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ESSAYS ON SOVEREIGN DEBT AND DEFAULT

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ESSAYS ON SOVEREIGN DEBT AND DEFAULT

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ABSTRACT

The first chapter studies the effects of government capital accumulation on sovereign debt default risk and debt restructuring renegotiation outcomes when a government has limited ability to extract revenues from households. To do so, this chapter develops a quantitative dynamic stochastic general equilibrium model of sovereign default, debt renegotiation, and fiscal policies, where the government chooses between the fiscal expenditures of government consumption and government investment. Government capital provides an additional means of adjustment in the face of a bad productivity shock. It also affects the government's incentive to re-access the international credit market when the government chooses to default. The model delivers three key predictions: (1) a higher level of government capital implies less risky sovereign debt and higher recovery rates when the government chooses to default; (2) a high debt to output ratio is sustainable with a sufficient level of government capital; (3) fiscal adjustment that reduces public investment may be self-defeating.

The second chapter investigates the empirical facts that government expenditures and taxes are procyclical in developing countries but countercyclical or acyclical in developed economies. This chapter provides a possible explanation for this stylized fact by introducing news about future total factor productivity and endogenous fiscal policy in an otherwise-standard small open economy model of sovereign default risk, as in Arellano (2008). News tends to be more precise in developed countries, which relaxes credit constraints on foreign borrowing and makes developed countries less reliant on tax revenues. This dampens and potentially reverses the high correlation between output and government expenditures/taxes

observed in developed countries.

The third chapter studies the impact of creditors' income process on the outcomes of sovereign debt restructurings. This chapter compiles a new dataset on foreign creditors' income process during negotiation. This chapter shows that when foreign creditors are facing high income, restructurings are protracted and result in smaller haircuts. To explain these stylized facts, this chapter develops a dynamic stochastic general equilibrium model of defaultable debt that embeds multi-rounds negotiations between a risk-averse sovereign and risk-averse creditors. The quantitative analysis shows that high creditors' income results in a longer duration of restructuring and higher haircuts.

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List of Abbreviations

AR ..... Autoregressive

BEA ... Bureau of Economic Analysis

CRRA .. Constant Absolute Risk Aversion

DARA . Decreasing Absolute Risk Aversion

EBP .... Excess Bond Premium

GHH ... Greenwood, Hercowitz, and Huffman

GZ ..... Gilchrist and Zakrajsek

MECON Ministry of Finance of Argentina

NPV ... Net Present Value

RBC ... Real Business Cycle

R&D ... Research and Development

RMSE .. Root Mean Square Error

SGP .... Stability and Growth Pact

TFP .... Total Factor Productivity

Chapter 1

Sovereign Default Risk, Fiscal Adjustment, and Debt Renegotiation

1.1 Introduction

How does government capital affect a government's incentive to default on its sovereign debt when the government has a limited ability to extract tax revenue from private sectors? When sovereign countries default and renegotiate with foreign creditors, how does the level of government capital affect the outcomes of debt restructuring renegotiation? Are there any fiscal rules or policies that enable governments to manage foreign debt or government spending more carefully such that a country is less vulnerable to negative shocks to the economy? This paper investigates the above questions within a quantitative framework that explicitly incorporates sovereign default, debt renegotiation, and government capital.

Recent European debt crises have ignited academic and policy debates on how to deal with sovereign debt crises. Faced with the high cost of debt and risk of default, many governments try to overcome their debt crisis by enacting fiscal austerity policies. However, a package of fiscal austerity policies such as reducing social security, public goods and services, and tax increases sparks social unrest and political instability leading to the replacement of some governments by opposition parties.[1] [2] On the other hand, some countries try to

[1]Voth (2011) describes the political instability and social unrest during the austerity policy. He shows that expenditure cuts and tax increase in a less extent carry a risk of riots, anti-government demonstrations, general strikes, political assassinations, and attempts at revolutionary overthrow of the established order. This may explain the delayed or not sufficient fiscal adjustment effort during the crisis.

[2]In Greece, three Prime Ministers (Papandreou, Papademos, and Pikrammenos) were replaced during debt crises while in Argentina, four presidents took office during debt crises between 1999 and 2005.

stimulate aggregate demand by borrowing more even though they are already debt ridden.[3] These examples show how hard it is to adjust fiscal resources to cope with the debt crisis. With the pressure from creditors to cut spending and to increase taxes, governments have been tempted to adjust government finances by slashing investment spending rather than transfers. As a result, both public investment and private investments are severely reduced during debt crises. This is one of the main causes that was cited for the long-lasting and sluggish economic recovery and financial autarky following debt default in the 1980s in Latin America.[4] As a result, several fiscal rules, such as the Maastricht Treaty and the Stability of Growth Pact (SGP), were proposed to prevent potential debt crises in advance.[5] These fiscal rules, however, did not pay attention to the role of reduced government capital and government investment during the period. To correct the shortcomings of the fiscal rules, recent rule changes such as the Golden Rule of Public Finance have attempted to secure government investment while limiting debt and deficit levels.[6] In addition several tax policies have been proposed to collect government revenues without exposing the country to the risk of default. Based on recent episodes and historical experience, we try to emphasize the role of government capital in debt default and debt renegotiation as well as the effectiveness of fiscal policies and rules in quantitative settings. [7]

[3]When French President Hollande took office in 2012, he emphasized more growth-supporting measures rather than the fiscal austerity measures led by Berlin.

[4]Easterly, Irwin, and Serven (2007) discuss the pitfalls of ”adjustment with growth” during macroeconomic stabilization in Latin America in the 1990s and suggest that some types of fiscal austerity not only fail to bring growth, they may not even bring ”adjustment” in the long run. Sachs (1990) comments on the public investment in Latin America where the foreign credit squeeze was most severe in that governments responded to the external shocks with a combination of spending cuts and increased domestic borrowing. In cutting spending, public investment projects were the first to go, public sector real wages the second, and public sector employment a distant third. See also Kuralbayeva (2013)

[5]The Maastricht Treaty, signed in 1992 by the members of European Community, was to keep ”sound fiscal policies, with debt limited to 60% of GDP and annual deficits no greater than 3% of GDP.” The Stability of Growth Pact was to ensure that fiscal discipline would be maintained and enforced in the European Monetary Union (EMU).

[6]The Golden Rule, first implemented in UK and soon to be followed by France, Germany, Spain, and Italy, is the guideline for fiscal policy that restricts government borrowing to investment rather than funding current consumption.

[7]Financial Times, July 3 2013, Brussels relaxes EU fiscal rules on infrastructure spending: Brussels is to ease strict budget deficit rules to give EU countries more flexibility to make key public investments aimed at boosting economic growth and lowering record unemployment

This paper develops a dynamic stochastic general equilibrium model of small open economy that incorporates sovereign default, debt renegotiation, and fiscal policy. Unlike most previous papers on sovereign default, we separate the household and government to examine the effect of government capital on default risk and debt renegotiation as well as on the effectiveness of fiscal rules. [8] Government spending can be decomposed into government consumption and government investment. Government consumption gives direct utility in the current period and is considered as a non-productive component of government spending. Government investment, on the other hand, is a productive component of government spending and one of the inputs in production function, which generates future consumption. We can think of government consumption as social security, pensions, and transfers. Government investment can be either physical capital, such as infrastructure, or human capital, such as education, health, or R&D. In our model, government capital provides two distinct roles in deciding to default or repay. First, government capital can be thought of as a government saving tool. It plays a precautionary saving role in smoothing consumption. Secondly, government capital can increase future output, enabling government to generate more tax revenues in the future. Thus, the inclusion of government capital plays a significant role in debt repayment and debt renegotiation. However, the distinction between private capital and government capital is not important for this paper. Government capital can be interpreted as the fraction of total capital of the economy that government can handle or liquidate in times of crisis. If the government can control the whole capital, then aggregate capital is government capital. In reality, however, the government cannot control much of the total capital in the economy; therefore, we only consider capital that the government can handle.

This paper endogenizes the debt renegotiation process by using a one-time Nash bargaining framework. Similar to Yue (2010), if the country defaulted on its debt, the country and foreign investors renegotiate over the recovery rate. Optimal recovery is derived to

[8] Cuadra, Sanchez, and Sapriza (2010) separate household and government to see the impact of default risk on pro-cyclical fiscal policy.

maximize the joint surplus between the government and its creditors. Once the recovery rate is determined and paid off by the country, it can re-access the international financial market again with no debt. We do not try to get equilibrium delay in this model. Benjamin and Wright (2008) investigated the optimal delay in debt renegotiation as well as recovery rates.

The first contribution is to show that as government capital increases, the optimal recovery rates tend to increase but in a diminishing manner for a given level of foreign indebtedness and productivity. For sovereign borrowers, the surplus for the debt renegotiation resolution is the difference between the value of the debt renegotiation agreement and the value of autarky. As a government's capital increases, the value of a debt renegotiation agreement priced by a discount factor also increases. Intuitively, this implies that the more capital the government has, the further the government will lose by failing to reach a debt renegotiation agreement since exclusion from the international credit market reduces the productivity of government capital. Thus, the country is likely to pay more to foreign investors in order to re-access the international credit market sooner. However, when the country already has a high level of government capital, the surplus of the debt renegotiation agreement for the country will no longer increase, and optimal debt recovery rates will remain same. While the value of autarky increases when capital increases as explained by "autarky channel"in Gordon and Guerron-Quintana (2013), we introduce the debt renegotiation process into the model and show that the value of returning to the credit market is greater than the value of staying in financial autarky. Therefore, we underscore the role of government capital in insurance even after a country's default. We provide an analytic characterization to explain why optimal recovery rates increase but in a diminishing manner as capital increases. In section 6, we quantify this argument and show that the value of debt renegotiation increases faster than the value of autarky, generating high recovery rates in our calibrated economy.

