending to small countries must be supported by the direct sanctions available to creditors, and cannot be supported by a country's reputation for repayment"; i.e., the penalty of no further borrowing would not deter repudiation and, consequently, a sovereign could not issue any uncollateralized debt. Bulow and Rogoff's result depends crucially on the controversial assumption that repudiation of debt does not mean that the defaulting country is to be cut off from international capital markets entirely and may keep on participating as a creditor without fearing that its assets would be seized by foreign financial institutions or governments. However, as Cole and Kehoe (1995, 1998) point out, that result has the counterfactual implication that the only explanation of why countries do not default is that there are large direct sanctions for doing so. English (1996) shows historic evidence suggesting that direct sanctions cannot explain why sovereign governments repay their debts.

of output" [Cole and Kehoe (1998)]. We assume that, in the case of default, there is an output loss factor of $(1-\lambda)$, for $\lambda \in [0,1]$, that corresponds to the negative effects that the default state causes in the country's international trade.[10] Thus, in case of default, the resource constraint for the non-tradable good is:

$$c_t^N = \lambda Y^N. \tag{4}$$

For the tradable good, the resource constraint, in case of full repayment, means that the economy keeps the ability to borrow from international lenders, and it is given by:

$$c_t^T = Y^T + z_t + d_t - (1+r)\, d_{t-1}. \tag{5}$$

In case of default, the economy does not have to pay $(1+r)\,d_{t-1}$, but cannot contract d_t and must operate in financial autarky from t onwards. The resource constraint then implies that the consumption of tradables is to be restricted to the stochastic tradable output minus the default-state output loss:

$$c_t^T = \lambda\left(Y^T + z_t\right). \tag{6}$$

The process for the shock z_t is assumed to follow a first-order Markov chain with transition probabilities given by $f\left(z_t | z_{t-1}\right)$ and compact support. The finite support for z_t allows the use of Zhang's (1997) approach, as mentioned above:

$$z_t \in \Omega_Z = \left[z_{\min}, z_{\max}\right]. \tag{7}$$

The central planner's problem is to maximize the objective function given by equation (1) subject to (2)-(7), a standard no-Ponzi-game condition, and to the following borrowing constraint:

$$d_t \leq \overline{d},$$

where:

$$\overline{d} = \min_{\Omega_Z}\left\{\overline{d}_t\left(z_t\right) : V_t^R\left(\overline{d}_t\left(z_t\right), z_t\right) = V_t^D\left(z_t\right)\right\}.$$

The constraint described above represents a way of capturing the widespread notion that borrowers face credit limits in reality and, as such, its use in economic models can mimic important features of the real world. Borrowing constraints are typically needed to prevent default and Ponzi schemes (a "natural" borrowing constraint), and to ensure the existence of equilibrium for incomplete-markets economies. However, the borrowing constraints used in the literature are often specified arbitrarily outside economic models. The borrowing constraints used in most studies take the form of a lower bound on an investor's bond holdings, which is a certain percentage of total

[10] Chuhan and Sturzenegger (2003) find that the per cent contraction in output in Latin America, following the default episodes in the 1990s, was 2 per cent.

income that is independent of the investor's individual characteristics and income streams that in reality are important factors in determining the borrowing limit.[11]

Notice that the borrowing constraint defined above depends not only on the country's representative agent's characteristics, such as time preference rate, risk aversion, and elasticity of substitution between the consumption of tradable and non-tradable goods, but also on the representative agent's exogenous endowment income stream, here completely determined by the shock z_t. Because the constraint can be interpreted as the borrowing limit such that an investor will not default and live in autarky, Zhang (1997) refers to it as the "no default borrowing constraint." In terms of this paper, it is assumed that emerging economies (given their history and, likely, their experienced default episodes) face this type of borrowing constraint while developed economies do not. Although it is not a feature of the model, one could think of "reputation" as an additional state variable and consider that, at this particular point in time, developed economies have a higher "stock of reputation" than emerging economies—higher enough to signal a very low propensity to default.

One can explore the recursive form of the problem. In terms of notation, henceforth the time subscript t is dropped from the (indirect) utility functions V^D, V^R, and V, which are going to represent time-invariant value functions. Considering the CES consumption index in (2) and using the resource constraints for the tradable and non-tradable goods, one can denote the instantaneous utility function, $u(c_t) = u\left(c_t^T, c_t^N\right)$, by:

$$u\left(c_t^T, c_t^N\right) = u\left(\lambda\left(Y^T + z_t\right)\ ; \lambda Y^N\right),$$

in case of default, and

$$u\left(c_t^T, c_t^N\right) = u\left(Y^T + z_t + d_t - (1+r)\, d_{t-1}\ ; Y^N\right),$$

in case of full repayment.

Let z_t and d_{t-1} be in Ω_Z and $D = \{d : d_{\min} \leq d \leq d_{\max}\}$, respectively. Conditional on the state variables in $S(d_{t-1}, z_t)$, and given the Markov process governing the shock, the central planner's problem can be expressed in recursive form as:

$$V^D(z_t) = u\left(\lambda\left(Y^T + z_t\right)\ ; \lambda Y^N\right) + \beta \mathrm{E}_z V^D(z_{t+1})$$

[11]Examples of models with ad hoc borrowing constraints include Aiyagari and Gertler (1991), Telmer (1993), and Lucas (1994), in the context of using incomplete markets with borrowing constraints in order to resolve the "equity premium puzzle." In the international macroeconomics literature, examples of the use of ad hoc borrowing constraints include Mendoza (2001) and other papers in the "sudden stop" literature, as mentioned in footnote 2.

in case of default, and as the solution to the following Bellman equation:

$$
\begin{aligned}
&V^R(d_{t-1}, z_t) = \max_{(d_t)} \left\{ u\left(Y^T + z_t + d_t - (1+r)\, d_{t-1}\ ; Y^N\right) + \beta \mathrm{E}_z V(d_t, z_{t+1}) \right\} \\
&st : d_t \leq \overline{d} = \min_{\Omega_Z} \left\{ \overline{d}(z_t) : V^R\left(\overline{d}(z_t), z_t\right) = V^D(z_t) \right\} \\
&\text{with } V(d_{t-1}, z_t) = \max\left\{ V^R(d_{t-1}, z_t), V^D(z_t) \right\}
\end{aligned}
$$

in case of full repayment.

The solution of the model consists of three objects: (i) a state-contingent optimal decision rule for the level of next-period debt[12] that depends on the current realization of the states, $d(d_{t-1}, z_t)$; (ii) a set of value functions $V^D(z_t)$, $V^R(d_{t-1}, z_t)$, and $V(d_{t-1}, z_t)$; and (ii) the level of the borrowing constraint, $\overline{d}$. Given the solution, the underlying probability distribution function of the production shock, jointly with the decision rule, determines the transition and limiting distributions of all endogenous variables in the model.

In the empirical application of the model, discussed in the next section, a constant relative risk-aversion (CRRA) specification for the instantaneous utility function:

$$
\begin{aligned}
u(c_t) &= \frac{c_t^{1-\gamma} - 1}{1-\gamma}, \text{ if } \gamma \neq 1 \\
&= \log(c_t), \text{ if } \gamma = 1
\end{aligned}
$$

is used, where $\gamma > 0$ is the (reciprocal) of the intertemporal elasticity of substitution on the consumption index (or the risk-aversion parameter).

The model also provides implications for the real exchange rate, as measured by the relative price of non-tradable with respect to tradable goods. In the model, the sectorial (shadow) prices are represented by the Lagrange multipliers on the respective resource constraints. At the optimum, there is an implied equation that links the real exchange rate to the $\left(c^T/c^N\right)$ ratio:

$$
p_t \equiv \frac{P_t^N}{P_t^T} = \frac{(1-\omega)}{\omega} \left(\frac{c_t^T}{c^N}\right)^{(1+\mu)}, \tag{8}
$$

where P_t^N and P_t^T are the Lagrange multipliers associated with the non-tradable and tradable resource constraints, respectively.

2.4 Numerical Solution, Calibration, and Simulation Results

Because the model developed in this paper does not have an analytical solution, we explore the recursive formulation of the central planner's problem to solve it numerically. We use the value function iteration method with discretization of the state-space $[D \times \Omega_Z]$, for which, given the

[12] Obviously, the decision rule for the dynamic path of d_t implies another, $c^T(d_{t-1}, z_t)$, for the consumption of tradable goods.

finite support Ω_Z for the shock, the limits $d_{\min}$ and $d_{\max}$ of the set $D = \{d : d_{\min} \leq d \leq d_{\max}\}$ are appropriately chosen to include the ergodic space.

The algorithm used in the numeric solution is the following. For each iteration j of the algorithm, given an initial guess for the borrowing constraint, $\overline{d}^{(j)}$, the model is solved and the value functions $V^{D(j)}(z_t)$ and $V^{R(j)}(d_{t-1}, z_t)$ are computed. During this step, every point in the decision rule $d^{(j)}(d_{t-1}, z_t)$ such that $d^{(j)} > \overline{d}^{(j)}$ is replaced by the critical level $\overline{d}^{(j)}$. After computing $V^{D(j)}$ and $V^{R(j)}$, an update of the borrowing constraint is obtained using

$$\overline{d}^{(j+1)} = \min_{\Omega_Z} \left\{ \overline{d}(z_t) : V^{R(j)}\left(\overline{d}(z_t), z_t\right) = V^{D(j)}(z_t) \right\}.$$

The procedure is implemented until convergence with $\overline{d}^{(j+1)} \simeq \overline{d}^{(j)}$.

The artificial economy is calibrated to match some aspects of the Brazilian economy during the period 1980Q1–2001Q4, when the net external debt (total debt minus international reserves) averaged $\theta_d = 28.34\%$ and reached a peak of 47.02% of the GDP,[13] which is roughly equivalent to two standard deviations from the mean. It is assumed that Brazil is an economy subject to a borrowing constraint like the one discussed in the previous section, and, as such, it could be used as a benchmark for the simulation exercise.

In order to calibrate the exogenous sectorial outputs, the procedure used here considers the tradable output share in total GDP observed in Brazil, $\theta_T = 29.05\%$, and normalizes the (deterministic) steady-state values of the tradable output and the relative price of non-tradables in terms of tradables to be $Y^T = 100$ and $p_{ss} = 1$, respectively. These figures imply: (i) that the value of the non-tradable output is $Y^N = 244.21$ and, given a debt-to-output ratio equal to the average value θ_d, (ii) that the level of debt (in units of tradable goods) at the steady state is $d_{ss} = 97.56$. In order to capture the potential movements of the simulated series of external debt, an evenly spaced $d-$grid of 800 points is constructed from the interval $[-100, 700]$, with negative values being assets instead of liabilities. Roughly, considering the total output at the steady state $\left(Y^T + p_{ss}Y^N = 344.23\right)$ as reference, the grid implies debt-output ratios in the range $[-0.29, 2.03]$.

For the discretization of the $z-$grid, the Markov chain is set to mimic a first-order autoregressive process of the type $z_t = \rho z_{t-1} + \varepsilon_t$, with $\varepsilon_t \backsim N(0, \sigma_\varepsilon)$, using Tauchen's (1986) procedure. The $z-$grid has five points, evenly spaced in the interval $[-17.11, 17.11]$ with an underlying matrix of transition probabilities given by:

$$\Pi = \begin{bmatrix} 0.3423 & 0.5984 & 0.0591 & 0.0002 & 0.0000 \\ 0.0467 & 0.5669 & 0.3744 & 0.0120 & 0.0000 \\ 0.0016 & 0.1611 & 0.6746 & 0.1611 & 0.0016 \\ 0.0000 & 0.0120 & 0.3744 & 0.5669 & 0.0467 \\ 0.0000 & 0.0002 & 0.0591 & 0.5984 & 0.3423 \end{bmatrix}.$$

[13] Actually, these figures refer to the period 1982Q4–2001Q4, since quarterly data on Brazilian external debt are not available for the whole period of reference.

Table 2.4 displays the values of the structural parameters used in the calibration exercise. The value for the reciprocal of the intertemporal elasticity substitution (or, equivalently, for the CRRA case, the risk-aversion parameter) is set to $\gamma = 1.5$, which is standard.[14] The exogenous interest rate is taken from what the Brazilian government pays in the international capital markets for its sovereign debt, as represented by the Federative Republic of Brazil's C bonds. Here, the idiosyncratic interest rate, r, is considered to be the quarterly equivalent of the average real annual rate on the U.S government bonds (4% per year, using the inflation rate on the consumer price index) plus the average spread paid on the C bonds (803.4 basis points).[15] Following the traditional hypothesis used in the small open economy literature, in order to avoid a unit root in the current account, the subjective discount factor has to satisfy $\beta(1+r) = 1$ and, thus, was set to $\beta = 0.9713$. It is worth mentioning that this value of β is consistent with estimations by Issler and Piqueira (2000) for the Brazilian economy.

Table 2.4
Summary of the Calibration Procedure

Parameter	Values	Target
1. Risk aversion	$\gamma = 1.5000$	Standard
2. Idiosyncratic interest rate	$r = 0.0295$	C bond spread over U.S. bonds
3. Subjective discount factor	$\beta = 0.9713$	$\beta(1+r) = 1$
4. Average tradable output	$Y^T = 100.00$	normalization
5. Constant non-tradable output	$Y^N = 244.23$	$\frac{Y^T}{Y^T + p_{ss}Y^N} = \theta_T = 29.05\%$
6. Elasticity of substitution between c^T and c^N	$\mu = 1.8750$	$\sigma_y = 2.95\%$
7. Weight of tradables in CES c aggregator	$\omega = 0.0659$	$p_{ss} = \frac{(1-\omega)}{\omega}\left(\frac{Y^T - rd_{ss}}{Y^N}\right)^{(1+\mu)} = 1$
8. Autocorrelation for z	$\rho = 0.6468$	OLS estimation
9. Std. dev. of the production shock z	$\sigma_\varepsilon = 4.3499$	OLS estimation
10. Output loss in state of default	$\lambda = 0.9750$	$avg\left(\frac{d_t}{Y_t^T + p_t Y^N}\right) \simeq \theta_d = 28.34\%$

The autocorrelation and volatility of the stochastic process of the z production shock is obtained from an ordinary least squares (OLS) estimation of the Hodrick-Prescott(HP)-detrended output of tradables against its one-period lagged value. Assuming that the output of tradables (Y_t^T) has a trend component (HPY_t^T) and a business cycle component with zero average (the production shock z), the following regression:

$$\left(Y_t^T - HPY_t^T\right) = k + \rho\left(Y_{t-1}^T - HPY_{t-1}^T\right) + \varepsilon_t$$

[14]For instance, the value used here is the mid-range value of two very common alternatives, $\gamma = 1.001$ or $\gamma = 2$, used by Greenwood, Hercovitz, and Huffman (1988) and Mendoza (1991), for example. Issler and Piqueira (2000) estimate $\gamma = 1.7$, using Brazilian data and the same type of utility function used in this paper. The results of the simulation of the model are virtually the same if one uses this value instead of $\gamma = 1.5$.

[15]For the average foreign real interest rate, the 10-year-maturity U.S. government bond is used, whose maturity is comparable with that of the C bonds. The average spread for the C bonds refers to the period 1995Q1–2001Q4, since data are not available before that.

is estimated, resulting in $\rho = 0.65$. and $\sigma_\varepsilon = 4.35$.[16]

The output loss in default states, $(1-\lambda)$, is calibrated to approximate the average level of debt-output ratio to the actual value ($\theta_d = 28.34\%$). Notice that the calibrated value $\lambda = 0.975$, which implies output losses of 2.5% during default states, is not very different from the empirical findings by Chuhan and Sturzenegger (2003), mentioned in footnote 10.

The less-straightforward parameters to calibrate are the weight of tradables in the CES consumption aggregator (ω) and the parameter governing the elasticity of substitution between the consumption of tradables and non-tradables (μ). Given equation (8) and the calibration procedure based on the deterministic steady state—at which the external debt-to-output ratio is constant at the average level, θ_d, the share of tradable output in total output is θ_T, and the real exchange rate is at the normalized level $p_{ss} = 1$– the following system of "steady-state" equations must be satisfied:[17]

$$\begin{aligned}
\theta_T &= \frac{Y_{ss}^T}{Y_{ss}^T + p_{ss}Y^N} \\
\theta_d &= \frac{d_{ss}}{Y_{ss}^T + p_{ss}Y^N} \\
c_{ss}^T &= Y_{ss}^T - rd_{ss} \\
p_{ss} &= \frac{(1-\omega)}{\omega}\left(\frac{c_{ss}^T}{c_{ss}^N}\right)^{(1+\mu)} = 1 \\
c_{ss}^N &= Y^N.
\end{aligned}$$

Given the above system of equations, the parameter ω can be expressed as a function of μ, as follows:

$$\omega = \left\{\left[\frac{\left(\frac{1}{\theta_T}-1\right)}{\left(1-\frac{r\theta_d}{\theta_T}\right)}\right]^{(1+\mu)} + 1\right\}^{-1}.$$

It should be noticed that, in principle, both parameters are important to the volatility of the real exchange rate. However, since the business cycle statistics are usually computed on the log variables, only μ will have an impact on the volatility of (the log of) p. For instance, by taking the logarithm on both sides of equation (8), it is easy to see that $VAR(\log p_t) = (1+\mu)^2 VAR(\log c_t^T)$, implying that the ratio between the volatilities of (the logs of) p_t and c_t^T, as measured by their standard deviations, must be constant and equal to $(1+\mu)$. Because of its effect on the volatility

[16] The estimated parameters (p-values in parentheses) are $\widehat{k} = 0.1240$ (0.846), $\widehat{\rho} = 0.6468$ (0.000), and $\widehat{\sigma}_\varepsilon = 4.3499$.

[17] Technically, because of the non-linear nature of the model, which in principle should induce agents to react asymmetrically to positive and negative shocks, a "deterministic steady state" may not be relevant to reflect the long-run "average" state of the system. Ideally, in this case, a more precise method of calibration should be carried out through the solution of the whole model for a given set of parameters (all of them), and successive improvements should be made until the target average values are obtained. However, this non-linearity does not seem to be important here and the calibration procedure used, based on a deterministic steady state, is able to generate the target averages quite accurately.

of p, the parameter μ has an influence in the volatilities of both total output, $Y_t^T + p_t Y^N$, and total consumption, $C_t = c_t^T + p_t c^N$. Among the different possible combinations of values for the two parameters that satisfy the above system of stationary equations, $\omega = 0.0659$ and $\mu = 1.875$ (which implies an elasticity of substitution between c^T and c^N equal to 0.35) are chosen in order to match the total output volatility, $\sigma_y = 2.95\%$, observed in the data (see Table 2.1).

