ESSAYS IN SOVEREIGN DEFAULT AND INTERNATIONAL FINANCIAL LIBERALIZATION

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Abstract

(Under the direction of Dr. Anusha Chari.)

My dissertation is a collection of three papers that deal with the issues of sovereign default and international financial liberalization. The first paper is titled: Debt Denomination, Exchange Rate Regimes, and Sovereign Default. This paper develops a dynamic stochastic open economy model where default occurs in equilibrium to study the welfare impact of abandoning a fixed exchange rate regime before a sovereign default crisis. The implications of abandoning a fixed exchange rate are captured using two key features: sticky nominal wages and foreign-currency denominated debt. Abandoning a fixed exchange rate allows governments to regain monetary independence to pursue employment and output goals. However, the accompanying nominal devaluation increases the external debt burden and the probability of default. Fixed exchange rates, on the other hand, involve a loss of monetary independence but less volatility in the foreign-currency denominated external debt burden. Therefore, in the model, the welfare impact of an exchange rate regime switch prior to sovereign default depends on two countervailing effects: the output effect and the debt burden effect.

The second paper is titled: Default, Austerity, and their Relative Costs. This paper uses the model developed in Cuadra et al. (2010) to find thresholds beyond which an increase in austerity is less optimal than default as a method to deal with an unsustainable debt burden.

The third paper is titled: Does Capital Scarcity Matter and is joint with Anusha Chari and Peter Blair Henry. This paper quantifies the welfare impact of a permanent increase in the level of per capita income brought about by a temporary increase in the growth rate of GDP per capita following capital account liberalization. In the immediate aftermath of liberalization, and under a range of assumptions, differences between the autarkic and integrated equilibrium consumption paths are large. Yet the welfare impact of these differences is small when using infinite horizon consumption streams to compute welfare. The results suggest that a finite
horizon framework may be more appropriate for evaluating the welfare consequences of economic policy changes that induce temporary growth effects but have a permanent impact on the level of per capita incomes.
Dedication

For Narges, Khalil, Lama, Mohammad, and Amr.
So many people helped me bring this project to fruition. I am extremely grateful for the guidance my advisor, Dr. Anusha Chari, has given me. I am also grateful for the excellent advice I received from my committee members, Dr. Patrick Conway, Dr. Lutz Hendricks, Dr. Riccardo Colacito, and Dr. Toan Phan. Also critical were conversations I had with Dr. Leonardo Marteniz, Dr. Horacio Sapriza, and Dr. Emine Boz, I am extremely thankful for their advice.
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Chapter 1

Debt Denomination, Exchange Rate Regimes, and Sovereign Default

1.1 Introduction

The sovereign debt crisis currently facing Greece is reminiscent of Argentina’s experience more than a decade ago. Idiosyncrasies aside, the two cases are similar in important ways. Both countries forfeited control over their monetary policy, Argentina by creating the currency board pegging the Peso to the US Dollar, Greece by joining the European Monetary Union. Both countries held sovereign debt in a currency whose value they did not control, Argentina in the US Dollar, Greece in the Euro. Both countries experienced an appreciation in the real exchange rate, Argentina because of the devaluation of the Brazilian Real, Greece because of domestic inflation. In the case of Argentina, pressure on the Peso continued to mount and the currency board was abandoned in 2001, causing the Peso/Dollar exchange rate to depreciate by 300% and the dollar-denominated debt burden to skyrocket. A few weeks after abandoning the currency board, Argentina announced the suspension of payments on all its debt instruments and entered a period of official sovereign default. Today, in similar vein, the debate continues over whether Greece would be better able to deal with its sovereign debt crisis if it left the Euro Zone and reinstated the Drachma.

This paper develops a dynamic stochastic open economy model where default occurs in equilibrium to study the welfare impact of abandoning a fixed exchange rate regime in the wake of a sovereign default crisis. The model captures the implications of abandoning a fixed exchange rate regime with two key features: sticky nominal wages and foreign currency denominated debt.

To see how sticky wages operate in the model, consider the following. Sticky nominal wages lead to periods of unemployment under a fixed exchange rate regime, whereas – despite nominal
wage stickiness – full employment is ensured at all times under a flexible exchange rate regime. Under a fixed exchange rate regime, a decline in productivity causes involuntary unemployment because nominal wages are sticky downward. Since an economy supporting a fixed exchange rate regime forfeits monetary independence, the government is unable to use monetary policy to lower the real wage and increase employment and output. Once a government abandons its fixed exchange rate regime, it regains monetary independence and allows the domestic currency to depreciate, causing the real wage to decrease and employment to increase, thereby increasing output.

When debt is denominated in a foreign currency, the sustainability of the debt burden depends on the nominal exchange rate regime. Default occurs in more states of the economy once a fixed exchange rate regime is abandoned. Under a fixed exchange rate regime, the value of foreign currency denominated debt does not change when measured in the domestic currency, meaning that the probability of default only depends on the productivity shock and the outstanding debt burden. However, once the fixed exchange rate regime is abandoned, the depreciated domestic currency causes the foreign currency denominated debt burden to increase when measured in the domestic currency. Under a flexible exchange rate regime, the probability of default depends on the productivity shock, outstanding debt burden, and nominal exchange rate. The added volatility from the nominal exchange rate increases the probability of default and the cost of borrowing for an economy that abandons the fixed exchange rate regime.

Therefore, the welfare impact of abandoning a fixed exchange rate regime in the wake of a sovereign default crisis depends on two countervailing effects: the output effect and the debt burden effect. When the government abandons a fixed exchange rate regime it regains monetary independence and can use monetary policy to pursue full employment and increase output. On the other hand, abandoning a fixed exchange rate regime is accompanied by a nominal devaluation, which increases the debt burden and the probability of default. Alternatively, when a government supports a fixed exchange rate regime, its foreign currency denominated debt burden is less volatile and the probability of default is lower, but monetary policy tools are lost as a mechanism to affect employment.

To measure the welfare impact of abandoning the fixed exchange rate regime I consider two scenarios. In the first scenario, the economy supports a fixed exchange rate regime until
it reaches a state where it must default. After the default, the economy abandons the fixed exchange rate regime. In the second scenario, the economy abandons the fixed exchange rate regime before a potential default occurs. I measure the welfare impact of a switch from the first scenario to the second. The welfare impact depends on whether gaining monetary independence and increasing output before a sovereign debt crisis will be welfare improving for an economy despite causing the foreign currency debt burden to fluctuate with the nominal exchange rate, which increases the probability of default and the cost of borrowing. I calibrate the model to Argentina and find that switching the exchange rate regime in regions of the state space where the default probability is very high reduces welfare or leaves it unchanged. Conditional on outstanding debt, abandoning a fixed exchange rate regime in all other states leads to improvements in welfare that are directly proportional to the existing level of the real wage. In a version of the model calibrated to Greece, the welfare implications of leaving the monetary union are similar and depend on default probabilities and the levels of outstanding debt and real wages.

To my knowledge, this is the first paper to incorporate the nominal exchange rate regime and foreign currency denominated debt in an Eaton and Gersovitz-type model where sovereign default occurs in equilibrium. Other papers that expand on the work of t (a) build their conclusions around real debt that is denominated in units of domestic goods. u (g) and e (r) show that their Eaton and Gersovitz-inspired models are successful in matching empirical regularities, such as countercyclical interest rates and countercyclical net exports, in emerging markets. e (u) and (i) detail the debt renegotiation process after a default occurs. n (e) endogenize output and are able to explain its dynamics around default episodes. a (u) incorporate endogenous fiscal policy. The real exchange rate plays a role in the model of m (u), which incorporates indexed and non-indexed debt, and that of p (o), which adds trade. However, these models do not allow one to examine the difference in dynamics under alternative nominal exchange rate regimes. For a review of the broad literature on sovereign default, see n (a).

Although the model presented in this paper shares some features with currency crisis models, the core objectives are different. Rather than to explain why currency crises occur, the objective of this model is to examine the welfare impact of switching to a more flexible exchange rate regime for countries with foreign currency denominated defaultable debt. Currency crisis models
broadly aim to explain the causes and implications of a break from a managed exchange rate regime. n (e) postulate that currency crises occur because of the rational expectations of investors about the probability of a devaluation. Investors form these expectations based on the evolution of foreign reserves in the central bank. r (u) postulate that the Asian currency crises were caused by prospective deficits. They argue that markets anticipated that many Asian governments would have large debt burdens in the future – because of their implicit guarantees to bail out the financial sector – and consequently would be forced to print money to cover their debt, undermining the value of their currency in the process. n (a) explains currency crises using policy switching and the fiscal theory of the price level. h (g) use financial frictions to explain currency crises. These currency crisis models do not include outright default on debt, which is a main feature in my model.

While papers in the optimal exchange rate regime literature try to assess what exchange rate regime is most suitable for an economy at a given time, the aim of this paper is more specific. I evaluate whether abandoning a fixed exchange rate regime will be welfare increasing for an economy that faces sovereign default. The rationale for why governments choose a particular exchange rate regime is outside the scope of this paper. More broadly, the optimal exchange rate regime literature addresses the implications different exchange rate regimes have on an economy. a (r) details the costs and benefits of alternative exchange rate regimes under different conditions. He notes that the optimal exchange rate regime will be different for different countries and even different at different times in a particular country. c (i) highlight that there is a close connection between the exchange rate regime and financial fragility. They examine different hypotheses about the nature of the connection in order to explore implications for the future of monetary policy and the international financial architecture. They conclude that because of high capital mobility, having a fixed exchange rate and independent monetary policy is impossible, and successfully floating is not likely o (o). According to c (i), the link between the exchange rate and financial fragility can only be broken by developing deep domestic financial markets or by dollarizing.

The paper proceeds as follows: Section 2 presents the model. Section 3 contains the quantitative analysis. Section 4 concludes.
1.2 Model

Consider a small open economy with four agents: households, firms, the government, and foreign lenders. Households consume both tradable and non-tradable goods, supply labor inelastically, and value government spending. There are two kinds of firms: those that produce tradable goods and those that produce non-tradable goods. Firms use labor to produce goods and take wages as given. Nominal wages are sticky downward. Tradable and non-tradable firms face technology shocks. The government finances spending by taxing tradables and non-tradables and smooths its revenue by borrowing from foreign lenders. Foreign lenders are risk neutral. Debt contracts are not enforceable, and the government can default at any time.

1.2.1 Households

Households consume both non-tradable and tradable goods and supply labor inelastically for the production of both types of goods. They choose tradable and non-tradable consumption to maximize lifetime utility:

\[ E_0 \sum_{t=0}^{\infty} \beta^t U(C(c^N_t, c^T_t), G(g^T_t, g^N_t)). \]  

Subject to the budget constraint:

\[ P_t c^N_t + c^T_t \leq (1 - \tau)(w_t L^T_t + \pi^T_t + P_t \pi^N_t), \]

\[ P_t \] is the relative price of non-tradable goods. From the intertemporal problem of the household it is equal to

\[ P_t = \frac{U_N(C(c^T_t, c^N_t), G(g^T_t, g^N_t))}{U_T(C(c^T_t, c^N_t), G(g^T_t, g^N_t))}. \]

\(E_0\) is the expectation at time zero of future utility. \( c^N_t \) and \( c^T_t \) are non-tradable and tradable consumption. \( g^N_t \) and \( g^T_t \) are non-tradable and tradable government spending. \( 0 < \beta < 1 \) and \( \tau \) is a fixed tax rate on income from non-tradables and tradables. \( w_t \) is the real wage denominated in units of tradable goods. \( \pi^T \) and \( \pi^N \) are profits from operating tradable and non-tradable firms. Tradable and non-tradable goods are produced using the labor input from households.
Households supply their one unit of labor inelastically and divide this time between producing tradable and non-tradable goods.

The period utility function is increasing, strictly concave, and twice continuously differentiable in all of its arguments:

$$U(C(c^T_t, c^N_t), G(g^T_t, g^N_t) = \frac{(C^T_t G^N_t)^{1-\sigma}}{1-\sigma}.$$  

$C(c^T_t, c^N_t)$ is the constant elasticity of substitution aggregator:

$$C(c^T_t, c^N_t) = \left[ \gamma^{1/\theta} (c^T_t)^{\theta-1} + (1 - \gamma)^{1/\theta} (c^N_t)^{\theta-1} \right]^{\theta}. $$

$G(g^T_t, g^N_t)$ is the government technology:

$$G(g^T_t, g^N_t) = g^T_t + P_t g^N_t.$$  

Purchasing power parity is assumed for tradable goods, since they are freely traded across borders. The price of tradables in the foreign currency is normalized to one, making tradable goods the numeraire for this economy.

1.2.2 Firms

Tradable and non-tradable firms are perfectly competitive and use labor, $L^T_t$ and $L^N_t$, as the only input to produce goods. Labor is mobile across sectors. The production technology for tradable and non-tradable firms is

$$Y^i_t = F^i(L^i_t),$$

where $F^i(L^i) = A^i_t(L^i)^{\alpha}$, $i = T, N$, and $L^T_t + L^N_t \leq 1$.

Production is subject to technology shocks $A^T_t$ and $A^N_t$. Each shock has a compact support and follows a Markov process. More detail about the processes is provided in Section 3B.

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1See a (u) and m (u) for models that also put government expenditures in the utility function of households.

2This is a common simplifying assumption. See n (e), s (e), and m (u) for examples.
Firms take wages and prices as given and choose labor to maximize profits. Labor demand from tradable firms is defined implicitly by

\[ F'^T(L'^T_t) = w_t. \]  

Labor demand from non-tradable firms is defined implicitly by

\[ P_tF'^N(L'^N_t) = w_t, \]  

where \( w_t \) is the real wage and is denominated in units of tradable goods.

Nominal wages in this economy are sticky downward. Firms face opposition if they try to decrease nominal wages past a certain point. This is represented by

\[ W_t \geq \phi W_{t-1}, \]  

where \( W_t \) is in units of domestic currency and \( \phi < 1 \) is the degree of wage stickiness.

Purchasing power parity holds in the tradable goods market, and the price of tradable goods in the foreign currency is normalized to one which makes tradable goods the numeraire. Thus, the wage stickiness condition can be represented by \( I_t w_t \geq \phi I_{t-1} w_{t-1} \), where \( I_t \) is the nominal exchange rate defined as the amount of domestic currency needed to purchase one unit of foreign currency. An increase in \( I_t \) signifies a depreciation.

Define the rate of depreciation of the domestic currency \( e_t = \frac{I_t}{I_{t-1}} \) and rearrange the wage stickiness condition to get

\[ w_t \geq \phi \frac{w_{t-1}}{e_t}. \]  

The dynamics of wages are as detailed by \( h(c) \) with the exception that I have both sectors of the economy using labor for production.

Consider an economy under a fixed exchange rate regime where \( e_t = 1 \). Without loss of generality, assume the economy is at full employment and receives an adverse shock to tradable productivity. From (7) it is clear that an adverse shock would necessitate either a decrease in the real wage \( w_t \) or a decrease in employment \( L'^T_t \). Because the nominal wage is sticky
downward, the real wage $w_t$ cannot be lower than a fraction $\phi$ of last period’s real wage $w_{t-1}$. Thus in order to accommodate the adverse shock, the amount of labor employed must decrease, causing involuntary unemployment. Because of the nominal wage rigidity in the labor market, households will only be able to work $L_t^T + L_t^N \leq 1$ each period. Although households supply labor inelastically, firms never display unfilled vacancies and are never forced to employ more workers than desired. Thus, under a fixed exchange rate regime, an economy will experience involuntary unemployment.

Under a flexible exchange rate regime, the monetary authority chooses depreciation $e_t$ such that (7) always holds. After an adverse shock to productivity the currency depreciates such that (7) binds making $e_t = \frac{W_{t-1}}{w_t}$. In other words, inflation allows the nominal wage today, $W_t$, to be larger than or equal to $\phi$ times the nominal wage yesterday $W_{t-1}$, while decreasing the real wage to the level that supports full employment. The lower value of domestic currency makes the nominal wage worth less in real terms. Thus despite nominal wage stickiness, a flexible exchange rate maintains full employment by allowing the real wage to adjust to adverse shocks. Since the nominal wage is only sticky downward, it can adjust freely to beneficial productivity shocks. Firms face no opposition if they increase the nominal wage. This means that the depreciation rate will never be lower than $e_t = 1$, and under a flexible exchange rate regime, $e_t = \max\{1, \frac{W_{t-1}}{w_t}\}$.

1.2.3 Government

Governments trade one-period non-state-contingent foreign currency denominated bonds with foreign creditors in order to smooth tax revenues. The volatility of tax revenues comes from the volatility of the stochastic processes for tradable and non-tradable productivity. Since government expenditures, $G_t$, are valued by households, smoothing government expenditures also smooths household utility. Debt contracts are not enforceable, and the government can default on its debt at any time. The cost of default is twofold. First, a government that defaults loses access to international credit markets and can no longer smooth its tax revenue. Regaining access to credit markets is exogenous and random. Each period, the economy has a probability $\psi$ of regaining access to international credit markets. The second cost of default is an exogenous loss in tradable and non-tradable productivity. During periods of default, the economy loses a
fraction $\theta$ of its tradable and non-tradable productivity.\(^3\)

The recursive optimization problem of the government is

$$V(S, Z) = \text{Max} \{ v^{nd}(S, Z), v^{d}(S, Z) \}. \quad (1.8)$$

The government decides to default when the value of defaulting $v^{d}(S, Z)$ is greater than the value of not defaulting $v^{nd}(S, Z)$. The state of the economy is fully described by four variables: two endogenous state variables – outstanding debt (bond holdings) $B$ and the real wage $w$ – and two exogenous state variables – non-tradable and tradable productivity, $A^N$ and $A^T$. $S = \{ B, w \}$ and $Z = \{ A^N, A^T \}$ are the vectors of endogenous and exogenous state variables.

In the following $X$ and $X'$ denote variable $X$ in this period and the next period, respectively.