The second contribution is to show that a high debt to output ratio can be sustained with reasonable default frequency when the economy has a sufficient level of capital. If the government has more government capital, recovery rates tend to be high and the benefit of default is reduced, thereby removing the incentive to default. As the government will pay lower interest rates and can accumulate more government capital, defaulting becomes less attractive. Therefore, even if the initial effect of government capital is small, an amplification mechanism can generate enough safety for the given level of sovereign debt. However, this amplification mechanism is absent in an endowment economy (Yue, 2010). Then, the government can raise more debt from foreign investors and the riskiness of sovereign default increases by a general equilibrium effect. Aguair and Gopinath (2006) generate a debt to output ratio of 19% but with a very low default frequency of 0.92%. In Arellano (2008) and Yue (2010), the figures are 5.95% and 10.13% respectively. On the other hand, D'Erasmo (2010) can generate debt to output ratio of 40% by introducing a country's reputation mechanism and an endogenous debt renegotiation in an asymmetric information setting. Pouzo and Presno (2012) study foreign investors' concerns about model misspecification and generate around 45% of a debt to output ratio. Our contribution is to deliver a high debt to output ratio of 20% with default frequency of around 4% by introducing a government capital and an endogenous debt renegotiation in a perfect information setting without explicitly calibrating debt to output ratio. Although our model cannot generate the high level of debt to output as seen in the data, we provide another mechanism in the right direction. [9]

The third contribution of this paper is that we investigate the effectiveness of fiscal rules and policies. We implement debt ceiling fiscal rules, particularly focusing on government spending dynamics. The first fiscal rule is the simplified Stability and Growth Pact (SGP), where the foreign debt is limited by some exogenous level. Then we evaluate the modified SGP, the Golden Rule, where some fraction of government investment is allowed by foreign debt financing and other government spending is only financed from tax revenues. Moreover, we implement various tax policies such as distortionary and non-distortionary tax systems. Based on these experiments, we show that fiscal rules or policies that secure government

[9] In the model of Arellano and Bai (2013) where no capital exists, the debt to output ratio is around 5%

investment and rely on non-distortionary tax systems generate a small loss for investors and a low default risk in the long run.

The model is calibrated to match the Argentina economy during 1980-2001. We find that the Argentina sovereign debt crisis is a suitable ground to test this model. Argentina's fiscal mismanagement is cited as one of the main culprits for sovereign debt crisis and default.[10] Furthermore, there are major debates whether a fiscal adjustment policy is appropriate and what kind of fiscal policies should be adopted to prevent the sovereign debt crisis.

Our paper is closely related to the work of Arellano and Bai (2013) in which a dynamic model of government borrowing and default is investigated. They evaluate the effect of increasing taxes during a debt crisis, when a government collects distortionary taxes to pay interest payments and government consumption. Our model differs from their model in that we divide government spending into government consumption and government investment. Then we investigate the effect of government investment and government capital accumulation on the incentive to default and on the outcomes of debt renegotiation. In policy experiments, we evaluate not only the effect of a tax increase as Arellano and Bai (2013) but we also study the effect of a fiscal rule on the dynamics of government spending.

The rest of the paper is organized as follows. Section 1.2 reviews related literature. Section 1.3 presents empirical evidence of fiscal spending, sovereign default risk, and debt renegotiation outcomes. Section 1.4 provides a theoretical model. Section 1.5 defines recursive equilibrium. The calibration and quantitative implications will be discussed in section 1.6. Policy experiments will be conducted in section 1.7. Section 1.8 provides conclusions.

[10] Braun (2006) argues that Argentina's federal fiscal institutions lead to a serious common pool problem that in turn causes a deficit bias.

1.2 Literature Review

This paper is related to the quantitative sovereign debt default literature.[11] Since the seminal paper of Eaton and Gersovits (1981), the sovereign debt default literature has developed quantitatively. Aguiar and Gopinath (2006) and Arellano (2008) develop quantitative sovereign default models in endowment economies to generate equilibrium default and volatile business cycle, which are commonly found in emerging economies.[12] Along with them, this paper is closely related to Arellano and Bai (2013), Cuadra, Sanchez, and Sapriza (2010) and Gordon and Guerron-Quintana (2013). Cuadra, Sanchez, and Sapriza (2010) develop a dynamic small open economy model to endogenize fiscal policy and optimal default under incomplete credit markets.[13] Their model separates the household and government to study endogenous fiscal policy and shows that default risk is the key to pro-cyclical fiscal policy, which is frequently observed in emerging economies. Their paper identifies government fiscal policies as government spending and tax rates. Even though their model concerns production economy, labor is the only input in their production function. Our paper introduces government capital as the other input in the production function and lets government control the accumulation of capital. By endogenizing government capital accumulation, we can investigate how government capital accumulation affects the incentive to default or repay. Gordon and Guerron-Quintana (2013) study the effect of physical capital accumulation on the sovereign's decision to default or repay. They investigate two opposing effects of physical capital accumulation, the smoothing role of capital, and the autarky channel. Capital provides an additional role of saving in the face of a negative productivity shock. This smoothing role alleviates an incentive to default, and default risk decreases.

[11] To name a few more. Political risk : Amador (2003), Cuadra and Sapriza (2008), Hatchondo, Martinez, and Sapriza (2009), Andreasen, Sandleris, and Van der Ghote (2013). Risk averse investor: Borri and Verdelhan (2011), Lizarazo (2005), Gilchrist, Yue, and Zakrajsek (2013), Pouzo and Presno (2012). Production economy: Mendoza and Yue (2012), Roldan (2012), Park (2012). Long-term debt: Hatchondo and Martinez (2009), Chatterjee and Eyigungor (2009), Arellano and Ramanarayanan (2012)

[12] Aguiar and Gopinath (2006) introduce shocks to trends and Arellano (200) uses asymmetric default output cost to derive counter-cyclical interest rates.

[13] For pro-cyclical fiscal policy in emerging economy, see Kaminsky, Reinhart, and Vegh (2005), Pouzo (2010), Ilzetzki (2011), and Kuralbayeva (2013)

On the other hand, as capital stock accumulates in the country, the value of autarky increases; this is an autarky channel. In this paper, we try to improve their prediction about the value of autarky by introducing the debt renegotiation process. Furthermore, since the household and the government are the same in their model, they cannot handle fiscal issues. We separate the household and government, as Cuadra, Sanchez, and Sapriza (2010), to investigate the dynamics of government spending and the effectiveness of fiscal policies.

As mentioned above, we introduce the endogenous debt restructuring renegotiation process in the model. Yue (2010) introduces a debt renegotiation of one-round Nash bargaining game. By generating endogenous debt recovery rates, Yue (2010) can improve the model to match debt reductions and business cycles statistics in defaulting countries. Benjamin and Wright (2008) and Bi (2008) extend Yue (2008) by introducing a multi-period bargaining model to derive equilibrium delays. Benjamin and Wright (2008) present a mechanism that shows current and future surpluses of debt resolution are limited by the debtor's limited commitment problem. So both parties wait until a future default risk is low. Bi (2008) uses the Merlo and Wilson (1995) framework of "waiting-for-a-larger-cake" to generate beneficial delays in debt restructuring. Asonuma (2012) extends Yue (2010) by considering not only the recovery rates but also the increases in the rate of new debt at the time of debt renegotiation to study the behavior of serial default. D'Erasmo (2012) investigates the reputation of a country along with the endogenous debt renegotiation in an asymmetric information setting to derive a realistic debt to output ratio, which previous papers fail to deliver. Our paper differs from these papers in that we investigate the role of capital accumulation on the outcomes of debt renegotiation and default risk.[14]

Finally, this paper is related to the fiscal rule literature. Hatchondo, Martinez, and Roch (2012) is closely related to this paper. They find the optimal target value of fiscal rules and

[14] Some of the sovereign debt renegotiation delay literatures are as follows: Pitchford and Wright (2012) investigate a theory of the sovereign debt restructuring process in which delay arises as individual creditor hold-up a settlement in order to extract greater payments from the sovereign. In Bai and Zhang (2012), delays in reaching agreements arise in equilibrium because the government uses costly delays to screen the creditors' reservation value. Asonuma and Joo (2015) present empirical evidence and a model that delay is due to not only sovereign's recovery in output but equally importantly creditors' risk appetite.

measure the aggregate effect in a quantitative sovereign default model. Their fiscal rule is defined as a debt ceiling. In this paper, however, we focus on the effect of fiscal rules and tax policies on government spending. Blanchard and Giavazzi (2005) identify the errors of The Stability of the Growth Pact (SGP) as a way of dealing with public investment. Modifying the rule to exclude public investment from the SGP would drive debt-GDP ratio to the ratio of public capital to GDP in their prediction. Minea and Villieu (2009) assessed the effect of fiscal deficits on economic growth and welfare in an endogenous growth model. They study the effectiveness of the "Golden Rule of Public Finance" and show that intertemporal welfare may increase or decrease, depending on consumption elasticity. In this paper, we investigate how these fiscal rules and policies affect business cycles as well as sovereign default risk.

1.3 Model Environment.

We investigate a small open dynamic stochastic general equilibrium model with sovereign default, fiscal policies, and endogenous debt renegotiation. The government can issue one-period zero coupon, non-contingent bonds to finance government spending. The government has an option to default on this contract, but investors are always committed to the contract.

1.3.1 General points

Our model considers sovereign default and debt renegotiation with government capital in a stochastic dynamic equilibrium model. We consider a risk-averse household, a risk-averse government, and a risk-neutral creditor. The government cannot affect world risk-free interest rates. Government expenditures can be decomposed into government consumption (g_t), government investment (i_t), and interest repayment. We assume an exogenous tax policy to capture the country's limited ability to raise resources from households. There are two types of taxes, a consumption tax (τ) and a lump-sum tax (T). The consumption tax is distortionary while the lump-sum tax is non-distortionary. We assume that government consumption is unproductive but gives utility directly whereas government investment is used as an input to the production function. We assume that it depreciates and contributes to the existing capital stock.

The country receives an exogenous productivity shock a_t. The productivity shock (a_t) is stochastic, drawn from a compact set $A = [a_{\min},\ a_{\max}] \subset R_+$. Given productivity a_t, $\mu(a_{t+1}|a_t)$ is the probability distribution of a shock a_{t+1} conditional on the previous realization a_t. Foreign investors are risk-neural and have perfect information on the country's bond holdings, credit record, productivity, and the level of government capital.

The international capital market is incomplete. The government and foreign investors can borrow and lend only via one-period zero-coupon bonds, where b_{t+1} denotes the amount of bonds to be repaid next period. When the government purchases bonds, $b_{t+1} > 0$, and when it issues new bonds, $b_{t+1} < 0$. The set of the amount of bonds is $B = [b_{\min},\ b_{\max}] \subset R$, where $b_{\min} \leq 0 \leq b_{\max}$. The upper bound is the highest level of assets that the government can accumulate and the lower bound is the highest level of debts that the government can hold. We assume $q(b_{t+1}, K_{g,t+1}, a_t)$ is the price of bonds with asset position (b_{t+1}), government capital $(K_{g,t+1})$ and a productivity shock (a_t). The bond price will be determined in equilibrium.