Table 2.5 shows the average results of 500 simulations of a time series of size 88, which is the number of quarterly observations for the 1980Q1–2001Q4 period. The simulated series are transformed according to the same procedure used in the actual data, as discussed in the previous section. In terms of the model, σ_c represents the volatility of (the log of) total consumption (in units of tradable goods) as given by $C_t = c_t^T + p_t c^N$. Notice that the comparison between the models for the constrained and unconstrained (perfect capital mobility) economies shows that the type of borrowing constraint used here has the effect of increasing the relative consumption volatility from 0.554 to 0.644, a 16% increase. Considering that the average figure implied by the data from Table 2.1 is 30%, one could conclude that the borrowing constraint used here is capable of accounting for 55% of the difference in relative consumption volatility between emerging and developed economies.[18]

Table 2.5
Brazil - Output and Consumption Volatility Statistics

	σ_y (%)	σ_c (%)	σ_c/σ_y
Brazil (1980Q1–2001Q4)	2.95	3.90	1.308
Model (constrained)	2.95	1.90	0.644
Model (unconstrained)	2.60	1.44	0.554

Although the model manages to increase the relative consumption volatility, it is not able to reproduce both the actual absolute and relative levels of consumption volatility, and cannot account for the fact that consumption is consistently more volatile than output. Neumeyer and Perri (2004) attribute this excess volatility of consumption to the dominant role played by interest rate shocks in these economies. In an economy that faces both income and interest rate volatility, consumption will be smoother than income if the transitory production shocks are dominant, and the opposite happens if, instead, the interest rate shocks are dominant. In this model, the absence of shocks that affect consumption independently of output, such as interest rate shocks, makes it impossible for consumption to fluctuate more than output. For instance, interest rate shocks affect the intertemporal decisions of consumption/savings and act on the consumption growth rate, but

[18] The constrained economy is calibrated for Brazil, rather than for an "average" of emerging economies. However, the observed values of σ_c/σ_y in Brazil and in the average of emerging economies are 1.30 and 1.27, respectively (see Table 2.1). At least in terms of the relative volatility of consumption, Brazil can be considered a typical representative of the group of emerging countries. In addition, as will become clear in the next subsection, the results are quite robust to a sensitivity analysis that tests different calibrations.

have only second-order effects on the production side (in a production economy, *ceteris paribus*, the main effect would be inducing a substitution of capital by labour). Aguiar and Gopinath (2004) explain the fact that $\sigma_c/\sigma_y > 1$ in emerging economies by adding permanent shocks to the growth rate of productivity. Since the model is not capable of accounting for the absolute volatility of consumption observed in the data from emerging economies, other sources of consumption volatility that should play a major role in emerging economies, while not playing much of a role in developed economies, are clearly missing here.[19]

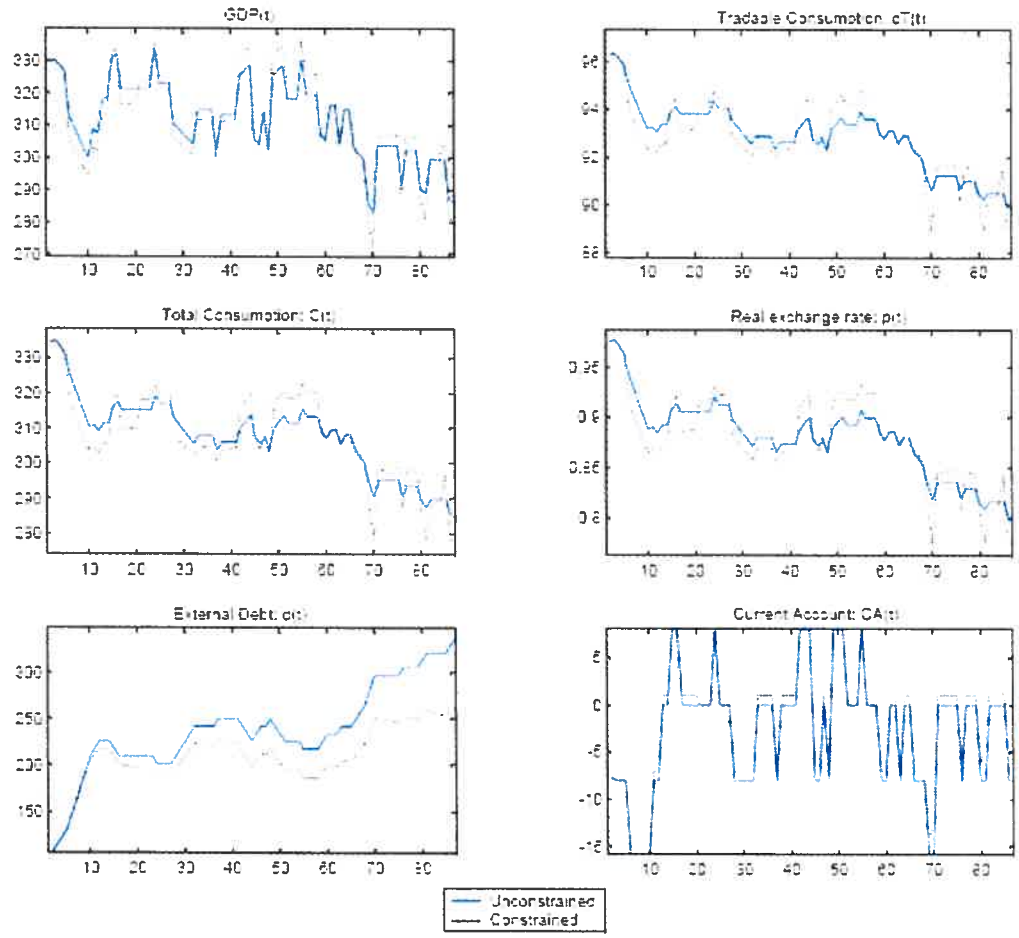

Fig. 2.1 - Simulated Series (unfiltered)

The results of one particular simulation are shown in Figures 1 and 2, for the unfiltered and HP-filtered simulated series. Notice that the model is capable of generating a pro-cyclical behaviour for the consumption series (both tradable consumption and total consumption) as well as for the

[19] These factors tend to be exogenously given. In order to properly assess the effect of the constraint alone, one would have to control for them anyway. The risk of not considering them is to miss some interactive effect between the exogenous factors and the endogenous borrowing constraint.

real exchange rate, as observed in the actual data from emerging economies [Arellano (2004)]. Also notice that the debt series in the constrained economy follows a similar path as in the unconstrained one, but at a lower level. This feature implies that the borrowing constraint affects the behaviour of the economy even when it is not binding. In terms of the supply of credits, the simple possibility of default means less credit to the small economy at all times. From the demand side, agents that consider the possibility of being credit constrained in the future will save more now (hence, less debt). The borrowing constraint will bind only when the cost of a bad production shock, in terms of reducing consumption today, is high enough to induce the agents to borrow up to the limit.

Finally, it should be mentioned that the simulated average of the debt-output ratio for the sample is 28.35% in the constrained economy, virtually identical to the actual average observed in Brazilian data. In addition, the level of the debt limit is such that it corresponds to 80.7% of the simulated average GDP. Notice that this level is well above the maximal level for the debt-output ratio observed in Brazil, in the period 1980Q1–2001Q4 (47.02%).

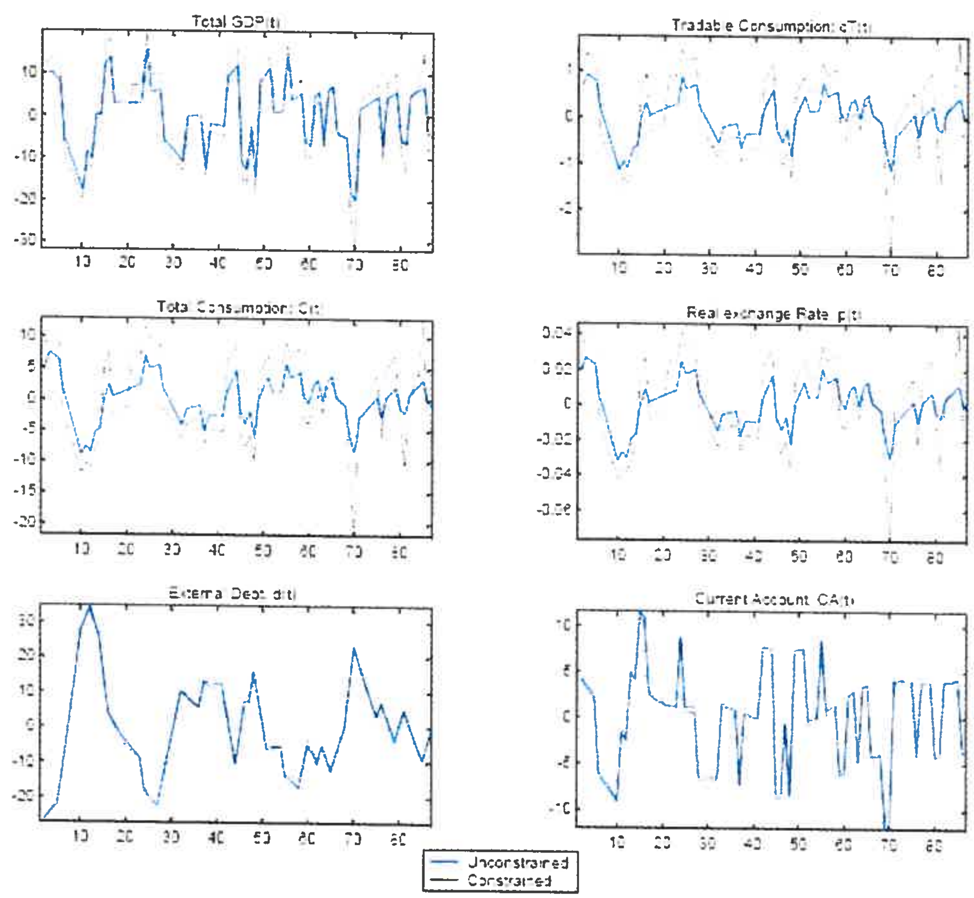

Fig. 2.2 - Simulated Series (HP-filtered)

2.4.1 Sensitivity analysis

Information displayed in Tables 2.6, 2.7(a), 2.8(a) and 2.9(a) shows how the model for a constrained economy behaves under different values of the structural parameters. The rows marked with a (*) refer to the baseline case. The columns in the tables, from left to right, provide information on the value of the relevant parameter (column 1), on the volatilities of output and consumption (columns 2 and 3, respectively), their ratio (column 4), the average level of debt as a percentage of the GDP (column 5), and the credit limit (column 6), both in level and as a percentage of the GDP (within parentheses). The tables also show the frequency at which the constraint binds (column 7) and a measure of the explaining power of the model (column 8). This measure of "success" is given by the proportion of the observed percentage difference in σ_c/σ_y from the data of emerging and developed economies (that is, the 30% gap between $\sigma_c/\sigma_y = 1.27$ in emerging countries, and $\sigma_c/\sigma_y = 0.98$ in developed economies) that is accounted for by the percentage difference in the relative consumption volatility obtained from the simulated model for the constrained and unconstrained economies. Tables 2.7(b), 2.8(b), and 2.9(b), in the appendix, show the results for the unconstrained economy.

Table 2.6
Constrained Model: Sensitivity to Changes in λ

λ	σ_y (%)	σ_c (%)	σ_c/σ_y	$avg\ d$ (% GDP)	$\bar{d}$ (% GDP)	% bind	"success" (%)
0.9725	2.88	1.80	0.625	30.18	300.5 (88.08)	0.22	43.5
*0.9750	2.95	1.90	0.644	28.35	279.5 (80.67)	0.31	55.2
0.9775	3.03	1.99	0.657	26.14	255.4 (73.51)	0.40	62.9
0.9800	3.11	2.10	0.675	23.10	229.4 (65.73)	0.51	74.2
0.9825	3.19	2.20	0.690	19.41	203.4 (57.92)	0.61	83.0
0.9850	3.29	2.32	0.705	15.43	177.4 (50.13)	0.71	92.5
0.9900	3.54	2.64	0.746	5.78	123.3 (34.15)	0.88	117.3
1.0000	4.83	4.12	0.853	-12.53	9.14 (2.42)	1.85	182.9

Note: Column 6 shows the borrowing constraint both in level and, inside the parentheses, as a percentage of the GDP.
(*): this row shows the baseline case.

Table 2.6 shows how the model for the constrained economy behaves under different values of the parameter λ, which represent the indirect costs of default. The economic principle at work is based on changes in the cost/benefit of defaulting. Notice that the credit limit $\bar{d}$ falls (rises) with increases (decreases) in the value of λ. In order to understand why this happens, one should recall that a higher (lower) value of λ means that the output losses during default states are less (more) important, which reduces (increases) the penalty for staying out of international capital markets. Thus, the higher the parameter λ is, the more likely are the domestic agents to default (because it costs less), *ceteris paribus,* and the more likely it is to trigger a defensive response from the external creditors, who will have to reduce their maximal level of conceded credits to avoid default. On the other hand, as λ decreases, it becomes more costly for the country to default and foreign investors can relax the borrowing constraint without fearing default.

Notice that as λ increases, and the constraint becomes more stringent, both output and consumption become more volatile, although the effect is more important on consumption, since the ratio σ_c/σ_y consistently increases. The intuition behind this result is that a lower credit limit imposes additional difficulties to risk sharing and consumption smoothing, causing the consumption of tradables to be more volatile. A more volatile c_t^T, in turn, reflects on a more volatile real exchange rate through equation (8).[20] Since total consumption is defined as $C_t = c_t^T + p_t c^N$, the more volatile consumption of tradables increases total consumption volatility directly and indirectly, through its effect on p_t (the effects cannot cancel each other, since c_t^T and p_t are positively correlated). The same is not true for total output $Y_t = Y_t^T + p_t Y^N$, which only suffers the effect of the more volatile real exchange rate.

Table 2.6 also shows that a higher λ induces a lower average level of debt-output ratio (which eventually becomes negative for the extreme value $\lambda = 1.0$) and, at the same time, increases the frequency at which the borrowing constraint binds, suggesting that the effect of an increasing λ is more important on reducing the credit limit $\overline{d}$ than on decreasing the domestic agents' borrowing motivation. One should expect that, as $\overline{d}$ is reduced, with incomplete markets, risk-averse agents would save more (hold less debt), because the risk of being credit constrained in the future is higher the lower the credit limit is.

Finally, notice that the explanatory power of the model would be improved if a higher value of λ were used, although the target values for the output volatility and debt-output ratio would be missed.

Table 2.7(a) shows that the results obtained for σ_y and σ_c in the benchmark (constrained economy) are relatively robust to changes in the coefficient of risk aversion, γ. In terms of the volatilities, observe that the results barely change (for σ_y) or are completely unchanged (σ_c) from the baseline case. The absolute value of the constraint, $\overline{d}$, is also the same. In addition, in terms of the "success" of the model in matching the data, no gain is possible by choosing alternative values for γ. There are a few changes, though. For instance, notice that as γ increases and agents become more risk-averse, given that markets are incomplete, they tend to save more or, equivalently, hold lower amounts of debt, since they become too scared of being credit constrained in the future. That explains why the average level of debt held by domestic agents falls with γ and, given that $\overline{d}$ remains unchanged, explains the reduction in the frequency at which the constraint is binding.

[20] Throughout the values of λ in Table 6, the volatilities of c^T and p rise monotonically from 0.7 per cent to 1.7 per cent and from 2.2 per cent to 5 per cent, respectively. This information is not displayed in the tables.

Table 2.7(a)
Constrained Model: Sensitivity to Changes in γ

γ	σ_y (%)	σ_c (%)	σ_c/σ_y	*avg d* (% *GDP*)	$\overline{d}$ (% *GDP*)	% bind	"success" (%)
0.50	2.95	1.90	0.644	28.58	279.5 (80.70)	0.33	53.7
1.00	2.95	1.90	0.644	28.44	279.5 (80.68)	0.32	53.7
*1.50	2.95	1.90	0.644	28.35	279.5 (80.67)	0.31	55.2
2.00	2.95	1.90	0.644	28.26	279.5 (80.66)	0.30	52.5
2.50	2.96	1.90	0.642	28.17	279.5 (80.65)	0.29	51.1
3.00	2.96	1.90	0.642	28.11	279.5 (80.64)	0.29	51.1
4.00	2.96	1.90	0.642	27.87	279.5 (80.61)	0.26	51.1

Note: Column 6 shows the borrowing constraint both in level and, inside the parentheses, as a percentage of the GDP.
(*): this row shows the baseline case.

On the other hand, one should also expect that more risk-averse agents would be less inclined to default, *ceteris paribus*, since they tend to care more about risk sharing, and the cost of defaulting and being deprived of risk sharing in the future becomes higher. In that case, agents do not want to default unless they hold a large amount of debt and/or are hit by a bad enough production shock. Since the cost of default increases for the country, the external investors may relax the credit limit and still receive back the conceded loans. Conversely, if agents have low risk-aversion, then they do not care very much about risk sharing in the future, which means that not paying back the debt becomes relatively attractive, forcing the external investors to make the borrowing constraint more stringent to avoid default. However, for the range of values of γ considered in Table 2.7(a), this effect is not quantitatively important and the level of $\overline{d}$ turns out to be constant. In terms of $\overline{d}$ as a percentage of the average GDP, the observed reduction is explained as follows. A lower level of (average) debt induces a higher level of average consumption of tradables, which can be fairly approximated by $avg\,(c^T) \simeq Y^T - r.avg\,(d)$, provided that $avg\,(d) \simeq \theta_d\left[Y^T + avg\,(p)\,Y^N\right]$ and (μ, ω) satisfy $avg\,(p) \simeq 1$, as is the case. A higher average level of c^T combined with an inelastic (here, constant) level of c^N, in turn, means a higher average relative price of non-tradable goods, p (see equation (8)). The consequence of this appreciation of the real exchange rate is a higher level of total GDP in units of tradable goods, which explains why the constant level of $\overline{d}$ falls as a percentage of the average GDP as γ increases. The fact that the borrowing constraint is not very sensitive to changes in γ while the average level of debt decreases explains why the borrowing constraint binds less frequently as γ rises.

Table 2.8(a) displays the sensitivity analysis to changes in the weight of the tradable good in the CES consumption aggregator, ω. One could think of two opposite effects of ω in terms of the incitation to default. Since a higher ω increases the marginal utility of the consumption of tradable goods at all times, first, there would be higher instantaneous gain from default because, in that event, the country would be able to consume more of a good (tradables) that has a higher weight on the consumption index. On the other hand, intertemporally, there would be a higher cost of default by the same motive (one could also think that a higher ω makes the agent care more about risk sharing, since the "insurable" part of the agent's consumption becomes more important for his utility). Again, higher benefits of default induce external agents to reduce the level of maximal credit available to the country and higher costs of default make the constraint less stringent. Thus, the first effect would reduce the level of $\overline{d}$, while the second effect would increase it. Notice that, since the level of $\overline{d}$ falls (although it increases as a percentage of the GDP because of a real depreciation that more than proportionally reduces the level of the average GDP in units of tradable goods) as ω increases, the quantitative relevance of the instantaneous benefits seems to dominate the intertemporal costs of default.