**No default.** If a country has access to international credit markets the government solves

$$v^{nd}(S, Z) = \text{Max}_{c^T, c^N, B', w'} U(C(c^T, c^N), G(g^T, g^N)) + \beta \int_{Z'} V(S', Z') f(Z'|Z) dZ', \quad (1.9)$$

subject to the resource constraints and labor demand for tradable and non-tradable goods, and the wage stickiness condition:

$$c^T + g^T = F^T(L^T) - q(S, Z)B' + eB, \quad (1.10)$$

$$c^N + g^N = F^N(L^N), \quad (1.11)$$

$$F_T^T(L_t^T) = w_t,$$

$$P_t F_T^N(L_t^N) = w_t,$$

$$w_t \geq \phi \frac{w_{t-1}}{e_t}. \quad (1.12)$$

\(^3\)The exogenous probability of regaining access to credit markets is standard in the literature. See e (r), a (u), and n (e) for some examples. The models in Arellano and Cuadra et al. have exogenous output costs in default.
If the exchange rate regime is fixed, the depreciation rate of the domestic currency is

\[ e = 1. \]

If the exchange rate regime is flexible, the depreciation rate of the domestic currency is

\[ e = \max\{1, \phi \frac{w}{w'}\}. \]

\( g^T \) and \( g^N \) are government expenditures on tradable and non-tradable goods and are determined by the tax rate \( \tau \) on tradable and non-tradable output, \( g^T = \tau Y^T \) and \( g^N = \tau Y^N \).

\( B_{t+1} \) is the value of bonds a government decides to issue or purchase in period \( t \). When a government purchases bonds, \( B_{t+1} > 0 \); when it issues bonds (i.e., when it borrows), \( B_{t+1} < 0 \). \( B \) is denominated in the foreign currency. In this model PPP holds in the tradable goods market and the price of tradables in foreign currency is normalized to one. This means \( B \) is effectively denominated in tradable goods.

\(-q(S', Z)\) is the endogenously determined price of the tradable denominated bond (details in Section 2D). If the government borrows \((B' < 0)\), it receives \(-q(S', Z)B'\) tradable goods today and repays \(e'B'\) tradable goods next period. The trade balance of the government this period is \(-q(S', Z)B' + eB\).

The value of outstanding debt in domestic currency at time \( t \), \( B_t \), depends on the depreciation rate of the domestic currency, \( e_t \). To see why, suppose that in period \( t-1 \) the government borrowed \( B_t \) at a price of \( q_{t-1} \) and the nominal exchange rate was \( I_{t-1} \). In period \( t-1 \) the value of issued debt in pesos is \( I_{t-1}B_t \) and the value in tradables is \( \frac{I_{t-1}B_t}{I_{t-1}} = B_t \). Assuming a peg will hold, the government expects to repay its debt in period \( t \) with \( B_t \) units of tradable goods. Suppose that in period \( t \) the nominal exchange rate depreciates, \( I_t > I_{t-1} \). In period \( t \) the government must repay \( B_t \) units of tradables whose value in pesos is now \( I_tB_t \). Because of the depreciation at time \( t \), the government will have to repay more units of tradables relative to what it expected to repay in period \( t-1 \). The value of its debt in tradable goods in period \( t \) relative to period \( t-1 \) expectations is \( \frac{I_tB_t}{I_{t-1}} = e_tB_t \). When the domestic currency depreciates, the burden of outstanding debt denominated in units of tradables increases. The ability of the
government to repay its debt will depend not only on real output, but also on how much the
depreciation of the domestic currency affects the debt burden.

**Default.** If a country is in default the government solves

\[
v^d(S, Z) = \max_{c^T, c^N, w^d} U(C(c^T, c^N), G(g^T, g^N)) + \beta \int_{Z'} \left( \psi V(S_0', Z') + (1 - \psi)v^d(S', Z') \right) f(Z' | Z) dZ',
\]

subject to the resource constraints and labor demand for tradable and non-tradable goods, and
the wage stickiness condition:

\[
c^T + g^T = (1 - \kappa)F^T(L^T),
\]

\[
c^N + g^N = (1 - \kappa)F^N(L^N),
\]

\[
(1 - \kappa)F^{dT}(L^T_t) = w_t,
\]

\[
(1 - \kappa)F^{dN}(L^N_t) = w_t,
\]

\[
w_t \geq \phi \frac{w_{t-1}}{e_t}.
\]

If the exchange rate regime is fixed, the depreciation rate of the domestic currency is

\[
e = 1.
\]

If the exchange rate regime is flexible, the depreciation rate of the domestic currency is

\[
e = \max \{1, \phi \frac{w}{w'}\},
\]

where \(S_0 = \{0, w\}\), \(\psi\) is the probability of regaining access to international financial markets,
and \(\kappa\) is the tradable and non-tradable productivity loss during default.

Given an endogenous state \(S = \{B, w\}\), there is a set of exogenous state variables \(Z = \{A^N, A^T\}\) for which default is the optimal choice. This set is defined as follows:
Thus, at any given state $S$ the probability of default is

$$\delta(S', Z) = \delta(S, Z) = \int_{\Gamma(S')} f(Z'|Z) dZ'.$$ (1.15)

If the default set $\Gamma(S)$ is empty, the probability of default, $\delta$ is zero. Conversely, if the default set is the entire space $Z$, the probability of default is one.

### 1.2.4 Foreign Creditors

Foreign creditors are risk neutral and choose $B_{t+1}$ to maximize expected profits $\Pi$.

$$\Pi(S_{t+1}, Z_t) = \begin{cases} q_t B_{t+1} - \frac{1}{1+r_f} B_{t+1} & \text{if } B_{t+1} \geq 0, \\ \frac{(1-\delta(S_{t+1}, Z_t))}{1+r_f}(-B_{t+1}) - q_t(-B_{t+1}) & \text{if } B_{t+1} < 0, \end{cases}$$

where the probability of default is endogenously determined as in (15) and $r_f$ is the risk-free interest rate.

Since foreign creditors are risk neutral, $\Pi(S_{t+1}, Z_t) = 0$ and the price of bonds is

$$q_t(S_{t+1}, Z_t) = \begin{cases} \frac{1}{1+r_f} & \text{if } B_{t+1} \geq 0, \\ \frac{(1-\delta(S_{t+1}, Z_t))}{1+r_f} & \text{if } B_{t+1} < 0. \end{cases}$$

Foreign creditors hold bonds denominated in tradable goods; as such, they are not directly affected by exchange rate risk. The only risk foreign creditors account for is the risk of default in the debtor country. Nevertheless, since debt is denominated in foreign currency, the nominal exchange rate affects the probability of default. As a result, foreign creditors take on exchange rate risk indirectly, because the denomination of debt affects the probability of default.

### 1.2.5 Recursive Equilibrium

**Definition 1.** *Equilibrium in this economy is defined as the set of policy functions for (i) employed labor $L_T$, $L_N$ and tradable and non-tradable consumption $c^T$, $c^N$; (ii) government*
issuance (purchase) of bonds $B'$ and the default set $\Gamma(B)$; (iii) wages $w'$ and the depreciation rate $e$ and (iv) the price function for bonds $q(S', Z)$ such that:

1. If the exchange rate regime is fixed,
   
   $e = 1.$

2. If the exchange rate regime is flexible,
   
   $e_t = \max\{1, \frac{\phi w_t - 1}{w_t}\}.$

3. After learning the shocks to tradable and non-tradable productivity, $A^T$ and $A^N$, the social planner determines wages $w'$ and employs tradable and non-tradable labor, $L^T$ and $L^N$.

4. After allocating consumption to households, taking the exchange rate and the bond price function as given, the social planner issues bonds and decides whether to default according to its maximization problem.

5. Bond prices are determined from the probability of default, which is derived from the default set. Bond prices are consistent with foreign creditors’ zero profit expectations.

1.2.6 Discussion

The difference between a fixed exchange rate regime and a flexible exchange rate regime can be summarized by the effect each has on debt and employment. Under a fixed exchange rate regime, the value of outstanding debt $eB$ is not affected by the depreciation rate, since $e = 1$. Thus the affordability of outstanding debt only fluctuates due to changes in technology shocks in the tradable and non-tradable sector. As a consequence, the probability of default is lower than it would be under a flexible exchange rate regime, and the price of bonds is higher.

Employment under a fixed exchange regime is no higher than it would be under a flexible exchange rate regime. Because of downward stickiness in the nominal wage, any negative shock to technology will cause involuntary unemployment and decrease output.

Under a flexible exchange rate regime, the value of outstanding debt $eB$ fluctuates with changes in the depreciation rate, $e = \max\{1, \phi \frac{w_t}{w'}\}$. This makes the debt burden more volatile.
than it would be under the fixed exchange rate regime. In states of the world where a depreciation occurs, the outstanding debt burden may suddenly become unaffordable. This volatility in the debt burden makes default occur in more states of the world; as a consequence the probability of default is higher than under the fixed exchange rate regime. The higher probability of default leads to a lower price for bonds.

Labor is always fully employed under a flexible exchange rate regime, making output higher than it would be under a fixed exchange rate regime. After an adverse shock to productivity, currency depreciation helps bypass the downward rigidity in nominal wages by causing a decrease in the real wage thereby increasing employment and output.

Technology shocks are the only shocks the economy in this model faces. In the context of a small open economy, one can think of an economy facing other kinds of shocks, such as world interest rate shocks or terms of trade shocks. The main results of this paper will not change if I included shocks to the world interest rate or terms of trade, but the mechanism through which the results occur would be different. For example, in the case of a shock to the world interest rate, an adverse shock will make the outstanding debt burden less affordable for all possible shocks to technology. This higher cost of borrowing will increase the risk of default in bad states when the desire to smooth consumption is greatest. In contrast, a beneficial shock to the world interest rate would make borrowing cheaper and would decrease the risk of default. A terms of trade shock would have the same effect on the cost of borrowing and the probability of default. I exclude these other types of shocks from the model because of the curse of dimensionality.4

The central bank in this model is non-standard. Under a fixed exchange rate regime it supports the fixed exchange rate and under the flexible exchange rate regime it supports full employment. Generally, price stability is a key objective of a central bank. Adding price stability to the objective function of the central bank in this model would mean that under a flexible exchange rate regime the bank would not pursue full employment if it causes an increased volatility in the price level that cancels the benefit of the increased employment. A

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4The model is solved using value function iteration because the social planner’s objective function is the Max function. The value function of the economy is evaluated for every combination of state variables. When more state variables are introduced into the model, the number of states for which the value function of the economy must be computed increases exponentially.
central bank that cares about both unemployment and price stability would evaluate the benefit of increased employment against the cost of higher price volatility to implement policies that increase welfare. This means that when an economy has a flexible exchange rate regime, its debt burden would not fluctuate as much. Thus, the cost of borrowing would be lower than that in the flexible exchange rate regime in my model, but higher than that in the fixed exchange rate regime in my model. Additionally, employment would be lower than that in the flexible exchange rate regime in my model, but higher than that in the fixed exchange rate regime in my model. I leave making modifications to the central bank for future work.

In the model described in this paper, the decision to default is endogenous while the decision to abandon the fixed exchange rate regime is exogenous. Imposing the exchange rate regime switch exogenously is enough for the purpose of this paper: to capture the welfare effect of abandoning a fixed exchange rate regime in an economy that could default on its foreign currency denominated debt. This is because I test, in each state, whether or not abandoning the fixed exchange rate regime would lead to welfare gains. It is true, however, that keeping the exchange rate regime decision exogenous ignores interesting dynamics regarding currency speculation. I leave endogenizing the exchange rate regime for future work and include a preliminary discussion in Appendix B.

1.3 Quantitative Analysis

1.3.1 Data

The default of Argentina in 2001 was one of the largest in history. On December 24, the Argentine government defaulted on $100 billion of privately owned and official bilateral debt. The size of the default was 38% of output in 2001. The cost of the default to Argentina and its creditors was also significant. From the first quarter of 2001 to the first quarter of 2002, the nominal exchange rate depreciated by 300% and real output decreased by 16%. In the process of debt restructuring after the default, creditors lost 40% of their claims on average $u(t)$. The government of Argentina remains excluded in 2013 from issuing debt in international financial markets.

Table 1.1 presents some business cycle statistics for Argentina from the first quarter of 1993
Table 1.1: Business Cycle Statistics for Argentina

<table>
<thead>
<tr>
<th></th>
<th>Fixed</th>
<th>Flexible</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>std($x$)  corr($x,T$)  corr($x,N$)</td>
<td>std($x$)  corr($x,Y^T$)  corr($x,Y^N$)</td>
</tr>
<tr>
<td>Interest rate spread</td>
<td>7.4765  -0.4446  -0.3701</td>
<td>24.6990  -0.3346  -0.6269</td>
</tr>
<tr>
<td>Exchange rate depreciation</td>
<td>-  -</td>
<td>18.25  -0.3531  -0.2073</td>
</tr>
<tr>
<td>Trade balance</td>
<td>1.5154  -0.4238  -0.4723</td>
<td>3.0288  -0.2912  -0.6320</td>
</tr>
</tbody>
</table>

Notes - Data are quarterly. Standard deviations are reported in percentages. Interest rate spreads are calculated as the difference between the EMBI for Argentina and the US 5-year Treasury rate. The trade balance is reported as a percent of output. Tradable and non-tradable output are log filtered with a linear trend. All series are HP filtered with a smoothing parameter of 1600.

Interest rate spreads are calculated using the difference between the Emerging Market Bond Index (EMBI) for Argentina and the US 5-year Treasury rate. EMBI data from 1993 to 2000 are constructed from the dataset in u (e), and the rest of the time series are from the Ministry of Finance of Argentina (MECON). Data on the US Treasury rate are from the Federal Reserve Economic Data (FRED). Data on the nominal exchange rate and consumer price indexes are from the International Financial Statistics (IFS) of the International Monetary Fund. The trade balance is reported as a percent of output. Tradable and non-tradable output are measured in 1993 prices and are log filtered with a linear trend. Following m (u), tradable output is computed using output in the manufacturing, agriculture, and energy sectors. The fixed exchange rate regime spans from the first quarter of 1993 to the last quarter of 2001. The flexible exchange rate regime spans the rest of the time series, from the first quarter of 2002 to the second quarter of 2011.

The interest rate spread is negatively correlated to tradable and non-tradable production under both exchange rate regimes, but the volatility is much larger under the flexible exchange rate regime. The trade balance is negatively correlated to tradable and non-tradable production under both exchange rate regimes. The volatility of the trade balance is larger under the flexible exchange rate regime owing to volatility in the exchange rate.

1.3.2 Calibration

I solve the model numerically to evaluate its quantitative predictions of default events under different exchange rate regimes. The numerical solution also assesses the ability of the model to predict business cycle statistics for the depreciation of the nominal exchange rate, trade balance, and tradable and non-tradable output. The dynamics are compared under both fixed
Table 1.2: Parameters for Argentina

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Target statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk aversion</td>
<td>$\sigma$</td>
<td>2</td>
</tr>
<tr>
<td>Discount factor</td>
<td>$\beta$</td>
<td>0.98</td>
</tr>
<tr>
<td>Elasticity of substitution</td>
<td>$\theta$</td>
<td>0.5</td>
</tr>
<tr>
<td>Weight of $c^T$ in CES</td>
<td>$\gamma$</td>
<td>0.5</td>
</tr>
<tr>
<td>Weight of $C$ in utility</td>
<td>$\zeta$</td>
<td>0.81</td>
</tr>
<tr>
<td>Tax rate</td>
<td>$\tau$</td>
<td>0.12</td>
</tr>
<tr>
<td>Productivity loss in default</td>
<td>$\kappa$</td>
<td>0.01</td>
</tr>
<tr>
<td>Probability of reentry</td>
<td>$\psi$</td>
<td>0.1</td>
</tr>
<tr>
<td>Nominal wage rigidity</td>
<td>$\phi$</td>
<td>0.873</td>
</tr>
<tr>
<td>AR(1) coefficient of T productivity shock</td>
<td>$\rho^{AT}$</td>
<td>0.0776</td>
</tr>
<tr>
<td>AR(1) coefficient of N productivity shock</td>
<td>$\rho^{AN}$</td>
<td>0.8119</td>
</tr>
<tr>
<td>Std. dev. of T productivity shock $\varepsilon^{AT}$</td>
<td>$\eta_{AT}$</td>
<td>0.0941</td>
</tr>
<tr>
<td>Std. dev. of N productivity shock $\varepsilon^{AN}$</td>
<td>$\eta_{AN}$</td>
<td>0.0412</td>
</tr>
<tr>
<td>Risk-free interest rate</td>
<td>$r^*$</td>
<td>0.01</td>
</tr>
</tbody>
</table>

and flexible exchange rate regimes.

Table 1.2 summarizes the parameter values used in the computational analysis of Argentina. The values of the coefficient of relative risk aversion and the discount factor are standard in business cycle studies. The elasticity of substitution between tradable and non-tradable goods is set to 0.5, a value close to the estimate of 0.48 in $u(e)$. The weight of consumption in the utility function, 81%, is set according to the average ratio of private to public consumption in data from MECON.

The tax rate, 12%, is set to match the average total tax revenue as a percent of GDP for Argentina using data from The World Bank’s economic indicators. Productivity loss during default is set close to the frequency of default for Argentina, 3 times in the last 100 years. The risk-free interest rate is set to 1%, roughly the rate on a US Treasury bill.\(^5\) The probability of reentry is set to 10%, meaning that after default a country is excluded from international financial markets for 3 years on average.\(^6\) The nominal wage rigidity is set to match the average unemployment rate for Argentina from 1993 to 2009 using data from The World Bank’s economic indicators.

\(^5\)This is similar to $i(r)$, $u(g)$, and $a(u)$.