We assume that foreign investors always commit to repay their debt. However, the government is free to decide whether to repay its debt or to default. If the government chooses to repay its debt, it will preserve access to the international credit markets next period. If the government chooses not to pay its debt, it is subject to exclusion from the international capital markets and suffers direct output cost. However, the government and foreign investors can renegotiate for recovery rates. [15] [16]. Next period, the government

[15] The default penatly is estimated by several papers. Sturzeneger (2002) esimates output loss as around 2% of GDP. On the contrary, De Paoli, Hoggarth, and Saporta (2006) suggest that the output loss in the wake of sovereign default apprears to be very large - around 7% a year on the median measure - as well as long lasting. Levy-Yeyati and Panizza (2011) indicate that the trough of the contraction coincides with the quarter of default, and that output starts to grow thereafter, implying negative impacts fo a default on output is driven by anticipation of default, rather than default itself.

[16] Mendoza and Yue (2008) propose two explanations of output cost: inefficient production caused by imperfect substitution between domestic and imported inputs and labor reallocation away from final good production to production of domestic inputs. Gopinath and Neinman (2013) provide empirical evidences of trade adjustment during the Argentine crisis and show significant heterogeneity in how firms adjusted their import mix.

can access the international credit markets if the country passes the renegotiated recovered debt.

1.3.2 Timing of the model

Timing of decisions is summarized in Figure 1.

1. Period t starts. Productivity shock (a_t) is observed.

2. The government enters the period with a level of sovereign debt (b_t) and public capital (K_t^g). The payoff relevant state variables are debt holdings, the level of public capital, and the productivity shock: (b_t, K_t^g, a_t)

3. The government makes a default decision : $d_t \in [0, 1]$

   (a) If the government chooses to repay,

      i. The household chooses consumption (c_t) and labor supply (l_t), given the current government policies of government consumption (g_t) and tax policies $(\tau,\, T)$

      ii. The firm maximizes profit, given government capital $(K_{g,t})$

      iii. The government chooses new borrowing (b_{t+1}), government consumption (g_t), government investment (K_{t+1}^g) given the optimal private sector's decisions

      iv. Default probability and the bond price are determined in equilibrium and foreign investors issue (b_{t+1}) with this belief.

   (b) If the government chooses to default, the country is excluded from the international credit markets and suffers default output loss of productivity $(h(A))$

      i. The household chooses consumption (c_t) and labor supply (l_t) given the current government policies of government consumption (g_t) and tax policies $(\tau,\, T)$

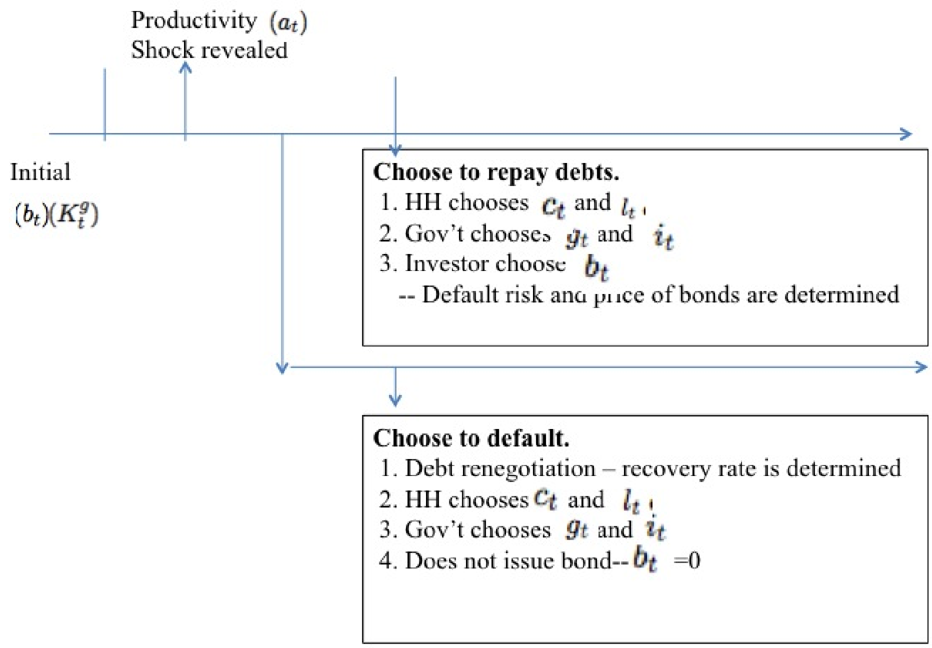

Figure 1.1: Timing of the model

ii. The firm maximizes profit, given government capital $(K_{g,t})$

iii. The government chooses government consumption (g_t) and government investment (K^g_{t+1}) given the optimal private sector's decisions.

iv. At the end of period t, the government and the foreign investors renegotiate for the recovery rates (α_t), the government repays the renegotiated debt to the foreign creditors and re-access the international credit markets next period.

1.4 Recursive Equilibrium

In this section, we define a stationary recursive equilibrium of the model.

1.4.1 Household's problem

A representative household chooses consumption (c_t) and labor supply (l_t) to maximize its expected lifetime utility, given the government polices (g_t, τ, T).

$$\max_{c_t, l_t} E_0 \sum_{t=0}^{\infty} \beta^t U(c_t, g_t, 1 - l_t) \ , \tag{1.1}$$

$$s.t. \quad (1 + \tau_t)c_t = w_t l_t \tag{1.2}$$

The per-period utility function is concave, strictly increasing, and twice differentiable. Households earn an income from supplying labor to firms. The discount factor is $\beta \in (0, 1)$ and households get utility from private consumption, government consumption, and leisure.

The private component and public component in the utility function are separated with the weight λ on government consumption.

$$U(c_t, g_t, 1 - l_t) = (1 - \lambda)u(c_t, l_t) + \lambda v(g_t) \tag{1.3}$$

We assume Greenwood, Hercowitz, and Huffman (GHH) per-period utility function to exclude the effect of wealth on labor supply decisions. We will provide detailed specifications in the calibration section. The household's problem in this setting is static in that households are not allowed to access the international financial markets to smooth consumption. The households provide labor supply, given the consumption tax policy.

Household's first order condition is

$$\frac{u_l}{u_c} = (\frac{w}{1 + \tau}) \tag{1.4}$$

Applying GHH utility form, we get

$$l_t = (\frac{w}{1 + \tau})^{\frac{1}{\psi}} \tag{1.5}$$

As seen in the optimality condition, the labor supply decision depends on the consumption tax τ. A high consumption tax rate induces less labor supply and, therefore, lower output.

1.4.2 Firm's Problem

Final goods production is subject to productivity shock A_t. Labor supply from households and public capital from the government are inputs in this economy. Output is divided into private consumption, public consumption, and public investment. The production technology follows the Cobb-Douglas form:

$$A_t F(l_t) = A_t K_{g,t}^{\theta} l_t^{1-\theta} \tag{1.6}$$

The law of motions of public capital is as follows

$$K_{g,t+1} = i_t + (1-\delta) K_{g,t} \tag{1.7}$$

Given the production function, a firm's problem is to choose labor demand to maximize the profits in the following equation.

$$\max_{l_t} \Pi_t = A_t F(K_{g,t}, l_t) - w_t l_t \tag{1.8}$$

Notice that the public capital is given in this problem.

1.4.3 Determination of Government Policies

The government's problem is to maximize the households' expected lifetime utility. The government makes a default decision and determines asset positions for the next period (b_{t+1}), government consumption (g_t), government investment (i_t) and tax rates (τ_t), given its current asset position (b_t), productivity shock (a_t), public capital ($K_{g,t}$) and household's optimal decisions. The value function of the government is denoted by $V(b_t, a_t, s_t)$. For $b_t > 0$, the country has savings.

For $b_t < 0$, the country has debts. The government has the option to default on its debt. If the government decides to pay its debt, it can choose its next-period's asset position b_{t+1}, government consumption (g_t), and tax rates (τ_t). If the government chooses to default, it will be excluded from the international financial markets, and the government chooses only government consumption (g_t) and consumption tax policy (τ_t). Given the option to default, $V(b_t, K_{g,t}, a_t)$ satisfies

$$V(b_t, K_{g,t}, a_t) = \max \left[V^R(b_t, K_{g,t}, a_t), V^D(b_t, K_{g,t}, a_t)\right] \tag{1.9}$$

where $V^R(b_t, K_{g,t}, a_t)$ is the value associated with paying debts and $V^D(b_t, K_{g,t}, a_t)$ is the value with defaulting debts. The optimal default decision of the government, then, is characterized by

$$D(b_t, K_{g,t}) = \left\{a_t \in A : V^R(b_t, K_{g,t}, a_t) < V^D\left(b_t, K_{g,t}, a_t\right)\right\} \tag{1.10}$$

The default set $D(b_t, K_{g,t})$ is defined over the set of productivity shock $a \in A$ for a given debt position (b_t) and the level of government capital ($K_{g,t}$).

The value of repayment , V^R, satisfies:

$$V^R(b, K_g, a) = \max_{g, K_g', b'} u(c^*, g, 1 - l^*) + \beta \int V(b', K_g', a') d\mu(a'|a) \tag{1.11}$$

$$s.t. \quad g + i = \tau c^* + T + b - q(b', K_g', a)b' - \frac{\Omega}{2}(K_g' - K_g)^2 \tag{1.12}$$

$$K_g' = i + (1 - \delta)K_g \tag{1.13}$$

$$\frac{u_l}{u_c} = \frac{AF_l(l^*, K_g)}{(1 + \tau)} \tag{1.14}$$

$$(1 + \tau)c^* + T = AF(l^*, K_g) \tag{1.15}$$

The government maximizes the household expected life time utility given the government budget constraint, (1.12), the law of motion for government capital, (1.13), the private sector optimality condition, (1.14), and the resource constraint, (1.15). The government budget constraint specifies the source of revenue and expenditure. The government gets revenue from household tax revenue, $\tau c^* + T$, and net foreign borrowing, $b - q(b', K_g', a)b'$. When the government adjusts the level of capital, capital adjustment costs incur, $\frac{\Omega}{2}(K_g' - K_g)^2$. The level of private consumption (c^*) and leisure ($1 - l^*$) are obtained by equation (1.14). The output that firms produce is factored into private consumption and tax revenues.