Table 2.8(a)
Constrained Model: Sensitivity to Changes in ω

ω	σ_y (%)	σ_c (%)	σ_c/σ_y	*avg d* (% *GDP*)	$\overline{d}$ (% *GDP*)	% bind	"success" (%)
0.0100	1.88	1.71	0.910	6.86	658.0 (36.38)	0.00	0.00
*0.0659	2.95	1.90	0.644	28.35	279.5 (80.67)	0.31	55.2
0.1000	3.42	1.98	0.579	28.63	215.4 (83.22)	0.56	99.2
0.2500	4.35	1.81	0.416	17.35	133.3 (86.04)	0.90	216.7
0.5000	4.97	1.53	0.308	6.27	104.3 (87.88)	0.98	297.4
0.7500	5.27	1.35	0.256	0.76	94.3 (88.69)	1.02	327.3
0.9900	5.44	1.24	0.228	-2.75	89.2 (89.05)	1.03	349.8

Note: Column 6 shows the borrowing constraint both in level and, inside the parentheses, as a percentage of the GDP.
(*): this row shows the baseline case.

The effects of the constraint are very clear if one compares the sensitivity of the model to changes in ω in the constrained (Table 2.8(a)) and unconstrained (Table 2.8(b), in the appendix) economies. Notice that, at the very low value $\omega = 0.01$, the two economies are virtually identical, since tradable consumption has a very small impact on the consumption index and the borrowing constraint is set at a very high level, as discussed in the previous paragraph. The level of $\overline{d}$ is high enough to imply a very low frequency at which the constraint is binding, which makes the two models very close in behaviour. Numerically, in the simulations, this frequency is zero, for two decimal places, although it is likely that a high-enough number of simulations would show some cases in which the constraint binds, since, theoretically, the two models are still different.

However, as ω rises, interesting differences show up regarding the constrained and the unconstrained economies. First, notice that the volatility of output departs from the same value (1.88%) and rises in both economies, but it increases more rapidly in the constrained case. The intuition of this result is the following: since $Y_t = Y_t^T + p_t Y^N$, the volatility of output depends on the (exogenous) volatility of Y_t^T, as well as on the (endogenous) volatility of p_t and the (also endogenous) covariance between the two, $cov\left(Y_t^T, p_t\right) > 0$. In the unconstrained economy, the volatility of p_t (not shown in the tables) is almost insensitive to changes in ω (it goes from 1.76% to 1.75% as ω changes from 0.01 to 0.99), and the volatility of Y_t^T is exogenously given. Thus, the only way that Y_t can become more volatile is through increases in $cov\left(Y_t^T, p_t\right)$, possibly due to the fact that the proportion of tradables in total consumption and total GDP increases with ω. In the constrained economy, on the other hand, on top of the effect described above, the volatility of p_t rises (from 1.77% to 3.56% as ω goes from 0.01 to 0.99), rather than stay constant, which explains the sharper increase in σ_y verified in Table 2.8(a) in comparison with Table 2.8(b).

The rising volatility of p_t in the constrained economy in response to changes in ω, while constant in the unconstrained economy, is certainly an effect of the borrowing constraint that becomes even more stringent with increases in ω, and it makes tradable consumption smoothing more difficult. Not surprisingly, the same happens with the volatility of c_t^T (constant at 0.61% in the unconstrained economy and rising from 0.61% to 1.24% int the constrained economy, as ω changes in Table 2.8(a)). Recall that, since the same standard procedure for business cycle statistics is being used here (in particular, the variables are treated in logarithmic scale), the ratio between the volatilities of p_t and c_t^T has to be equal to $(1+\mu) = 2.875$.[21]

A second difference observed in Tables 2.8(a) and 2.8(b), for the constrained and unconstrained economies, is that the volatilities of total consumption are identical in both economies for $\omega = 0.01$, but, similar to what happens with σ_y, they become different as ω rises. In the unconstrained economy, σ_c falls monotonically with increases in ω, while in the constrained economy there is an initial phase in which σ_c rises. In the case of an unconstrained economy, the monotonic fall in σ_c is purely mechanical, a consequence of the reduction of the term $(1-\omega)/\omega$. Note that, since $C_t = c_t^T + p_t c^N$ and p_t is given by equation (8), one can write:

$$C_t = c_t^T + \left[\frac{(1-\omega)}{\omega}\left(c^N\right)^{-\mu}\right]\left(c_t^T\right)^{(1+\mu)},$$

and, as ω goes from 0 to 1, the term $(1-\omega)/\omega$ goes from infinity to zero and the volatility of total consumption converges (falls) to the volatility of tradable consumption, which does not change with ω, as discussed above. That is also the reason for the more depreciated real exchange rate (lower p_t) that follows from the increase in ω (see equation (8)). The same effects occur in the constrained case, with the important difference that, because the constraint becomes more stringent with a rising value of ω, tradable consumption volatility increases sharply. The net effect on σ_c depends on the relative importance of these direct and indirect effects (through increases in tradable consumption volatility) induced by a rise in ω. The direct effect makes σ_c fall, while the indirect

[21] For instance, up to a rounding error effect (the values are presented with only two decimal places):

$$\frac{1.76\%}{0.61\%} \simeq \frac{1.75\%}{0.61\%} \simeq \frac{1.77\%}{0.61\%} \simeq \frac{3.56\%}{1.24\%} \simeq 2.875.$$

effect acts in the opposite direction. It seems that the indirect effect dominates for small values of ω (up to 0.1 in Table 2.8(a)) and, as $(1-\omega)/\omega$ converges to zero, for higher values of ω, the direct effect becomes more important and forces σ_c down.

In terms of the effects of different values of ω, a final difference between the constrained and unconstrained economies is the behaviour of the average level of debt-to-output ratio. Since a higher ω makes tradable consumption more important for the CES consumption aggregator index and for utility, it makes the representative agent attach more importance to risk sharing at all times. If markets were complete, this would probably not affect the agent's total savings, since there would be complete risk sharing and a reallocation of contingent assets would occur without important effects on total savings. However, with no contingent assets, agents more concerned with risk sharing will tend to save more for self-insurance. In fact, in both the constrained and unconstrained economies, the average *level* (not shown in Table 2.8(a)) of debt falls.

In the unconstrained economy, where there is no risk of a shortage of credits, the average level of debt falls by 11% (124 to 110.6), but in the constrained economy, where the risk of becoming credit constrained is real, and increasing with ω, the average level of debt falls by 102.2% (from the same 124 as in the unconstrained economy to -2.75), and the agent becomes a net creditor.

In terms of the debt-to-output ratio, in the constrained economy, the fall in the level of debt is less than proportional to the fall in the value of the GDP for lower values of ω, and the debt-to-output ratio actually rises. But for $\omega \geq 0.1$, the higher motivation for savings dominates the real depreciation, debt falls quicker than GDP, and the opposite occurs. In the unconstrained economy, since there is no risk of being credit constrained, the fall in debt is smoother and the effects of the real depreciation on total GDP always dominate, which makes the debt-to-output ratio grow monotonically with ω.

Table 2.9(a) displays the sensitivity of the model to changes in the elasticity of substitution between c^T and c^N. The most obvious effect of an increase in μ,[22] which means that c^T and c^N tend to work more as complements than as substitutes, is a rise in the volatility of p_t for a given volatility of tradable consumption, according to equation (8). For a given volatility of tradable consumption, a lower elasticity of substitution between c^T and c^N implies a lower percentage variation in c^N/c^T for a given percentage change in p, or, alternatively, that a higher proportional change in p is required for a given change in the consumption of tradable, relative to the consumption of non-tradable, goods. Notice that, as μ rises, both σ_y and σ_c increase as a consequence of the higher

[22] The results for $\mu = 1.0$ and $\mu = -0.25$ are particularly important, because they represent a possible alternative for the calibration procedure, if one wants to consider values of μ close to those implied by the estimates of the elasticity of substitution between c^T and c^N used in Arellano (2004) and Mendoza and Uribe (1999). Arellano relied on estimation of the elasticity of substitution between tradable and non-tradable consumption for Argentina by Gonzales-Rosada and Neumeyer (2003), who find it to be 0.48, implying $\mu = 1.0833$. Mendoza and Uribe (1999) use $\mu = -0.218$, the same value as used in Mendoza (1995), which implies an elasticity of substitution of 1.28. Needless to say, the existence of empirical studies that provide estimations of μ that are lower than the value used in the baseline case is an important caveat for the results of this paper.

volatility of the real exchange rate. At first, for lower values of μ, the effect on σ_c is stronger than that on σ_y, and σ_c/σ_y rises, but the inverse occurs after $\mu \geq 0.01$.[23]

Table 2.9(a)
Constrained Model: Sensitivity to Changes in μ

μ	σ_y (%)	σ_c (%)	σ_c/σ_y	*avg d (% GDP)*	$\bar{d}$ (% *GDP*)	% bind	"success" (%)
-0.750	0.31	0.17	0.548	3.89	641.9 (22.66)	0.00	0.0
-0.250	0.67	0.47	0.701	6.17	641.9 (35.23)	0.00	0.0
0.010	0.86	0.62	0.721	7.81	641.9 (43.93)	0.00	0.0
0.250	1.06	0.75	0.708	9.67	651.9 (54.74)	0.00	0.0
0.500	1.26	0.88	0.698	12.02	670.9 (69.42)	0.00	0.0
1.000	1.73	1.16	0.671	18.18	493.7 (76.35)	0.00	5.0
1.500	2.37	1.53	0.646	25.02	351.6 (78.89)	0.09	23.0
*1.875	2.95	1.90	0.644	28.35	279.5 (80.67)	0.31	55.2
2.000	3.14	2.00	0.637	28.87	260.5 (81.26)	0.37	61.9
3.000	4.39	2.47	0.563	24.35	163.3 (84.91)	0.78	140.9
4.000	5.12	2.37	0.463	14.78	121.3 (87.33)	0.95	222.1
5.000	5.42	2.02	0.373	6.82	102.3 (89.72)	1.02	283.9

Note: Column 6 shows the borrowing constraint both in level and, inside the parentheses, as a percentage of the GDP.
(*): this row shows the baseline case.

As in the case of changes in ω, there are two effects caused by variations in μ, one instantaneous and the other intertemporal. The relative importance of how the changing μ affects the two effects will ultimately determine what happens with the level of the borrowing constraint. For instance, if the two goods are substitutes (low μ), then risk sharing is relatively less important at all times because, when facing a bad tradable output shock, agents can always substitute away their tradable consumption for non-tradable consumption. Thus, the instantaneous gain in terms of a higher tradable consumption in case of default is reduced with reductions in μ. However, since this substitution is also possible in the future, the intertemporal cost of default is also reduced. The opposite occurs when μ rises: the instantaneous benefits are higher and, also, the intertemporal costs of default are higher, since substitutability between the two goods becomes weak and a bad tradable output shock hurts more at all times. Notice, in Table 2.8(a), that the intertemporal effect

[23]Notice that, since:

$$C_t = c_t^T + \left[\frac{(1-\omega)}{\omega}\left(c^N\right)^{-\mu}\right]\left(c_t^T\right)^{(1+\mu)},$$

and

$$Y_t = Y_t^T + \left[\frac{(1-\omega)}{\omega}\left(c^N\right)^{-\mu}\right]\left(c_t^T\right)^{(1+\mu)},$$

the absolute effects of μ are the same in both σ_c and σ_y, given the volatilities of c_t^T and Y_t^T. However, the percentage increase depends on the relative share of the volatilities of c_t^T and Y_t^T, respectively, on σ_c and σ_y.

dominates for lower values ($\mu \leq 0.5$) and, as μ increases, the borrowing constraint, $\overline{d}$, becomes less stringent. For $\mu \geq 0.5$, on the other hand, the benefits of default increase faster than the costs, and external investors have to reduce the credit limit to avoid default.

The borrowing constraint as a percentage of the average GDP is monotonically increasing with μ, even when the borrowing constraint becomes more stringent. Again, the reason for this is a sharp real depreciation that follows the increase in μ, which causes the GDP in units of tradable goods to fall more than proportionally to the fall in $\overline{d}$. This real depreciation is a consequence of the fact that non-tradable consumption is constant in equilibrium and the two goods tend to become complements, as μ increases. With low values of μ and higher substitution between the two goods, given that non-tradable output and consumption are constant, the relative scarcity of tradable goods is reduced, which requires a lower price of tradables relative to non-tradables (that is, p has to rise); the opposite (i.e., real depreciation; a fall in p) happens for high values of μ.

As the value of μ rises, the *level* of the average debt increases initially and falls afterwards (this information is not displayed in Table 2.9(a)). For $\mu \leq 1.0$, the debt level rises by 6.2% (from 110.7 to 117.6) as μ goes from -0.75 to 1.0. For values of μ that are higher than 1.0, the level of debt falls by 93.3% (from 117.6 to 7.9) as μ goes from 1.0 to 5.0. This result is a consequence of the effect that μ has on the borrowing constraint, $\overline{d}$. While μ is still low, and the borrowing constraint becomes less stringent as μ rises, agents that are risk-averse and fear being credit constrained will save less, because $\overline{d}$ is too high. Actually, this explains why the constraint does not bind at low values of μ and, also, why the constrained and unconstrained economies are virtually the same for values of μ that are lower than 1.0 (the constraint is so loose that, numerically, the two economies behave almost the same). However, as μ increases and the constraint becomes more stringent, the risk of being credit constrained increases and agents will tend to start saving more, reducing their debt.

In terms of the debt-to-output ratio, the initial increase is due both to the rise in the average level of debt and to the reduction in the value of total GDP in units of tradables that follows the real depreciation. The fall observed for $\mu \geq 2.0$ is explained by the fact that the level of debt decreases more than proportionally to the fall in the value of GDP.

2.5 Conclusion

This paper presented empirical evidence of higher relative consumption volatility (to output volatility) experienced by emerging economies compared with developed small open economies. The data indicate that emerging economies have 30% more relative consumption volatility than small open developed economies, and this difference is statistically significant. Using a dynamic-general equilibrium model of an endowment, two-goods, small open economy subject to an endogenous borrowing constraint, the paper suggests that the constraint alone, although having limited explanatory power on the relative consumption volatility differential, is able to increase the relative consumption volatility by 16.3%, which corresponds to more than 55% of the gap observed in the data from emerging (likely to be constrained) and small developed open economies.

The model does relatively well, quantitatively, in explaining the empirical evidence discussed here and, qualitatively, in a number of dimensions such as the pro-cyclical movements of consumption and real exchange rate, as mentioned in the previous section. However, the model does not perform well in other aspects. For example, it is not able to reproduce actual levels of absolute output and consumption volatilities, nor is it capable of explaining the fact that consumption is consistently more volatile than output in emerging economies. Also, since there is no investment or production in the model, any positive production shock translates into an amelioration of the current account, since only the consumption-smoothing mechanism is at work and the investment motive does not exist. Future extensions of this paper intend to address those matters.

2.6 Appendix

Tables 2.7(b), 2.8(b), and 2.9(b) display information about the sensitivity analysis of the model for the unconstrained economy.

Table 2.7(b)

Unconstrained Model: Sensitivity to Changes in γ

γ	σ_y (%)	σ_c (%)	σ_c/σ_y	*avg d* (% *GDP*)
0.50	2.59	1.44	0.556	34.95
1.00	2.59	1.44	0.556	34.93
*1.50	2.60	1.44	0.554	34.91
2.00	2.60	1.45	0.558	34.89
2.50	2.60	1.45	0.558	34.88
3.00	2.60	1.45	0.558	34.87
4.00	2.60	1.45	0.558	34.83

Table 2.8(b)

Unconstrained Model: Sensitivity to Changes in ω

ω	σ_y (%)	σ_c (%)	σ_c/σ_y	*avg d* (% *GDP*)
0.0100	1.88	1.71	0.910	6.86
*0.0659	2.60	1.44	0.554	34.91
0.1000	2.97	1.33	0.448	46.51
0.2500	4.02	1.02	0.254	75.75
0.5000	4.82	0.79	0.164	95.86
0.7500	5.22	0.68	0.130	105.22
0.9900	5.44	0.61	0.112	110.41

Table 2.9(b)

Unconstrained Model: Sensitivity to Changes in μ

μ	σ_y (%)	σ_c (%)	σ_c/σ_y	*avg d* (% *GDP*)
-0.750	0.31	0.17	0.548	3.89
-0.250	0.66	0.47	0.712	6.17
0.010	0.86	0.62	0.721	7.81
0.250	1.06	0.75	0.708	9.67
0.500	1.26	0.88	0.698	12.02
1.000	1.71	1.13	0.661	18.27
1.500	2.20	1.33	0.605	26.86
*1.875	2.60	1.44	0.554	34.91
2.000	2.73	1.47	0.539	37.86
3.000	3.80	1.51	0.397	63.92
4.000	4.65	1.30	0.280	86.65
5.000	5.13	1.04	0.203	100.37

(*): this row shows the baseline case.

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Chapitre 3

IMF-Supported Adjustment Programs: Welfare Implications and the Catalytic Effect

3 IMF-Supported Adjustment Programs: Welfare Implications and the Catalytic Effect

3.1 Introduction

This paper is a quantitative study of the welfare implications of adjustment programs supported by the International Monetary Fund (IMF). More specifically, it investigates whether IMF-supported programs may help countries improve their access to international capital markets and quantifies the associated welfare gains.

It is fair to say that IMF programs have been partially responsible for much of the economic policy carried out around the transition and/or emerging economies in the sense that, in some periods, they can be seen as "*the* critical element in macroeconomic policy" [Fischer (1997), p. 23]. The question of whether IMF programs actually help the countries that seek them, and to what extent, is central to the evaluation of the Fund's performance.

The literature on the evaluation of IMF-supported programs is relatively extensive and biased towards empirical work based on reduced-form econometric models applied to cross-country samples [for surveys, see Haque and Khan (1998), Barro and Lee (2002), Mody and Saravia (2003), Joyce (2003), and Bordo, Mody, and Oomes (2004)]. In general, these cross-country studies look at estimated coefficients from the regressions of selected macroeconomic variables (current account, overall balance of payments, inflation, growth, private capital flows, etc.) interacted with an IMF program dummy. This maybe not the appropriate metric to evaluate the success of these programs, since there is no clear mapping between welfare measures and the regression coefficients.

This paper takes a different approach to evaluating IMF programs, by considering a model in the tradition of Eaton and Gersovitz (1981) and Kletzer (1984), where an endogenous borrowing constraint limits the ability of a small open economy to smooth consumption. Countries optimally decide if they will repay or default on their external debt. The benefit of default (a higher level of consumption today) is balanced against the costs (an output loss associated with indirect costs of default plus the exclusion from international capital markets in the future). Foreign lenders impose a debt ceiling such that the country never chooses to default. As shown elsewhere [Resende (2005)], this type of borrowing constraint helps explain part of the excess consumption volatility (normalized by output volatility) experienced by emerging economies in comparison with more developed ones. Any increase in the relative benefits of default *vis-à-vis* repayment induces the lenders to lower the level of the borrowing constraint, generating even more consumption volatility. In this context, IMF programs can be welfare improving if they help ease the constraint and reduce volatility.