\(^6\)Argentina has experienced longer periods of exclusion. $n(e)$ calibrate to match 2 years of exclusion for Argentina and $a(u)$ calibrate to match 2.5 years of exclusion for Mexico, both undershooting actual exclusion periods.
<table>
<thead>
<tr>
<th></th>
<th>Fixed</th>
<th></th>
<th>Flexible</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>std(x)</td>
<td>corr(x, Y^T)</td>
<td>corr(x, Y^N)</td>
<td>std(x)</td>
</tr>
<tr>
<td>Interest rate spread</td>
<td>0.0438</td>
<td>-0.0899</td>
<td>-0.0841</td>
<td>654.8421</td>
</tr>
<tr>
<td>Exchange rate depreciation</td>
<td>·</td>
<td>·</td>
<td>·</td>
<td>3.8731</td>
</tr>
<tr>
<td>Trade balance</td>
<td>3.6816</td>
<td>-0.8151</td>
<td>-0.7871</td>
<td>3.2828</td>
</tr>
</tbody>
</table>

Notes - Standard deviations are reported in percentages. The trade balance is reported as a percent of total output. All series are HP filtered with a smoothing parameter of 1600.

The shocks to tradable and non-tradable productivity, $A_i^t$ where $i = \{T, N\}$ are log-normal AR(1) processes:

$$\log(A_i^t) = \rho A_i^t \log(A_i^{t-1}) + \varepsilon_i^A, \quad (1.16)$$

with $E[\varepsilon_i^A] = 0$ and $E[(\varepsilon_i^A)^2] = \eta_i^2$. The values for $\rho A_i$ and $\eta_i A_i$ are estimated using quarterly data on tradable and non-tradable output from MECON from 1993 to 2011. Following a (u), the shocks are then discretized into a Markov chain using the quadrature-based procedure in u (a).

### 1.3.3 Business Cycle Implications

Table 1.3 shows some moments from the model. Tradable output is negatively correlated with the interest rate spread under the fixed exchange rate regime, as in the data for Argentina. Like the data, the volatility of the interest rate spread is also higher under the flexible exchange rate regime. Tradable and non-tradable output are positively correlated to the interest rate spread under the flexible exchange rate regime. This is because in the model, increases in output are driven by a depreciation in the exchange rate, which increases the probability of default and causes an increase in the interest rate spread. Tradable and non-tradable output are negatively correlated to the trade balance; the government borrows more when output is lower.

In this model, under a flexible exchange rate regime the probability of default is higher and the price of bonds is lower than under a fixed exchange rate regime. Figure 1.1 shows the price of bonds, $q(S', Z)$, faced by an economy with a flexible exchange rate regime and an economy with a fixed exchange rate regime. Given a state of exogenous shocks $Z = \{A_N, A_T\}$ and real wage $w$, the price of bonds under a fixed exchange rate regime is larger than or equal to the bond price under a flexible exchange rate regime. This makes borrowing under a flexible
exchange rate regime more expensive than borrowing under a fixed exchange rate regime. The price of bonds, \( q(S', Z) \), is endogenously determined and is inversely related to the probability of default, \( \delta \). Thus, an economy with a flexible regime is more susceptible to default in bad times since rolling over debt becomes more costly.

Under a fixed exchange rate regime, the government defaults in fewer states than in a flexible exchange rate regime. The shaded regions in figures 1.2 and 1.3 indicate the states \( \{S, Z\} \) where default is the optimal policy.\(^7\) The default space for the fixed exchange rate regime (figure 1.2) is smaller than the default space for the flexible exchange rate regime (figure 1.3). Default risk coming from domestic currency depreciation is smaller under a fixed exchange rate regime than a flexible exchange rate regime. With a fixed exchange rate regime both creditors and debtors are certain that the nominal exchange rate will be constant \( e = 1 \), thus the sustainability of debt will only depend on fluctuations in the productivity of tradables and non-tradables.\(^8\) In contrast, the sustainability of debt in a flexible exchange rate regime depends on both the fluctuations in tradable and non-tradable productivity and on the depreciation of the currency.

1.3.4 Welfare Analysis

The welfare impact from abandoning a fixed exchange rate regime depends on how the depreciated currency affects employment and the debt burden. Abandoning a fixed exchange rate regime before default allows the depreciation rate to decrease the real wage, overcoming the stickiness of nominal wages. As a result, employment and output will increase, helping the economy repay its debt. At the same time, however, depreciation increases the value of outstanding debt and decreases the price of bonds. Higher outstanding debt and lower prices for newly issued bonds increase the debt burden and the probability of default. The welfare impact of abandoning a fixed exchange rate regime before default depends on whether the depreciation’s positive effect on employment outweighs its negative effect on debt.

The exchange rate regime switch is exogenous in this model, thus the welfare calculations

\(^7\)The edges of the default spaces in figures 1.2 and 1.3 are not monotonic because of the arrangement of the states of shocks to tradable productivity, non-tradable productivity, and wages, along the axis titled ‘Z’. For each level for the wage and each shock to non-tradable productivity, I list the grid for the shock to tradable productivity. The size of the axis titled ‘Z’ is the product of the size of the grids for tradable productivity shocks, non-tradable productivity shocks, and wages.

\(^8\)Runs on the currency are not possible in this model. If they were, the probability of default would include that risk.
carried out here are a counterfactual exercise. There is no mechanism within the model by which the government can switch the exchange rate regime.

For an economy that supports a fixed exchange rate regime, I compare welfare in two scenarios. In scenario A the government waits until a default episode to abandon a fixed exchange rate regime, while in scenario B the government abandons the fixed exchange rate regime before the default. The welfare impact, $\mu$, is the consumption equivalent variation between scenario A and scenario B. $\mu$ is calculated as the percent change in lifetime aggregate consumption $C(c^T, c^N)$ that is required to equate expected welfare in scenario A to that in scenario B:

$$E_0^A \sum_{t=0}^{\infty} \beta^t U((1+\mu)C(C_t^N, C_t^T), G_t) = E_0^B \sum_{t=0}^{\infty} \beta^t U(C(C_t^N, C_t^T), G_t),$$

$$\mu = \left[ \frac{E_0^B \sum_{t=0}^{\infty} \beta^t U(C(C_t^N, C_t^T), G_t)}{E_0^A \sum_{t=0}^{\infty} \beta^t U(C(C_t^N, C_t^T), G_t)} \right]^{\frac{1}{\sigma(1-\gamma)}}.$$

Figure 1.4 shows the change in welfare that a government can expect when it abandons a fixed exchange rate regime given the state of outstanding debt and existing wages $\{B, w\}$. At each state the government faces a tree of possible future realizations for each scenario. $\mu$ is the percent increase in lifetime aggregate consumption that is required to make the government indifferent between the expected utility in the two scenarios.\(^9\) For Argentina, a welfare increase of around 20% occurs most often in the $\{B, w\}$ state space (figure 1.5).

Figure 1.4 has two distinct regions. The first region is one in which $\mu$ is zero or negative. In this region of the state space, default is the optimal policy under both fixed and flexible exchange rate regimes. If an economy is in a state where it will almost surely default the next period under either regime, there is very little difference in welfare between abandoning the exchange rate regime or not. This is because under scenario A the economy abandons the fixed exchange rate regime after a default occurs which means the switch will occur anyway.

The second region consists of the rest of the state space. Here, controlling for outstanding debt, the welfare effect of abandoning a fixed exchange rate regime is positive and directly proportional to the existing level of the real wage. This is because the higher the state of real wages, the more likely unemployment will be high in the next period. And the higher

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\(^9\)See Appendix for details on the calculation of $\mu$ in figure 1.4.
In order to examine how sensitive the results for $\mu$ are to parameters related to default and unemployment, I consider alternate values for the probability of regaining access to international financial markets after a default, $\psi$, and the nominal wage rigidity, $\phi$. Figure 1.6 plots $\mu$ when the nominal wage is more sticky, $\phi = 0.973$. The gains from switching in region two are higher than those in figure 1.4 because the unemployment rate is higher the more sticky nominal wages are. The higher the unemployment rate, the larger the welfare gain from abandoning a fixed exchange rate regime to implement full employment. Conversely, figure 1.8 plots $\mu$ when the nominal wage is less sticky, $\phi = 0.773$. The gains from switching here are lower than they are in figure 1.4 because the unemployment rate declines when nominal wages are less sticky, which lowers the benefit of abandoning a fixed exchange rate regime to implement full employment.

Figure 1.10 plots $\mu$ when the probability of regaining access to international financial markets after a default is higher, $\psi = 0.2$. A higher probability of reentry decreases the costs of default and makes default the optimal policy in more states of the world under both fixed and flexible exchange rate regimes. As a consequence, the region of the state space where the decision to default coincides under both exchange rate regimes is larger. This in turn makes the region where the change in welfare is negative or nearly zero larger. Figure 1.12 shows that the opposite is true when the probability of regaining access to international financial markets is lower, $\psi = 0.05$. Default does not occur under this parametrization; thus, switching the exchange rate regime leads to welfare gains in all states.

The welfare effect of abandoning a fixed exchange rate regime is influenced by the degree of nominal wage stickiness and the probability of regaining access to international credit markets after a default. The more sticky wages are, the higher the unemployment rate and the larger the gains in welfare from abandoning a fixed exchange rate regime. The greater the probability of regaining access to international credit markets, the lower the cost of default and the more states where default is optimal, thus increasing the number of states where abandoning a fixed exchange rate regime leaves welfare unchanged or decreases it.

In addition to the state of the economy at the switch, the timing of the switch is another factor that determines whether or not the employment effect outweighs the debt burden effect. The earlier the switch from the time of default, the sooner the economy can benefit from increased employment, which increases tradable and non-tradable output. But the larger the
Table 1.4: Welfare Change as a Percent of Aggregate Consumption

<table>
<thead>
<tr>
<th>Timing of Switch</th>
<th>Mean $\mu$</th>
<th>Std $\mu$</th>
<th>Max $\mu$</th>
<th>Min $\mu$</th>
<th>Percent of Positive $\mu$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 quarter before default</td>
<td>0.43%</td>
<td>0.80</td>
<td>2.94%</td>
<td>-0.19%</td>
<td>39.34%</td>
</tr>
<tr>
<td>2 quarters before default</td>
<td>1.23%</td>
<td>2.00</td>
<td>9.38%</td>
<td>-2.37%</td>
<td>50.82%</td>
</tr>
<tr>
<td>3 quarters before default</td>
<td>2.30%</td>
<td>2.66</td>
<td>12.18%</td>
<td>-0.26%</td>
<td>80.33%</td>
</tr>
<tr>
<td>4 quarters before default</td>
<td>3.18%</td>
<td>3.10</td>
<td>13.18%</td>
<td>-0.92%</td>
<td>98.91%</td>
</tr>
<tr>
<td>5 quarters before default</td>
<td>4.17%</td>
<td>3.82</td>
<td>17.78%</td>
<td>-0.73%</td>
<td>98.91%</td>
</tr>
<tr>
<td>6 quarters before default</td>
<td>4.72%</td>
<td>4.48</td>
<td>20.83%</td>
<td>-1.04%</td>
<td>99.45%</td>
</tr>
</tbody>
</table>

Notes - I simulate the model economy under scenario A 10,000 times. For each simulation under scenario A, I have a corresponding simulation under scenario B. For simulations under scenario A where default occurs, I calculate $\mu$ for the corresponding pair of simulations from scenarios A and B.

state of the debt burden at the time of the switch, the more likely a default episode will occur after the switch. Depreciation increases the outstanding debt burden, and the lower price of bonds makes rolling over debt more difficult.

Table 1.4 shows values of $\mu$ calculated under perfect foresight. Each $\mu$ represents the percent change in consumption required to equate welfare from a stream of realizations under scenario A to the alternate stream that would have occurred under scenario B.\(^{10}\) On average, the earlier the switch to a flexible exchange rate regime, the larger the average gain in welfare (Mean $\mu$), reflecting the welfare increasing affect of having full employment for more periods. The worst case scenario for welfare cost (Min $\mu$) also tends to be larger the earlier the switch, reflecting that the increased volatility in the debt burden increases episodes of default. Generally, the exchange rate regime switch is highly likely to result in an increase in welfare (Percent of Positive $\mu$).

The generally positive welfare gains recorded by this model suggest that in abandoning a fixed exchange rate regime, the effect of implementing full employment generally outweighs the increased likelihood of default and higher borrowing costs. In my model, the stability of the currency is never in question, which excludes speculation on the currency and the possibility of currency crises. Including currency crises is likely to change the welfare analysis. When a country is under a flexible exchange rate regime, volatility in the exchange rate coming from speculators is likely to exacerbate the already high borrowing cost and high probability of default. I leave this extension for future work.

\(^{10}\)See Appendix for details on the calculation of $\mu$ in table 1.4.
Table 1.5: Parameters for Greece

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Target statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk aversion</td>
<td>$\sigma$</td>
<td>2</td>
</tr>
<tr>
<td>Discount factor</td>
<td>$\beta$</td>
<td>0.98</td>
</tr>
<tr>
<td>Elasticity of substitution</td>
<td>$\theta$</td>
<td>0.5</td>
</tr>
<tr>
<td>Weight of $c^T$ in CES</td>
<td>$\gamma$</td>
<td>0.5</td>
</tr>
<tr>
<td>Weight of $C$ in utility</td>
<td>$\zeta$</td>
<td>0.75</td>
</tr>
<tr>
<td>Tax rate</td>
<td>$\tau$</td>
<td>0.23</td>
</tr>
<tr>
<td>Productivity loss in default</td>
<td>$\delta$</td>
<td>0.01</td>
</tr>
<tr>
<td>Probability of reentry</td>
<td>$\psi$</td>
<td>0.18</td>
</tr>
<tr>
<td>Nominal wage rigidity</td>
<td>$\phi$</td>
<td>0.927</td>
</tr>
<tr>
<td>AR(1) coefficient of T productivity shock</td>
<td>$\rho^{AT}$</td>
<td>0.0289</td>
</tr>
<tr>
<td>AR(1) coefficient of N productivity shock</td>
<td>$\rho^{AN}$</td>
<td>0.4013</td>
</tr>
<tr>
<td>Std. dev. of T productivity shock</td>
<td>$\eta^{AT}$</td>
<td>0.0535</td>
</tr>
<tr>
<td>Std. dev. of N productivity shock</td>
<td>$\eta^{AN}$</td>
<td>0.0207</td>
</tr>
<tr>
<td>Risk-free interest rate</td>
<td>$r^*$</td>
<td>0.01</td>
</tr>
</tbody>
</table>

1.3.5 Application to Greece

I also calibrate my model to Greece in order to examine the welfare impact of leaving the European Monetary Union. Greece belongs to the Euro Zone, effectively under a fixed exchange rate regime, and is currently facing a debt sustainability crisis. Much like Argentina, countries that belong to the European Monetary Union face the trade-off specified in my model. Leaving the monetary union would allow Greece to regain monetary independence to pursue higher employment and output, but the accompanying nominal devaluation of its new domestic currency would increase its Euro-denominated debt burden and increase its probability of defaulting.

Table 1.5 summarizes the parameter values used in the computational analysis of Greece. The weight of consumption in the utility function is set to match the average ratio of public to private consumption in Greece using data from the OECD. The tax rate is set according to the average total tax revenue as a percent of GDP for Greece using data from The World Bank’s economic indicators. Productivity loss during default is set to match a frequency of default of 2%. This captures the idea that though default is an option for Greece, it is unlikely to be exercised. The probability of reentry is set to 18% to match the exclusion period of 2 years, roughly the amount of time Iceland was excluded from international financial markets. The nominal wage rigidity is set to match the average unemployment rate for Greece using data from The World Bank’s economic indicators. Tradable and non-tradable productivity shocks
Table 1.6: Welfare Change as a Percent of Aggregate Consumption—Greece

<table>
<thead>
<tr>
<th>Timing of Switch</th>
<th>Mean $\mu$</th>
<th>Std $\mu$</th>
<th>Max $\mu$</th>
<th>Min $\mu$</th>
<th>Percent of Positive $\mu$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 quarter before default</td>
<td>0.42%</td>
<td>0.51%</td>
<td>1.94%</td>
<td>-0.13%</td>
<td>63.79%</td>
</tr>
<tr>
<td>2 quarters before default</td>
<td>0.73%</td>
<td>0.88%</td>
<td>4.35%</td>
<td>-2.57%</td>
<td>75.57%</td>
</tr>
<tr>
<td>3 quarters before default</td>
<td>1.53%</td>
<td>1.11%</td>
<td>6.95%</td>
<td>-1.93%</td>
<td>97.13%</td>
</tr>
<tr>
<td>4 quarters before default</td>
<td>2.10%</td>
<td>1.47%</td>
<td>8.10%</td>
<td>-1.38%</td>
<td>98.56%</td>
</tr>
<tr>
<td>5 quarters before default</td>
<td>2.54%</td>
<td>1.87%</td>
<td>9.68%</td>
<td>-4.04%</td>
<td>96.55%</td>
</tr>
<tr>
<td>6 quarters before default</td>
<td>2.91%</td>
<td>2.09%</td>
<td>11.42%</td>
<td>-1.28%</td>
<td>97.13%</td>
</tr>
</tbody>
</table>

Notes - I simulate the model economy under scenario A 10,000 times. For each simulation under scenario A, I have a corresponding simulation under scenario B. For simulations under scenario A where default occurs, I calculate $\mu$ for the corresponding pair of simulations from scenarios A and B.

follow the AR(1) process in (16), and the parameters are calibrated using quarterly data on tradable and non-tradable output from the OECD. As in the case with Argentina, following a shock, these shocks are discretized using the quadrature-based procedure in (a). The remaining calibrations are standard in the literature and are as reported in table 1.2. All data for Greece are reported for the period spanning 2001 to 2010, from its adoption of the Euro to the present.

Figure 1.14 shows that the gains from welfare are generally lower for Greece than they are for Argentina. For Greece, a welfare increase of around 10% occurs most often in the state space (figure 1.15). Like Argentina, in the region of the state space where default is the optimal policy under both exchange rate regimes, abandoning the fixed exchange rate regime will either decrease welfare or leave it unchanged. In the rest of the state space, conditional on outstanding debt, abandoning a fixed exchange rate regime leads to a gain in welfare that is directly proportional to the existing level of real wages.

The lower welfare gains experienced by Greece are due to two differences from Argentina’s case. The first is that the average unemployment rate is smaller for Greece, so the gains from implementing full employment after abandoning the fixed exchange rate regime are smaller. The second is that the probability of Greece regaining access to international credit markets is higher, lowering both the cost of defaulting and the gains to welfare from a switch. Changes in $\mu$ for Greece under different calibrations for the nominal wage rigidity and probability of reentry are the same as those for Argentina. The welfare gains are higher the more sticky wages are and the less likely reentry to international credit markets after a default.