$V^D(b_t, K_g, a)$ is the value associated with default.

$$V^D(b, K_g, a) = \max_{g, K_g'} u(c^*, g, 1 - l^*) + \beta \int V(0, K_g', a') d\mu(a'|a) \tag{1.16}$$

$$s.t. \quad g + i = \tau c^* + T + \alpha(b, K_g, a)b - \frac{\Omega}{2}(K_g' - K_g)^2 \tag{1.17}$$

$$K_g' = i + (1 - \delta)K_g \tag{1.18}$$

$$\frac{u_l}{u_c} = \frac{h(A)F_l(l^*, K_g)}{(1 + \tau)} \tag{1.19}$$

$$(1 + \tau)c^* + T = h(A)F(l^*, K_g) \tag{1.20}$$

When the government defaults on its debt, the country is excluded from the international credit markets. The government cannot issue debts in that period. Furthermore, the country suffers a default penalty in the form of productivity loss, $h(A_t)$. However, at the end of the period, the country and its foreign investors can renegotiate for the recovery rates of the defaulted debt. Endogenous debt recovery rates are determined in the debt renegotiation process, and the country pays off the recovered debt. Then the country can re-access the international credit markets.

1.4.4 Debt Renegotiation Problem

The debt renegotiation takes the form of a generalized Nash bargaining problem. Depending on the level of debt, productivity shock, and the level of government capital, debt recovery rates are determined through the debt restructuring renegotiation process. The value to the country when debt renegotiation is resolved is as follows:

$$V^D(b, K_g, a) = \max_{\tau, g, K_g^{'}} u(c^*, g, 1 - l^*) + \beta \int V(0, K_g^{'}, a^{'}) d\mu(a^{'}|a) \tag{1.21}$$

$$s.t. \quad g + i = \tau c^* + T + \alpha(b, K_g, a)b - \frac{\Omega}{2}(K_g^{'} - K_g)^2 \tag{1.22}$$

$$K_g^{'} = i + (1 - \delta)K_g \tag{1.23}$$

$$\frac{u_l}{u_c} = \frac{h(A)F_l(l^*, K_g)}{(1 + \tau)} \tag{1.24}$$

$$(1 + \tau)c^* + T = h(A)F(l^*, K_g) \tag{1.25}$$

When the restructuring renegotiation is resolved, the country has to pay recovered debt, $\alpha(b, K_g, a)b$ and can re-assess the international credit markets next period with no debt on hand.

In order to get the borrower's surplus of debt resolution, we need to find the threat point. The threat point of the bargaining game is that the country stays in permanent autarky and the foreign investors get nothing.

The value of financial autarky is as follows:

$$V^{aut}(K_g, a) = \max_{g, K_g^{'}} u(c^*, g, 1 - l^*) + \beta \int V(K_g^{'}, a^{'}) d\mu(a^{'}|a) \tag{1.26}$$

$$s.t. \quad g + i = \tau c^* + T - \frac{\Omega}{2}(K_g^{'} - K_g)^2 \tag{1.27}$$

$$K_g^{'} = i + (1 - \delta)K_g \tag{1.28}$$

$$\frac{u_l}{u_c} = \frac{AF_l(l^*, K_g)}{(1 + \tau)} \tag{1.29}$$

$$(1 + \tau)c^* + T = h(A)F(l^*, K_g) \tag{1.30}$$

When the country is in autarky, the government cannot issue sovereign bonds. The government can only choose government consumption and government investment.

For any debt recovery rate, the surplus for the country, Δ^B, is defined by the difference between the value of debt renegotiation, V^D, and the value of financial autarky, V^{aut}.

$$\Delta^B(b, K_g, a) = V^D(b, K_g, a) - V^{aut}(K_g, a) \tag{1.31}$$

The surplus of the risk-neutral investor is recovered debt when recovery rates are renegotiated.

$$\Delta^L(b, K_g, a) = -\alpha b \tag{1.32}$$

Following Yue (2010), we assume that the country has a bargaining power θ and foreign investors have a bargaining power $1-\theta$. Recovery rates are determined by the Nash bargaining problem. The bargaining power parameter summarizes the institutional arrangement of debt renegotiation. We define the bargaining power set $\Theta \subset [0,1]$ such that the negotiation surplus has a unique optimum for any asset position (b_t), government capital ($K_{g,t}$), and productivity state (a_t). Then recovery rates $\alpha(b_t, K_{g,t}, a_t) \in$ A solves following Nash bargaining problem, given the level of debt (b), government capital ($K_{g,t}$), and productivity state (a).

$$\alpha(b, K_g, a) = arg\max_{\alpha}[((\Delta^B(b, K_g, a))^{\theta}(\Delta^L(b, K_g, a))^{1-\theta}] \tag{1.33}$$

$$s.t. \quad \Delta^B(b, K_g, a) > 0 \tag{1.34}$$

$$\Delta^L(b, K_g, a) > 0 \tag{1.35}$$

Since the debt recovery schedule that maximizes the total renegotiation surplus depends on the country's debt level, the level of government capital, and productivity state, the renegotiation provides better insurance to the country if it chooses to default.

1.4.5 Foreign Investor's Problem

Foreign investors choose the next period's debt level to maximize their profits π, taking the bond price function as given. Expected profits depend on the next period's debt level, the next period's government capital, and the current state of the economy given the current productivity state. $\lambda(b^{'}, K_g^{'}, a)$ is the expected probability of default for a country given the debt level ($b^{'}$), government capital level ($K_g^{'}$), and productivity state (a).

Expected profits are, then, as follows:

$$E[\pi(b^{'}, K_g^{'}, a)] = \begin{cases} q(b^{'}, K_g^{'}, a)b^{'} - \frac{1}{1+r}b^{'} & \text{if } b^{'} \geq 0 \\ \frac{[1-\lambda(b^{'}, K_g^{'}, a)+\lambda(b^{'}, K_g^{'}, a)\alpha(b^{'}, K_g^{'}, a)]}{1+r}(-b^{'}) - q(b^{'}, K_g^{'}, a)(-b^{'}) & \text{if } b^{'} > 0 \end{cases} \tag{1.36}$$

Since we assume completely competitive sovereign debt markets, risk-neutral foreign investors get zero expected profit. The bond price is, then, given by

$$q(b^{'}, K_g^{'}, a) = \begin{cases} \frac{1}{1+r} & \text{if } b^{'} \geq 0 \\ \frac{[1-\lambda(b^{'}, K_g^{'}, a)+\lambda(b^{'}, K_g^{'}, a)\alpha(b^{'}, K_g^{'}, a)]}{1+r} & \text{if } b^{'} > 0 \end{cases} \tag{1.37}$$

where λ reflects the default probability.

$$\lambda = \int_D d\mu(a^{'}, a), \tag{1.38}$$

When the government lends to the foreign investors, $b^{'} \geq 0$, the government gets a risk-free interest rate. When the government faces the possibility of default, foreign investors have to consider two things. The first term, $1 - \lambda(b^{'}, K^{g'}, a)$, compensates the foreign investors for the risk of default. The second term $\lambda\alpha(b^{'}, K_g, a)$ represents the outcomes of debt renegotiation. In this paper, we argue that the government capital K_g affects the default risk and recovery rates, which previous papers have not considered.

1.4.6 Recursive Competitive Equilibrium

The equilibrium is a stationary recursive equilibrium.

Definition 1.4.1. A recursive equilibrium is a set of value functions for (i) the country's value function $V^*(b, K_g, a)$, (ii) a set of policy functions for the government default decision set $D^*(b, K_g)$, asset holdings $b^{'*}(b, K_g, a)$, government consumptions $g^*(b, K_g, a)$, government investment $i^*(b, K_g, a)$, (iii) a set of policy functions for household's consumption $c^*(b, K_g, a)$ and household's labor supply $l^*(b, K_g, a)$, (vi) bond price functions $q^*(b^{'}, K^{'}_g, a)$, (v) recovery rate $\alpha^*(b, K_g, a)$

such that

[1]. Given the bond price function $q^*(b^{'}, K^{'}_g, a)$, debt recovery rates $\alpha^*(b, K_g, a)$, and household consumption $c^*(b, K_g, a)$ and labor supply decision $l^*(b, K_g, a)$, the value function $V^*(b, K_g, a)$, asset positions $b^{*'}(b, K_g, a)$, government consumption $g^*(b, K_g, a)$, and government investment $i^*(b, K_g, a)$, and default set satisfy the country's optimization problem.

[2]. Given the government consumption $g^*(b, K_g, a)$, government investment $i^*(b, K_g, a)$ and tax policies (τ, T) and bond price function $q^*(b^{'}, K^{'}_g, a)$, the household private consumption $c^*(b, K_g, a)$ and labor supply decision $l^*(b, K_g, a)$ satisfy the household's optimization problem.

[3]. Given the bond price function $q^*(b^{'}, K^{'}_g, a)$, the country's value function $V^*(b, K_g, a)$, the recovery rates $\alpha^*(b, K_g, a)$ solve the debt renegotiation problem.

[4]. Given the recovery rate $\alpha^*(b, K_g, a)$, the bond price function $q^*(b^{'}, K^{'}_g, a)$ satisfies the zero expected profit function for foreign investors.

In equilibrium the default probability $\lambda^*(b^{'}, K^{'}_g, a)$ is defined by using the country's default decision:

$$\lambda^*(b^{'}, K^{'}_g, a) = \int_{D^*(b,K_g,a)} d\mu(a^{'}, a), \tag{1.39}$$

The expected recovery rate $\alpha^*(b, K_g, a)$ in equilibrium is given by

$$\gamma^*(b, K_g, a) = \frac{\int_{D^*(b,K_g,a)} \alpha^*(b, K_g, a) d\mu(a^{'}, a)}{\int_{D^*(b,K_g,a)} d\mu(a^{'}, a)} = \frac{\int_{D^*(b,K_g,a)} \alpha^*(b, K_g, a) d\mu(a^{'}, a)}{\lambda^*(b^{'}, K^{'}_g, a)} \tag{1.40}$$

The numerator is the expected proportion of debt that the country pays to the foreign investors and the denominator is the default probability.

1.4.7 Characterization of Recursive Equilibrium

We now provide the main result of the model and characterize the equilibrium property.

For a bargaining power $\kappa \in K$, the equilibrium debt recovery function $\alpha^*(b_t, K_{g,t}, a_t)$ is increasing and concave with respect to the government capital $(K_{g,t})$, given asset holdings (b_t) and productivity shock (a_t).