Agents derive utility from the consumption of tradable and non-tradable goods, which can be consumed both as private or public goods. The economy can borrow abroad from private agents or from the IMF, upon formaly signing an adjustment program. The decision of joining an IMF program is endogenous. The immediate cost of joining an agreement is driven by *IMF conditionality* - the country must satisfy some restrictions on the level of consumption of public goods in order to borrow from the IMF. The benefits are two-fold: 1) the interest rate on IMF loans is lower than that charged by private agents, and 2) there may be additional consumption smoothing if IMF lending positively affects the total amount of available funds for the country to borrow.

In the model, the borrowing constraints related to the two components of total external debt (private lenders and the IMF) are set up differently. While IMF loans are subject to an exogenous institutional limit, there is an endogenous constraint on the borrowing from private agents *given* the ceiling for IMF loans. The IMF can relax the borrowing constraint on total debt in two ways. *First*, there is the direct effect of a higher level of IMF lending for a given level of (maximal) debt from private lenders. *Second*, IMF-supported programs may have an indirect, general-equilibrium *positive catalytic effect* on private lending, by inducing a relaxation of the endogenous borrowing constraint and the displacement of the private lenders' supply of funds. The main driving force behind positive catalysis of private lending is the reduction of the likelihood of default induced by the incentives and punishments associated with IMF programs. If they reduce the *ex-ante* relative incentives to default, then private lenders may relax their borrowing constraint.

The likelihood of default is affected by IMF programs when they induce a higher *ex-ante* propensity to save through conditionality. Its is shown numerically that this mechanism does not work when the consumption of public goods is optimally chosen. The reason is that, when conditionality is too strong, the economy does not save more because it stays out of IMF programs, since the forced savings are too costly in terms of suboptimal levels of consumption of public goods. When conditionality is less strict, then IMF program participation is positive, but there is no additional savings because the economy is already optimizing at a level of public goods consumption that is lower than that required by conditionality.

In an alternative set up, the economy cannot commit to a low level of consumption of public goods unless it signs an IMF program. In this case, when the IMF acts as a "commitment device", conditionality can simultaneously force a higher propensity to save while driving the economy closer to the optimal level of consumption of public goods. As a result, IMF program participation is positive and there is positive catalysis of private lending.

The model is calibrated to the Brazilian economy. Two relevant questions for the literature on IMF-supported programs can be answered based on the results from the simulations. *First*, can conditionality, in the form of restrictions to domestic absorption, help relax the borrowing constraint imposed by private foreign lenders? That is, can it produce a positive catalytic effect on the country's access to international private capital markets? *Second*, for reasonable values of the structural parameters, what are the welfare gains associated with a less stringent borrowing constraint?

The structure of the paper is as follows. Section 2 briefly describes some real aspects of IMF programs and discusses their effects on the borrowing economies as measured in the empirical literature. The theoretical model is discussed in Section 3. Then, the calibration procedure and a quantitative exercise are presented in Sections 4 and 5, respectivelly. Section 6 offers some conclusions.

3.2 On IMF Programs

This section briefly describes the actual process of setting up an agreement between a country-member and the IMF. In addition, it provides a summary of the literature about evaluations of IMF-supported adjustment programs.

3.2.1 Setting Up an IMF Program

The Fund has a mandate to offer financial and technical assistance to members experiencing external account imbalances on the condition that the recipient country agrees on implementing specific economic policy measures intended to improve the country's overall economic situation and reduce its vulnerabilities. These agreed upon policy actions are known as *IMF conditionality* and usually include intermediate goals that must be undertaken as a condition for the country to receive subsequent tranches over the duration of the program, usually one to three years. These targets are often related to fiscal and monetary austerity measures, aiming at the reduction of domestic absorption. Although it is beyond the scope of this study to provide a *rationale* of the IMF's behaviour, one possible reason for this observed reaction is the Fund's primary goal of improving the external payments position of its members, as stated in its *articles of agreement.*[1] In that sense, these policies may be understood as a way of forcing borrowing countries to save more in order to improve their current account balances.

On the roadmap for an agreement, a country that wishes to withdraw funds up to 25% of its own quota within the IMF (in the so-called first credit tranche programs) can do so almost automatically, with only minimal requirements and no discussion or commitment with specific economic policy measures. In order to use the Fund's resources beyond that threshold, countries must almost always sign a formal agreement and accept conditionality. Mussa and Savastano (1999) detail the underlying process for the signing of an IMF-supported program, as consisting of six broadly defined phases. First, in the inception phase, a country member explicitly requests the Fund's assistance. Then a blueprint is prepared by the Fund's staff to be used as basis for the negotiation process. After an agreement is reached, a letter of intent summarizes the outcome of the negotiations and all aspects of the program. The letter of intent is sent to the Executive

[1] Available at <http://www.imf.org/external/pubs/ft/aa/index.htm.>

Board for approval. Disbursements of the credit tranches follow automatically if the agreed-upon performance clauses are met as assessed by the Fund's monitoring of the country's situation. This phase lasts until the completion of the program.[2]

3.2.2 Evaluating IMF Programs

Many studies have tried to evaluate IMF programs using reduced-form econometric models, applied to cross-country samples. The two most common methodological problems in evaluating the IMF's performance based on cross-country econometric studies are both the difficulty in finding a good *counterfactual* against which to compare IMF programs, and the need to control for *selection bias* due to self-selection of countries that seek a program.. The counterfactual issue arises because the proper standard for measuring program effects, in terms of key variables, should be the comparison of the macroeconomic outcomes under a program, with the outcomes that would have emerged in the absence of a program, which is unobservable and must be approximated. Unfortunately, as pointed out by Dicks-Mireaux, Mecagni and Schadler (2000), results are very sensitive to the different techniques used to approximate the counterfactual.

In terms of the selection bias problem, since countries self-select to IMF programs, the actual outcome observed after a program is likely to be a consequence of both the initial conditions and the program itself. These pre-program conditions would probably be very different in a country that actually ended up seeking IMF assistance, compared to the (counterfactual) situation in which the same country would stay out of an IMF program. If the two effects cannot be disentangled, the results will be biased.[3]

These cross-country reduced-form econometric studies provide some "stylized facts" regarding IMF-supported stabilization programs. For convenience, a summary of the results found in the literature is presented in Tables 3.1, 3.2 and 3.3, regarding the pre-program characteristics of countries which seek the IMF's assistance, the effects of IMF programs on some selected macroeconomic variables[4] and the catalytic effect, respectively. They suggest the following:

1. *Countries which seek the IMF's assistance have different initial, pre-program, conditions than those which do not seek the Fund's help;*

2. *IMF programs seem to help countries improve their external payments positions;*

[2] Edwards (1989) summarizes the steps leading to the final design of an IMF program, starting with the evaluation of the country's situation, defining the target variables and envisaging the course of policy actions.

[3] The preferred approach in current econometric studies to approximate the counterfactual is the so-called Generalized Evaluation Estimator (GEE), first suggested by Goldstein and Montiel (1986), and further popularized by Khan (1990), Conway (1994) and Hutchison (2001), among others. Although not without criticism [see Dicks-Mireaux, Mecagni and Schadler (2000) and Barro and Lee (2002)], the GEE approach also tries to control for the potential selection bias problem.

[4] Table 2 is a modified and updated version of Table 1 presented in Haque and Khan (1998).

3. *Inflation rates are not affected by the implementation of an IMF program, while the evidence is mixed for growth;*

4. *There is no strong evidence that IMF lending acts as a "catalyst" to other (private) capital flows, but there is good indirect evidence that IMF programs can help countries improve their access to international private capital markets.*

Regarding the first point, evidence that program countries differ from non-program countries in terms of initial conditions can be found in Joyce (1992), Edwards and Santaella (1993), Santaella (1995), Bird (1996) and Knight and Santella (1997), among others. Table 3.1 displays a summary of pre-program characteristics of countries that seek the IMF's financial assistance according to 12 independent econometric studies. Note that 7 out of 8 studies found that a worse current account position increases the likelihood of a country joining an IMF program (4 out of 5 studies, in terms of the overall balance of payments). In general, prior to entering a program, IMF borrowers experience - besides worse external payments positions - higher external debt, lower reserves, more overvalued currencies and lower levels of both GDP per capita and/or GDP growth rates. IMF borrowers also tend to follow more expansionary economic policies.

Table 3.1

Pre-Program Characteristics of Countries that Seek the IMF's Financial Assistance

				Effects on the likelihood of an IMF program									
Study	No. of Progs	No. of Countries	Sample Period	*BoP*	*CA*	*R*	d^*	π	*e*	*G*	*M*	*y*	Past IMF
GM (1986)	68	58	1974 – 81	–*	–*	...	...	+*	...	...	...	–*	...
ES (1992)	48	31	1954 – 71	...	–	–*	...	...	+	+*	+*	–*	...
Joyce (1992)	72	45	1980 – 84	...	–*	–*	–	+	...	+*	+*	–*	...
Conway (1994)	217	73	1976 – 86	...	+*	–*	+*	...	...	...	...	–*	+*
Santaella (1995)	324	78	1973 – 91	–*	–*	–*	+*	+*	–*	+*	0	–*	...
Bird (1996)	...	...	...	–	...	–	?	...	+	...	...	–	+
KS (1997)	...	91	1973 – 91	+	–*	–*	+*	–	+*	+*	+*	–*	+*
PV (2000)	678	135	1951 – 90	–*	...	–*	+*	...	...	+*	...	...	+
Edwards (2000)	...	106	1979 – 95	...	...	–*	...	–*	...	–	+*	–*	...
Hutchison (2001)	461	67	1975 – 97	...	–	...	...	+	...	+	+	–*	...
BL (2002)	...	80	1975 – 99	...	...	–*	...	...	...	...	...	+/–*	...
BHJ (2004)	371	90	1980 – 96	...	–*	–*	+*	0	...	–*	0	–*	...
			Expected sign:	–	–	–	+	+	+	+	+	–	+
			Right sign:	4/5	7/8	10/10	5/7	4/7	3/4	6/8	5/7	11/11	4/4
			Significant and right sign:	3/5	5/8	9/10	5/7	2/7	1/4	5/8	4/7	10/11	2/4

Note: (*) = results are statistically significant at standard levels; (?) = results are inconclusive; and (0) = no effect.

Legend:

BoP = Balance of Payments; *CA* = Current Account; *R* = reserves; d^* = total external debt; π = inflation; *e* = exchange rate (increase = depreciation); G = government spending or deficit; M = money or credit creation; y = per capita GDP or GDP growth.

GM = Goldstein and Montiel (1986); ES = Edwards and Santaella (1993); KS = Knight and Santaella (1997); PV = Przeworski and Vreeland (2000); BL = Barro and Lee (2002); BHJ = Bird, Hussain and Joyce (2004)

The second item in the list is the strongest empirical regularity found in the cross-country studies. Both the current account and the balance of payments seem to improve following an agreement with the Fund, which seems to be consistent with the idea that improving the borrower country's external payments situation would be the Fund's principal objective and the focus of its analytical approach.[5] According to Table 3.2, the balance of payments improved in 7 out of 9 studies and the current account, in 8 out of 11.

Table 3.2
Effects of IMF Programs on Selected Macroeconomic Variables

Study	No. of Progs	No. of Countries	Sample Period	Effects of IMF program on: *BoP*	*CA*	π	*G*	*M*	*y*
Before - After									
RS (1978)	79	...	1963 – 72	0	...	0	...	–*	+
Connors (1979)	31	23	1973 – 77	...	+	0	0	...	0
Pastor (1987)	...	18	1965 – 81	+*	0	+*	...	...	0
Edwards (1989)	34	34	1983	...	+	+	0	–	– / +
Schadler et al. (1993)	...	19	1983 – 93	+	–	–	–	?	+
KMM (1995)	...	16	1979 – 85	+*	+*	–*	–	–	– / +
With - Without									
Donovan (1981)	12	12	1970 – 76	...	...	–	...	...	+
Donovan (1982)	78	44	1971 – 80	+	+	–	...	...	–
Gylfason (1987)	32	14	1977 – 79	+*	...	0	...	0 (–*)	0
ES (1992)	48	31	1954 – 71	+*	+*	–	...	–	– / +
Generalized Evaluation									
GM (1986)	68	58	1974 – 81	–	–	+	...	...	–
Khan (1990)	259	69	1973 – 88	+*	+*	–	...	...	–*
Conway (1994)	217	73	1976 – 86	...	+*	–	–*	+	– / +*
PV (2000)	678	135	1951 – 90	...	...	...	...	...	–*
D-MMS (2000)	...	61	1986 – 91	...	...	–	...	...	+*
Hutchison (2001)	461	67	1975 – 97	...	...	...	...	...	–*
IV Estimation									
BL (2002)	...	80	1975 – 99	...	...	...	...	...	0 / –*
Easterly (2005)	...	...	1980 – 99	...	...	...	...	...	+
Other									
BMO (2004)	...	29	1980 – 02	...	+*	–*	...	...	+*
			Right sign:	(+) 7/9	(+) 8/11	(–) 9/15	(–) 3/5	(–) 5/7	(+) 10/19
			Significant and right sign:	5/9	5/11	2/15	1/5	2/7	3/19

Note: (*) = results are statistically significant at standard levels; (?) = inconclusive results; and (0) = no effect.

Legend:

BoP = Balance of Payments; *CA* = Current Account; π = inflation; G = government spending or government deficit; M = money or credit creation; y = per capita GDP or GDP growth.

RS = Reichmann and Stllson (1978); KMM = Killick, Malik and Manuel (1995); ES = Edwards and Santaella (1993); GM = Goldstein and Montiel (1986); PV = Przeworski and Vreeland (2000); D-MMS = Dicks-Mireaux et al. (2000); BL = Barro and Lee (2002); BMO = Bordo, Mody and Oomes (2004).

In the case of the effects on inflation, only 2 out of 15 studies managed to find a negative and significant effect of IMF programs on inflation, while one study found a significant positive effect. Several studies indicate a negative effect, but regression coefficients are generally not statistically significant at standard levels. In terms of the growth effects of IMF programs, results are mixed

[5]See Mussa and Savastano (1999) and Mody and Saravia (2003).

and not robust to the methodology, period covered and types of countries and programs being analyzed. Although 10 out of 19 studies found positive effects of IMF programs on growth and/or per capita GDP, only 3 studies reported statistically significant effects (see Table 3.2).

The last point, regarding the catalytic effect of IMF programs, is more directly related to this paper. In the literature, this expression is used to broadly characterize the ability of the IMF to facilitate the access to international capital markets [See Cottarelli and Giannini (2002), pp. 5-7]. The Fund claims that positive catalysis is a very important feature of its lending, since it provides only a small portion of a country's external financing requirements and the attached conditionality clauses help to reassure investors and the official community, acting as an important lever, or catalyst, for attracting other funds.[6]

Table 3.3
Evidence of the Catalytic Effect of IMF Lending

Study	No. of Progs	No. of Countries	Sample Period	Catalysis?	Dependent Variable
Emprirical					
Ozler (1978)	...	26	1968 – 81	Negative*	Spreads on bank loans
KMM (1995)	...	16	1979 – 85	Negative	Net capital flows
Rodrik (1996)	...	...	1970 – 93	Negative	Net private capital flows
BR-1 (1997)	...	90	1974 – 89	Negative	New lending commitments
BMR (2000)	17	17	1970s – 1990s	?	
Edwards (2000)	...	106	1979 – 95	Negative, ?	Net capital flows
BR-2 (2002)	...	117	1977 – 99	Negative, ?	Net capital flows
Marchesi (2003)	...	87	1983 – 95	Positive*	Commercial debt rescheduling
MS (2003)	259	69	1973 – 88	Positive*	Bond issuance and spreads
BMO (2004)	...	29	1980 – 02	Positive*	Gross capital flows
EKM (2005)	678	135	1991 – 02	Positive	Bond spreads
Theoretical					
CGR (2004)				possible	
M-Shin (2005)				possible	

Note: (*) = results are statistically significant at standard levels; (?) = inconclusive results.

Legend:

KMM = Killick, Malik and Manuel (1995); BR-1 = Bird and Rowlands (1997);
BMR = Bird, Mori and Rowlands (2000); BR-2 = Bird and Rowlands (2002); MS = Mody and Saravia (2003);
BMO = Bordo, Mody and Oomes (2004); EKM = Eichengreen, Kletzer and Mody (2005);
CGR = Corsetti, Guimarães and Roubini (2004); M-Shin = Morris and Shin (2005).

Table 3.3 reports the results found in 11 empirical and 2 theoretical studies regarding the catalytic effect of IMF programs. Earlier studies such as Ozler (1993), Killick, Malik and Manuel (1995), Bird and Rowlands (1997, 2001) and Edwards (2000) found no evidence of a strong positive catalytic effect. Overall, six studies, among which 5 tried to measure catalysis through the response of net capital flows following IMF programs, found negative, often not significant, effects. However, more recent papers seem to be more successful in finding signs of positive catalysis by IMF programs, in terms of facilitating private debt rescheduling [Marchesi (2003)], allowing more frequent and more

[6] See *What Is The IMF?*, at <http://www.imf.org>.

favorable (lower spreads) bond debt issuance by sovereign countries [Mody and Saravia (2003) and Eichengreen, Kletzer and Mody (2005)] and keeping capital flows to the program countries [Bordo, Mody and Oomes (2004)]. Theoretical predictions by Morris and Shin (2005) and Corsetti, Guimarães and Roubini (2004) suggest that although IMF programs cannot catalyze capital flows to countries in severe distress, they can help countries in a vulnerable but not insolvent condition. Bordo, Mody and Oomes (2004) and Mody and Saravia (2003) empirically confirm these predictions.

3.3 The Model

This section presents a model in the tradition of Eaton and Gersovitz (1981) and Kletzer (1984) extended by an endogenous decision of joining an IMF program.

Consider a small open economy, where a central planner seeks to maximize the lifetime utility of a representative agent. The agent enjoys utility from the consumption of both private and public goods, summarized by the indices c_t and g_t, respectively. Formally, the planner's objective function is:

$$V_0 = \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t u\left(c_t, g_t\right), \tag{1}$$

where $\beta \in (0,1)$ is the subjective discount factor, and the function u is strictly concave and strictly increasing in both arguments, twice continuously differentiable and satisfies the Inada conditions with respect to both arguments.