Like the case for Argentina, the representation in figure 8 ignores the timing of default in

\[11\] Results for alternate calibrations for Greece available upon request.
the welfare calculation. Table 1.6 shows the perfect foresight results for the welfare gain, $\mu$. As Argentina’s experience indicates, abandoning a fixed exchange rate regime generally leads to welfare gain that becomes larger on average but more volatile the earlier the switch.

## 1.4 Conclusion

In this paper, I have presented a model that can be used to assess the welfare impact of switching to a flexible exchange rate regime before a default episode. The two key elements in the model are nominal wages that are sticky downward and foreign currency denominated debt. The welfare impact from switching to a flexible exchange rate regime depends on how the depreciated currency affects employment and the debt burden. I calibrate the model to Argentina and find that switching the exchange rate regime in regions of the state space where the default probability is very high reduces welfare or leaves it unchanged. Conditional on outstanding debt, in all other states, abandoning a fixed exchange rate regime leads to improvements in welfare that are directly proportional to the existing level of the real wage. In a version of the model calibrated to Greece, the welfare implications of leaving the monetary union are similar and depend on default probabilities and the level of outstanding debt and real wages.

The welfare effect of abandoning a fixed exchange rate regime is influenced by the degree of nominal wage stickiness and the probability of regaining access to international credit markets after a default. The more sticky wages are, the higher the unemployment rate and the larger the gains in welfare from abandoning a fixed exchange rate regime. The greater the probability of regaining access to international credit markets, the lower the cost of default and the more states where default is optimal, thus increasing the number of states where abandoning a fixed exchange rate regime leaves welfare unchanged or deceases it.

The model in this paper does not have amplifying phenomena that are observed in cases of sovereign default in countries with fixed exchange rate regimes. This model abstracts from growth and currency crashes. The benefit from increased employment after an exchange rate depreciation does not increase the production possibilities for an economy. Additionally, the exchange rate regime switch does not cause panic in financial markets, and it is always assumed that the government is in complete control of its peg and its flexible exchange rate. These two elements influence the welfare impact of switching to a flexible exchange rate regime before default. Exploring the implications these amplifying effects have on welfare is an interesting avenue for future research.
Figure 1.1: Bond Price Schedule
Figure 1.2: Default Space: Fixed Exchange Rate Regime
Figure 1.3: Default Space: Flexible Exchange Rate Regime
Figure 1.4: Argentina: Welfare Change per State

![Graph showing the relationship between Outstanding Debt and Existing Wages]
Figure 1.5: Argentina: Histogram of Welfare Change
Figure 1.6: Greater Nominal Wage Stickiness: Welfare Change per State
Figure 1.7: Greater Nominal Wage Stickiness: Histogram of Welfare Change
Figure 1.8: Less Nominal Wage Stickiness: Welfare Change per State
Figure 1.9: Less Nominal Wage Stickiness: Histogram of Welfare Change
Figure 1.10: Greater Probability of Regaining Access to International Credit Markets: Welfare Change per State
Figure 1.11: Greater Probability of Regaining Access to International Credit Markets: Histogram of Welfare Change
Figure 1.12: Lower Probability of Regaining Access to International Credit Markets: Welfare Change per State
Figure 1.13: Lower Probability of Regaining Access to International Credit Markets: Histogram of Welfare Change
Figure 1.15: Greece: Histogram of Welfare Change
Chapter 2

The Relative Costs of Austerity and Default

2.1 Introduction

Today, several advanced economies are grappling with high debt burdens and the threat to debt sustainability that they present. These economies, Italy, Spain, Portugal, and Greece, have chosen to combat their high debt burdens by implementing austerity measures, a combination of decreasing government spending and increasing taxes. Austerity measures are implemented in order to restore debt sustainability. The reasoning is that austerity measures increase the government’s ability to repay its debt by increasing government revenue. However, austerity policies have also been associated with declines in output which cause the debt to GDP ratio to increase, keeping an economy on an unsustainable debt path despite efforts to decrease the debt burden. The severity of austerity measures that have been implemented has spurred debate among policymakers about when austerity is a good tool for combating a debt sustainability crisis and when it is counter productive.

Using the quantitative dynamic stochastic open economy model developed by a (u), this paper examines when austerity measures are no longer productive in combating an unsustainable debt burden and default becomes the better alternative. The model in a (u) is suitable for evaluating the limit of the usefulness of austerity measures because it includes two main features. First is the option to default. The government issues non-state contingent bonds and can chose to renege on repayments at any time. This means that default is always an option for the government, and it occurs as an equilibrium outcome. Thus, when austerity measures are taken within the model, they are preferred to the option of default. Second is distorting taxes. The government sets distorting taxes on consumption and uses the tax revenues along with proceeds from the bonds for government spending, which is valued by the representative agent. When the government is facing debt sustainability issues, increasing the tax rate has
two countervailing effects. On one hand a higher tax rate allows the government to increase its revenue to repay its outstanding debt burden. On the other hand, the higher tax rate decreases the incentive to supply labor and hence, decreases output.

The International Monetary Fund generally assesses the sustainability of an economy’s debt burden using its Debt Sustainability Analysis (DSA). The DSA framework relies heavily on assessing the viability of the government’s intertemporal budget constraint. Using projections for output growth, interest rate spreads, and other macroeconomic variables, the DSA can prescribe the change in taxes and government spending that is required to keep debt on a sustainable path. The DSA explicitly assumes that the government will always choose to honor its debt contracts. The possibility that a government may default on its debt burden is not addressed within the DSA framework.

The model in a (u) is one of strategic default. It belongs to the class of models that expand on the seminal work of t (a), a theoretical model of international borrowing where default is a strategic choice that occurs in equilibrium.\(^1\) a (u) endogenize their distorting taxes which allows for the study of austerity policies in times of an unsustainable debt burden. Because default is strategic in the a (u) model, when austerity occurs it is preferred to defaulting as a way to deal with the outstanding debt burden. However, when default is the optimal choice, austerity, any amount of it, will not be implemented. The question is: in what environments does austerity no longer become a useful way to deal with a debt sustainability crisis?

In contrast to the DSA framework, the model in a (u) has micro foundations and is built on the principle of maximizing the utility of infinitely lived agents. The DSA finds a value for the primary balance adjustment needed to make the debt level sustainable, but it has nothing to say about whether or not the government will make that adjustment. The a (u) framework treats the government as a welfare optimizing entity that decides whether or not to default on its outstanding debt. Their model has something to say about the willingness of a government to make the primary balance adjustment necessary to avert a default. In practice, countries never default purely for strategic reasons t (o). However, incorporating the willingness of a country to repay its debt enables a richer discussion of debt sustainability. In particular, it allows for a clearer articulation of the costs and benefits of austerity relative to the option to default.

\(^1\)There has been a recent resurgence of interest in models of strategic default that expand on the work of t (a). See u (g), e (r), p (o), e (u), and ( (i) for examples.
This paper is related to the broad literature on optimal fiscal policy, see r (a) and a (h) and the references therein for a comprehensive review of that literature. g (n) approaches optimal fiscal policy by finding an environment within the neoclassical model that can support a non-variant tax rate. An invariant tax rate is socially optimal because when taxes are distortional, any increase will cause social welfare to decline. He finds the optimal maturity structure for non-state contingent bonds that would support a non-variant tax rate: issuing long term debt while investing in short term assets. In this paper, I do not attempt to design the fiscal structure or the debt structure of the economy, but to examine what amount of austerity an economy chooses to implement before it prefers to default.

More recently, there has been a debate about the optimal way for high debt Euro Zone economies to make their fiscal adjustments. a (l) emphasize that it is important not to front load the fiscal adjustment, because the negative effect on output would cause the debt to GDP ratio to remain large, or even increase, rendering the austerity measures self defeating. They also highlight the importance of anchoring future expectations of the government’s fiscal balances by making long term plans for deficit reduction. In their opinion, focusing on short run crisis control is not a sufficient way to deal with a debt sustainability. In addition to those short term measures, long term plans for deficit reduction must be made to anchor expectations. This emphasis on anchoring expectations for the governments deficit is also reflected in e (l) where they argue that fiscal reforms that cause agents to expect lower future government deficits may actually be expansionary by causing aggregate demand to increase as a consequence of lower expected default and lower expected interest rates. This paper does not highlight the importance of expectations of future government deficits. The approach focuses on the short run effects of austerity policies and on the tradeoff between austerity and default.

l (o) argue that the threat of debt restructuring, which includes default, is overstated for highly indebted Euro Zone economies. They argue that the cost of default would outweigh the cost of austerity because of the effect reputation would have on future borrowing and spreads. They also argue that it is not the primary balance that causes default, rather, the financing cost of debt that is important in determining whether or not a country will default. They show that although the marginal interest rate for highly indebted Euro Zone economies is high, the average interest rate is low, making overall financing costs manageable2.

---

2The marginal interest rate is defined as the interest rate they would face if issuing new debt. The average interest rate is the average of the rates they face on all their outstanding debt, of all maturities.
This paper does not discount the probability of default and does not impose a preference for either austerity or default as a way to deal with an unsustainable debt burden. Both policies have associated costs and in each state the government evaluates those costs and makes the optimal choice. This setup allows us to examine what amount of austerity an economy chooses to implement before it prefers to default.

The paper proceeds as follows: Section 2 presents the model. Section 3 contains the quantitative analysis. Section 4 contains comparative statics exercises. Section 5 concludes.

2.2 The Baseline Model

The analysis in this paper will be carried out using the model developed by a (u). The model will be refereed to as the baseline hereafter.

The baseline is a representative agent model with households, a government, and foreign creditors. Households are identical. They have an elastic labor supply, and government spending is in their utility function. The government is benevolent and optimizes welfare for the household by trading bonds with foreigners, spending on public goods, and taxing household consumption. Foreign creditors are risk neutral. The model is outlined below:

2.2.1 Households

The representative household values government spending $G_t$. It chooses the time it allocates to production $l_t$ and consumption $C_t$ to maximize lifetime expected utility.

$$E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, G_t, 1 - l_t)$$

The per period utility function is well behaved, it is concave, strictly increasing, and twice differentiable in all its variables.

$$U(C_t, G_t, 1 - l_t) = \pi \left( \frac{G^{1-\sigma}}{1 - \sigma} \right) + (1 - \pi) \left( \frac{(C - l^{1+\psi})(1-\sigma)}{1 - \sigma} \right)$$

The households own the firms are perfectly competitive and use the following technology:

$$y_t = A_t F(l_t) = A_t l_t$$
Where productivity, $A_t$, follows a log normal AR(1) process:

$$\ln(A_t) = \rho \ln(A_{t-1}) + \varepsilon_t$$

The government raises revenue by imposing distortionary taxes on household consumption. The representative household maximizes lifetime utility given government expenditures $G_t$ and the tax rate $T_t$ subject to the following budget constraint:

$$(1 + T_t)C_t = A_t F(l_t)$$  \hspace{1cm} (2.3)

The first order condition from the household’s problem is:

$$\frac{U_l(C_t, G_t, 1 - l_t)}{U_c(C_t, G_t, 1 - l_t)} = \frac{A_t F_l(l_t)}{(1 + T_t)}$$  \hspace{1cm} (2.4)

The optimal labor supply of households is:

$$l^* = \left( \frac{A_t}{1 + T_t} \right)^{\frac{1}{\psi}}$$

When the government increases taxes, households work less hours.

### 2.2.2 Government

The government is benevolent and maximizes the utility of households. It borrows and lends in international markets, and funds its borrowing and public spending by raising distorting taxes on consumption.

Financial markets are incomplete. Each period the government issues one-period non-state contingent bonds $B_{t+1}$. Repayment is not enforceable, and the government may decide to default at any time.

Each period, the government evaluates the value of repaying its debt, and the value of defaulting. If the value of repayment is higher (lower) than the value of default, the government decides to repay (default). The government solves the following problem: \(^3\)

$$V_0(B, A) = \max \{V^c(B, A), V^d(A)\}$$  \hspace{1cm} (2.5)

\(^3\)Everything will be defined recursively hereafter. Variables with a ’ denote values in the next period.
where $V_c(B, A)$ is the value of retaining access to credit markets, and $V_d(A)$ is the value of defaulting.

When $B'$ has a negative face value, $B' \leq 0$, the government is borrowing money from abroad. It receives $-q(B, A)B'$ this period, and repays $B'$ next period. $q(B, A)$ is the price of the bond.

When the government has access to credit markets, it chooses consumption and labor supply for households using their budget constraint. It also chooses the tax rate, labor supply, and bond purchases using the government budget constraint. Formally, the government solves the following problem:

$$V_c(B, A) = \max_{T, G, B'} \{U(C^*, G, 1 - l^*) + \beta \sum_{A'} V_0(B', A')Q(A'/A)\} \quad (2.6)$$

subject to

$$G = TC^* + B - q(B', A)B' \quad (2.7)$$

$$AF(l^*) = (1 + T)C^*$$

$$AF_l(l^*) = \frac{U_t(C^*, G, 1 - l^*)}{U_c(C^*, G, 1 - l^*)}$$

As shown in equation (7) the government uses its tax revenue, $TC^*$, and funds raised from borrowing abroad, $-q(B', A)B'$, to purchase public goods that are valued by households. This signifies a sort of transfer made to households by the government.

When the government defaults, it is penalized in two ways:

1. It is shut out of financial markets temporarily. Re-entry is exogenous with a probability of $\mu$.

2. It suffers an exogenous productivity loss represented by $h(A)$ where:

$$h(A) = \begin{cases} 
\theta E(A) & \text{if } A > \theta E(A) \\
A & \text{if } A \leq \theta E(A)
\end{cases}$$

When in default, the government solves the following optimization problem:
\begin{align*}
V^d(A) &= \max_{T_d, G_d} \{ U(C^*_d, G_d, 1 - l^*_d) + \beta \sum_{A'} [\mu V_0(0, A') + (1 - \mu) V^d(A')] Q(A' / A) \} \\
\text{(2.8)}
\end{align*}

subject to
\begin{align*}
G_d &= T_d C^*_d \\
h(A) F(l^*_d) &= (1 + T_d) C^*_d \\
\frac{h(A) F(l^*_d)}{(1 + T_d)} &= \frac{U_i(C^*_d, G_d, 1 - l^*_d)}{U_c(C^*_d, G_d, 1 - l^*_d)}
\end{align*}

Given a value for the productivity shock, \( A \), define the set of debt holdings \( \Gamma(B) \) for which default is the optimal choice as:
\begin{align*}
\Gamma(B) &= \{ B \in \Phi | V^c(B, A) < V^d(A) \} \\
\text{(2.9)}
\end{align*}

\( \Phi \) is the set of all debt \( B \). It is a connected set, thus for any output shock \( A \), if \( B \in \Psi \) and \( \hat{B} < B \) then \( \hat{B} \in \Psi \). This means that for a given productivity shock, once a certain level of debt warrants default, all higher levels of debt will warrant default.

Given the government’s decision to repay its debt, define \( \Xi(A, B) \) as the set of the states of the economy where the tax rate would have been lower had the government defaulted.
\begin{align*}
\Xi(B, A) &= \{ B \in \Phi, A \in \Upsilon | T(B', B, A) > T_d(B', B, A) \} \\
\text{(2.10)}
\end{align*}

\( \Xi(A, B) \) determines the austerity region, which will be discussed in Section 3.

### 2.2.3 Foreign Lenders

Foreign lenders choose \( B' \) to maximize profits \( \pi \).
\begin{align*}
\pi(B', A) &= \begin{cases} 
q B' - \frac{1}{1 + r_f} B', & \text{if } B' \geq 0; \\
\frac{(1 - \delta(B', A))}{1 + r_f} (-B') - q(-B'), & \text{if } B' < 0.
\end{cases}
\end{align*}

Where \( \delta \) is the probability of default, and is defined as \( \delta(B', A) = \sum_{A' \in \Gamma(B')} Q(A'|A) \). \( r_f \) is the risk free interest rate. \( \Gamma(B) \) is the set of values for the productivity shock for which
default is the optimal decision, given the debt level \( B \). It is defined as \( \Gamma(B) = \{ B \in \Phi | V^c(B, A) \leq V^d(A) \} \). The probability of default is zero when the default set is empty, \( \Gamma(B') = \emptyset \), and one when the default set is the entire set of assets, \( \Gamma(B') = \Upsilon \).

Since foreign lenders are risk neutral, \( \pi(B', A) = 0 \), and the price of bonds is:

\[
q(B', A) = \begin{cases} 
\frac{1}{1+r_f}, & \text{if } B' \geq 0; \\
\frac{(1-\delta(B', A))}{1+r_f}, & \text{if } B' < 0.
\end{cases}
\]

2.2.4 Timing

1. Period \( t \) begins. The government has debt, \( B \), from last period. The productivity shock, \( A \), is revealed.

2. Prices are determined.

3. The government either has access to credit markets or is in default.

(a) If the government is not in default, it decides whether or not to default. In order to do this, it must evaluate welfare conditional on the decision to default, and conditional on the decision to repay.

i. If the government repays:

A. It chooses the tax rate \( T \). Households choose the labor supply \( l \).

B. It chooses debt for the next period \( B' \).

C. Private consumption \( C \) is determined from the household budget constraint.

   Government expenditures \( G \) are determined from the government budget constraint.

ii. If the government defaults:

A. It walks away from its outstanding debt \( B \) and is shut out of international financial markets.

B. It chooses the tax rate \( T \). Households choose the labor supply \( l \).

C. Private consumption \( C \) is determined from the household budget constraint.

   Government expenditures \( G \) are determined from the government budget constraint.
iii. If the welfare from i is greater (lower) than the welfare from ii the government
decides to repay (default).

(b) If the government is in default it solves $V^d(A)$ and regains access to markets for the
next period with probability $\theta$. Welfare will be $V^c(0, A)$ if it regains access.