This prediction implies that when the government has a high level of government capital, exclusion from the international financial markets reduces the productivity of government capital, therefore, it has more to lose by failing to reach debt renegotiation agreement. However, the marginal increase of a debt renegotiation agreement surplus will diminish as capital increases. The analytic expressions of equilibrium recovery rates are derived by maximizing a joint surplus of the debt renegotiation agreement.

$$\alpha^*(b_t, K_{g,t}, a_t) = -\frac{1-\theta}{\theta}\frac{V^D - V^{aut}}{-b\lambda} \tag{1.41}$$

The Lagrangian multiplier λ is the shadow value of the government budget constraint of (1.22) and depends on state variables. Therefore, the optimal recovery rates are a constant fraction of the country's leverage when debt renegotiation is resolved. For a given level of debt and productivity, the relationship between optimal recovery rates and government capital depends on how the country's surplus and shadow value change as capital changes. Furthermore, we show in our calibration that as the government capital increases, the shadow value decreases faster than the country's surplus, therefore, the optimal recovery rates increase. This compares with the corporate finance literature, where corporate recovery rates are determined by the constant fraction of firm leverage. V^D can be thought of as a firm's equity value and $-b\lambda$ is the value of debt, when priced by the shadow value of funds in the corporation.

1.4.8 Fiscal Rules and Fiscal Policies

In this subsection, we present some fiscal rules and tax polices. First, fiscal rules restrict the level of foreign debt by some exogenous debt limit.

$$b_{t+1} \leq \bar{b} \tag{1.42}$$

As for tax policies, we investigate how different tax policies affect the default incentives without changing tax revenues. There are two kinds of tax policies: consumption tax τ and lump-sum tax T. Consumption tax is distortionary in that it distorts labor supply decisions and lump-sum tax is non-distortionary.

1.5 Quantitative Analysis

This section provides calibrations, solves the model numerically, and analyzes the qualitative and quantitative implications of the model.

1.5.1 Parameters and Functional Forms

We calibrate the parameters to match the business cycle, financial, and fiscal statistics of Argentina. We define one period as a quarter. We use the Greenwood, Hercowitz, and Huffman (GHH) utility to exclude the wealth effect on labor supply. This utility is commonly used in open macroeconomics following Mendoza (1991) and Schmitt-Grohe and Uribe (2003).

$$u(c_t, g_t, 1 - l_t) = (1 - \lambda)\frac{(c_t - \frac{l_t^{1+\psi}}{1+\psi})^{1-\gamma}}{1-\gamma} + \lambda\frac{g_t^{1-\gamma}}{1-\gamma} \tag{1.43}$$

Private consumption and labor supply decisions are separable as GHH (1998). As Cuadra, Sanchez, and Sapriza (2010), government consumption and private sector variables are separable in per-period utility specification. The risk aversion parameter γ is equal to 2, following standard RBC literature. The labor elasticity is chosen to be $\frac{1}{\psi} = 2.22$

following Mendoza (1991) and Cuadra et al. (2010). The parameter $\lambda = 0.3$ is set to match the ratio of public consumption to output equal to 20%.

The productivity process is calibrated to match the Argentina quarterly real GDP for 1980Q1 TO 2003Q3 from the Ministry of Finance of Argentina (MECON). We assume that the productivity process follows the lognormal AR(1) process:

$$\ln(A_t) = \rho \ln(A_{t-1}) + \epsilon_t \tag{1.44}$$

with $E(\epsilon) = 0$ and $E(\epsilon^2) = \sigma_\epsilon^2$.

The quarterly series data are detrended by using Hodrick-Prescott filter of 1600. The parameters $\rho = 0.9$ and $\epsilon = 0.01$ are obtained. We approximate this stochastic process as discrete Markov chains of 21 equally spaced grids by using the quadrature method of Tauchen and Hussey (1991). The risk-free rate r is set to equal to 0.01, which matches with average quarterly real interest rate on 3-month U.S. Treasury bills. The bargaining power κ=0.7 is calibrated to match the recovery rates of 30 % for Argentina during 2005 international debt restructuring. The cost of default is specified following Arellano (2008). Asymmetric functional form indicates that output cost is more severe when the economy is hit by good shock whereas the cost of default is not as severe when the economy is in a bad state. This is an important component in Arellano (2008) in deriving a counter-cyclical interest rate, which is commonly found in emerging economies. The default penalty ϕ is set to 0.96.

$$h(A_t) = \begin{cases} \phi E(A) & \text{if } A > \phi E(A) \\ A & \text{if } A \leq \phi E(A) \end{cases} \tag{1.45}$$

The set of parameter $\{\beta, \Omega\}$ are jointly calibrated to match the default frequency and the government investment to output ratio.

The discount factor β and adjustment cost parameter Ω are calibrated to be 0.85 and 20, respectively.[17] Argentina defaulted on its foreign debt five times between 1824 and

2001. A default frequency of 3% can be rationalized on this ground.[18] The adjustment cost parameter is somewhat large in our calibration $\Omega = 20$. However, this large adjustment cost is needed to achieve a reasonable investment ratio. The government capital depreciation is set to be at $\delta = 0.05$ The elasticity of public investment θ is set to 0.034, following Azzimonti (2013).[19] The consumption tax τ and the lump-sum tax T are jointly calibrated to match tax revenue and consumption to output ratio in the Argentina economy. Tax revenue in Argentina is approximated as 15-20% of GDP. The consumption to output volatility ratio is 1.03%

[17] The discount factor in the sovereign default literature ranges from 0.6 to 0.97. A low discount factor reflects the myopic behavior of the government which stems from instability of political environment

[18] See Reinhart and Rogoff (2010)

[19] Baxter and King (1993) included military spending and get 0.05

Parameter	Value	Sources
Risk aversion	$\gamma = 2$	RBC Literature
Labor elasticity	$1/\psi = 2.22$	Mendoza (1991)
Risk free rate	$r = 0.01$	U.S. quarterly interest rate
Productivity persistence	$\rho = 0.95$	Argentina, 1980Q1-2002Q4
Standard deviation	$\sigma = 0.01$	Argentina, 1980Q1-2002Q4
Gov't consumption weight	$\lambda = 0.3$	Gov'con/GDP 20%
Public capital share of income	$\theta = 0.034$	Azzimonti (2013)
Public capital depreciation	$\delta = 0.05$	Gordon and Guerron-Quintana (2013)
Bargaining power	$\kappa = 0.7$	recovery rate 40%
Default penalty	$\phi = 0.96$	Arellano (2008)
Adjustment cost	$\Omega = 20$	Gov investment/GDP 2%
Discount factor	$\beta = 0.85$	default frequency 4%(Annual)
Consumption tax	$\tau_c = 0.30$	tax revenue=18%
Lump-sum tax	$T = 0.02$	$\sigma(c)/\sigma(y) = 1.03$

Table 1.1: Model Parameters

1.6 Model Implication

In this section, we study the equilibrium properties of the calibrated model. Then, we investigate the simulation results.

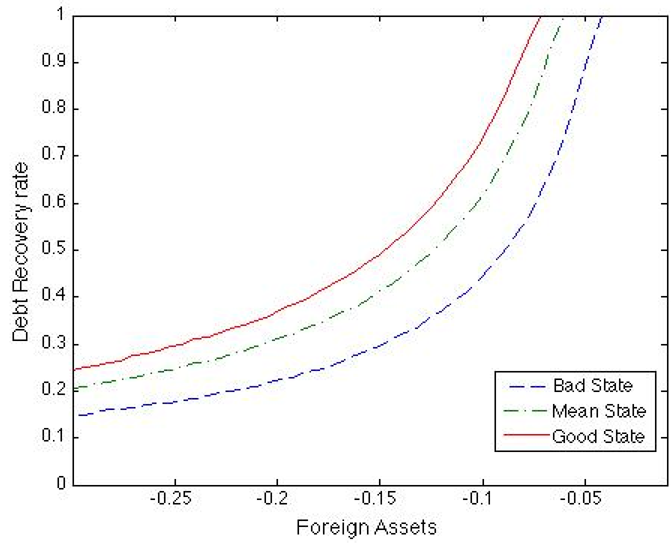

Figure 1.2: Recovery rates, debt holdings, and productivity states

Figure 1.2 presents the equilibrium debt recovery rates schedule. As shown in Yue (2010), figure 1.2 presents the relationship between recovery rates and debt holdings for three states of the economy. It is clear from the figure that when the amount of defaulted debt is high, the recovery rates tend to be small. As the amount of defaulted debt decreases, the debt reduction decreases and reaches a threshold beyond which there is no further debt reduction. In addition, the figure shows that debt recovery rates are high when the government defaults with a good productivity shock. This implies that if the country's economic situation is relatively good when the country defaults on its debt and would likely improve in the future, debt renegotiation is resolved with low debt reduction and the country can re-access the international financial market immediately after.[20] The debt reduction threshold also increases as the country's productivity improves.

[20] Kovrijnykh and Szentes (2007) study a mechanism that monopolistic lenders find it profitable to let the borrower to access the international credit market after a sequence of good shocks. Benjamin and Wright (2008) provide an empirical relationship that recovery rates tend to be high with good state of the country.

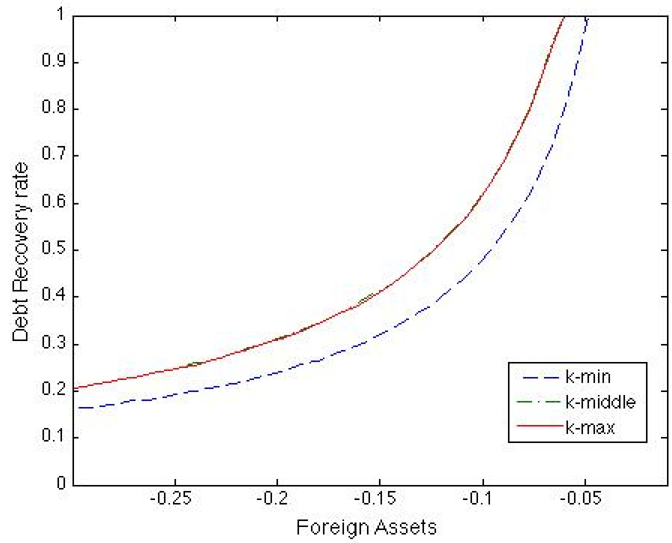

Figure 1.3: Recover rates and government capital

The new feature in this paper is figure 1.3. Figure 1.3 provides the relationship between the level of government capital and recovery rates. The more government capital the country has, the higher the recovery rates tend to be renegotiated during the debt restructuring process. This increase in recovery rates, however, tends to diminish as more government capital is accumulated. When the level of government capital is low, there is not much to lose by not re-accessing the international financial market. Therefore, the government does not need to pay much to re-access the international financial markets. However, as the government capital increases, the benefits of rejoining the international financial markets increase sharply. The marginal increase in surplus, however, slows down as government capital is accumulated. Figure 1.4 shows the joint surplus of debt renegotiation agreement. The optimal recovery rates that maximize the joint surplus increase in a concave manner when the level of government capital increases.