Indices c_t and g_t are Constant Elasticity of Substitution (CES) aggregators of the consumption of tradable and non-tradable goods:

$$c_t = \left[\omega_c \left(c_t^T\right)^{-\mu_c} + (1-\omega_c)\left(c_t^N\right)^{-\mu_c}\right]^{-\frac{1}{\mu_c}}, \tag{2}$$

$$g_t = \left[\omega_g \left(g_t^T\right)^{-\mu_g} + (1-\omega_g)\left(g_t^N\right)^{-\mu_g}\right]^{-\frac{1}{\mu_g}}, \tag{3}$$

where c_t^T and c_t^N denote private consumption of tradables and non-tradables, respectively, while g_t^T and g_t^N have similar interpretations for public goods. Parameters μ_c and μ_g determine the elasticities of substitution between tradable and non-tradable goods within the indices c_t and g_t, given by $1/\left(1+\mu_i\right) > 0$, $i = c, g$, respectively. The weights of tradables in the respective indices are ω_c and ω_g, both in the $[0,1]$ interval.[7]

3.3.1 Endowments

The supply side of the economy is characterized by:

$$y_t^N = y^N, \tag{4}$$

[7] It is common to think of public goods as being mostly related to services, which are non-tradable goods. One interpretation of (3) is that the planner buys both tradable and nontradable goods, uses them to produce g_t according to the CES technology and then allocates the "output" to the representative consumer.

$$y_t^T = y^T + z_t. \tag{5}$$

Equations (4) and (5) represent the constant flow of non-tradable goods $\left(y^N > 0\right)$ and the stochastic endowment of tradable goods $\left(y_t^T > 0\right)$, received by the representative agent, respectively. The only source of uncertainty in the model is the shock to the tradable endowment, $z_t \in \Omega_Z$, which is assumed to follow a first-order Markov chain with transition probabilities given by $\pi\left(z_t|z_{t-1}\right)$ over the compact set Ω_Z.

The introduction of tradable and non-tradable goods is not crucial. However, it adds some interesting dynamics through movements in the real exchange rate (p_t) as defined by the relative price of non-tradables in terms of tradables. In particular, the volatility of an aggregate variable $X_t = x_t^T + p_t x_t^N$, for $X = C, G, Y$ and $x = c, g, y$, will depend not only on the exogenous underlying volatility associated with the stochastic process for z_t, but also on the *endogenous* volatility of p_t.[8]

3.3.2 External Debt

International asset/capital markets are incomplete and no contingent contracts are signed.[9] It is assumed that the country can always borrow $d_t \in \boldsymbol{D} \subseteq \mathcal{R}$, from private lenders (or "banks"). It can also borrow $f_t \in \boldsymbol{F} \subseteq \mathcal{R}^+$ from the IMF *only* if it agrees to sign an adjustment program and comply with the conditions imposed by the Fund, as discussed later on in the paper. Both types of loans[10] are expressed in units of the tradable good, and are contracted at time $t-1$, to be paid at time t. Loans from banks charge the constant interest rate, r, while Fund loans are signed at a lower interest rate, $r^* < r$.

As it will become clearer later on, the assumption of lower interest rates on IMF loans has both theoretical and technical/computational implications. On one hand, it affects the relative incentives to default and, as a consequence, the possibility of positive catalysis of private loans by IMF lending. On the other hand, it helps to substantially reduce the computational cost of the model's numerical solution,[11] while being representative of actual IMF lending.[12]

The total external debt, $d_t^* \in \boldsymbol{D}$, observed at the end of every period t is:

$$d_t^* = d_t + IMF_t f_t \ , \tag{6}$$

[8] An interrelated reason for having tradable and non-tradable goods was pointed out by Arellano (2004). The relative size of the tradable sector has a negative effect on the probability of default, *ceteris paribus*.

[9] This differs from Kehoe and Levine (1993), who discuss endogenous borrowing constraints with complete markets. The assumption of incomplete markets used in this paper seems to better reproduce the evidence that countries tend to default during "bad times." With the insurance given by contingent assets, agents tend to leave the credit contract (that is, to default) during "good times," when they have to make payments as opposed to the bad times, when they receive the insurance.

[10] We refer to loans, but the analysis is equaly valid for debt in form of bonds.

[11] For instance, when combined with a an upper limit on f_t imposed by the IMF (see sub-section 3.5), the planner's problem is well defined and, since the economy will always borrow up to that limit when it decides to borrow from the IMF, the state-space for f_t can be discretized into only two points, consisting of zero and that upper limit.

[12] For instance, the average annual "rate of charge", the interest rate on IMF loans, from 1981 to 2005 was about 5.3 per cent, while sovereign bond yields from IMF borrowing countries, such as Brazil, paid more than 12 per cent a year.

where the discrete choice variable IMF_t takes the value of 1, if the country optimally decides to join an IMF program, or 0, otherwise.

Following Eaton and Gersovitz (1981), there is no commitment technology that forces the country to repay its external debt. The choice between defaulting or repaying the debt is endogenous. Should the planner optimally choose to default at time t, it is assumed that: (1) default would occur in both types of loans (i.e. countries cannot default on IMF loans and repay private loans, and *vice versa*); and (2) international lenders, both private banks and the IMF, would exclude the country from intertemporal asset trading forever.[13] That is, the country not only faces a discrete choice of joining an IMF program or not, but must also choose between default ($DEF_t = 1$) or repayment ($DEF_t = 0$). The discrete choices involving both IMF_t and DEF_t will be explained later on in the paper.

3.3.3 Resource Constraints

The economy is subject to two resource constraints. For the non-tradable good, the constraint is:

$$c_t^N + g_t^N = DEF_t \lambda y^N + (1 - DEF_t)\, y^N \ , \tag{7}$$

where $\lambda \in (0, 1)$.

The $(1 - \lambda)$ reduction in y^N, when $DEF_t = 1$, is a reduced-form way of introducing an "output loss" due to indirect costs associated with the default state.[14] The factor λ is effective as long as the economy remains in the default state. Given the assumption of permanent exclusion from international capital markets in case of default, this cost is permanent.[15]

In terms of the tradable good, the resource constraint is:

$$c_t^T + g_t^T = DEF_t \lambda y_t^T + (1 - DEF_t)\left[y_t^T + d_t^* - (1+r)\, d_{t-1}^* + (r - r^*)\, IMF_{t-1} f_{t-1}\right]. \tag{8}$$

Notice that in case of full repayment the available resources for consumption, after servicing the outstanding debt, come from the endowment and/or new loans. The last term in (8) accounts for the fact that part of d_{t-1}^*(i.e. $IMF_{t-1} f_{t-1}$) is contracted at the lower interest rate r^*. In case of default, the country does not pay the debt services, cannot contract d_t^*, and must consume the endowment reduced by the factor λ.

[13] In reality, defaulting countries are able to borrow again after some renegotiation of their debts. In terms of the model presented in this paper, the penalty for defaulting countries is higher than what actually occurs. Arellano (2004) introduces an exogenous probability of leaving the default state at each period. Yue (2004) endogenizes the renegotiation process as a Nash bargaining game between the sovereign and the creditors.

[14] These costs may include the disruption in the countries' ability to engage international trade, sanctions imposed by foreign creditors, or damages caused to the financial system [see Cole and Kehoe (1998)]. For instance, Chuhan and Sturzenegger (2003) found that the percent contraction in output in Latin America, following the default episodes in the 1990s, was about 2%.

[15] As in other empirical studies that rely on RBC models based on the Eaton and Gersovitz's (1981) framework [for example, Arellano (2004) and Aguiar and Gopinath (2004)], λ is necessary for calibration purposes. For reasonable values of the structural parameters, the threat of autarky alone cannot generate the debt-to-output ratios observed in actual indebted economies.

3.3.4 The Borrowing Constraint

The lack of commitment to repay the external debt introduces another imperfection to the international capital markets, in addition to the fact they are incomplete. The possibility of choosing optimal default is reflected in the following endogenous borrowing constraint faced by the planner:

$$d_t^* \leq \overline{d}_t^* = \min_{\Omega_Z} \left\{ \overline{d}_t^* (S_t) : V_t^R \left(\overline{d}^* (S_t), S_t \right) = V_t^D (z_t) \right\}, \tag{9}$$

where V_t^R and V_t^D are the time-t values of the indirect utility obtained by the representative agent in the states of repayment and default, respectively; and $S_t = \{z_t, IMF_{t-1}, f_{t-1}\}$ is a partition of the state of the economy, given by $\langle d_{t-1}^*, S_t \rangle$.

The constraint (9) differs from others used in the literature, often specified arbitrarily outside economic models.[16] It captures the notion that borrowers face credit limits that depend not only on their characteristics, but also on their income streams and on the endogenous current state of the economy. Notice that $\overline{d}_t^*$ is the maximal amount of funds that the domestic economy can borrow, including private and IMF loans, without triggering the strategy of optimal default. As implied by the constraints (7) and (8), there are two costs associated with the default option. *First*, there is the output loss given by $(1 - \lambda)$. *Second*, since it must stay in financial autarky forever once it chooses to default, the country loses the ability to use international borrowing to smooth consumption in the future. More volatile consumption is welfare-reducing, because of the concavity of the agent's utility function. On the other hand, the benefit of default is the possibility of higher consumption at t. In terms of default, costs are intertemporal, benefits are immediate. The planner balances the costs against the benefit to choose the value of DEF_t and decides to default at t whenever $V_t^R < V_t^D$. Repayment takes place whenever $V_t^R \geq V_t^D$.

In order to force the country to pay back its debt in all possible dates and states, fully-informed international lenders will set up and enforce the rule formally defined in (9), and will not lend any amount of funds that makes the planner choose default over repayment. That is, lenders will define the credit limit for the borrowing country, $\overline{d}_t^*$, such that its representative agent's expected lifetime utility from participating in the asset market is at least as high as that of staying in financial autarky. The approach used for the identification of $\overline{d}_t^*$, proposed by Zhang (1997), is based on the worst case scenario given by the minimal value of z_t in Ω_Z.

3.3.5 The IMF

Let $\theta_t \in \Theta = \{\theta^0, \theta^1\}$ be a set of restrictions on $\langle DEF_t, d_t, f_t, g_t^N, g_t^T \rangle$, that characterize the *IMF conditionality rule*. The country must satisfy a different rule depending on its choice to join an

[16] For example, Aiyagari and Gertler (1991), Telmer (1993) and Lucas (1994). In the international macroeconomics literature, examples include papers in the "sudden stop" literature, such as Mendoza (2001).

IMF program or not. The collection Θ contains two types of conditionality sets as follows:

$$\begin{aligned} \text{if } IMF_t &= 0 : \theta_t = \theta^0 = \left\{DEF_t \in \{0,1\};\ d_t \in \mathbf{D};\ f_t = 0;\ 0 \leq g_t^i,\ i = T, N\right\}, && (10) \\ \text{if } IMF_t &= 1 : \theta_t = \theta^1 = \left\{DEF_t = 0;\ d_t \geq 0;\ 0 \leq f_t \leq \overline{f} < \infty;\ 0 \leq g_t^i \leq \overline{g}^i,\ i = T, N\right\}. && (11) \end{aligned}$$

IMF conditionality is "turned on" when the country chooses to sign an IMF program. Note that whenever $IMF_t = 1$, the economy is subject to $\theta_t = \theta^1$, indicating additional restrictions regarding the default choice, the level of debt from private banks and from the IMF, and the consumption of public goods. For instance, embedded in the conditionality rules above, there are four assumptions about the behaviour of the IMF:

(i) The IMF will not lend to a country that chooses to default or does not need borrowing;

(ii) There is an upper bound $\overline{g}^i$, for $i = T, N$, to the consumption of public goods when $IMF_t = 1$;

(iii) Countries cannot lend to the IMF; and

(iv) The IMF does not have "deep pockets", being limited to lend up to $\overline{f}$.

The way the IMF is introduced in the model, as represented by assumptions (i) to (iv), is exogenous and not a result of any optimizing behaviour by the Fund. From a *positive* perspective, the Fund's behaviour is modeled based on what seems to occur in actual IMF adjustment programs: whenever a country requires financial assistance, the IMF follows its mandate to lend, conditional upon the borrowing country accepting some (potentially) costly conditions in terms of economic policy.

The initial portion of assumption (i), that requires $DEF_t = 0$ whenever $IMF_t = 1$, simply re-states the previous assumption that once a country defaults, it cannot borrow abroad from t onwards. The last portion is required to prevent a country from borrowing from the IMF at a lower interest rate and lending to private banks at the market rate. This is consistent with the Fund's concern about only lending when there is a "balance-of-payments need" and when countries "cannot find sufficient financing on affordable terms to meet its net international payments."[17] Given its public nature as an international organization, it is hard to justify providing subsidized loans to countries that are not in need.[18]

Assumption (ii) is motivated by the fact that restraint on central government expenditure (a proxy for the consumption of public goods) is indeed a key element for the Fund to approve an arrangement [see Mussa and Savastano (1999)]. Whenever the constraint $g_t^i \leq \overline{g}^i$, $i = T, N$, is

[17] See the "factsheet" on IMF Lending at <http://www.imf.org/external/np/exr/facts/howlend.htm.>

[18] Corsetti, Guimarães and Roubini (2004) have a static model of IMF optimal lending in which the issue of no subsidized loans by the IMF - when there is no expected gain in terms of improving a borrowing country's external payments position - is explicitly taken into account.

binding, the consumption of public goods will be set at sub-optimal levels and IMF conditionality will be a cost, at least in the short run.

There are at least two findings in the empirical literature indicating that restrictions on the consumption of public goods are implemented by countries borrowing from the IMF, and that those restrictions would not take place, or not at the same extent, without the Fund's support: (1) countries that seek the IMF's assistance tend to follow more expansionary fiscal policies (see in Table 3.1 that 6 out of 8 empirical studies found that government spending or government deficit increase the likelihood that a country signs an IMF program), and (2) there is a negative relationship between the adoption of an IMF program and the rate of growth of government consumption [see Conway (1994), Killick, Malik and Manuel (1995) and Marchesi (2003)].[19]

Regarding assumption (*iii*), most resources for IMF loans are provided by member countries, primarily through their quota payments, which is not the same as lending to the IMF. Although concessionary lending and debt relief for low-income countries are financed through separate contribution-based trust funds, this is not the case for the adjustment programs.[20]

Assumption (*iv*) implies an asymmetry in how private and IMF lending are limited by credit suppliers. The latter is exogenously limited by $\overline{f}$, while the former has the endogenous limit $\overline{d}_t = \overline{d}_t^* - \overline{f}$, as implied by (9). Because of the difference in interest rates charged in private and Fund loans, an upper bound on f_t is needed for a well defined problem. This is so because the lower interest rate on IMF loans favors the substitution of debt from private agents to IMF loans and, if there is no limit on on f_t the economy can borrow a large (infinity) amount from the IMF and then default on both types of debt.[21] Indeed, this is true even if the overall effect on the likelihood of default is ambiguous, since the different interest rates also imply a higher cost of default: defaulting countries will not only be prevented from borrowing abroad in the future, but will also loose the access to cheapear loans from the IMF. The first (substitution) effect will force private lenders to be more strict when they set up their borrowing constraint, while the second one (intertemporal) will allow them to relax their borrowing constraint.

Ideally, one would like to explicitly model the behaviour of the IMF, as well as allow for separate decisions about defaulting only on IMF loans, but not on private loans, or vice-versa. This would eliminate the asymmetry, by allowing an endogenous borrowing constraint for the IMF loans similar to $\overline{d}_t$. However, this would considerably increase the state-space of the problem and, as a

[19] Political economy arguments may be used to explain why countries cannot commit with lower levels of government spending, and how the signing of an IMF program can affect the political game in a way that allows the implementation of fiscal reforms. See Corsetti, Guimarães and Roubini (2004) and Morris and Shin (2005).

[20] The assumption is really not necessary since the country would always prefer to lend to private banks, at a higher interest rate. However, in terms of the numerical method used for the solution of the model, it is always convenient to restrain the state-space for computational purposes.

[21] Thus, a natural upper bound on $\overline{f}$ would be the value such that private banks can avoid default by setting $\overline{d}_t^* - \overline{f} > 0$.

consequence, the computational cost of the numerical solution.[22] In order to keep things simple, the approach used here fixes $\overline{f}$ such that $\overline{d}_t$ is determined *given* (that is, as a function of) $\overline{f}$ and the country never defaults [23]. Nevertheless, if $\overline{f}$ is set too high, the country would end up by borrowing only from the IMF.[24]

One way to interpret the exogenous and constant value of $\overline{f}$ is as an institutional rule that ensures $f_t < \infty$. For instance, countries usually cannot borrow in excess of 300% of their quotas and, although exceptional access criteria do exist, they depend on country-level analysis by the Fund and are ultimately limited by the Fund's budget. The quota that each member of the IMF is assigned to is based broadly on its relative size in the world economy. Quotas are reviewed at least every five years, but revisions are not frequent,[25] implying that $\overline{f}$ is country-specific and changes slowly over time. In terms of the borrowing constraint, the private banks' actions are taken given the level of $\overline{f}$.

Thus, the optimal choice in terms of joining an IMF program or not is based on the net effect of conditions (10) and (11). On one hand, the country has more options for borrowing, including cheaper loans from the IMF, but must optimize subject to caps on the consumption of public goods. On the other hand, the country loses the option of additional borrowing from the IMF, but may freely choose the consumption allocations.

3.3.6 The Planner's Problem

Formally, the planner's problem is to maximize the objective function (1) subject to constraints (2) to (11), by choosing the sequence $\{c_t^T, c_t^N, g_t^T, g_t^N, d_t^*, d_t, f_t, IMF_t, DEF_t\}_{t=0}^{\infty}$. The timing of events, represented in Figure 3.1, is as follows. Once the state $\langle d_{t-1}^*, S_t \rangle$ is known, the central planner decides: (1) whether the outstanding debt (both from private banks and from the IMF) including interest services is going to be repaid or defaulted, and (2) whether to sign an IMF program or not. Then, international lenders set $\overline{d}_t^*$, given $\overline{f}$. Finally, given expectations about the next realization of the shock, and the endogenous borrowing constraint, the planner chooses the next period levels of the endogenous state and control variables.

The planner's problem admits a recursive formulation. Recall that, given the definitions of c_t and g_t in (2) and (3), one can write the instantaneous utility function as $u\left(c_t^T, c_t^N, g_t^T, g_t^N\right)$. In addition, let the time subscript t be excluded from the (indirect) utility functions so that V^D and V^R represent time-invariant value functions.

[22] For the moment, we leave this for future research.

[23] Note that, because $r^* < r$, it iwould be always in the interest of the economy to first default on the debt from private lenders.

[24] This means that, by changing the value of $\overline{f}$ from zero to a value that is high enough, it is possible to generate different shares of IMf lending on the total debt in the $[0, 1]$ interval. In the calibration exercise for the Brazilian economy discussed in Section 3.4, $\overline{f}$ is calibrated to match a realistic $\overline{f}/\overline{d}_t^*$ ratio.