4. Period $t + 1$ begins.

2.2.5 Equilibrium

First order conditions from the government’s problem

After simplification, the first order condition for the tax rate is:

$$U_c(C, G, 1 - l) \frac{AF(l^*)}{(1 + T)^2} = U_g(C, G, 1 - l) \left[ \frac{AF(l^*)}{(1 + T)^2} + \frac{TAF_l(l^*)}{(1 + T)} \frac{\partial l}{\partial T} \right]$$

The Euler equation for the government is:

$$U_g(C, G, 1 - l) \left[ q + B' \frac{\partial q}{\partial B'} - \frac{TAF_l(l^*)}{(1 + T)} \frac{\partial l}{\partial B'} \right] = \beta \sum_{A' \in \Delta(B)} U_g(C', G', 1 - l') Q(A'|A)$$

We are interested in examining the relative cost of increasing taxes to repay outstanding debt
when defaulting is a viable option. In order to examine this question, substitute $U_g(C, G, 1 - l)$
from (10) into (11) and rearrange to get:

$$U_c(C, G, 1 - l) \frac{AF(l^*)}{(1 + T)^2} = \beta \sum_{A' \in \Delta(B)} U_g(C', G', 1 - l') Q(A'|A) \left[ \frac{AF(l^*)}{(1 + T)^2} + \frac{TAF_l(l^*)}{(1 + T)} \frac{\partial l}{\partial T} \right]$$

Suppose the government has a high level of outstanding debt and wants to increase taxes to
cover the debt burden. This is referred to as an austerity measure. The austerity measure will
affect the labor supply, private consumption, future holdings of debt, and public consumption.

If the taxes raised are used to cover outstanding debt $B$, the level of future borrowing $B'$ will be low, as will the level of government expenditures today $G$. An increase in
taxes decreases consumption today by $\frac{AF(l^*)}{(1 + T)^2}$ and increases future government expenditure by $\left[ \frac{AF(l^*)}{(1 + T)^2} + \frac{TAF_l(l^*)}{(1 + T)} \frac{\partial l}{\partial T} \right]$. The increase in taxes causes the labor supply to decrease, i.e. $\frac{\partial l}{\partial T} < 0$. 

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Thus the magnitude of the increase in future government spending will depend on the elasticity of labor supply with respect to taxes.

In an austerity scenario, there are two factors that affect the ability to repay outstanding debt, and as a consequence, affect the amount of future debt the country needs to hold. First, the decline in labor supply could cause tax revenues to go down. If the revenue raised is not sufficient, the level of future borrowing might not be low enough to be considered sustainable. Second, the price of bonds is decreasing in the level of debt $\frac{\partial q}{\partial B} < 0$. The higher the level of debt, the higher the probability of default, and the lower the price of the bond $q$. This may force the government to issue higher levels of debt in the future to roll over the unpaid portion of outstanding debt. This causes $B' \frac{\partial q}{\partial B}$ to increase.\(^4\)

Thus, the country may not find immediate relief from its debt problems after its austerity plan and could find itself in a “slippery slope” situation where the higher level of taxes only increases the need to borrow more in the future to smooth consumption for households. The extent of this will depend on the value of $[q + B' \frac{\partial q}{\partial B} - \frac{TAF_l(l^*)}{(1+T)} \frac{\partial l}{\partial B}]$. As long as the government has access to credit markets, it will smooth households’ utility by making public purchases in bad times. When the next period occurs, the government can decide to default if given the productivity shock the new outstanding debt level is higher than the threshold. The threshold in turn depends on the state of the economy, it is increasing in the productivity shock $A$ and decreasing in the level of outstanding debt $B$.

### 2.3 Quantitative Analysis

#### 2.3.1 Data and Calibration

a (u) calibrate their model to explain Mexican data from 1980 to 2007. The data are from Banco de Mexico and are seasonally adjusted quarterly real series. Data for interest rate spreads are from EMBI for 1994 to 2007. Table 2.1 shows the parameters used in a (u).

Table 2.2 shows a comparison of moments from the baseline model and the data. a (u) find that their model matches the data well. Models of strategic default are generally not able to generate debt to GDP ratios that match those of countries that default n (a). Even so, this

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\(^4\)High debt means that $B'$ will be large and negative. Since $\frac{\partial q}{\partial B} < 0$, $B' \frac{\partial q}{\partial B}$ will be larger the more the country borrows.
Table 2.1: Parameters for Mexico

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Target statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk aversion</td>
<td>$\sigma$</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Consumption volatility 3%</td>
</tr>
<tr>
<td>Discount factor</td>
<td>$\beta$</td>
<td>0.97</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Standard RBC value</td>
</tr>
<tr>
<td>Labor elasticity</td>
<td>$\frac{1}{\psi}$</td>
<td>2.22</td>
</tr>
<tr>
<td></td>
<td></td>
<td>n (e)</td>
</tr>
<tr>
<td>Probability of reentry</td>
<td>$\mu$</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Length of exclusion (10 qtrs)</td>
</tr>
<tr>
<td>Default penalty</td>
<td>$\phi$</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Debt service to GDP ratio 4.5%</td>
</tr>
<tr>
<td>Weight of G in utility</td>
<td>$\pi$</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>G to C ratio of 16%</td>
</tr>
<tr>
<td>Risk-free interest rate</td>
<td>$r_f$</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US annual interest rate</td>
</tr>
<tr>
<td>Output shock</td>
<td>$\rho$</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Output data</td>
</tr>
<tr>
<td></td>
<td>$\sigma_\varepsilon$</td>
<td>0.006</td>
</tr>
</tbody>
</table>

Table 2.2: Benchmark model results

<table>
<thead>
<tr>
<th></th>
<th>Mexican data (1980-2007)</th>
<th>Benchmark model</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma$(GDP)</td>
<td>2.37</td>
<td>2.37</td>
</tr>
<tr>
<td>$\sigma$(C)</td>
<td>2.90</td>
<td>2.44</td>
</tr>
<tr>
<td>$\sigma$(Tax)</td>
<td>0.57</td>
<td>0.20</td>
</tr>
<tr>
<td>$\sigma$(TB/GDP)</td>
<td>2.04</td>
<td>0.22</td>
</tr>
<tr>
<td>$\rho$(GDP,C)</td>
<td>0.92</td>
<td>0.99</td>
</tr>
<tr>
<td>$\rho$(GDP,G)</td>
<td>0.55</td>
<td>0.97</td>
</tr>
<tr>
<td>$\rho$(GDP,Tax)</td>
<td>-0.33</td>
<td>-0.35</td>
</tr>
<tr>
<td>$\rho$(GDP,Spread)</td>
<td>-0.63</td>
<td>-0.29</td>
</tr>
<tr>
<td>$\rho$(GDP,TB/GDP)</td>
<td>-0.72</td>
<td>-0.36</td>
</tr>
</tbody>
</table>

model remains a suitable framework to analyze the limits of austerity policies in dealing with a debt sustainability burden when default is an option because taxes are distorting and default occurs in equilibrium.

2.3.2 Default and Austerity

Here I will discuss the spaces defined in equations 9 and 10 in light of the quantitative results of the model.

Each period, the government decides whether or not to default on its outstanding debt burden. Because the government maximizes welfare, the decision it makes is the optimal one. The costs and benefits of both default and austerity are taken into account in order to arrive at the decision. These costs and benefits are:

- **Default**
  - **Cost:** when a country is in default, it loses access to international credit markets and consequently, the ability to smooth household consumption.
– **Benefit:** the debt burden is eliminated. Upon regaining access to financial markets, the government will have no outstanding debt.

• **Austerity**

  – **Cost:** an increase in taxes causes the supply of labor to decrease. As a consequence, output also declines.

  – **Benefit:** if the debt burden is lowered, the country will be closer to a more sustainable debt level and can potentially avert default.\(^5\)

Before beginning the discussion on how much austerity is implementable before default becomes the better option for dealing with high debt, I calculate the welfare effect of using either austerity or default as the only policy to deal with an unsustainable debt burden. I measure welfare as the percent change in utility that would be required to equate welfare between two scenarios.\(^6\) First, I measure the welfare effect of austerity, \(\mu_{aust}\), by eliminating the possibility of default. An economy that does not default will use austerity as its primary tool for dealing with debt sustainability issues, allowing me to measure the cost of only using austerity to combat an unsustainable debt burden. Welfare here is the change in utility required to equate welfare in the baseline economy to an economy with no default. I find that \(\mu_{aust} = -0.065\%\). This means that using austerity as the sole policy to combat an unsustainable debt burden decreases utility in the baseline economy by -0.065%.

Similarly, in order to calculate the welfare effect of default, I eliminate the ability to implement austerity policies by fixing the tax rate. An economy that does not impose austerity will use default as its primary tool for dealing with debt sustainability issues, allowing me to measure the cost of only using default to combat an unsustainable debt burden. The welfare effect, \(\mu_{defa}\), is the percent change in utility required to equate welfare from the baseline model to the model with no austerity. I find that \(\mu_{defa} = -0.04\%\). This means that using default as the sole policy to combat an unsustainable debt burden decreases utility in the baseline economy by -0.04%.\(^7\)

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\(^5\)There is no certainty the austerity measures will prevent default. There are two reasons for this. The first is because the new debt level might be too high given the future state of the economy. The second is that the price of bonds might be too low.

\(^6\)Please see Appendix A for details on the calculation of the welfare effect.

\(^7\)The welfare effects are small because I do not control the timing of policy. If austerity or default
The welfare effects of austerity and default suggest that an economy is better off using both policy tools rather than only one of them when combating a debt sustainability crisis. The analysis in this paper focuses on examining when austerity measures are no longer productive in combating an unsustainable debt burden and default becomes the better alternative.

**The Default Space**

The shaded region in Figure 2.1 shows the states of the world where default is the optimal choice; the space defined by $\Gamma(B)$ in equation 9. The default decision depends on the state variables: debt outstanding and the shock to productivity. Given a productivity shock, default becomes the optimal choice at some threshold level of outstanding debt. For every level of debt higher than the threshold level of debt, default is the optimal choice. This can be seen by noting that in Figure 2.1, the default space does not have holes. Figure 2.2 plots the threshold level of debt as a percent of GDP against shocks to productivity. The more favorable the productivity shock, the higher the amount of debt the country can hold before default becomes the optimal choice. For adverse shocks to productivity, default becomes the optimal choice at low levels of debt.

Figure 2.3 shows the price of bonds, which is endogenous to the probability of default. To understand prices more clearly, divide the space in Figure 2.3 into three regions. The first region is composed of states where debt holdings are larger than the threshold level for that state. In this region, default is the optimal choice and the price of debt is near zero. The second region includes states with debt levels around the threshold level. This region includes both states where defaulting is the optimal choice and where it is not. The price of bonds in this second region is between the price at the risk free rate and the near-zero lower bound. Here, the probability of default is non-zero. The third region is composed of states where the debt level is so low, the probability of default is zero and the price of bonds is that at the risk free rate. The correspondence between the default set and the prices of bonds stems from the fact that the information creditors have on the probability of default of the country is identical to the information that the country has in this model. Prices are formed based on future levels of debt $q(B', A)$, the expected probability of default matters in their calculation.
The Austerity Space

The austerity space is defined by the set $\Xi(B, A)$ in equation 10. It is composed of states where:

- Repayment is preferred to default.
- The tax rate under repayment is higher than that under default.

Figure 2.4 illustrates the difference in the tax rate between the repayment scenario and the autarkic scenario in states where repayment is optimal. The states where this difference is positive represent the austerity space, because the government prefers to raise the tax rate than to default. The difference in the tax rate is increasing with the debt burden and the productivity shock. The lower the debt burden, the less the adjustment. For adverse productivity shocks, a larger increase in the tax rate is needed to keep the debt burden sustainable. The more adverse the productivity shock, the less effective austerity measures are in averting a default. This can be seen in Figure 2.4 by noting that at low levels of debt, the country defaults before implementing austerity measures.

Figure 2.5 plots the level of austerity against the threshold level of debt. For a threshold level of debt, the corresponding difference in tax rates is the amount of austerity that is still preferred to default, needed to keep the economy on a sustainable debt path. In essence, Figure 5 represents the limits of austerity given a debt to GDP ratio. Any increase in the tax rate beyond what is shown would make default preferable to austerity. The graph is increasing in the debt to GDP ratio because at low levels of productivity the amount of debt that can be sustained without default is low. Additionally, at low levels of productivity, the amount of austerity an economy can implement to maintain the sustainability of debt is low, and default quickly becomes preferred to austerity. For example, at threshold levels of debt below 4%, austerity is never an optimal policy. The decline in labor supply and output that austerity would cause would harm welfare more than a default. On the other hand, in better states of productivity, the threshold level of debt is higher and an economy would find implementing austerity measures to the tune of a 6% increase in the tax rate more optimal than default.

2.3.3 The cost of austerity relative to the cost of default

In order to understand the relative cost of austerity with respect to default, I examine the tradeoffs associated with raising taxes and defaulting. In the baseline model presented above,
the indebted government evaluates austerity and default within the Bellman equation in (12). The outcome, whether to default or increase taxes, depends on assessing the costs and benefits of default and austerity. In order to unpack the elements that go into this decision, I examine the costs and benefits of default and austerity using the policy functions generated by the model.

Revenue generated from austerity policies are used to repay part of this period’s outstanding debt, which would decrease the amount of outstanding debt in the next period. Indeed, the purpose of austerity measures is to decrease the debt burden for the future and decrease the probability of default. The effectiveness of austerity policies in improving debt sustainability depends on two things: tax revenues and the price of bonds. If the increase in taxes affects the labor supply enough to decrease tax revenues, the amount of debt repayment will be low. Additionally, the price of bonds is decreasing in the level of debt. Lower bond prices make rolling over outstanding debt more costly. The ability to finance outstanding debt, either by repayment or by rolling over the debt burden, is important because it determines future debt holdings which in turn affect the probability of default. Deciding whether to implement further austerity measures or to default depends not only on welfare today, but also on the expectation of welfare in the future. This is where the importance of the future debt level appears. I will discuss the relationship of future borrowing $B'$ with the productivity shock $A$, outstanding debt $B$, and bond prices $q(B', A)$.

This will frame the comparison between austerity policies and default by detailing the chain of events that lead from an increase in the tax rate to a change in future debt holdings.

It will be helpful for the discussion to reiterate the partition of the price of the bond into three regions: the price at the risk free interest rate, the price in default (zero), and the price in between those two extremes (the intermediate price).

Figure 2.6 plots, for a bad shock to productivity (-3%), the decision to borrow in the future $B'$ against outstanding debt $B$ expressed as a % of GDP. The red line represents cases where the level of future borrowing is larger than the level of outstanding debt, the portion above the 45 degree line. For low outstanding levels of debt to GDP ratios, the government chooses debt to GDP ratios for the future that are higher than those today in order to smooth the utility of households. At a certain debt to GDP ratio the government starts to cut back on its

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8Since the price of bonds depends on the amount of future borrowing, we cannot make causal statements on the relationship between them.
debt levels and borrow less in the future than the amount of outstanding debt today. I will refer to this level of debt as the inflection point of debt. After the inflection point of debt, the government implements austerity measures and cuts back on borrowing to maintain debt sustainability. In Figure 2.6 the inflection point occurs when the outstanding debt level is 4.5% of GDP. Figure 2.7 plots the price of bonds given the same shock to productivity in Figure 2.6. Around the inflection point of debt, 4.5% of GDP, the price of the bond drops dramatically, making rolling over debt very costly. In the same state that the government is implementing austerity to decrees its debt burden, it also starts to face very high financing costs for its debt burden. The probability of default is very high since efforts to bring the debt level back to a sustainable level face an uphill battle.

At the steady state level of productivity, Figure 2.8 plots the future borrowing decision against the outstanding debt to GDP ratio. The government starts to cut back on its debt burden when the outstanding debt to GDP ratio is almost 6%. At that same debt to GDP ratio, 6%, Figure 2.9 shows that the price of bonds is lower than the risk free price, but still much greater than the price at default, which makes rolling over outstanding debt a reasonable albeit costly way to maintain debt sustainability. At the steady state for the productivity shock, the economy defaults after the debt to GDP ratio of 11% (Figure 2.8). But in the states where the outstanding debt burden is between 6% and 11% the government is cutting back on its debt burden using austerity measures. In those states the price of bonds is not very low and the government can also roll over its debt burden, aiding the austerity efforts in maintaining debt sustainability.

Figures 2.10 and 2.11 are plotted given a good shock to productivity. Figure 2.10 shows that the government cuts back on the outstanding debt burden when the outstanding debt to GDP ratio is between 20% and 27%. During these states, the price of bonds is in the intermediate region and quite high, making rolling over debt affordable. When productivity shocks are favorable, austerity measures have a greater chance of being effective. The better the state of productivity when the government decides to cut back on its borrowing, the higher the price of bonds during states of cutting back debt, and the easier it is to finance the remaining debt burden.
2.4 Comparative Statics

I explore how changes in the parameters of the baseline model affect the threshold debt to GDP ratio and the the cost of austerity relative to default.

2.4.1 Haircut

Default in the baseline model allows the government to walk away from its outstanding debt obligations. Thus, upon re-entry to markets, a sovereign that has defaulted will have no outstanding debt. In practice, default usually involves restructuring the country’s debt in some way. A country that defaults rarely imposes a 100% haircut on its creditors. Rather, the sovereign makes repayments on terms different than the original. This could mean a change in the coupon rate, maturity date, par value, or a combination of these.

In order to account for this reality, I impose a haircut that is less than 100% on creditors after a default. As a consequence, when the sovereign regains access to credit markets, its outstanding debt burden will be the debt level it defaulted on minus the haircut. I find that the average haircut creditors face after a default is 37% and this is the value that I use.

Introducing a haircut that is lower than 100% changes the incentive to default in a significant way. When a sovereign must repay part of its outstanding debt burden after default, the cost of default increases and default is the optimal choice in fewer states of the world. This can be seen by noting that the shaded region in Figure 2.12 is smaller than that in Figure 2.1. Since governments prefer to default in fewer states of the world, the debt to GDP threshold for default is higher for all states of productivity. Figure 2.13 plots the threshold debt to GDP ratio and the difference in tax rates between access and autarky.