Figure 1.5 plots the default probability as a function of debt holdings for good, average, and bad states of productivity, given a median level of public capital.

The probability of default increases as the level of debt increases. For a high level of debt, it is optimal for the government to default regardless of its economic states since the

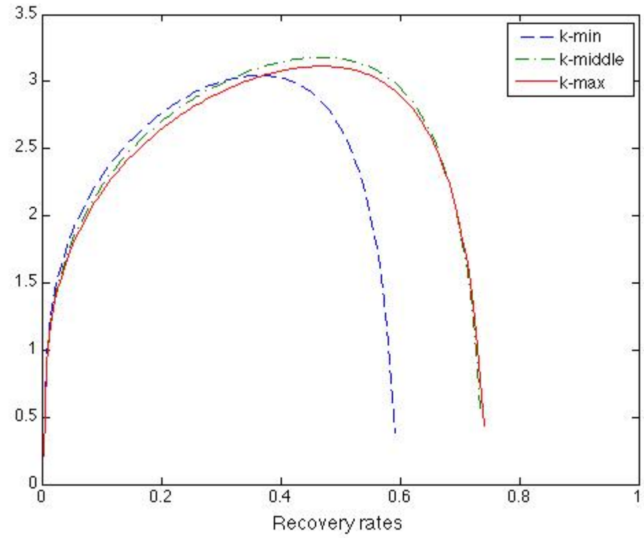

Figure 1.4: Joint surplus and optimal recovery rates

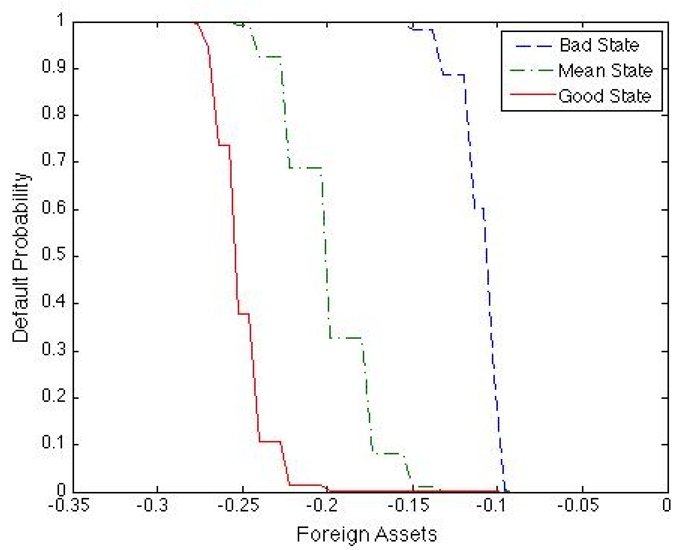

Figure 1.5: Default probability and productivity states

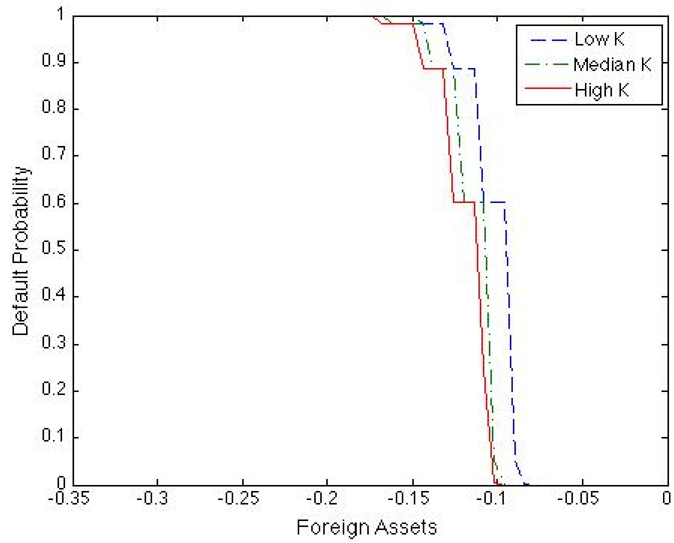

Figure 1.6: Default probability and government capital

cost of repaying its debt is high. On the other hand, the government has no incentive to default when the level of debt is low. In the mid range, however, the government may default or not, depending on the productivity states. The higher the country is in a productivity state, the lower the government's incentive to default.

Figure 1.6 illustrates the default probability for different levels of government capital. It is obvious from the figure that high government capital reduces the government's default probability.

Figure 1.7 provides the default/repayment regions in productivity states and debt spaces, (a, b), for high and low levels of government capital. The boundary between default and repayment regions has negative slope in (a, b) space. The lower line represents high government capital and the upper line is for low government capital. The lower-left region shows the default region while the upper-right region indicates the repayment region for both levels of government capital. This implies that as foreign borrowing increases, default incentive increases for a given level of productivity state. Likewise, the default incentive increases when the economic states deteriorate. What is interesting in this feature is that as government capital increases, the default region shrinks. This fact underscores the importance of

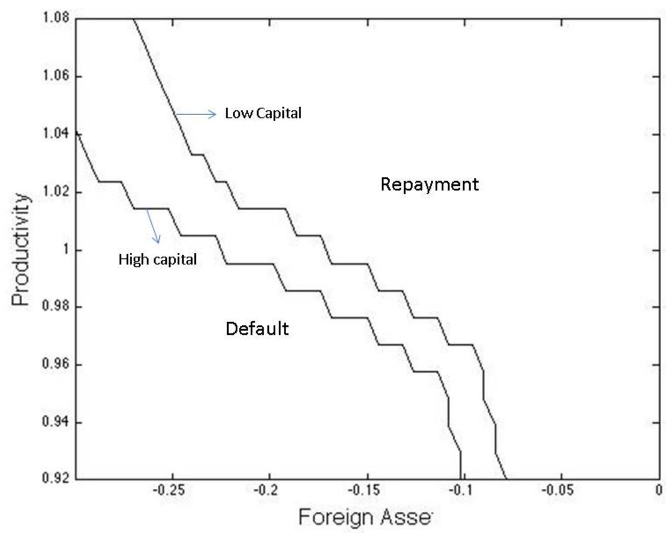

Figure 1.7: Default set in productivity and asset space

government capital as a tool to adjust in response to shocks.

Figure 1.8 presents the bond price functions with three different productivity levels in the current period. It shows that the bond price increase with productivity. Low default probabilities and high recovery rates generate high bond prices. Figure 1.9 shows that the bond price functions increases with government capital when the country is in a median productivity state. It is interesting to note that the increase in the bond price is particularly marked when government capital is low. The reason is that as government capital increases, the equilibrium recovery rates increase sharply at a low level of government capital but slowly at a high level of government capital.

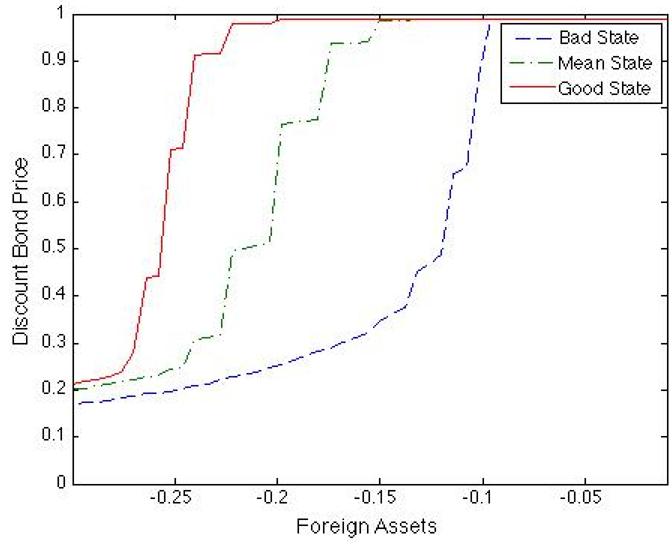

Figure 1.8: Bond price and productivity state

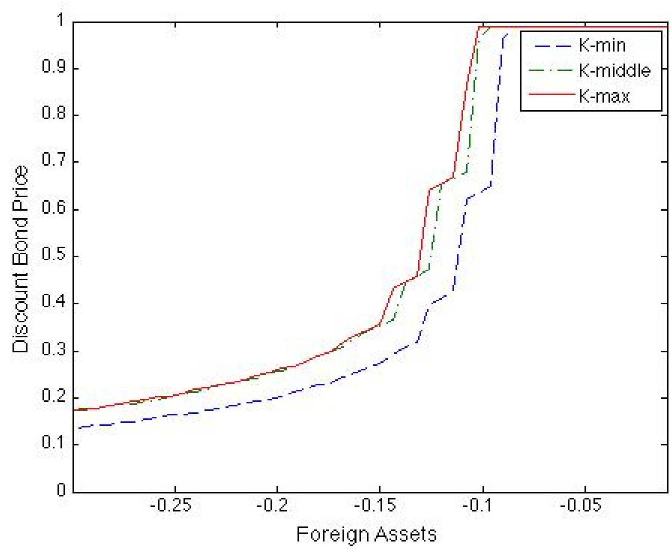

Figure 1.9: Bond price and government capital

1.6.1 Simulation Results

We conduct 1000 rounds of simulations, with 300 periods for each round. Then, we extract the last 100 periods to investigate business cycles, financial, and fiscal features in the stationary distribution of the model. The simulated series are logged and filtered. Our results are presented in table 1.2.

The model matches the business cycle statistics. The model generates the high volatility of private consumption relative to the volatility of output.[21] Since the country is not allowed to borrow in bad times, the volatility of consumption behaves very similarly with the output process. The ratio of private consumption volatility to output volatility is 1.03% in our calibrated model just as data. The trade balance volatility of 1.69% is somewhat lower than the data of 2.75%. The correlation between the trade balance and output is counter-cyclical as the data indicates, but small in magnitude. When a negative productivity shock hits the economy, the government can sustain government consumption by adjusting government capital and relying less on foreign debt. Therefore, the cost of credit does not increase severely, and the government can still access the international financial markets.