[25] For instance, in 1998 the quota review led to a 45 per cent increase in IMF quotas, but the review concluded in January 2003 resulted in no change in quotas.

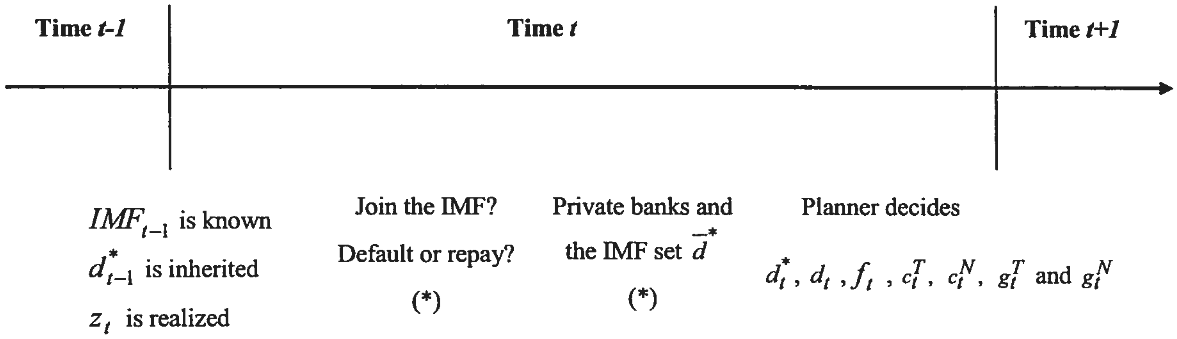

Fig. 3.1 - Sequence of Events

In the default case, the country cannot choose the IMF option, which implies $IMF_t = 0$. The planner has to choose optimal decision rules for c_t^T, c_t^N, g_t^T and g_t^N in order to solve the following Bellman equation:

$$V^D(z_t) = \max_{\langle c_t^T, c_t^N, g_t^T, g_t^N \rangle} \left\{ u\left(c_t^T, c_t^N, g_t^T, g_t^N\right) + \beta \mathrm{E}_z V^D(z_{t+1}) \right\},$$

subject to:

$$\begin{aligned} c_t^T + g_t^T &= \lambda\left(y^T + z_t\right); \\ c_t^N + g_t^N &= \lambda y^N. \end{aligned}$$

When $DEF_t = 0$, a set of decision rules for $c_t^T, c_t^N, g_t^T, g_t^N$, IMF_t, f_t and d_t^* are required for the solution of the following Bellman equation:

$$\begin{aligned} V^R\left(d_{t-1}^*, S_t\right) &\equiv \max_{\langle c_t^T, c_t^N, g_t^T, g_t^N, d_t^*, IMF_t, f_t \rangle} \left\{ u\left(c_t^T, c_t^N, g_t^T, g_t^N\right) + \beta \mathrm{E}_z \max\left[V^R\left(d_t^*, S_{t+1}\right), V^D(z_{t+1})\right] \right\}, \\ \text{where } S_t &= \{z_t, IMF_{t-1}, f_{t-1}\}_t,\ f_t \in \mathbf{F} \subseteq \mathcal{R}^+ \text{ and } d_t^* \in \mathbf{D} \subseteq \mathcal{R}, \end{aligned}$$

subject to:

$$\begin{aligned} & c_t^N + g_t^N = y^N; \\ & c_t^T + g_t^T = y^T + z_t + d_t^* - (1+r)\, d_{t-1}^* + (r - r^*)\, IMF_{t-1} f_{t-1}; \\ & d_t^* = d_t + IMF_t f_t; \\ & d_t^* \le \overline{d}_t^* = \min_{\Omega_Z} \left\{ \overline{d}^*(S_t) : V^R\left(\overline{d}^*(S_t), S_t\right) = V^D(z_t) \right\}; \\ & \text{if } IMF_t = 0: DEF_t \in \{0,1\};\ d_t \in \mathbf{D};\ f_t = 0;\ 0 \le g_t^i,\ i = T, N; \\ & \text{if } IMF_t = 1: DEF_t = 0;\ d_t \ge 0;\ 0 \le f_t \le \overline{f} < \infty;\ 0 \le g_t^i \le \overline{g}_t^i,\ i = T, N. \end{aligned}$$

The solution consists of three objects: (1) a set of state-contingent optimal decision rules for the level of next-period debt with private lenders, for the IMF program indicator binary variable, and for the next-period debt with the IMF, $d^*\left(d^*_{t-1}, S_t\right)$, $IMF\left(d^*_{t-1}, S_t\right)$ and $f\left(d^*_{t-1}, S_t\right)$; (2) two value functions $V^D\left(z_t\right)$ and $V^R\left(d^*_{t-1}, S_t\right)$; and (3) the state-dependent level of the borrowing constraint, $\overline{d}^*_t = \overline{d}^*\left(S_t\right)$. Given the solution, the underlying probability distribution function of the shock, jointly with the decision rules, determine the transition and limiting distributions of all endogenous variables in the model.

Note that, in this setup, whenever the country chooses $IMF_t = 1$, it will always decide to withdraw the totality of the resources made available by the Fund (i.e $f_t = \overline{f}$). This is because there is substitution in borrowing from private banks, at interest rate r, and from the Fund, at a lower (financial) cost. Once the country accepts the cost of conditionality, then it will always borrow from the IMF up to the limit, at a lower interest rate, and then supplement its borrowing needs from private banks. Also note that, although default is a possible choice for the planner, for any given value of $\overline{f}$, there will be no default at the optimum, since the enforcement of condition (9) will force the planner to always choose $DEF_t = 0$.

In the empirical application of the model we use a constant relative risk-aversion (CRRA) specification for instantaneous utility function, with a CES aggregator for c_t and g_t:

$$\begin{aligned} u\left(c_t, g_t\right) &= \frac{\left\{\left[\delta c_t^{-\nu} + (1-\delta)\, g_t^{-\nu}\right]^{-\frac{1}{\nu}}\right\}^{1-\gamma} - 1}{1-\gamma}, \text{ if } \gamma \neq 1 \\ &= \log\left\{\left[\delta c_t^{-\nu} + (1-\delta)\, g_t^{-\nu}\right]^{-\frac{1}{\nu}}\right\}, \text{ if } \gamma = 1 \end{aligned}$$

where $\gamma > 0$ is the (reciprocal) of the intertemporal elasticity of substitution on the composite CES consumption index (or the risk-aversion parameter), $\delta \in [0,1]$ gives the weight of private consumption in the aggregator and $1/\left(1+\nu\right) > 0$ is the elasticity of substitution between the consumption of private and public goods.

The first-order conditions of the planner's problem imply the following optimal conditions:

$$p_t = \frac{(1-\omega_c)}{\omega_c}\left(\frac{c_t^T}{c_t^N}\right)^{(1+\mu_c)}, \tag{12}$$

$$\begin{aligned} p_t &= \frac{(1-\omega_g)}{\omega_g}\left(\frac{g_t^T}{g_t^N}\right)^{(1+\mu_g)}, \text{ if } IMF_t = 0 \\ &= \frac{\Psi_t\left(1-\omega_g\right)\left(g_t^N\right)^{-(1+\mu_g)} - q_t^N}{\Psi_t \omega_g \left(g_t^T\right)^{-(1+\mu_g)} - q_t^T}, \text{ if } IMF_t = 1, \end{aligned} \tag{13}$$

$$P_t^T = \beta\left(1+r\right) \mathrm{E}_t P_{t+1}^T, \tag{14}$$

where $p_t \equiv P_t^N / P_t^T$ is the optimal level of the real exchange rate, as measured by the relative (shadow) price of non-tradable with respect to tradable goods; P_t^N and P_t^T are the Lagrange multipliers associated with the non-tradable and tradable resource constraints, respectively; q_t^N and q_t^N are the Lagrange multipliers for the conditionality rule $g_t^i \leq \overline{g}^i$, $i = T, N$, and $\Psi_t = (1-\delta)\, g_t^{(\mu_g-\nu)} \left[\delta c_t^{-\nu} + (1-\delta)\, g_t^{-\nu}\right]^{(\gamma-\nu-1)/\nu}$. Notice that, when $IMF_t = 1$ and the conditionality rule is binding, there is a wedge between the optimal levels of consumption of public goods and what would be otherwise. This wedge represents the potential cost of conditionality, preventing the shadow prices P_t^N and P_t^T from being equal to the marginal utility of the consumption of public goods as non-tradables and tradables, respectively.

3.4 Calibration

In this section, quantitative implications of the model are presented. The artificial economy was calibrated for the Brazilian data. The calibration procedure took as reference a normalized, long-run mean of the system, in which $\mathrm{E}(z_t) = 0$ and the values of the tradable endowment and the real exchange rate are $y^T = p = 1$. On this average path, the economy is assumed to participate in an IMF program with frequency α. For instance, the frequency at which Brazil was under an IMF program during the period of reference was 50 out of 98 quarters, which implies the calibrated value $\alpha = 51.0\%$.

Table 3.4
Targeted Average Long-Run Ratios

"Big Ratios"	Values
1. Share of tradables in total output	$k_T = 0.4045$
2. Debt-to-output ratio (private lenders)	$k_d = 0.2597$
3. Debt-to-output ratio (IMF loans)	$k_f = 0.0136$
4. Share of $G_t = g_t^T + p_t g_t^N$ in total output	$k_g = 0.2057$
5. Frequency of IMF programs	$\alpha = 0.5102$

Let $Y = y^T + py^N$, d and f be the long-run average levels of the total endowment, private and IMF loans, in units of tradable goods, respectively. In addition, denote g^T and g^N as the long-run average values for the consumption of public goods in tradable and non-tradable goods, respectively. Three types of long-run ratios were targeted: (1) the average share of the tradable output in total output, $k_T = y^T/Y$; (2) the average debt-to-output ratios from banks and Fund loans, $k_d = d/Y$ and $k_f = f/Y$, respectively; and (3) the ratio of government spending (as proxy for total consumption of public goods) to total output, $k_g = \left(g^T + pg^N\right)/Y$. The "big ratios" implied from the data are shown in Table 3.4.[26]

[26] Data on GDP, tradable GDP (proxyied by the GDP excluded of the sum of before taxes GDP of services, construction industry plus a financial dummy) and government spending were obtained at the *Intituto Brasileiro de Geografia e Estatística* (IBGE). The total net external debt (external debt minus international reserves) refers to the period 1982:4-2004:2 and are available from the *Banco Central do Brasil*. IMF loans and country participation in IMF programs were obtained at the IMF. In computing k_d, "private loans" are simply all outstanding external debt not contracted from the IMF and may include other sources than private banks, such as loans from the World Bank and other multilateral agencies.

The normalized values for y^T and p, combined with k_T, k_d, k_f and k_g taken from the data, imply the calibrated long-run averages $Y = 1/k_T = 2.4722$, $y^N = 1/k_T - 1 = 1.4722$, $d = k_d/k_T = 0.6420$ and $f = k_f/k_T = 0.0336$. Under the additional assumption that the share of tradables in total consumption of public goods is also equal to k_T, then $g^T = k_g = 0.2057$ and $g^N = k_g(1/k_T - 1) = 0.3028$.

Exploring the recursive formulation of the central planner's problem, a numerical solution was obtained using the value function iteration method, with discretization of the state-space $\boldsymbol{S} = [\boldsymbol{D} \times \Omega_Z \times \boldsymbol{F} \times \{0,1\}]$, which is the support for the state $\langle d^*_{t-1}, S_t \rangle$, such that $d_t, d^*_t \in \boldsymbol{D} \subseteq \mathcal{R}$, $z_t \in \Omega_Z$, $f_t \in \boldsymbol{F} \subseteq \mathcal{R}^+$ and $IMF_t \in \{0,1\}$. In the numerical solution, $\boldsymbol{D}$, Ω_Z and $\boldsymbol{F}$ are approximated by the discrete sets $\widetilde{\boldsymbol{D}}$, $\widetilde{\Omega}_Z$ and $\widetilde{\boldsymbol{F}}$, respectively.

In order to capture the potential movements of the simulated series for the external debt, $\boldsymbol{D}$ is approximated by $\widetilde{\boldsymbol{D}} = \{d^*_t : d^*_{\min} \leq d^*_t \leq d^*_{\max}\}$, an evenly spaced d^*–grid (except for $d^*_t = 0$ and $d^*_t = d + f$) with $N_d = 602$ points. Given the average Y, the limits $d^*_{\min} = -1.0$ and $d^*_{\max} = 7.0$ imply debt-to-output ratios approximately in the range $[-0.4, 2.83]$, and were appropriately chosen to include the ergodic space. Negative values represent assets instead of liabilities.

Table 3.5
Summary of the Calibration Procedure

Exogenous Variables	Values	Motivation
1. Interest rate (IMF loans)	$r^* = 0.0081$	U.S. bonds deflated by CPI
2. Interest rate (private loans)	$r = 0.0282$	C bond spread over U.S. bonds
3. Average tradable output	$y^T = 1.0000$	normalization
4. Average real exchange rate	$p = 1.0000$	normalization
5. Non-tradable output	$y^N = 1.4722$	$k_T = y^T / (y^T + p y^N)$

Structural Parameters	Values	Motivation / Target
1. Risk aversion	$\gamma = 1.5000$	Standard
2. Share of c_t in CES aggregator	$\delta = 0.9850$	$k_g \cong \text{avg}[G_t / (y^T_t + p_t y^N)]$
3. Subjective discount factor	$\beta = 0.9726$	$\beta(1+r) = 1$
4. Elasticity of substitution between c and g	$\nu = 2.1500$	$1/(1+\nu) = 0.3175$
5. Elasticity of substitution between c^T and c^N	$\mu_c = 4.6600$	$\sigma_y = 2.76\%$
6. Elasticity of substitution between g^T and g^N	$\mu_g = 4.6600$	symmetry with c
7. Weight of tradables in CES c aggregator	$\omega_c = 0.0893$	$p = \frac{(1-\omega_c)}{\omega_c} \left(\frac{c^T}{c^N}\right)^{(1+\mu_c)} = 1$
8. Weight of tradables in CES g aggregator	$\omega_g = 0.0893$	symmetry with c
9. Autocorrelation for $z_t = \rho z_{t-1} + \varepsilon_t$	$\rho = 0.7188$	OLS estimation
10. Std. dev. for $z_t = \rho z_{t-1} + \varepsilon_t$	$\sigma_\varepsilon = 0.0229$	OLS estimation
11. Conditionality rule on g^i (% y^i), $i = T, N$	$\overline{g}^i = 20.9417$	$\alpha = 51.02\%$
12. Standard IMF loan (% Y)	$\overline{f} = 2.6700$	$k_f \cong \text{avg}[f_t / (y^T_t + p_t y^N)]$
13. Output loss in state of default	$\lambda = 0.9750$	$k_d \cong \text{avg}[d_t / (y^T_t + p_t y^N)]$

Table 3.5 displays the values of the exogenous variables and structural parameters used in the

calibration. For the exogenous stochastic process for the tradable endowment shock, we proceeded as follows. *First,* we detrended the data on tradable output, by removing a smooth trend with a Hodrick-Prescott (HP) filter and a smoothing parameter of 1600, for quarterly data. *Then,* we estimated a first-order autoregressive process of the type $z_t = \rho z_{t-1} + \varepsilon_t$, with $\varepsilon_t \backsim N(0, \sigma_\varepsilon)$, using ordinary least squares (OLS) on the HP-detrended data against its one-period lagged value. The autocorrelation (ρ) and the volatility (σ_ε) parameters obtained from the regression were $\rho = 0.7188$. and $\sigma_\varepsilon = 0.0229$, respectively.[27] *Finally,* the estimated stochastic process was discretized into a 5-point Markov chain, using Tauchen's (1986) procedure, resulting in an evenly spaced grid $\widetilde{\Omega}_Z = \{z_1, ..., z_5\}$, such that $z_3 = 0$, $z_1 = -z_5 = 0.0989$ and $z_2 = -z_4 = 0.0494$,[28] and in an underlying probability transition matrix given by:

$$\Pi = \begin{bmatrix} 0.3423 & 0.5984 & 0.0591 & 0.0002 & 0.0000 \\ 0.0467 & 0.5669 & 0.3744 & 0.0120 & 0.0000 \\ 0.0016 & 0.1611 & 0.6746 & 0.1611 & 0.0016 \\ 0.0000 & 0.0120 & 0.3744 & 0.5669 & 0.0467 \\ 0.0000 & 0.0002 & 0.0591 & 0.5984 & 0.3423 \end{bmatrix}$$

As for the IMF loans, we used the set $\widetilde{\boldsymbol{F}} = \{0, \overline{f}\}$, consisting of only two possible choices. The economy gets $f_t = 0$ when the planner chooses $IMF_t = 0$. As previously mentioned, the assumption that $r > r^*$ ensures $f_t = \overline{f}$ whenever $IMF_t = 1$, which allows $\widetilde{\boldsymbol{F}}$ to have only two points and substantially reduces the dimension of the state-space and the computational cost of the numerical solution discussed below. The IMF standard loan, $\overline{f}$, was calibrated to match the average value of IMF loans as a proportion of the GDP, given by k_f. Notice that, since the country will participate in an IMF program with frequency α, the long-run average IMF loan, f, has to be equal to $\alpha\overline{f}$. Given the values of α and f defined above, $\overline{f}$ was set to 0.0659, which corresponds to approximately 2.7% of the targeted average total output, Y.[29]

Accordingly, the caps $\overline{g}^i$, $i = T, N$, to be satisfied as conditionality rule when $IMF_t = 1$, were calibrated to approximate the frequency at which Brazil participates in an IMF program, α. They were set to $\overline{g}^T = 0.2094$ and $\overline{g}^N = 0.3087$, which correspond to about 21% of the endowments.

Following the traditional hypothesis used in the small open economy literature, in order to avoid a unit root in the current account, the subjective discount factor must satisfy $\beta(1 + r) = 1$

[27] Using data on tradable output (gdp^T), the following regression was estimated:

$$\left(gdp_t^T - HPgdp_t^T\right) = \alpha_0 + \rho\left(gdp_{t-1}^T - HPgdp_{t-1}^T\right) + \varepsilon_t$$

with $R^2 = 0.5227$ and estimated parameters (p-values in parentheses) $\widehat{\alpha}_0 = -0.0272$ (0.9073), $\widehat{\rho} = 0.7188$ (0.000) and $\widehat{\sigma}_\varepsilon = 0.0229$.

[28] In the OLS estimation, we normalized the data on tradable output (gdp^T) such that the sample average was equal to 1. Although, the points $z_1, ..., z_5$ cannot be interpreted as percentage deviations of the trend, they are such that $y_t^T > 0$ at all times, since we impose $y^T = 1$. The use of $\log(gdp^T)$ in the OLS estimations produced similar results in terms of percentage deviations of the HP-trend.