The peculiar shape of the threshold debt to GDP ratio in Figure 2.13 is a result of the dynamics of debt overhang and labor supply. At low productivity levels, households supply less labor than they would in autarky and pay much lower taxes than they would in autarky (Figure 2.13). In these states of bad productivity shocks and debt levels just lower than the default threshold, the government takes policy measures opposite to those in autarky. It smooths household utility by imposing less taxes and borrowing to its limit to make transfers to households in the form of public spending.

The threshold debt to GDP ratio is also influenced by debt overhang that occurs after a default. As noted earlier, the main benefit of default is to decrease the debt burden. In the
baseline mode, when a government defaults it walks away from its outstanding debt burden. In contrast, when an economy cannot impose a 100% haircut, there will be a debt burden to repaid even after default. An economy that defaults and gives creditors a haircut of 37% will have to repay 63% of its outstanding debt burden while enduring a post default environment with lower productivity and no access to international borrowing and lending. For these reasons, the threshold level of debt in bad productivity shocks is around the threshold with the best productivity shocks, about 33% (Figure 2.13). In contrast, the baseline economy defaults at a low threshold debt to GDP ratio in bad states of the world, from 5% to 10% (Figure 2.2). When there is a haircut, default is so costly that even an economy in a bad state of the world would want to avoid it. In these bad states, the government borrows more and taxes households less in order to smooth their utility.

2.4.2 Productivity Volatility

I examine how the specification of the productivity shock affects policy outcomes. In the baseline model, productivity is assumed to follow an AR(1) process:

$$ln(A_t) = \rho ln(A_{t-1} + \varepsilon_t)$$

with $E(\varepsilon) = 0$ and $E(\varepsilon^2) = \sigma^2$ where $\rho = 0.85$ and $\sigma = 0.0058$.

I change the process to exhibit more volatility and persistence, $\rho = 0.945$ and $\sigma = 0.025$. With this specification for the productivity shocks, default occurs almost exclusively during bad productivity shocks (Figure 2.14).\footnote{This is the process for productivity in Argentina as noted in e (r)} There is a notable absence of default in the good states of the world. The contrast between default in good and bad states is largely due to the increase in persistence. In good states of the world the economy is likely to remain in good states, making the probability of default zero and keeping the price of bonds at the risk free rate. High bond prices make rolling over debt affordable. In bad states of the world, the opposite is true. Since the probability of remaining in a bad state is so high, the probability of default is positive and high, and the price of bonds is very low. Low bond prices make rolling over debt very costly, thus default becomes the optimal policy for most bad states.

Since persistence is higher than in the baseline model, the value of consumption smoothing is higher, and as a consequence the value of maintaining access to international credit markets
is high. This is reflected in the threshold debt to GDP levels and in the amount of austerity the economy will tolerate. The threshold level of debt to GDP in Figure 2.15 is larger and steeper than it is in the baseline (Figure 2.2). When the state of the economy shows any improvement, the threshold debt to GDP ratio increases dramatically. Figure 2.15 shows that at a productivity shock of -1% the threshold debt to GDP ratio is 7% and at the steady state level of productivity it is 36%. Whereas in the baseline, a similar change in productivity pushes the threshold debt to GDP ratio from 5% to 10%. Persistence causes the more drastic change in threshold because when the state of the economy improves, the government uses the opportunity to maintain access to credit markets in order to smooth consumption.

Persistence also makes the austerity measures more drastic than those in the baseline. Figure 2.15 shows that the difference between the tax rate with access to markets and in austerity at the steady state level of productivity is 9% whereas it is 4% in the baseline (Figure 2.5). Given a bad state of productivity, the economy with higher volatility and persistence in its output shock will make larger adjustments to the fiscal balance before deciding to default. This is because the value of maintaining access to international credit markets high when the probability of remaining in bad states of the world is high.

2.4.3 Output Cost of Default

Once default becomes more costly, the government defaults in fewer states of the world. We have seen how a lower haircut and higher persistence for the productivity shock add to the cost of default. In this section, I impose a larger productivity loss for an economy after a default. This causes the costliness of default to increase in the same proportion for every state of the world resulting in much less default than the baseline and all other cases. Figure 2.16 shows the results for an economy that loses 4% of productivity after a default (\( \phi = 0.04 \)). When the cost of default is loosing 4% of productivity, the government only defaults in the worst states: those with the lowest productivity and the highest outstanding debt. As a consequence to the government’s aversion to default, the threshold debt to GDP ratio in Figure 2.17 is much higher than that in the baseline.

Figure 2.17 also shows that there is very low tolerance for austerity policies as a tool to alleviate the debt burden. The largest increase in the tax rate occurs at a shock of -2% to productivity, here the government raises the tax rate by 2.5% to deal with the debt burden. As we have seen, the tolerance for austerity is lowest for the most adverse shocks to productivity.
This is because in bad states, the price of bonds deteriorates quickly, making rolling over the debt burden very costly. Since default only occurs in the worst productivity states, and we are interested in the amount of austerity that is implemented before a default becomes the optimal choice, the austerity space that we are examining is also in the worst productivity states.

2.5 Conclusion

Using the quantitative dynamic stochastic open economy model developed by a (u), this paper examines when austerity measures are no longer productive in combating an unsustainable debt burden and default becomes the better alternative. The model in a (u) is suitable for evaluating the limit of the usefulness of austerity measures because it includes two main features: the option to default and distorting taxes.

I find that in the baseline model, in the face of an unsustainable debt burden, the amount of austerity an economy can implement before a default becomes the preferable policy is increasing in the threshold debt to GDP ratio. When the threshold debt level is 5% of GDP, the economy can tolerate almost no austerity. When the threshold is 15%, the economy can increase the tax rate by 4% before default becomes the better alternative. This positive correlation between the threshold and the limits of austerity stems from the state of the economy. When the state of the economy is bad, the threshold is low and the tolerance for austerity is low.

As we have seen, the specifics of the tradeoff between austerity and default vary depending on the parametrization of the model. But one thing remains common, the worse the state of productivity shocks, the less willing the government is to implement austerity measures. As for the willingness to default, it depends on how the cost of default is modeled. The more costly the default, the less willing a country is to default and the higher the threshold debt to GDP levels.

The price function for bonds has important implications for the preference of austerity over default as a way to deal with debt sustainability issues. When the price of bonds is a steep function of the state of productivity, the tolerance for austerity is very low and the ability to roll over the debt burden is limited because of the high financing cost. This is reminiscent of the Greek scenario. The difference is that the outstanding debt burden Greece has is very large. The model here can not replicate a debt burden as high as 170% of GDP because bonds are one period, and the government is a rational welfare maximizing agent. Alternatively, if the price of bonds is a constant function of the state of the economy and always valued at the risk...
free rate, as is the current case in the United States, the government would be able to roll over its debt burden without having to resort to severe austerity measures.

In the model presented in this paper, the welfare cost of each of austerity and default is small and very close. Because of this, other factors may be important in determining the extent to which austerity measures will be chosen over default when dealing with a debt sustainability crisis. This may depend on a host of political economy factors. For example, the ideology of the government would play an important role in determining how much austerity to employ. If default is not considered an option for dealing with a debt sustainability crisis, the government will use only austerity, and vice versa. Political economy factors do not play a role in the paper presented here, but incorporating them into the framework is an interesting avenue for future research.

Going forward it will be important to evaluate when austerity measures are no longer productive in combating an unsustainable debt burden and default becomes the better alternative using empirical estimates for the the cost of default and the cost of austerity. It will also be interesting to incorporate monetary policy into the theoretical framework. In this way, it will be possible to discuss both monetary and fiscal policies aimed at restoring debt sustainability. I leave these topics for future research.
Figure 2.2: Default Threshold

Threshold level of Debt as % of GDP

Output Shock

Debt to GDP ratio

0.97 0.98 0.99 1 1.01 1.02 1.03 1.04

0 5 10 15 20 25 30
Figure 2.3: Bond Prices

The Price of Bonds

Output Shock

Bond Price

Outstanding Debt

64
The diff. in tax rates (access–autarky) in states where repayment is optimal.
Figure 2.5: Austerity Threshold
Figure 2.6: Future Borrowing – Bad Productivity Shock
Figure 2.7: Bond Price – Bad Productivity Shock
Figure 2.8: Future Borrowing – Steady State Productivity
Figure 2.9: Bond Price – Steady State Productivity
Figure 2.10: Future Borrowing – Good Productivity Shock
Figure 2.11: Bond Price – Good Productivity Shock
Figure 2.12: Haircut – Default Space

![Haircut - Default Space](image-url)
Figure 2.13: Haircut – Threshold Debt and Austerity
Figure 2.14: Volatility and Persistence – Default Space
Figure 2.15: Volatility and Persistence – Threshold Debt and Austerity
Figure 2.17: Output Cost – Threshold Debt and Austerity
3.1 Introduction

The neo-classical model predicts that capital account liberalization will increase allocative efficiency by allowing capital to flow from countries where it is abundant to countries where it is scarce. The incipient flow of capital into liberalizing economies lowers their cost of capital, increases investment and economic growth leading to a permanent increase in the standard of living $s (i,i); s (b); g (o); m (u); n (e)$.

Research on the macroeconomic impact of capital account liberalization finds few, if any, robust effects of liberalization on real variables (i.e. investment and GDP per capita). n (e) argues that we should not regard the prevailing null effect findings as conclusive because most papers employ cross-sectional regressions designed to measure long-run permanent differences in growth rates in economic variables of interest (See surveys by i (d) and s (o) and the studies therein). In contrast to tests for permanent effects, the textbook theory of liberalization calls for a temporary impact on growth rather than a permanent one n (e). Therefore, cross-sectional regressions that do not find permanent growth effects of liberalization do not undermine the predictions of the neo-classical model.

This paper quantifies the welfare impact of a permanently higher level of income per capita brought about by temporarily higher growth in the aftermath of capital account liberalization. If agents are infinitely-lived, the increase in consumption (welfare) brought about by liberalization may not be quantitatively important over the infinite lifetime consumption path $u (o)$. However, if the lion’s share of the welfare benefits from liberalization accrues over relatively short horizons, and in the early years after policy implementation, then calculating the welfare benefits over a finite horizon may be more appropriate, and policy-relevant.

We use the technical apparatus in $u (o)$ to measure the welfare effects of closing the capital
gap in moving from financial autarky to financial integration. Agents live in an infinite-horizon Ramsey world where under autarky, the economy has an endogenous consumption path that depends on the rate of time preference. We assume that the autarkic economy will converge to a world steady state where the capital to effective ratio is given by an exogenously given world interest rate. This assumption allows us to fix the size of the capital gap between the capital to effective labor ratio in autarky and the capital to effective labor ratio implied by the world interest rate under integration. This setup assumes that an economy instantaneously converges to its steady state when it opens up. We make this assumption to abstract from speed of convergence issues. The model apparatus is then used to quantify the Hicksian consumption equivalent welfare gain from moving to financial integration from autarky.

In the neo-classical framework the increase in growth following capital account liberalization is a transitory phenomenon driven by a windfall accumulation of capital. The neo-classical model predicts that capital account liberalizations lead to a permanent increase in the level of the capital stock. The decline in the interest rate brought about by capital account liberalization leads the economy to transition to its steady state level of capital immediately. Along the transition path, capital grows temporarily at a higher rate. Once the economy reaches its steady state implied by the world interest rate, the level of the capital stock is permanently higher. The temporary increase in the growth rate of capital thus leads to a permanent increase in the level of the capital stock.

Once the capital-output ratio adjusts from its initial level to the level predicted by an integrated equilibrium, the steady state growth rate in the liberalizing economy returns to its growth rate in autarky. Therefore while capital account liberalization leads to a permanent increase in the level of per capita output, the growth effect is only transitory.

The temporary growth effect prediction of the neo-classical model suggests examining transition dynamics to judge the value of liberalization more accurately. In looking at transitional short-term effects an obvious question is whether these effects are economically meaningful. In other words, how do we quantify the welfare gains from capital account liberalization? By recognizing that theory only predicts a temporary growth effect from liberalization, we can identify the timing of the increase in growth and measure its impact on welfare.

Computationally, the point is a simple one. If the increase in growth is temporary and occurs in the early years following the policy change, measuring the percent increase in annual consumption relative to the infinite horizon consumption stream results in the welfare gains
from capital account liberalization being very small. However, when the percent increase in annual consumption is viewed in relation to a shorter finite horizon consumption stream, the welfare effects of liberalization are quite considerable. The reason is that a very large fraction of the benefits of opening up happen in the early years.

To quantify the temporary growth effect, we begin by asking, what is the capital to effective labor ratio implied by an exogenously given world interest rate? The answer to this question determines how much the autarkic capital to effective labor ratio will change for an exogenously given world interest rate when a country opens up. We use the change in the capital to effective labor ratio to evaluate the welfare implications of capital account liberalization. The welfare effects of moving from autarky to an open capital account depend of the size of the capital gap, i.e., the difference between the capital to effective labor ratio in autarky and under financial integration. The degree of capital scarcity in autarky is used to evaluate the welfare benefits of capital account liberalization across different horizons. We find that 95% of the increase in annual consumption from capital account liberalization accrues in the first 10-15 years after the opening.

The finite horizon methodology for measuring welfare gains tells us the amount of compensation people would require to make them indifferent between implementing liberalization or not. For example, in the first ten years, what is the percent change in autarkic consumption that agents would need to be compensated in order to not implement the policy? Our estimates show that in the first few years, people require large amounts of compensation in order to make them indifferent between implementing the policy change or not. The large initial impact of the policy change drives this finding.

Evaluating welfare gains from liberalizations under an infinite time horizon underestimates the gains enjoyed in the decades immediately following liberalization. This is because differences in the consumption paths of autarky and integration are largest soon after liberalization, yet they comprise a small portion of welfare gains when calculated using the infinite stream of consumption.

It is important to note that permanent growth effects are caused by an increase in TFP changes and in the context of the neo-classical growth model, TFP changes are independent of the capital account regime. Since cross sectional regressions test whether liberalizations lead to a permanent growth effect, it is not surprising that they do not find a significant relationship.

We implement a number of additional tests to examine the robustness of our results. First,
we examine the assumption made about the nature of the evolution of the interest rate across time in the autarkic economy versus the integrated economy. The u (o) framework calls for absolute convergence to a world steady state pinned down by the world interest rate, we perform an additional computation assuming conditional convergence. We use stock market data to use country-specific earnings price ratios as a measure of the capitalization rate.

Second, we account for the financing cost of capital inflows. The magnitude of the welfare gain from liberalization is affected by the cost associated with liberalizing the capital account. Capital that flows into a newly liberalized economy is not costless. If this capital is in the form of debt, interest repayments must be made in the future. This will impact domestic consumption under integration and thus, welfare. Like u (o), in the baseline model we assume that the infinitely-lived economy services the capital it borrows from the rest of the world to finance its instantaneous convergence to the world steady state as interest payments in perpetuity. Here, the principal is never paid off. In order to quantify the net benefits of capital account liberalization we examine alternative financial contracts. We examine the baseline and alternative debt contracts of varying horizons to quantify the costs of capital account liberalization and their impact on finite horizon welfare gains in liberalizing economies.

The paper is organized as follows. Section 2 presents a brief sketch of an infinite-horizon Ramsey model. Section 3 quantifies the Hicksian consumption equivalent welfare gains from capital account liberalization in the infinite and finite horizons. Section 4 presents robustness checks and Section 5 concludes.


u (o), or GJ, use an infinite-horizon Ramsey model to examine the gains from a shift from financial autarky to openness to international capital flows. Production is Cobb-Douglas. Raw labor grows at the population growth rate $n$. Labor-augmenting technical change grows increases the ratio of effective labor to raw labor at a rate of $g$. The rate of pure time preference is $\rho$. The discount factor is thus $\beta = \frac{1}{1 + \rho}$. The rate of capital depreciation is $\delta$.

GJ calculate the welfare benefits of capital account liberalization in terms of a Hicksian equivalent variation defined as the percentage increase in consumption an autarkic economy would enjoy as a result of liberalization. The domestic autarkic interest rate is assumed to
converge to the world interest rate and the autarkic economy eventually reaches the same steady state level of capital as the liberalized economy. Capital account liberalization in this framework, therefore, serves to expedite a country’s convergence to its own steady state.

GJ’s findings suggest that in Hicksian consumption equivalent terms the welfare gains from capital account liberalization are quite small. For example, a liberalization that more than doubles the capital stock of an economy leads only to a population weighted average 1.74% permanent increase in annual consumption. To understand why GJ find such small welfare gains, we begin by outlining their model. Consumers maximize the infinite sum of their discounted utility from consumption as follows:

\[ U_t = \sum_{s=0}^{\infty} \beta^s N(t + s) u(c_{t+s}) \]  

subject to:

\[ \tilde{c}_t + n g \tilde{k}_{t+1} = f(\tilde{k}_t) + (1 - \delta) \tilde{k}_t \]  

Using \( f(\tilde{k}_t^\alpha) = \tilde{k}_t^\alpha \) and \( u(c) = c^{1-\gamma} \), the first order conditions are:

\[ R_t = \alpha \tilde{k}_t^{\alpha - 1} + 1 - \delta \]  

\[ \tilde{c}_t = (\beta R_{t+1})^{\frac{\gamma - 1}{\gamma}} g \tilde{c}_{t+1} \]  

\( \beta, n \) and \( c \) are the discount factor, population, and per-capita consumption, respectively. At the steady state, the world interest rate is equal to: \( R^* = \frac{\delta^\gamma}{\beta} \). Additionally, GJ assume that the domestic interest rate converges to a long run interest rate \( R^* \), which is the same as the world interest rate by assumption.

\[ \lim_{t \to \infty} R_t = R^* = R^*_{w} \]  

The assumption made in (5) has significant implications for the impact of capital account liberalization. Consider two economies, one in autarky and the other that liberalizes. Assume

---

1This welfare gain is dwarfed compared to policy changes that affect domestic factor productivity. In order to illustrate this point, GJ present a model with human capital accumulation in a "Mincer" framework and introduce distortions to the process of physical and human capital accumulation. Policies that improve the quality of education or remove distortions from the economy are found to have a profoundly greater welfare benefit than policies that liberalize the capital account.
that both economies have the same initial capital stock, $k_0$. The capital stock in the autarkic economy evolves according to (2), (3), and (4) until it eventually reaches its steady state $k^*$. At this steady state, the interest rate is equal to its long run value $R^*$ which according to (5) is also equal to the world interest rate $R^*_w$. Because of this, the steady state of the autarkic economy is the same as the steady state of the rest of the world. Consumption in the autarkic economy endogenously reaches $c^*_w$.