One of the interesting findings of the paper is that a high debt to output ratio is possible with a reasonable default frequency when we introduce government capital and an endogenous debt renegotiation process without explicitly targeting this ratio in the calibration process. We generate a debt to output ratio around 20% with an annual default frequency around 4%. The debt to output ratio is relatively small compared with an average external debt to output ratio of 46.5% from 1980 to 2002 in Argentina. However, our results improve on previous papers in matching the ratio and we provide a complementary mechanism.[22] The mechanism behind this result is that it is costly for the country to remain in financial autarky if it has a high level of government capital. The defaulting country must, then,

[21] Emerging economy is characterized by high volatile private consumption whereas advanced economy has less volatile consumption process. See Neumeyer and Perri (2005).

[22] Arellano (2008) generates a debt to output ratio of 5.95%. Aguiar and Gopinath (2006) get relatively high debt to output ratio of 19% but with very low default frequency, 0.92%. Yue (2010) succeeds in improving the ratio to 10.13% by introducing endogenous debt renegotiation processes.

pay a high cost to re-access the international financial markets, (i.e high recovery rates). This implies that there is not much to gain by defaulting because of the output cost during default as well as the high recovery rates during the renegotiation process. This reduces the risk of sovereign debt default, thereby lowering interest rates. Then the country has room to increase government investment and accumulate government capital further. This generates an amplification mechanism, making sovereign bonds safer. The country can, then, take more debt from foreign investors by the general equilibrium effects.

The model generates reasonable financial statistics from the calibrated model. The sovereign bond spreads in the model are counter-cyclical in that the sovereign spread and output are negatively correlated (-0.1%). This implies that when the country is hit by negative productivity shocks, default risk increases and the recovery rate decreases. However, a negative productivity shock also implies a low rate of return on government capital. Hence, interest rates do not increase enough to exhibit high counter-cyclical spreads, -0.43, as in the data. The annual average sovereign spread in the model is around 5.2% with default frequency around 4.5%. The volatility of the spread is 8.5%. This value is large compared with 2.67% in the data. The endogenous debt recovery rates break the strict relationship between default probability and bonds price.

We are modestly successful in matching the level of fiscal statistics. The government consumption volatility is high compared with the output volatility. The volatility ratio is around 1.2. The correlation of government consumption and output is 0.82 in our simulations, similar to the data of 0.78. Other papers such as Cuadra, Sanchez and Sapriza (2010) for Mexico generate a high correlation. The government consumption to output ratio is around 23%, a little higher than 16% in the data. The government investment ratio to output of 1.4% is similar to the data of 2.0%.

	Data	Model	A&G (2006)	Arellano (2008)	Yue (2010)
$\sigma(C)/\sigma(GDP)$	1.03	1.03	1.05	1.10	1.04
$\sigma(TB)/\sigma(GDP)$	2.75	1.69	0.95	1.50	2.81
$\rho(GDP, TB/GDP)$	-0.39	-0.01	-0.19	-0.25	-0.16
$Debt/Output\ ratio$	46.5	20	19	5.95	10.13
$\rho(GDP, Spread)$	-0.43	-0.1	-0.03	-0.29	-0.11
$E(spread)$	7.17	5.2	0.92	3.58	1.86
$\sigma(spread)$	2.67	8.5	0.32	6.36	1.58
$Default\ frequency(\%)$	2.7	4.5	0.92	3	2.7
$Average\ recovery\ rate(\%)$	27	40	-	-	27.31
$\sigma(G)/\sigma(GDP)$	1.7	1.18	-	-	-
$\rho(GDP, G)$	0.78	0.79	-	-	-
G/GDP	15-20	23.5	-	-	-
K_g/GDP	30	28	-	-	-
i/GDP	2.0	1.4	-	-	-

Table 1.2: Model statistics for Argentina

1.6.2 Sensitivity Analysis

In this subsection, we conduct a sensitivity analysis to evaluate the robustness of the model. First, we investigate how government shortsightedness affects fiscal and business cycle statistics.

Since the discount factor, β, governs the patience of the government, it is interesting to see how government myopia affects government capital accumulation and its subsequent effects on default incentives. It is well known that political uncertainty or instability is one of the important factors in government capital accumulation.[23] Myopic governments prefer current consumption to future consumption. In the context of our paper, this implies that the government is more likely to choose government consumption rather than government investment. Particularly, when negative productivity shocks hit the economy, the government's debt consolidation strategy tends to focus on cutting productive government investment, and securing unproductive current government consumption. In our model, this

[23] Azzimonti (2013) shows that political turnover between two parties who have a different degree of short-sightedness can generate systematic underinvestment in public investment and overspending on non-productive government spending.

	$\beta = 0.8$	$\beta = 0.85$	$\beta = 0.9$
G/GDP	27	26	25
K_g/GDP	26	28	31
i/GDP	1.3	1.4	1.56
i/G	4.8	5.4	6.2
Tax Revenue	17	18	19.5
Default probability	7	4.5	3.5

Table 1.3: Sensitivity analysis of government shortsightedness

translates into a low level of government capital accumulation. This generates low output and reduces tax revenues in the long run.

Table 1.3 shows these arguments. $\beta = 0.8$ and $\beta = 0.9$ represent myopic and patient society, respectively. When β increases, the government consumption to output ratio decreases. However, government investment increases as the patient government cares more about future consumption than the myopic government, from 1.3% to 1.56% of total output. The government investment to government consumption ratio increases as the β increases. Furthermore, since government investment is one of the components in the production function, the increase in government investment results in an increase of tax revenue in the long run, as shown in the table. The default probability of the government is therefore reduced.

The sensitivity analysis implies that the endogenous default risk and the government capital accumulation can generate a negative amplification mechanism, similar to Bernanke, Gertler, and Gilchrist (1999) and Kiyotaki and Moore (1998). Therefore, emerging or developing countries that tend to be myopic can be more vulnerable to negative productivity shocks.

1.7 Fiscal rule and fiscal austerity

In this section, we evaluate the effectiveness of fiscal austerity policies that increase taxes and a fiscal rule that limits the level of foreign debt in the model.

Table 1.4 presents the long run average statistics of three policy experiments. When the government increases a distortionary consumption tax rate from 0.3 to 0.4, tax revenue

	Benchmark $\tau = 0.3, T = 0.02$	High τ $\tau = 0.4$	High T T=0.04	Debt Ceiling b=0.1
GDP	0.74	0.67	0.79	0.73
G/GDP	23.5	28.5	25	23.7
K_g/GDP	28	36	32	27
i/GDP	1.4	1.8	1.6	1.35
Debt/GDP	20	27	27	13
Tax Revenue	24	30.5	26.9	25.2
E(spread)	5.2	5.22	3.5	0.3
Default prob	4.5	4.6	3.0	0.28

Table 1.4: Fiscal policies

increases in this economy. This implies that the country lies on the left side of the Laffer curve. With the high government revenue, the government can increase government spending on both government consumption and government investment. With a more relaxed government budget constraint, the default incentive of the government decreases, given the productivity shock. This generates a higher debt to output ratio around 27%, compared with 20% of the benchmark economy with the similar default probability. If the government implements a non-distortionary lump-sum tax from 0.02 to 0.04, tax revenues also increases.

Government consumption to output ratio and government capital to output ratio decrease compared with consumption tax policy. However, the decrease of the ratio is caused not by the decreases in government spending but by the output increases. Furthermore, the default probability is reduced to around 3%.

Next, the debt ceiling fiscal rule prevents the country from borrowing more than the specified exogenous level of debt. The debt to output ratio, then, decreases severely from 20 to 13. The default probability also decreases substantially. The government spending is the same as the benchmark model. This policy experiment implies that a fiscal rule can help the government to maintain a manageable level of debt and reduce the risk of default without hurting government capital accumulation.

1.8 Conclusion

Emerging economies or developing countries sometimes experience severe sovereign debt crises followed by drops in output and consumption and exclusion from the international financial markets. Even advanced countries can suffer sovereign debt crises as the recent European debt crises show. Therefore, it is important to understand why the government defaults and how the debt restructuring renegotiation resolutions are reached in sovereign debt markets. In this paper, we particularly pay attention to the role of government capital in the default incentive and market re-access incentive. We find that government capital plays a significant role during sovereign debt crises when the government has a limited ability to extract tax revenues from the private sector. When the government defaults on its debt, endogenous recovery rates tend to be high if the government has a high level of government capital. The high debt recovery rates make the government less likely to default in the ex-ante, reducing default risks even further. The low level of default risk and the debt renegotiation insurance enable the government to raise more credits from the international financial markets. Thus, the introduction of government capital and endogenous debt renegotiation generate reasonable business cycle features, including a reasonable debt to output ratio. In this sense, we provide another mechanism for sustaining high debt to output ratios.

Bibliography

[1] Aguiar, M., and G. Gopinath, 2006, "Defaultable Debt, Interest Rates and the Current Account," *Journal of International Economics*, Vol.69(1), pp.64-83.

[2] Amador, M., 2003. A political economy model of sovereign debt repayment. Stanford University. Manuscript.

[3] Andreasen, E., Sandleris, G., and A, Van Der Ghote, "The Political Economy of Sovereign Defaults," Working Paper, Universidad Torcuato Di Tella

[4] Arellano, C., 2008, "Default Risk and Income Fluctuation in Emerging Economies," *The American Economic Review*, Vol.98(3), pp. 690-712

[5] Arellano, C. and Y. Bai, 2013, "Fiscal Austerity during debt crisis," Working Paper, University of Rochester.

[6] Arellano, Cristina and Ananth Ramanarayanan, "Default and the Maturity Structure in Sovereign Bonds, *Journal of Political Economy*, 2012, 120, 187232

[7] Asonuma, T., 2012, "Serial Default and Debt Renegotiation," forthcoming IMF Working Paper.

[8] Asonuma, T., and H. Joo, 2015 "Delay in Sovereign Debt Renegotiation and Risk-Averse Investors," manuscript, IMF.

[9] Azzimonti, M., 2013, "The Dynamics of Public Investment under Persistent Electoral Advantage," Federal Reserve Bank of Philadelphia, Working Paper.

[10] Bai, Y., and J, Zhang., 2012, "Duration of Sovereign Debt Renegotiatio," *Journal of International Economics*, Vol.86(1), pp.252-268.

[11] Baxter, M., and R, King., 1993, "Fiscal Policy in General Equilibrium," *The American Economic Review*, Vol.83 (3), pp. 315-334

[12] Benjamin, D., and M, Wright., 2009, "Recovery Before Redemption? A Theory of Delays in Sovereign Debt Renegotiation," Manuscript, UCLA.