[29] This calibrated value satisfies the condition $\overline{d}_t^* - \overline{f} > 0$ as discussed in footnote 20.

and, thus, was set to $\beta = 0.9713$. It is worth mentioning that this value of β is consistent with estimations by Issler and Piqueira (2000), using the same utility function as here, for the Brazilian economy.

The value for the reciprocal of the intertemporal elasticity substitution (or, equivalently, for the CRRA case, the risk-aversion parameter) was set to $\gamma = 1.5$, which is standard.[30] The exogenous interest rate was set at the average level that the Brazilian government pays on its sovereign debt, as represented by the Federative Republic of Brazil's *C-Bonds*. Here, the idiosyncratic market interest rate, r, is considered to be the quarterly equivalent of the average real annual rate on the U.S. Government Bonds ($r^* = 4.\%$ per year, or 0.81% per quarter, using the U.S. CPI inflation rate) plus the average spread paid on the *C-Bonds* (803.4 basis points, or $\zeta \simeq 8\%$ per year).[31] The result is $r = r^* + \zeta = 2.82\%$ per quarter. In addition, the parameter ν was set to 2.15, which is inside the range of values usually observed in empirical studies [see Bouakez and Rebei (2003)], and implies an elasticity of substitution between c and g equal to 0.3175.

The share of private consumption goods in the CES composite consumption index, was calibrated to $\delta = 0.9850$ in order to match the average of total government consumption as a proportion of the GDP, represented by k_g. The parameter governing the output loss observed in default states was set to $\lambda = 0.9750$, which implies output losses of 2.50% during default episodes and helps to approximate the target k_d. This value is (roughly) in line with the empirical findings by Chuhan and Sturzenegger (2003).

For known values of k_T, k_d and k_g, the normalized version of condition (12), computed at the long-run average target path, implies a one-to-one relationship between ω_c and μ_c.[32] Among the different possible combinations of ω_c and μ_c that satisfy that relationship, $\omega_c = 0.0893$ and $\mu_c = 4.66$ (which imply an elasticity of substitution between c^T and c^N equal to 0.1767) were chosen

[30] For instance, the value used here is the mid-range value of two very common alternatives, $\gamma = 1.001$ or $\gamma = 2$, used by Greenwood et al (1988) and Mendoza (1991), for example. Issler and Piqueira (2000) estimated $\gamma = 1.7$, using Brazilian data and the same type utility function used in this paper. The results of the simulation of the model are virtually the same if one uses this value instead of $\gamma = 1.5$.

[31] For the average risk-free real interest rate, the 10-year-maturity U.S. Government Bond was used, since its maturity is comparable to that of the C bonds. Because of data limitations, the average spread for the C bonds refer to the period 1995:1-2004:2.

[32] Because of the non-linear nature of the model, which in principle should induce agents to react asymmetrically to positive and negative shocks, a "deterministic steady state" may not be relevant to reflect the long run average state of the system. Ideally, in this case, a more precise method of calibration should be carried out through the solution of the whole model for a given set of parameters (all of them) and successive improvements should be made until the target average values were obtained. However, this non-linearity did not seem to be important here and the calibration procedure used, based on a deterministic steady state, was able to generate the target averages quite accurately.

in order to match the total output volatility $\sigma_y = 2.76\%$ observed in the Brazilian data.[33,34]. The corresponding parameters for g^T and g^N were set to $\mu_g = \mu_c$, and $\omega_g = \omega_c$, by symmetry.

The algorithm used in the numeric solution is the following. For each iteration j of the algorithm, given the discretized state-space $\widetilde{\boldsymbol{S}} = \left[\widetilde{\boldsymbol{D}} \times \widetilde{\Omega}_Z \times \widetilde{\boldsymbol{F}} \times \{0,1\}\right]$ and an initial guess for the borrowing constraint, $\overline{d}^{*(j)}$, the unconstrained model (with no borrowing constraint) is solved and value functions $V^{D(j)}(z_t)$ and $V^{R(j)}\left(d_{t-1}^*, \widehat{S}_t\right)$, as well as the decision rule $d^{*(j)}\left(d_{t-1}^*, S_t\right)$, are computed through iteration on the Bellman equation.[35] During this step, the borrowing constraint is imposed, meaning that whenever $d^{*(j)}\left(d_{t-1}^*, S_t\right)$ is such that $d^{*(j)} > \overline{d}^{*(j)}$, then we set $d^{*(j)} = \overline{d}^{*(j)}$. Updates of the borrowing constraint are obtained using:

$$\overline{d}^{*(j+1)} = \min_{\widetilde{\Omega}_Z}\left\{\overline{d}^*(S_t) : V^{R(j)}\left(\overline{d}^*(S_t), S_t\right) = V^{D(j)}(z_t)\right\}.$$

The procedure is implemented until convergence when $\overline{d}^{*(j+1)} \approx \overline{d}^{*(j)}$.

3.5 Results

Tables 3.6 and 3.7 show the average results of 500 simulations of a time series of size 98, corresponding to the 1980Q1–2004Q2 period. The actual Brazilian series for private consumption, government consumption and total GDP, expressed in per capita values at average prices of 1991Q1, came from the *Instituto de Pesquisa Economica Aplicada* (IPEA), available at *www.ipeadata.gov.br* . They are consistent with data from the International Monetary Fund's *International Financial Statistics* when they happen to overlap. Data on external debt and GDP in US dollars, used to compute debt-to-GDP ratios, came from the Central Bank of Brazil. Both the actual and simulated series for consumption and GDP were transformed previously to the computation of their second moment statistics, as follows. First, all the variables were expressed in logarithms. Second, for the actual series, a seasonal adjustment on the log-variables was implemented using the multiplicative ratio-to-moving-average method. Finally, a smooth trend was subtracted by using the HP filter with smoothing parameter of 1600.

[33] In principle, both parameters, ω_c and μ_c, are important to the volatility of the real exchange rate p. However, since the business cycle statistics are usually computed on the log variables in order to control for scale effects, only μ_c will have an impact on the volatility of (the log of) p. For instance, by taking the logarithm on both sides of equation (12), it is easy to see that $VAR(\log p_t) = (1+\mu_c)^2\, VAR\left(\log c_t^T\right)$, implying that the ratio between the volatilities of (the logs of) p_t and c_t^T, as measured by their standard deviations, must be constant and equal to $(1+\mu_c)$. Because of its effect on the volatility of p, the parameter μ_c has an influence on the volatilities of total output, $Y_t^T + p_t Y^N$, total consumption of private $\left(C_t = c_t^T + p_t c_t^N\right)$ and public goods $\left(G_t = g_t^T + p_t g_t^N\right)$.

[34] At the long-run average, given the two resource constraints and the normalized version of condition (12), the implied relationship between ω_c and μ_c is:

$$\omega_c \approx \left\{1 + \left[\frac{(1-k_T)(1-k_g)}{k_T(1-k_g) - r k_d - r^* k_f}\right]^{(1+\mu_c)}\right\}^{-1}.$$

[35] This step itself requires initial guesses for the value functions and the iterations on the Bellman equation are undertaken until convergence.

In general, the baseline model of a borrowing constrained economy with the option of seeking the IMF's assistance performs well. Note that the model is able to replicate the debt-to-output ratios, both from private lenders and from the IMF, the consumption of public goods as a proportion of the GDP, as well as Brazil's participation in IMF programs.

Table 3.6
Results (I)

Variable (%)	Data Brazil (1980Q1–2004Q2)	Model Unconstrained NO IMF	Model Constrained IMF	Model Constrained NO IMF
σ_c	3.63	1.53	1.99	2.02
σ_y	2.76	2.41	2.76	2.79
G/Y	20.60	20.76	20.79	20.78
d^*/Y	27.33	33.42	27.52	27.38
d/Y	25.97	33.42	26.17	27.38
f/Y	1.36	–	1.34	–
α	51.02	–	56.27	–

In Table 3.6, σ_c and σ_y represent the volatility of (the log of) total consumption of private goods and total GDP, in units of tradable goods, as given by $C_t = c_t^T + p_t c_t^N$ and $Y_t = y_t^T + p_t y^N$, respectively. Note that the comparison between the constrained and unconstrained economies shows that the borrowing constraint has the effect of increasing consumption and GDP volatility from 1.53% and 2.41%, respectively, in the unconstrained economy (with no IMF), to 1.99% and 2.76% in a constrained economy when the Fund is present, and to 2.02% and 2.79% when it is not. That is, given that the economy faces a borrowing constraint, the IMF means less volatility.

On the down side, although it generates a higher relative consumption volatility ($1.99/2.76 = 72.1\%$) in comparison with the unconstrained economy without the IMF option (63.5%), the model cannot reproduce the absolute level of consumption volatility observed in the data. This is a shortcoming of this analysis since consumption is more volatile than output in emerging economies [see Resende (2005)], meaning that other sources of consumption volatility may be missing here, such as interest rate shocks or permanent shocks to the growth rate of productivity [see, respectively, Neumeyer and Perri (2004) and Aguiar and Gopinath (2004)].

The comparison between the constrained economies with and without the IMF seems to suggest that IMF loans crowd out private loans, having a *negative catalytic effect.* In Table 3.6, note that, despite the small increase in total debt when the IMF is present, the amount of private loans is higher when there is no IMF, and the difference is almost totally accounted for by Fund loans. Nevertheless, even though private loans behave as substitutes to Fund loans (rather than as complements), the country's access to international capital markets is indeed facilitated by the Fund because the direct effect of IMF lending makes the borrowing constraint on *total debt* less stringent.

Potentially, the increase in available funds for the country to borrow may come from two sources. *First,* there is the direct increase due to the possibility of borrowing from the Fund, given the maximum amount of private loans. *Second,* there is the possibility that the borrowing constraint $\overline{d}_t^*$ may be positively affected by a general-equilibrium effect of the country's decision of joining an IMF program, when this decision reduces the likelihood of default on the external debt. If the borrowing constraint on private loans, $\overline{d}_t^* - \overline{f}$, turns out to be higher than it would be in the absence of the IMF, then there is positive catalysis of private capital flows by IMF lending. In the above exercise, the opposite situation was observed.

Table 3.7
Results (II)

Model	IMF_{t-1}	f_{t-1} (% GDP)	$\overline{g}^i$ (% y^i)	$\overline{d}_t^*$ (% GDP)	$\overline{d}_t^* - \overline{f}$ (% GDP)	Binding $\overline{d}_t^*$ (%)
Constrained NO IMF	–	0.0	∞	77.79	77.79	0.63
Constrained IMF	0	0.0	∞	77.89	75.30	0.58
	1	2.59	20.94	79.07	76.48	

Observe in Table 3.7 that, considering the triplet $(IMF_{t-1}, f_{t-1}, \overline{g}^i)$, there is no difference in $\overline{d}_t^*$ between the model without the IMF and the model with the IMF when $IMF_{t-1} = 0$.[36] However, the borrowing constraint on total debt is less stringent when $IMF_{t-1} = 1$. Given the country's participation in IMF programs reported in Table 3.6, this means that almost 60% of the time the economy has more room for consumption smoothing than would be the case if it did not have the option of seeking the Fund's assistance. The lower volatility associated with the presence of the IMF, in the constrained economies as shown in Table 3.6, is a result of this less stringent borrowing constraint. This also explains why the frequency at which the borrowing constraint binds is lower in the IMF case (see Table 3.7).[37]

Figure 3.2, below, shows how the baseline model changes when the conditionality rule on $\overline{g}^i$ becomes less stringent. In all four graphs, from left to right, the caps $\overline{g}^i$, $i = T, N$, imposed by the IMF are relaxed. Notice that, as conditionality is just slightly stronger (i.e. $\overline{g}^i$ is less than 0.012% of the GDP lower) than our baseline case, IMF participation and IMF lending (upper-left corner) are null. As we move to the right, and conditionality is relaxed, IMF participation and IMF lending increase, reducing the volatilities of C and Y (upper-right corner), as well as the frequency

[36] In percentage of the GDP, the small difference (77.89% – 77.79%) is due to effects of the real exchange rate on the total GDP. The levels of $\overline{d}_t^*$ are the same in both cases.

[37] Notice also that the level of the debt limit as a proportion of the simulated average GDP, both with and without the IMF, was such that it corresponds to more than the lower bound of 47.02%, given by the maximal level for the debt-output ratio observed in Brazil, in the period 1980:1-2004.4.

at which the borrowing constraint binds (lower-left corner). The negative catalysis of IMF lending can be seen in the lower-right corner of Figure 3.1: since $\overline{d}_t^*$ is not affected, as $\overline{f}$ increases, the private borrowing constraint $\overline{d}_t^* - \overline{f}$ is reduced and d_t is crowded out by f_t.

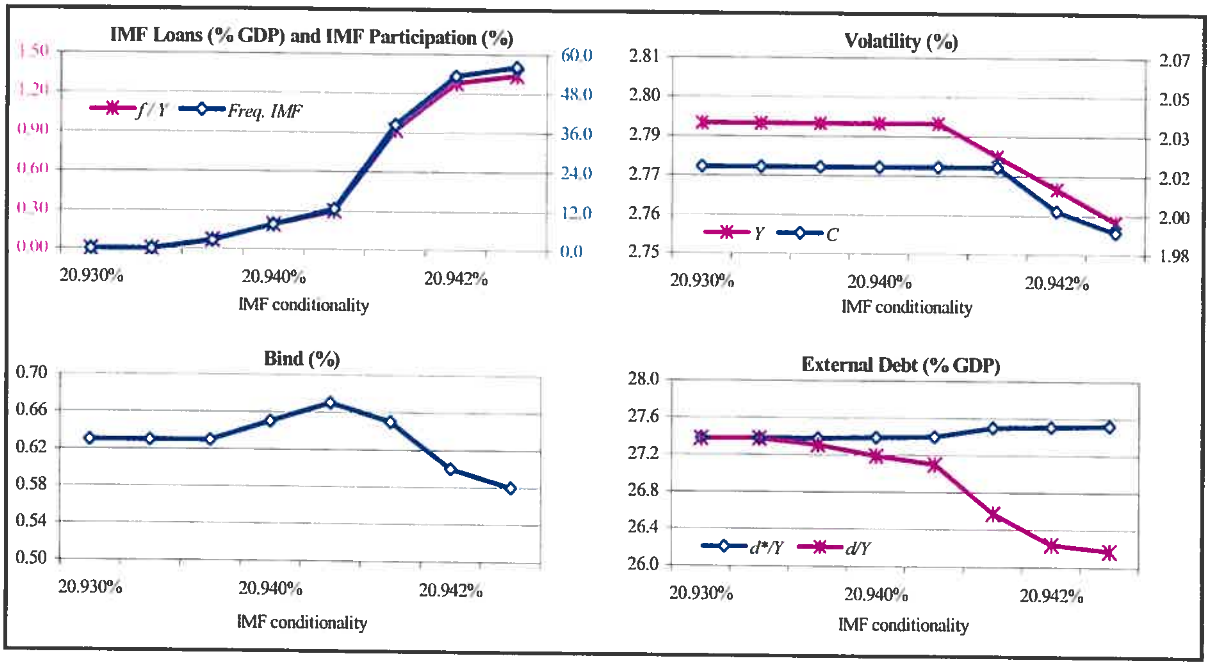

Fig. 3.2 - Effects of Changes in $\overline{g}_i$

It is important to understand why IMF lending does not catalyze private loans in this set up. In general, positive catalysis of private lending occurs when there is a reduction in the likelihood of default induced by the IMF programs. If they can reduce the incentives of default, foreign lenders may relax their borrowing constraint. Strictly in terms of IMF lending, abstracting from the conditionality aspect of adjustment programs, its effect on the likelihood of default is ambiguous because of the lower interest rate charged on IMF loans, as explained in Section 3.

As for the effect of IMF conditionality on positive catalysis, it depends on how much it increases the economy's *ex-ante* propension to save. To the extent that highly indebted economies can benefit more, instantaneously, from the higher current consumption that can be achieved in case of default, higher propension to save and lower demand for debt means less incentives to default. Figure 3.3 ilustrates how the ability of IMF conditionality in stimulating savings and program participation depends on the structural parameters.

To better understand this point, *first* note that consumption of private and public goods are strategic complements (substitutes) whenever $1+\nu$ is higher (lower) than γ. That is, if the elasticity of substitution between c and g is lower than the intertemporal elasticity of substitution, then the marginal utility of c_t^i is increasing in g_t^i, for $i = T, N$, implying that the consumption of public and private goods must change in the same direction. Given the calibration discussed above, the relevant case is that of complementarity between c and g.

IMF Conditionality and Structural Parameters

Elasticity of Substitution between c and g: $\varepsilon^{c,g} = 1/_{1+\nu}$

Intertemporal Elasticity of substitution between c and g: $\varepsilon^{t,t+1} = 1/_{\gamma}$

Share of c_t in *CES* aggregator: δ

High $\varepsilon^{c,g}$, δ and low $\varepsilon^{t,t+1}$:

- c and g are strategic substitutes and/or g is not very important for overall utility;
- Lower cost of sub-optimal g^i;
- More incentives to sign an IMF program;
- Small *ex-ante* increase in savings;
- Small reduction on the likelihood of default;
- IMF lending is likely to take place, but with NO Catalytic Effect.

Low $\varepsilon^{c,g}$, δ and high $\varepsilon^{t,t+1}$:

- c and g are strategic complements and/or g is important in overall utility;
- Higher cost of sub-optimal g^i;
- Less incentives to sign an IMF program;
- Higher *ex-ante* increase in savings;
- Higher reduction on the likelihood of default;
- IMF lending not very likely (prohibitive costs); Catalytic effect may be unobservable.

Fig. 3.3 - IMF Conditionality, Forced Savings and the Catalytic Effect

Second, let $g^i_{NO\ IMF}\left(d^*_{t-1}, z_t\right)$, $i = T, N$, be the decision rule that would determine the optimal consumption of public goods in the case the IMF did not exist. If the IMF actually imposes caps $\overline{g}^i$ such that $g^i_{NO\ IMF}\left(d^*_{t-1}, z_t\right) > \overline{g}^i$, then conditionality is too harsh relatively to the first best and there is a welfare cost of satisfying the IMF conditionality rule, since compliance implies sub-optimal g^i_t. Agents can always substitute the (forced) reduction in his consumption of g^i_t by consuming more c^i_t, but there is an misallocation cost. On one hand, when private and public goods are substitutes, this cost is low and the relative incentives to sign an IMF program are larger, but conditionality is not likely to increase savings and, as a consequence, the catalitic effect is not likely to occur. This is also true if the weight of g_t in the CES consumption aggregator is small.

On the other hand, complementarity between c and g implies that the lower level of g^i_t, compared to the case of no IMF, must be followed by a corresponding lower level of c^i_t. If the resulting oversaving is too costly for the country, it tends not to go to the IMF for assistance. Observe that (see Figure 3.1) the country always chooses $IMF_t = 0$ when $\overline{g}^i$ is set too low. Obviously, in the case there is no IMF program participation there is no catalytic effect.