A financially integrated economy faces the world interest rate, $R^*_w$, directly upon liberalization. Capital flows into the liberalizing economy and the steady state $k^*_w$ is reached instantly. Since the steady state level of capital is identical to that of the autarkic economy, capital account liberalization serves to expedite an economy’s movement towards its own (world) steady state. Figure 3.1 shows the consumption path of an economy in autarky and integration assuming that the capital inflow upon liberalization was costless. Of course, capital that flows into a newly liberalized economy is not costless.

Gourinchas and Jeanne (2006) assume that the infinitely-lived economy services the capital it borrows from the rest of the world to finance its instantaneous convergence to the world steady state as interest payments in perpetuity. Therefore steady state consumption under integration is reduced by these payments every period. Figure 3.2 presents a graphical representation of the results. Note that the consumption stream under integration is lower than in Figure 3.1 because of the financing costs associated with financial liberalization.

### 3.3 Are Transitional Growth Effects Economically Meaningful?

In looking at transitional short-term effects an obvious question is of course whether these effects are economically meaningful. In other words, what is the magnitude of the welfare gains from capital account liberalization?

#### 3.3.1 The Magnitude of Welfare Gains in the Infinite Horizon

GJ report the gains from liberalization in terms of a Hicksian equivalent variation, $\mu$, which is the percentage increase in consumption it would take to equate the welfare of the autarkic economy to that of the liberalized economy. Welfare is calculated as the lifetime utility from the optimal consumption path, $U_t = \sum_{t=0}^{\infty} (\beta^n)^t \log(g^t \tilde{c}_t)$. Hence, welfare in the autarkic economy and integrated economy is calculated as $U_{aut} = \sum_{t=0}^{\infty} (\beta^n)^t \log(g^t \tilde{c}_{aut}^t)$ and
\( U_{\text{int}} = \sum_{t=0}^{\infty} (\beta n)^t \log(g^t c^\text{int}_t) \), respectively. Thus, calculating \( \mu \) involves equating the following:

\[
\sum_{t=0}^{\infty} (\beta n)^t \log(g^t c^\text{aut}_t (1 + \mu)) = \sum_{t=0}^{\infty} (\beta n)^t \log(g^t c^\text{int}_t)
\]

This leads to the following expression for \( \mu \):

\[
\mu = \exp[(1 - \beta n) (U_{\text{int}} - U_{\text{aut}})] - 1
\]

(3.6)

Which is derived in the following manner:

\[
\sum_{t=0}^{\infty} (\beta n)^t \log(g^t c^\text{aut}_t (1 + \mu)) = \sum_{t=0}^{\infty} (\beta n)^t \log(g^t c^\text{int}_t)
\]

\[
\sum_{t=0}^{\infty} (\beta n)^t \log(g^t c^\text{aut}_t) + \log(1 + \mu) \sum_{t=0}^{\infty} (\beta n)^t = \sum_{t=0}^{\infty} (\beta n)^t \log(g^t c^\text{int}_t)
\]

\[
\log(1 + \mu) = \frac{\sum_{t=0}^{\infty} (\beta n)^t \log(g^t c^\text{int}_t) - \sum_{t=0}^{\infty} (\beta n)^t \log(g^t c^\text{aut}_t)}{\sum_{t=0}^{\infty} (\beta n)^t}
\]

\[
\mu = \exp \left( \frac{\sum_{t=0}^{\infty} (\beta n)^t \log(g^t c^\text{int}_t) - \sum_{t=0}^{\infty} (\beta n)^t \log(g^t c^\text{aut}_t)}{\sum_{t=0}^{\infty} (\beta n)^t} \right) - 1
\]

Since

\[
\sum_{t=0}^{\infty} (\beta n)^t = 1/(1 - \beta n)
\]

Using the parameters in Table 3.1, GJ report average population weighted \( \mu \) equal to 1.74\%. The average initial population weighted capital-output ratio\(^2\) is 1.4 for the 82 non-OECD countries in their sample.

Following GJ’s interpretation of capital account liberalization, and using their parameter values, we calibrate the consumption paths of the autarkic and integrated economies in order to calculate \( \mu \). Since it is assumed that the initial capital-output ratio is 1.4, the autarkic

\(^2\)This is the population-weighted average capital-output ratio equal to 140 for 82 non-OECD countries in the Penn World Tables in 1995.
Table 3.1: Parameters

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Discount factor</td>
<td>$\beta$</td>
<td>0.96</td>
</tr>
<tr>
<td>Capital share in production</td>
<td>$\alpha$</td>
<td>0.3</td>
</tr>
<tr>
<td>Depreciation rate</td>
<td>$\delta$</td>
<td>0.06</td>
</tr>
<tr>
<td>Output growth rate</td>
<td>$g$</td>
<td>0.012</td>
</tr>
<tr>
<td>Population growth rate</td>
<td>$n$</td>
<td>0.0074</td>
</tr>
</tbody>
</table>

economy will climb from the resulting initial level of capital, 1.62, to the steady state level of capital, 3.97. We compute the optimal consumption path by Euler equation iteration in the de-trended version of the representative agent problem. With that in hand it’s a simple matter to plug-in the initial capital stock and iteratively solve for the consumption path in autarky and integration.

In the case of capital account liberalization, the economy is assumed to enjoy the world interest rate $R_w^*$ from the onset, it is thus at steady state from the initial period onward. This also means that consumption is at its steady state level, minus interest repayment, from the initial period onward. The population weighted average value of $\mu$ that GJ get as a result of these calculations for the 82 non-OECD countries in their sample is 1.74%. This means that in a neoclassical economy with no frictions, capital scarcity keeps consumption in the autarkic economy from being, on average, 1.74% higher forever.

3.3.2 The Magnitude of Welfare Gains in the Finite Horizon

The measure for welfare gain, $\mu$, as calculated in (6), finds the permanent percent increase in autarkic consumption that would equate welfare in the autarkic economy to welfare in the integrated economy in the infinite horizon. In other words, if the autarkic economy liberalized its capital account, it will enjoy $\mu$ percent more consumption every period, forever. Intuitively, calculating $\mu$ involves measuring the welfare from the infinite streams of integrated and autarkic consumption, $U_{int}$ and $U_{aut}$ respectively, and backing out the percentage by which each observation in the infinite autarkic consumption stream must increase in order to equate the welfare in autarky to the welfare under integration.

From the formulation of capital account liberalization presented above, we know that the difference between the autarkic and integrated consumption streams come from the pre-convergence segment of the two streams. In the GJ formulation, after the autarkic economy converges to the steady state, its consumption stream is the same as that of the integrated
economy less interest payments.

The same welfare measure calculated using the infinite streams of consumption is used to calculate the percentage increase in autarkic consumption resulting from liberalization in the finite horizon. Since the majority of the difference in the autarkic and integrated consumption streams occurs before convergence, the difference between welfare calculated using the infinite streams of consumption comes about because of that small, finite, pre-convergence portion of the infinite streams of consumption.

In the infinite horizon setup, the difference in welfare arising from these finite segments is used to calculate the percentage increase, $\mu$, for the entire stream of autarkic consumption over the infinite horizon. In other words, the percentage increase for an infinite stream is calculated using the welfare difference coming from a finite segment of the infinite stream. In addition, the farther out consumption is in the future, the more it is discounted. Appendix C presents an alternative way to evaluate the gains in consumption that are largely accumulated in the short run.

In order to address the horizon issue, we can calculate the percentage by which autarkic consumption must increase in a finite time period following liberalization in order to equate autarkic and integrated welfare over that same finite time period. Let welfare be measured up to time $T$ where $t \leq T$ and denote the percentage change in consumption by $\mu_T$. We know that $\mu_T$ is calculated such that welfare in autarky and integration over that finite time period are equivalent in a Hicksian sense. Thus:

$$\sum_{t=0}^{T} (\beta n)^t \log(g^t \tilde{c}^{int}_t (1 + \mu_T)) = \sum_{t=0}^{T} (\beta n)^t \log(g^t \tilde{c}^{out}_t)$$

This leads to the following expression for $\mu_T$:

$$\mu_T = \exp \left( \frac{1 - \beta n}{1 - (\beta n)^{T+1}} (U_{int} - U_{aut}) \right) - 1 \quad (3.7)$$

which is derived as follows:

$$\sum_{t=0}^{T} (\beta n)^t \log(g^t \tilde{c}^{int}_t (1 + \mu)) = \sum_{t=0}^{T} (\beta n)^t \log(g^t \tilde{c}^{out}_t)$$

---

3The argument holds for $t^* \geq T$ as well. Explaining the intuition behind $\mu_T$ is more involved when $t^* \leq T$, which is why that is the case presented above.
\[
\sum_{t=0}^{T} (\beta n)^t \log(g_t^\text{c}_{\text{int}}) + \log(1 + \mu) \sum_{t=0}^{T} (\beta n)^t = \sum_{t=0}^{T} (\beta n)^t \log(g_t^\text{c}_{\text{aut}})
\]

\[
\log(1 + \mu) = \frac{\sum_{t=0}^{T} (\beta n)^t \log(g_t^\text{c}_{\text{int}}) - \sum_{t=0}^{T} (\beta n)^t \log(g_t^\text{c}_{\text{aut}})}{\sum_{t=0}^{T} (\beta n)^t}
\]

\[
\mu = \exp \left( \frac{\sum_{t=0}^{T} (\beta n)^t \log(g_t^\text{c}_{\text{int}}) - \sum_{t=0}^{T} (\beta n)^t \log(g_t^\text{c}_{\text{aut}})}{\sum_{t=0}^{T} (\beta n)^t} \right) - 1
\]

\[
\mu_T = \exp \left( \frac{1 - \beta n}{1 - (\beta n)^{T+1}} (U_{\text{int}} - U_{\text{aut}}) \right) - 1
\]

Since

\[
\sum_{t=0}^{T} (\beta n)^t = \frac{1 - (\beta n)^{T+1}}{1 - \beta n}
\]

Notice that in equation (7), \((U_{\text{int}} - U_{\text{aut}}) = \sum_{t^*}^{T} (\beta n)^t \log(g_t^\text{c}_{\text{int}}) - \sum_{t^*}^{T} (\beta n)^t \log(g_t^\text{c}_{\text{aut}})\) just as in (6). This is because the only gain in welfare occurs before convergence; autarkic and integrated consumption streams from \(t^*\) to \(T\) are equal. Yet, there is a difference in the way this gain in welfare is weighed and this is reflected by the inverse of the finite geometric sum of the discount factor multiplied by the population growth rate, \(\frac{1 - \beta n}{1 - (\beta n)^{T+1}}\). Since \(\beta n < 1\) we know that \(1 - \beta n < \frac{1 - \beta n}{1 - (\beta n)^{T+1}}\); therefore, \(\mu < \mu_T\). Intuitively, this result makes sense because we are trying to translate the welfare gain \((U_{\text{int}} - U_{\text{aut}})\), which is identical in both the infinite horizon and the finite horizon ending at \(T\), into a percentage increase in autarkic consumption for a finite stream of consumption, \(\mu_T\), rather than a percentage increase in autarkic consumption for an infinite stream of consumption, \(\mu\). Table 3.2 illustrates this point for a sample of 82 non-OECD countries.

This alternative measure of the increase in welfare, \(\mu_T\), takes into account the timing of the gains from liberalization and would be better suited to evaluate certain liberalization policies. Take the GJ (2006) formulation for liberalization for example. We know that the lion’s share of the gain in welfare from liberalization occurs in the short run. Thus, in evaluating the benefit from liberalization, we would like to know what the percentage increase in autarkic consumption would be for the observations before convergence. A quick comparison to \(\mu\) shows that it underestimates the short run benefits of liberalization.

For the sample of 82 non-OECD countries, the infinite horizon average \(\mu\) is a mere 1.47%
Table 3.2: Welfare Gains Over Finite Horizons

<table>
<thead>
<tr>
<th>Sample Average $k_0$</th>
<th>Average</th>
<th>First</th>
<th>Second</th>
<th>Third</th>
<th>Fourth</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>1.81</td>
<td>0.65</td>
<td>1.20</td>
<td>1.88</td>
<td>3.35</td>
</tr>
<tr>
<td>10</td>
<td>22.85</td>
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<td>13.59</td>
<td>4.30</td>
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<td>15.97</td>
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</tr>
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<td>30</td>
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<td>2.26</td>
</tr>
<tr>
<td>35</td>
<td>7.43</td>
<td>13.41</td>
<td>9.02</td>
<td>5.93</td>
<td>1.92</td>
</tr>
<tr>
<td>40</td>
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<td>10.67</td>
<td>7.80</td>
<td>5.10</td>
<td>1.67</td>
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<td>5.67</td>
<td>10.32</td>
<td>6.85</td>
<td>4.45</td>
<td>1.47</td>
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<td>5.06</td>
<td>9.26</td>
<td>6.10</td>
<td>3.94</td>
<td>1.31</td>
</tr>
<tr>
<td>$\infty$</td>
<td>1.47</td>
<td>3.08</td>
<td>1.68</td>
<td>0.90</td>
<td>0.36</td>
</tr>
</tbody>
</table>

Notes - $\mu_T$ reported in percentage points. Data are for 82 non-OECD countries. We use the capital stock in 1995 for the initial level of capital. The sample is also divided into quartiles based on the size of the capital stock in 1995.

increase in annual consumption. In contrast, the five year finite horizon $\mu_T$ is an order of magnitude higher at 32.03%. As the finite horizon increases, consistent with theory $\mu$ declines as the autarkic consumption path converges to its steady state value closing the gap between the instantaneous increase in consumption afforded by integration.

Table 3.2 also shows that the magnitude of the finite horizon increase in welfare represented by $\mu_T$ is directly proportional to the size of the capital gap between autarky and integration. Appendix A lists countries by initial capital stock values by quartile. For the highly capital-scarce countries in the first quartile of initial capital stock values $k_0$, the finite horizon $\mu_T$ at five years is a 59.59% increase in annual consumption. For non-OECD countries that are relatively more capital-abundant, the five year finite horizon $\mu_T$ is a more modest increase in annual consumption of 8.07% for countries in the fourth quartile of initial capital stock values.

The short run representation of the welfare gain captures the increase in welfare due to the timing of the increase in consumption. Under the assumption that the newly integrated economy will instantaneously enjoy the steady state consumption level, less interest payment, the finite horizon calculation of $\mu$ measures this instant increase upon liberalization. It is clear that the shorter the horizon, the larger the measure of the welfare gain from liberalization.
Table 3.3: Welfare Gains Using $\frac{E}{P}$ Ratio

<table>
<thead>
<tr>
<th>$\frac{E}{P} - r^*$</th>
<th>First</th>
<th>Second</th>
<th>Third</th>
<th>Fourth</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\mu_T$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>20.31</td>
<td>14.99</td>
<td>15.59</td>
<td>5.89</td>
</tr>
<tr>
<td>10</td>
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<td>10.86</td>
<td>10.63</td>
<td>3.83</td>
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<td>7.43</td>
<td>2.73</td>
</tr>
<tr>
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<td>9.97</td>
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<td>5.38</td>
<td>2.11</td>
</tr>
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<td>25</td>
<td>8.38</td>
<td>5.07</td>
<td>4.00</td>
<td>1.71</td>
</tr>
<tr>
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<td>4.19</td>
<td>3.03</td>
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<td>2.33</td>
<td>1.26</td>
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<td>1.38</td>
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</tr>
<tr>
<td>50</td>
<td>4.81</td>
<td>2.35</td>
<td>1.05</td>
<td>0.93</td>
</tr>
<tr>
<td>$\infty$</td>
<td>2.39</td>
<td>0.54</td>
<td>-0.88</td>
<td>0.45</td>
</tr>
</tbody>
</table>

Notes - $\mu_T$ reported in percentage points. Data on $\frac{E}{P}$ ratios are from the Emerging Markets Data Base. The sample is also divided into quartiles based on the size of the premium $R_i^* - R^*$. Details on the countries is included in Appendix B.

3.4 Robustness Checks

3.4.1 Conditional Convergence.

Assuming conditional convergence allows for cross country heterogeneity, in educational attainment, fertility decisions, technology, and institutions, that would make the steady state levels of capital of countries differ $r$ (a). Here, upon liberalization, instead of a country moving to a steady state which is the same as the world steady state, it moves to its own unique steady state. Recall that the steady state capital is determined by $k_i^* = \left( R_i^* \frac{\alpha}{R_i^* - \delta - 1} \right)^{\frac{1}{1-\alpha}}$. Under conditional convergence, the country specific interest rate $R_i^*$ determines a country specific steady state level of capital. When a country’s interest rate $R_i^*$ is lower than the world interest rate $R^*$, the steady state level of capital for that country is higher than the world steady state level of capital. This means that the welfare effect of liberalization under conditional...
convergence will be higher than under absolute convergence. Liberalization here means that the economy converges faster to a higher steady state. The opposite is true for an economy where the interest rate is lower than the world interest rate.

The premium in Table 3.3 is $R_i^* - R^*$. With the calibration in Table 3.1, the world interest rate, $R^*$, is approximately 5.42%. When the premium is negative, the steady state level of capital that the country is converging to is higher than the world steady state level of capital. Liberalization will allow these countries to reach that higher steady state of capital faster. The opposite is true when the premium is positive: the country’s steady state level of capital is lower than the world steady state level of capital. Upon liberalization this country will converge to a lower steady state and it will experience lower welfare than under the assumption of absolute convergence.

3.4.2 Alternate Financial Contracts.

We also account for the financing cost of capital inflows. Capital that flows into a newly liberalized economy is not costless. The magnitude of the welfare gain from liberalization is affected by the cost associated with liberalizing the capital account. In order to quantify the net benefits of capital account liberalization we examine alternative financial contracts. We assume that the infinitely-lived economy services the capital it borrows from the rest of the world to finance its instantaneous convergence to the world steady state as interest payments in perpetuity. Here, the principal is never paid off. We examine alternative debt contracts to quantify the costs of capital account liberalization and their impact on finite horizon welfare gains in liberalizing economies.

**Infinite horizon model in Obstfeld-Rogoff (1996).** In an infinite horizon problem, the transversality condition implies that:

$$\lim_{T \to \infty} \left( \frac{1}{\beta} \right)^T B_{t+T+1} = 0$$

This means that after substituting for $B_t$ in the per period budget constraint and solving for steady state consumption we get $RB_t = C_t + I_t - Y_t + B_{t+1}$ and steady state consumption is given by:

$$\bar{C} = \frac{R - 1}{R} \left( RB_t + \lim_{T \to \infty} \left( \frac{1}{\beta} \right)^t (\bar{Y} - \bar{I}) \right)$$
Table 3.4: Welfare Gains: Obstfeld-Rogoff

<table>
<thead>
<tr>
<th>Sample Average $k_0$</th>
<th>Average</th>
<th>First</th>
<th>Second</th>
<th>Third</th>
<th>Fourth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time Horizon (Years)</td>
<td>$\mu_T$</td>
<td>0.65</td>
<td>1.20</td>
<td>1.88</td>
<td>3.35</td>
</tr>
<tr>
<td>5</td>
<td>37.34</td>
<td>68.89</td>
<td>44.83</td>
<td>29.13</td>
<td>9.32</td>
</tr>
<tr>
<td>10</td>
<td>27.70</td>
<td>49.82</td>
<td>33.77</td>
<td>22.36</td>
<td>6.94</td>
</tr>
<tr>
<td>15</td>
<td>21.48</td>
<td>38.04</td>
<td>26.35</td>
<td>17.67</td>
<td>5.47</td>
</tr>
<tr>
<td>20</td>
<td>17.49</td>
<td>30.69</td>
<td>21.52</td>
<td>14.54</td>
<td>4.51</td>
</tr>
<tr>
<td>25</td>
<td>14.80</td>
<td>25.82</td>
<td>18.24</td>
<td>12.39</td>
<td>3.85</td>
</tr>
<tr>
<td>30</td>
<td>12.91</td>
<td>22.44</td>
<td>15.93</td>
<td>10.86</td>
<td>3.38</td>
</tr>
<tr>
<td>35</td>
<td>11.53</td>
<td>19.98</td>
<td>14.23</td>
<td>9.72</td>
<td>3.03</td>
</tr>
<tr>
<td>40</td>
<td>10.49</td>
<td>18.14</td>
<td>12.95</td>
<td>8.87</td>
<td>2.77</td>
</tr>
<tr>
<td>45</td>
<td>9.68</td>
<td>16.72</td>
<td>11.96</td>
<td>8.20</td>
<td>2.56</td>
</tr>
<tr>
<td>50</td>
<td>9.04</td>
<td>15.60</td>
<td>11.17</td>
<td>7.67</td>
<td>2.40</td>
</tr>
<tr>
<td>$\infty$</td>
<td>5.28</td>
<td>9.05</td>
<td>6.54</td>
<td>4.52</td>
<td>1.42</td>
</tr>
</tbody>
</table>

Notes - $\mu_T$ reported in percentage points. Data are for 82 non-OECD countries. We use the capital stock in 1995 for the initial level of capital. The sample is also divided into quartiles based on the size of the capital stock in 1995.

We return to a benchmark economy with an autarkic capital-output ratio of 1.4\textsuperscript{4} and impose the transversality condition which holds if and only if the economy in the infinite horizon has neither unpaid debts nor unused resources to compute the welfare gains across different horizons. Here, both the principal and interest are paid off at infinity. The welfare estimates are presented in Table 3.4.

The economy in the infinite horizon has neither unpaid debts nor unused resources. If the repayment occurs far enough into the future, it will not affect welfare in a drastic way because of the discount factor. Comparing Table 3.4 to Table 3.3, we can see that the welfare gains here are larger. Unlike the case with making repayments in perpetuity, here, the government may schedule repayments to begin farther into the future. Using this mode for repayment we only care about the resolution of debt by infinity, without specifying the way repayments are distributed in the interim. The next section focuses on the way repayments are allocated through time.

**50 year debt contract.** Consider an alternative debt contract with a finite, 50 year repayment horizon where once again both principal and interest are paid off. If external debt is amortized in equal payments over 50 years, then annual amortization will be $\frac{\text{Principal}}{t}$.

\textsuperscript{4}Note that this is the average population weighted autarky-level capital output ratio in GJ.
Table 3.5: Welfare Gains: 50 Year Debt Contract

<table>
<thead>
<tr>
<th>Time Horizon (Years)</th>
<th>Quartiles</th>
<th>µT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>First</td>
<td>Second</td>
</tr>
<tr>
<td>5</td>
<td>34.82</td>
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<td>10</td>
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<td>10.49</td>
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<tr>
<td>15</td>
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<td>20</td>
<td>5.82</td>
<td>2.04</td>
</tr>
<tr>
<td>25</td>
<td>2.68</td>
<td>0.03</td>
</tr>
<tr>
<td>30</td>
<td>0.68</td>
<td>-1.24</td>
</tr>
<tr>
<td>35</td>
<td>-0.61</td>
<td>-2.05</td>
</tr>
<tr>
<td>40</td>
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<td>-2.56</td>
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<tr>
<td>45</td>
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<td>-2.85</td>
</tr>
<tr>
<td>50</td>
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<td>-3.00</td>
</tr>
<tr>
<td>∞</td>
<td>-0.98</td>
<td>-1.45</td>
</tr>
</tbody>
</table>

Notes - µT reported in percentage points. Data are for 82 non-OECD countries. We use the capital stock in 1995 for the initial level of capital. The sample is also divided into quartiles based on the size of the capital stock in 1995.

and the corresponding amount of debt outstanding at the end of year t will be $Principal_t = Principal_0(1 - t/T)$, for $t < 50$ and zero thereafter. In addition to principal, the country must pay interest on the amount of its external debt outstanding, in the amount $zR^*Principal_t$, where $R^*$ is the world interest rate. The results are presented in Table 3.5.

Consider the results in Table 3.5. Though $µ$ at the infinite horizon is negative, the short run calculations for $µ$ are positive and large and slowly become negative for all quartiles except the fourth. This effect depends on the size of the initial capital inflow. Consider the fourth quartile, where the initial level of capital is the highest. Since the initial level of capital is close to the steady state level, in the short run, upon liberalization, the repayment associated with the capital inflow will cause the consumption stream under integration to be lower than the consumption stream under autarky, making $µ$ negative. However, because the amount these countries had to borrow was low, the payments are small and eventually the consumption stream under integration will become higher than under autarky. Conversely, for all other quartiles, the initial level of capital is much lower than the steady state level. In the short run, the consumption stream under liberalization, even after repayment, will be higher than that under autarky, contributing to the positive $µ$. However, since the amount initially borrowed was large, the cost of repayment catches up with the economy later, eventually causing the level of consumption under liberalization to be lower than autarky, contributing to the negative $µ$. 

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As can be noted by the negative values in Table 3.5, the way financing costs are repayed greatly influences the welfare effect of financial liberalization. If the bulk of the repayment occurs far enough into the future the short run welfare gain will be larger. Conversely, when the repayment of debt is spread out evenly across states (Table 3.2) or front loaded (Table 3.5) the gain in welfare will be lower. This brings to attention the importance of considering the allocation of the costs from financial liberalization across time. When measuring welfare using a short run horizon, these effects will be amplified.

3.5 Conclusion

This paper studies the transitional dynamics of a policy change that leads to a temporary growth effect. We find that that the methodological approach to measure the welfare impact of a policy change like capital account liberalization can drive the magnitude of policy effect estimates. Evaluating welfare gains from liberalizations under an infinite time horizon underestimates the gains enjoyed in the decades following liberalization as differences in the consumption paths of autarky and integration are large soon after liberalization. Yet these differences comprise only a small fraction of welfare gains calculated using the infinite lifetime consumption stream. Calculating welfare benefits over finite horizons may be more appropriate and policy-relevant for evaluating policy changes such as capital account liberalization that lead to temporary growth effects but permanent level effects on per capita incomes.

We do not claim that policies that lead to permanent effects on TFP and growth are not important. We simply point out that policy changes that lead to temporary growth but permanent level effects of this sort (like capital account liberalization) can add up to significant increases in levels of per capita incomes. Examining the welfare consequences of a temporary growth (and permanent level) effect is also the more consistent way of testing the predictions of the neo-classical growth model in the context of capital account liberalization.
Figure 3.1: Consumption Streams in Autarky and Integration: Ramsey Model

Figure 3.2: Consumption Streams in Autarky and Integration: GJ
Appendix A

Appendix to Chapter 1

A.1 Calculating $\mu$: The Percent Change in Lifetime Consumption

**Figures 1.4 - 1.15.** For an economy that supports a fixed exchange rate regime, I compare welfare in two scenarios. In scenario A the government waits until a default episode to abandon a fixed exchange rate regime, while in scenario B the government abandons the fixed exchange rate regime before the default. The welfare impact, $\mu$, is the consumption equivalent variation between scenario A and scenario B. $\mu$ is calculated as the percent change in lifetime aggregate consumption, $C(c^T, c^N)$, that is required to equate expected welfare in scenario A to that in scenario B:

$$
E^A_0 \sum_{t=0}^{\infty} \beta^t U((1 + \mu)C(c_t^N, c_t^T), G_t) = E^B_0 \sum_{t=0}^{\infty} \beta^t U(C(c_t^N, c_t^T), G_t),
$$

$$
\mu = \left[ \frac{E^B_0 \sum_{t=0}^{\infty} \beta^t U(C(c_t^N, c_t^T), G_t)}{E^A_0 \sum_{t=0}^{\infty} \beta^t U(C(c_t^N, c_t^T), G_t)} \right]^{\frac{1}{1-\sigma}}.
$$

At each state for wages and outstanding debt, $\{w,B\}$, the government faces a tree of possible future realizations for each scenario. $\mu$ is the percent increase in lifetime aggregate consumption that is required to make the government indifferent between the expected utility in the two scenarios. I calculate $\mu$ for each point on the $\{w,B\}$ state space. Given a starting point $\{w,B\}$ I make 1,000 simulations of streams with a length of 200 periods under each scenario. $\mu$ is the change in lifetime consumption required to make the government indifferent to the utility expected from either waiting until a default to abandon a fixed exchange rate regime or immediately abandoning a fixed exchange rate regime.

**Tables 1.4 and 1.6.** Here $\mu$ is calculated assuming perfect foresight. I simulate the model economy under scenario A 10,000 times. For each simulation under scenario A, I have a corresponding simulation under scenario B. For simulations under scenario A where default occurs, I calculate $\mu$ for the corresponding pair of simulations from scenarios A and B:

$$
\sum_{t=0}^{\infty} A \beta^t U((1 + \mu)C(c_t^N, c_t^T), G_t) = \sum_{t=0}^{\infty} B \beta^t U(C(c_t^N, c_t^T), G_t),
$$
The discount factor $\beta^t$ makes utility in earlier periods affect welfare with a greater magnitude than utility in later periods. Since default episodes occur at different times in different simulation streams, the welfare effect of a preemptive exchange rate regime switch will be affected by the period the default occurs in. Take two identical default episodes; one occurs in period 10, the other in period 1000. Though the effect of the regime switch on economic fundamentals will be identical, the welfare effect of an exchange rate regime switch ahead of the default will be larger for the earlier episode since $\beta^{10} > \beta^{1000}$. To avoid the effect that the time of default has on welfare, I calculate $\mu$ after aligning the default episodes to the same period in the stream. Once default episodes are aligned, the welfare effect of the exchange rate regime switch, $\mu$, is comparable across streams.

### A.2 Endogenizing the Exchange Rate Regime: A Discussion

In the model described in this paper, the decision to default is endogenous while the decision to abandon the fixed exchange rate regime is exogenous. Imposing the exchange rate regime switch exogenously is enough for the purpose of this paper: to capture the welfare effect of abandoning a fixed exchange rate regime in an economy that could default on its foreign currency denominated debt. This is because I test, in each state, whether or not abandoning the fixed exchange rate regime would lead to welfare gains. It is true, however, that keeping the exchange rate regime decision exogenous ignores interesting dynamics regarding currency speculation.

It is generally acknowledged that fixed exchange rate regimes tend to be unstable. Endogenizing the exchange rate regime decision means that the central bank’s decision to support a fixed exchange rate regime is not regarded as fully credible by agents in the economy. Foreign creditors and the government have the same information set and agents know when the government will decide to abandon the fixed exchange rate regime and can calculate the probability that they will abandon it.

I will describe the options that a government will have when it can decide both whether to default and whether to abandon a fixed exchange rate regime. In order to simplify the problem computationally, each period the government can either decide to default or to abandon the fixed exchange rate regime. It can not do both in the same period.

<table>
<thead>
<tr>
<th></th>
<th>Fixed</th>
<th>Flexible</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Default</td>
<td>1 $\downarrow$</td>
<td>2 $\downarrow$</td>
</tr>
<tr>
<td>Default</td>
<td>3 $\rightarrow$</td>
<td>4</td>
</tr>
</tbody>
</table>

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The choice set for the government given the state of the economy is as follows. When an economy is not in default and is supporting a fixed exchange rate regime (cell 1), the government can either default (move to cell 3) or abandon the fixed exchange rate regime (move to cell 2). When an economy is not in default and has a flexible exchange rate regime (cell 2), the government can decide to default (move to cell 4). When an economy is in default and supports a fixed exchange rate regime (cell 3) it can abandon the fixed exchange rate regime (move to cell 4).
Appendix B

Appendix to Chapter 2

B.1 Calculating the Welfare Effect of Austerity and Default

I measure welfare as the percent change in utility that would be required to equate welfare between two scenarios. First, I measure the effect of austerity on welfare, $\mu_{aust}$, by eliminating the possibility of default. Welfare here, $\mu_{aust}$, is the change in utility required to equate welfare in the baseline economy to one with no default and is calculated as follows:

$$\sum_{t=0}^{\infty} nd \beta^t (1 + \mu_{aust}) U(C_t, G_t, 1-l_t) = \sum_{t=0}^{\infty} b \beta^t U(C_t, G_t, 1-l_t),$$

$$\mu_{aust} = \left( \frac{\sum_{t=0}^{\infty} b \beta^t U(C_t, G_t, 1-l_t)}{\sum_{t=0}^{\infty} nd \beta^t U(C_t, G_t, 1-l_t)} \right) - 1$$

where $nd$ represents the economy where default is eliminated and $b$ represents the baseline economy. In order to calculate $\mu_{aust}$ I run a simulation of the economy under both scenarios 10,000 times, calculate $\mu$ for each pair, and report the average $\mu$ across these simulations.

Similarly, in order to calculate the welfare effect of default, I eliminate the ability to implement austerity policies by fixing the tax rate. Here, the welfare effect, $\mu_{defa}$, is the percent change in utility required to equate welfare from the baseline model to the model with no austerity. The method for calculating $\mu_{defa}$ is as above.
Appendix C

Appendix to Chapter 3

C.1 Quartiles by Capital to Output Ratio in 1995 for Non-OECD Countries

<table>
<thead>
<tr>
<th>First</th>
<th>Second</th>
<th>Third</th>
<th>Fourth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uganda</td>
<td>Bangladesh</td>
<td>South Africa</td>
<td>Panama</td>
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<tr>
<td>Madagascar</td>
<td>Burkina Faso</td>
<td>Dominican Republic</td>
<td>Argentina</td>
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<tr>
<td>Mozambique</td>
<td>Cameroon</td>
<td>Nepal</td>
<td>Iran</td>
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<tr>
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<td>India</td>
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<td>Ecuador</td>
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<td>Uruguay</td>
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<td>Comoros</td>
<td>Barbados</td>
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<td>Philippines</td>
<td>Korea</td>
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<td>Togo</td>
<td>Trinidad</td>
<td>Malaysia</td>
<td>Tanzania</td>
</tr>
<tr>
<td>Mali</td>
<td>Guinea</td>
<td>Venezuela</td>
<td>Singapore</td>
</tr>
</tbody>
</table>

C.2 Quartiles by Capital to Output Ratio in 1995

<table>
<thead>
<tr>
<th>First</th>
<th>Second</th>
<th>Third</th>
<th>Fourth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mexico</td>
<td>Philippines</td>
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<td>Colombia</td>
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<tr>
<td>Malaysia</td>
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<tr>
<td>Brazil</td>
<td>Portugal</td>
<td>Venezuela</td>
<td>Turkey</td>
</tr>
</tbody>
</table>

Notes - $\mu_T$ reported in percentage points. Data on $P^E$ ratios are from the Emerging Markets Data Base. The sample is also divided into quartiles based on the size of the premium $R_i^* - R^*$. 
Another Way to Think of Welfare in the Short Run

The fact that the welfare effect of financial liberalization is accumulated mostly in the short run can be illustrated in a different way. Here, I calculate the per period percent change in utility between autarky and integration $\Delta_t = \frac{U^{\text{int}}_t - U^{\text{aut}}_t}{U^{\text{aut}}_t}$. Because the difference between consumption in autarky and integration is greatest during the periods following liberalization, the value of $\Delta_t$ is declining over time.

Figure C.1 plots $\Delta_t \beta^t$ for different values of time preference $\beta$. For the value of $\beta$ used in this paper, 0.96, 72% of the gain in welfare from liberalization is realized by year 5, and 94% of the welfare gain is realized by year 10. The time preference of agents in the economy affect the way they value the timing of consumption. Since liberalization serves to push consumption to its steady state level in the short run, the value of time preference affects the way $\Delta_t$ is valued by the agent. As the discount factor decreases, the agent’s value of the percent change in consumption decreases, implying that the value of liberalization decreases.


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