Now, consider the opposite situation, such that $g^i_{NO\ IMF}\left(d^*_{t-1}, z_t\right) < \overline{g}^i$. Conditionality is "soft" and IMF participation will be positive for some $\overline{g}^i$, since the constraint $g^i_t \leq \overline{g}^i$ will not be binding and, at the same time, the country still can enjoy the benefits of cheaper IMF loans in case of need. In this situation, conditionality *is not* a real cost for the country because optimal g^i_t is always achieved without violating the IMF conditionality. However, the country is not forced to save more (than it would do freely) and, as a consequence, for each realization of the shock there is no reduction in the likelihood of default and no positive catalytic effect takes place. On the contrary, the cheaper IMF lending compared to the private banks, combined with a non-binding conditionality rule, will induce the economy to consume more of both private and public goods. In particular, this is true for tradable goods, which leads to higher demand for external debt, forces private banks to be even more strict in their lending and explains the negative catalytic effect on private lending reported above.

3.5.1 IMF Programs as Commitment Devices

Now, consider a different model in which the planner does not choose g^i_t optimally. Instead, consumption of public goods is exogenous and such that $g^i_t \in \left\{g^i_L, g^i_H\right\}$, where $g^i_L < g^i_H$. Furthermore, assume that the country cannot commit with the low level of consumption of public goods, g^i_L, even if it would be better for the representative agent to do so, but IMF programs can act as a commitment device [see See Marchesi and Thomas (1999) and Morris and Shin (2005)]. That is, assume that the support of the IMF can affect the domestic political game in such way that allows the country to commit with spending g^i_L. Formally, in this modified model, the planner's problem is identical to the original, as presented in the previous section, except for the conditionality rules (10) and (11). Given the new assumptions, those rules change into:

$$\text{if } IMF_t = 0 : \theta_t = \theta^0 = \left\{DEF_t \in \{0,1\}\,;\ d_t \in \mathbf{D};\ f_t = 0;\ g^i_t = g^i_H < y^i_t,\ i = T, N\right\}, \qquad (15)$$

$$\text{if } IMF_t = 1 : \theta_t = \theta^1 = \left\{DEF_t = 0;\ d_t \geq 0;\ 0 \leq f_t \leq \overline{f} < \infty;\ g^i_t = g^i_L < g^i_H,\ i = T, N\right\}. \qquad (16)$$

Note that, if we consider the situation where $g^i_{NO\ IMF}\left(d^*_{t-1}, z_t\right) < g^i_L < g^i_H$, then the reduction from g^i_H to g^i_L as part of IMF rules will actually force the country to save more and, at the same time, push the country closer to what would be the optimal levels of g^i_t. In this case, the catalytic effect follows through as can be seen in Tables 3.8 and 3.9. These tables display similar information to Tables 3.6 and 3.7, respectively, but for the results from the modified model proposed above. The new set of results were obtained using the same basic calibration discussed previously, in the context of the original model. All parameters are the same, with the only difference that, instead of calibrated values for the caps $\overline{g}^i$, $i = T, N$, now we have to calibrate values for the exogenous levels g^i_H and g^i_L. For that, we proceed as follows.

Let k^j_g be the average ratio of consumption of public goods to GDP when $IMF = j$, for $j = 0, 1$.

In addition, let $\varkappa$ be the average reduction in the consumption of public goods as a percentage of the GDP required by IMF programs, implying $k_g^0 = k_g^1 + \varkappa > k_g^1$. According to Killick, Malik and Manuel (1995), the average reduction in government spending in IMF borrowers, comparing situations before and after an IMF program, is approximately 1% of the GDP. Given $\varkappa = 1\%$, we calibrated k_g^0 in order to approximate the target $\alpha = 51.02\%$ for program participation. The resulting calibrated values for the exogenous consumption of public goods are $g_H^i = k_g^0 y^i = 0.2131$, when $IMF_t = 0$, and $g_L^i = k_g^1 y^i = 0.2031$, when $IMF_t = 1$, for $i = T, N$.

Table 3.8
Alternative Model:.Results (I)

calibration: $g_H^i/y^i = 21.3\%$; $g_L^i/y^i = 20.3\%$

Variable (%)	Data Brazil (1980.1 - 2004.2)	Model Constrained IMF	Model Constrained NO IMF
σ_c	3.63	2.39	2.57
σ_y	2.76	3.14	3.21
G/Y	20.60	20.81	21.32
d^*/Y	27.33	28.81	22.25
d/Y	25.97	27.32	22.25
f/Y	1.36	1.49	–
α	51.02	51.23	–

Observe in Table 3.8 that, compared to the model with no IMF, the presence of the Fund implies: (1) a lower ratio of consumption of public goods to GDP, as required by IMF conditionality; (2) a higher total external debt as a percentage of the GDP, as in the original model; (3) lower volatilities σ_c and σ_y; and, most importantly; (4) a higher level of private loans as a proportion of the GDP, suggesting a positive catalytic effect of IMF lending that improves the country's access to international *private* loans (not only to total loans).

The evidence of a positive catalytic effect of IMF lending, in this modified model, can also be seen in Table 3.9. Note that, not only is the borrowing constraint for the total external debt higher when the IMF exists, but so is the borrowing constraint on private loans, $\overline{d}_t^* - \overline{f}$. Again, as a consequence, the borrowing constraint binds with less frequency for the model with the IMF.

Table 3.9
Alternative Model:.Results (II)

Model	IMF_{t-1}	f_{t-1} ($\%\ GDP$)	g^i ($\%\ y^i$)	$\overline{d}_t^*$ ($\%\ GDP$)	$\overline{d}_t^* - \overline{f}$ ($\%\ GDP$)	Binding $\overline{d}_t^*$ (%)
Constrained NO IMF	–	0.0	21.3%	79.56	79.56	0.36
Constrained IMF	0	0.0	21.3%	83.96	81.33	0.31
	1	2.63	20.3%	85.95	83.33	

The mechanism through which the positive catalysis takes place is based on the increase in the country's external payments position due to IMF conditionality that forces the country to adjust (reduce) its level of consumption of public goods from g_H^i to g_L^i. Since the consumption of private and public goods are not perfect substitutes, and given that agents care about their future levels of consumption, the reduction in g_t actually forces the country to save more. By locking countries into a program of reform that ultimately improves their external payments position, conditionality provides external investors and private banks with a high degree of assurance about the country's decision to repay past debt instead of defaulting. Thus, *ceteris paribus*, the reduced likelihood of default allows private banks to relax the borrowing constraint.

To summarize the results so far:

1. IMF lending helps relax the borrowing constraint on total debt and, as a consequence, reduces the volatility of private consumption and GDP.

2. When countries optimally choose their allocations of public goods, then IMF conditionality based on restraining the consumption of public goods does not catalyze private capital flows. The reason is that when conditionality imposes a real cost in terms of sub-optimal higher savings, countries choose not to sign IMF programs; and when conditionality is not binding, countries will sign IMF programs but will not be forced to save more.

3. When countries use the IMF as a commitment device to reduce their spending on public goods, then IMF conditionality forces a higher level of savings, reduces the likelihood of default, and allows private banks to be less strict in their lending, which produces the positive catalytic effect on private loans, as the Fund claims.

The remaining question is: by how much does a less stringent borrowing constraint, due to the direct effect of IMF lending and/or to a positive catalytic effect induced by conditionality, improve welfare?

3.5.2 Welfare Analysis

In terms of the welfare implications of IMF programs, there are two forces at play here. The potential cost of joining a program is having to adjust the country's domestic absorption to the conditionality clauses, meaning that the country has to face the constraint (11) and set g_t^T and g_t^N at potentially suboptimal levels - or rule (16), in the case of the alternative model. The benefits, besides the lower interest on IMF loans, are related to the additional amount of external funds available for borrowing, on top of $\overline{d}_t$, which will allow a higher degree of consumption smoothing.

To assess the welfare effects of IMF-supported programs, the consumption equivalent approach is used. In particular, we computed the per cent increase in consumption across dates and states, such that the representative agent would receive the same utility, considering worlds with and without the IMF. Let ϑ be this equivalent variation in consumption allocations and let the superscripts ^{IMF} and ${}^{NO\ IMF}$ indicate the utility functions and value functions for the equilibrium values of consumption in worlds with and without the IMF, respectively. The value of ϑ can be computed from:

$$\int_S \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t u^{IMF} \left(qc_t^T, qc_t^N, qg_t^T, qg_t^N\right) d\phi = \int_{S'} V_0^{NO\ IMF}\ d\phi', \tag{17}$$

where:

$V_0^{NO\ IMF} = \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t u^{NO\ IMF} \left(c_t^T, c_t^N, g_t^T, g_t^N\right)$ is the value function obtained under the assumption that there is no IMF in the world, and $q = 1 + \vartheta$. The set $\boldsymbol{S'} = [\boldsymbol{D} \times \Omega_Z]$ is the support for the state of the economy in a world with no IMF. Note that the IMF is welfare improving in the case that $q < 1$, meaning that the consumption in a world with the option of joining an IMF program has to be decreased by ϑ in order to generate the same level of welfare as that of a world without an institution as the IMF.

In the quantitative exercise, using the original model presented in Section 5 to compare two economies that are identical except for the fact that one operates in a world with the IMF and the other in a world without the IMF, q was found to be equal to 0.9903. That is, in order to match the same welfare obtained in a world where there is no option of seeking the IMF's assistance, the consumption sequence observed in a world with the IMF has to be *decreased* by 0.97%. In the alternative model, with no optimal choice of consumption of public goods, we found $q = 0.9958$, implying a 0.42% reduction in consumption required to compensate for the lower welfare observed in the same economy if it did not have the option of seeking the IMF's assistance. Therefore, results suggest that the IMF has an overall small positive effect on welfare.

3.6 Conclusions

This paper presented a dynamic model of an endowment, two-good, small open economy subject to an endogenous borrowing constraint, where the planner can optimally choose to join an IMF-supported adjustment program. The quantitative exercise consisted of a comparison between one economy that has the option of seeking the IMF's assistance with another, identical in all aspects to the first one except that there is no IMF in the world (the counterfactual). The paper provides answers to two questions. *First*, can IMF conditionality, focused on the reduction of domestic absorption and control of the consumption of public goods, generate a positive catalytic effect, as the Fund claims? *Second*, what is welfare gain associated with IMF programs?

In terms of the numeric results, the answer to the first question depends on whether IMF conditionality can force the country to save more while offering enough compensation for this additional sub-optimal savings such that the country can actually decide to sign an IMF program. If the consumption of public goods is chosen optimally by the central planner, whenever the conditionality rule is too strict (relative to the optimal level for the no-IMF case) the country will not participate in IMF programs. The oversaving implied by conditionality is too costly for the economy.

On the other hand, when conditionality clauses are redundant (because the country optimally consumes less of public goods than the level determined by conditionality), not forcing the economy to save, then IMF participation is positive, but there is no improvement in the prospective of repayment of the external debt by the borrowing country. On the contrary, since conditionality is not a real cost and the country can still borrow at a lower interest rate from the IMF, private banks must be more strict in order to avoid default. This, in turn, generates a negative catalytic effect of IMF lending on private capital flows, although the borrowing constraint on total external debt may be relaxed.

Only by increasing a country's external payments position may the Fund help the country signal to foreign private lenders that the opportunity cost of defaulting has become higher, and the likelihood of debt repudiation has been reduced. That situation is possible when the planner does not optimally choose the allocations of consumption of public goods. In that case, under the assumption that the IMF can act as a commitment device that allows the economy to operate with a lower level of consumption of public goods than it would otherwise, IMF conditionality produces a positive catalytic effect on private capital flows. Catalysis occurs because the reduction in consumption forces the country to save more and, at the same time, pushes the economy closer to what would be the optimal allocation. As a result, the likelihood of default is reduced and international private creditors can relax their borrowing constraints. Both the direct (additional source of loans) and indirect (positive catalysis on private loans) effects of IMF lending imply a less stringent borrowing constraint that allows more room for consumption smoothing.

However, a less stringent borrowing constraint, either resulting from direct lending or (also from) positive catalysis of private flows, is not a measure of "success" or "failure" of IMF programs. The welfare effects associated with IMF lending by the Fund do not seem to be very quantitatively important. It is true that the less stringent borrowing constraint allows the country easier access to international capital markets and, as such, improves the country's consumption smoothing opportunities. The reduction in volatility does produce welfare improvements. For the set of parameters used in the calibration exercise, which were set to approximate the Brazilian economy during the 1980-2004 period, IMF lending generates improvements in welfare equivalent to less than 1% in additional consumption.

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Conclusion

Conclusion

Dans le premier chapitre, j'ai étudié comment les politiques fiscale et monétaire interagissent pour déterminer le niveau des prix, avec un modèle simple d'une économie monétaire à l'horizon infini. Le comportement du gouvernement est caractérisé par une règle de politique fiscale selon laquelle une fraction de la dette courante a comme contrepartie la valeur présente escomptée du surplus primaire, courant et future. La partie restante est financée par la création de monnaie, au présent et/ou dans le future, avec les recettes de *seigniorage* associées. Une économie peut, donc, être indexée par la fraction de la dette courante financée par l'autorité fiscale. J'ai démontré que seulement dans le cas extrême d'un régime fiscal Ricardien, quand la totalité de la dette est (intertemporellement) financée par la politique fiscale, le niveau de prix est déterminé par le stock de monnaie. De façon général, la proportion de la dette financée par la création de monnaie a le même rôle que la monnaie elle-même pour la détermination du niveau des prix. Avec des techniques économétriques standards de racines unitaires et cointegration, en utilisant des donnés de consommation, de base monétaire et de dette du gouvernement, le paramètre qui indexe le régime de politique a pu être estimé pour les pays de l'OCDE. Les résultats suggèrent que le régime fiscal Ricardien est une approximation raisonnable pour ces pays. Ceci implique que: (i) l'autorité fiscale est l'ultime responsable du financement total de la dette, et (ii) la dette joue un rôle mineur dans la détermination du niveau des prix.

Dans le deuxième chapitre, j'ai étudié la différence entre la volatilité relative de la consommation par rapport à l'output existant entre les économies émergentes et les petites économies ouvertes et développées. Les donnés indiquent que la volatilité relative de la consommation est 30 pourcent plus grande dans les économies émergentes par rapport aux économies développées. De plus, cette différence est statistiquement significative. Avec un modèle d'équilibre général dynamique à deux biens, appliqué à une petite économie ouverte qui fait face à une contrainte d'endettement endogène, j'ai démontré qur l'effet de la contrainte est suffisant pour augmenter la volatilité relative de la consommation de 16.3 pour cent. Cela explique plus de 50 pourcent de la différence observée dans les donnés des économies émergentes (contraintes) et les économies plus développés (non contraintes). Le modèle fonctionne relativement bien soit du point de vue quantitative, pour expliquer l'évidence empirique mentionnée, soit du point de vue qualitative, dans certaines dimensions (e.g. les mouvements pro cycliques de la consommation et du taux de change réel).

Dans le troisième chapitre, avec un modèle similaire à celui mentionné dans le paragraphe précédant, j'ai étudié les programmes d'ajustement du Fond Monétaire International (FMI). L'élément nouveau est la decision optimale du planificateur central entre signer ou ne pas signer un programme avec le FMI, de façon à ce que l'économie puisse emprunter des banques privées et/ou du FMI (à un taux d'intérêt plus faible). La comparaison entre les résultats du modèle simulé dans une économie qui a l'option d'avoir l'aide financière du FMI et les résultats obtenus dans le cas où le FMI n'existe pas (counterfactual analysis) permet de répondre à deus questions. D'abord, est-ce que les clauses de *conditionnalité* des prêts du FMI, basées sur la réduction et le contrôle du montant de consommation des biens publiques, sont capables de générer un effet catalytique positif sur des flous de capitaux privés, comme le FMI l'affirme? Deuxièmement, quels sont les gains de bien-etre associés aux programmes du FMI?

Je démontre que une réponse affirmative à la premiere question dépend des clauses de conditionnalité (si elles peuvent forcer le pays à épargner plus en même temps que le programme du FMI offre des compensations au pays pour cette épargne sous-optimale). Si la consommation de biens publiques est choisie de façon optimale, alors les règles de conditionnalité sont trop strictes (en comparaison avec le *first best* pour le cas où le FMI n'existe pas) et le pays décide de ne pas participer dans un programme du FMI. Ceci s'explique par le fait que l'épargne additionnelle entraînée par la règle de conditionnalité est trop coûteuse en termes de bien-être.

Par contre, lorsque la conditionnalité est redondante (dans le cas où le pays décide de façon optimale à consommer une quantité de biens publiques qui est plus faible que le montant défini par la règle de conditionnalité), alors l'économie n'est pas forcée à épargner plus, et la participation aux programmes du FMI est positive. Dans ce cas, il est à noter que la probabilité de défaut par le pays emprunteur n'est pas de réduite. Au contraire, la conditionnalité n'etant pas un coût, et puisque les prêts du FMI sont faits à un taux d'intérêt plus faible, les banques privées ont besoins d'être plus strictes dans leurs prêts afin d'éviter le défaut. Ceci produit un effet catalytique négatif des prêts du FMI sur des prêts des banques privées, même si la contrainte d'endettement sur la dette totale (FMI plus banques) devient moins contraignante.

Par ailleurs, le FMI peut aider à augmenter le coût d'opportunité de faire un défaut seulement si ses programmes d'ajustement sont capables d'améliorer la situation de paiement *ex-ante* d'une économie. Cela est possible lorsque le planificateur central ne choisi pas de façon optimale les allocations de consommation de biens publiques. Se basant sur l'hypothèse selon laquelle le FMI peut jouer le rôle d'un *commitment device* (qui permet à l'économie de s'engager avec un niveau de consommation de biens publiques plus faible que celui qui aurait eu lieu en l'absence du FMI), j'ai démontré que la conditionnalité peut générer un effet catalytique positif sur les flous de capitaux privés. La catalyse a lieu puisque que la réduction de la consommation force le pays à épargner plus et, au même temps, pousse l'économie vers une allocation plus proche du point optimal. Ceci réduit la probabilité de défaut et les banques privées peuvent relaxer la contrainte d'endettement imposée au pays. Les effets direct (une source additionnelle de prêts) et indirect (la catalyse des prêts privés) des prêts du FMI entraînent une contrainte d'endettement moins stricte et permettent une lissage de la consommation plus facile.

Cependant, une contrainte moins stricte n'implique pas nécessairement le "succès" des programmes du FMI. Les effets sur le bien-être obtenus d'après la simulation du modèle ne semblent pas être très importants. Une économie moins contrainte a un accès plus facile aux marchés internationaux de capitaux et peut lisser davantage sa consommation. Cette réduction de la volatilité génère des gains de bien être. D'après l'exercice de calibration du modèle pour l'économie du Brésil, pour la période 1980–2004, les prêts du FMI produisent des gains de bien-être équivalents à moins de 1 pourcent en termes de consommation additionnelle.