[13] Bernanke, B. , Gertler, M S, Gilchrist, 1999, "The financial accelerator in a quantitative business cycle framework," Handbook of Macroeconomics, in: J. B. Taylor M. Woodford (ed.), Handbook of Macroeconomics, edition 1, volume 1, chapter 21, pages 1341-1393 Elsevier

[14] Bi, R., 2008, "Beneficial Delay in Debt Restructuring Negotiation,"IMF working paper No. WP/08/38, International Monetary Fund

[15] Blanchard, ., and M, Giavazzi., 2005, "Improving the SGP through a Proper Accounting of Public Investment," Manuscript.

[16] Borri, N, and A. Verdelhan, 2012, "Sovereign Risk Premia," Working Paper, MIT Sloan.

[17] Braun, M., 2006, "The Political Economy of Debt in Argentina, or Why History Repeats Itself," Working Paper, World Bank.

[18] Chatterjee, Satyajit and Burcu Eyigungor, Maturity, Indebtedness, and Default Risk, *American Economic Review*, 2012, 102, 267499.

[19] Cruces, J. and C. Trebesch, 1982, "Sovereign Default: The Price of Haircuts ," *American Economic Journal: Macroeconomics.*, Vol.5(3), pp. 85-112

[20] Cuadra, G., Sanchez, M., and Sapriza, H., 2010, "Fiscal Policy and default Risk in Emerging Markets," *Review of Economic Dynamics*, 13 (2010), pp.452-469.

[21] Cuadra, G. and H. Sapriza, "Sovereign Default, Interest Rates, and Political Uncertainty in Emerging Market," *Journal of International Economics*, 76 (2008), 78-88

[22] Cubas, G., 2010, "Accounting for Cross-Country Income Differences with Public Capital," Working Paper, Central Bank of Uruguay

[23] D'Erasmo, P., 2011, "Government Reputation and Debt Repayment in Emerging Economies," manuscript, University of Maryland.

[24] De Paoli, B., Hoggarth, G., and V. Saporta, 2006, "Cost of Sovereign Defaults," Financial Stability Paper No.1, Bank of England.

[25] Easterly, W, Irwin, T. and L. Serven, 2007, "Walking Up the Down Escalator: Public Investment and Fiscal Stability," WPS4158, The World Bank

[26] Eaton, J. and M. Gersovitz, 1982, "Debt with Potential Repudiation: Theoretical and Empirical Analysis," *Review of Economic Studies*, Vol.48, pp.289-309

[27] Everhart, S. and M. Sumlinski, "Trends in Private Investment Spending in Developing Countries: Statistics for 1970-2000," Working Paper No. 44, The World Bank, International Finance Corporation, Washington 2001.

[28] Gilchrist, S., Yue, V. and E. Zakrajsek, "Sovereign Risk and Financial Risk," Working Paper, Federal Reserve of Board.

[29] Gopinath, G. and B. Neiman, 2011,"Trade Adjustment and Productivity in Large Crises," NBER Working Paper

[30] Gordon, G., and P. Guerron-Quintana, 2013, "Dynamics of Investment, Debt, and Default," Working Paper, Federal Reserve Bank of Philadelphia.

[31] Kiyotaki, N., and J. Moore, 2007, "Equilibrium Default Cycles, *Journal of Political Economy*, Vol. 105, No. 2 pp. 211-248.

[32] Kovrijnykh, N., and B. Szentes, 2007, "Equilibrium Default Cycles, *Journal of Political Economy*, Vol. 115, No. 3 (June): pp. 403-446.

[33] Kuralbayeva, K., 2013, "Optimal Fiscal Policy and Different Degrees of Access to International Capital Markets," *Journal of Development Economics*, 103, pp.336-352.

[34] Hatchondo, Juan Carlos and Leonardo Martinez, "Long-Duration Bonds and Sovereign Defaults," *Journal of International Economics*, 2009, 79, 117125.

[35] Hatchondo, J., Martinez, L., and Roch, F., 2012, "Fiscal Rules and the Sovereign Default Premium," Working Paper, Federal Reserve Bank of Richmond.

[36] Hatchondo, J., Martinez, L., and Sapriza, H., 2009, ""Heterogeneous Borrowers In Quantitative Models of Sovereign Default," *International Economic Review*, Volume 50, Issue 4, pages 1129-1151.

[37] Lizarazo,. S, 2013 "Default Risk and Risk Averse International Investors," *Journal of International Economics*, Volume 89, Issue 2, 317-330

[38] Mendoza, Enrique G. and Vivian Z. Yue, " General Equilibrium Model of Sovereign Default and Business Cycles," *Quarterly Journal of Economics*, Forthcoming.

[39] Merlo, Antonio and Charles Wilson, 1995, A Stochastic Model of Sequential Bargaining with Complete Information, *Econometrica*, Vol. 63, No. 2, 371-399.

[40] Minea, A and M, Villieu., 2009, "Borrowing to Finance Public Investment? 'The Golden Rule of Public Finance' Reconsidered in an Endogenous Growth Setting," *Fiscal Studies*, Vol.30, pp.103-133

[41] Neumeyer, P., and F, Perri., 2005, "Business Cycles in Emerging Economies: the Role of Interest Rates" *Journal of Monetary Economics*, Vol.52(2), pp.345-380

[42] Park J. (2012). Sovereign Default Risk and Business Cycles of Emerging Economies: Boom- Bust Cycles. Unpublished Manuscript, University of Wisconsin Economics Department.

[43] Pitchford, R., and M, Wright., 2012, "Holdout in Sovereign Debt Restructuring: A theory of Renegotiation in a Weak Contractual Economy" *Review of Economic Studies*, Vol.79, pp.812-837.

[44] Ponticelli, J. and H, Voth., 2011, "Austerity and Anarchy: Budget Cuts and Social Unrest in Europe, 1919-2009," CEPR discussion paper 8699.

[45] Pouzo, D, "Optimal Taxation with Endogenous Default under Incomplete Market," Working Paper, UC Berkeley.

[46] Pouzo, D., and I. Presno, 2012, "Sovereign Default Risk and Uncertainty Premia," Working Paper, Federal Reserve Bank of Boston.

[47] Reinhart, C. and K. Rogoff, 2010, "Growth in a Time of Debt," NBER Working Paper

[48] Roldan J. (2012). Default Risk and Economic Activity: A Small Open Economy Model with Sovereign Debt and Default. Unpublished Manuscript, Banco Central de Mexico.

[49] Sachs, J., 1990, "Introduction. In: Sachs,. J (Ed.) Developing Countries Debt and Economic Performance: Country Studies -Argentina, Bolivia, Brazil, Mexico, 2 pp. 1-39," .

[50] Strurzeneger, F., 2002, "Default Episodes in the 90s; Fact Book Preliminary Lessons," manuscript, Universidad Torcuato Di Tella.

[51] Yeyati, E. and U, Panizza, 2011, "The Elusive Costs of Sovereign Defaults," *Journal of Development Economics*, vol. 94(1), pages 95-105.

[52] Yue, V., 2010, "Sovereign Default and Debt Renegotiation," *Journal of International Economics*, Vol.80(2), pp.176-187.

Chapter 2

Can News Shock Help to Explain Differences in Fiscal Policy Cyclicality Between Developing and Developed Countries?

2.1 Introduction

Emerging countries or developing countries tend to exhibit procyclical fiscal policy: government expenditures tend to rise and tax policy tends to fall when the economy expands, while the government expenditures tend to fall and tax policy tends to rise when the economy recedes. Developed countries tend to have acyclical or countercyclical fiscal policy in that government expenditures and tax policies do not align with or counter the economic output process.[1] Procyclical fiscal policy is not desirable in the eyes of academics and policy makers because government expenditures are most needed when the economy is in recession. Furthermore, procyclical fiscal policy exacerbates the business cycle, making output and consumption more volatile and reducing welfare in the economy.

Another interesting feature between developing and developed countries is a difference in the precision of news about future fundamentals. Developed countries have more accurate and higher quality data that can be used to forecast future economic fundamentals. Furthermore, more transparent macroeconomic policy, data availability, and accounting devices

[1] Following Kaminsky et al. (2004), we define fiscal policy cyclicality as following: countercyclical fiscal policy involves lower (higher) government spending and higher (lower) tax rates in good (bad) times whereas procyclical fiscal policy involves higher (lower) government spending and lower (higher) tax rates in good (bad) times. Acyclical fiscal policy involves contant government spending and constant tax rates over business cycles.

help to protect investors from abrupt changes in economic situations. On the other hand, lack of credible data and less transparent statistics in developing countries make it hard for investors to forecast future fundamentals.[2] Thus, it is possible that investors demand an additional risk premium to hold government debt.

The objective of this paper is to provide an explanation that can account for the difference in fiscal policy dynamics between developing and developed countries by introducing news related shock and endogenous fiscal policy in the small open economy model in spirit of Arellano (2008). Recently, the changes in expectations about future fundamentals - due to news announcement or news- have been recognized as one of the driving forces in the deepening European sovereign debt crisis: the pessimistic forecasts from credit ratings announcements, international organizations, and the private sectors caught the eyes of investors in the sovereign debt markets, driving the sovereign default risk high enough to deter capital inflow.[3] Lack of foreign borrowing makes fiscal austerity more severe and therefore a debt crisis is more likely to lead to default. Greece actually defaulted in 2012 in the midst of pessimistic economic outlooks for future growth rates and public finances.[4] In this sense, it is important to see the effect of changing expectations or news about future fundamentals on sovereign default risk and its interconnection with fiscal policy. We investigate this possibility with a standard sovereign debt default framework.

The key intuition is that more precise information about future fundamentals makes it easier for agents to prepare for the possible negative shocks. Households and the government can smooth consumption streams over the period. Foreign investors can also accurately predict the future fundamentals and prepare for a default possibility more effectively. Moreover,

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[2]Boz et al (2011), Gelos and Wei (2005) show that high income countries are more closely monitored, have better quality and transparent macroeconomic data. Frankel et al. (2013) emphasize the role of institutional quality on fiscal policy cyclicality. Among the institutional qaulity, the role of independent forecast council is crucial in escaping from procyclical fiscal policy.

[3]For instance: Poul Thomsen, deputy director of the IMF's European department and its mission chief to Greece, said: "We have revised growth down significantly to -6% in 2011 and -3% in 2012. We expected 2011 to be an inflection point when the recession bottomed out, followed by a slow recovery. But the economy is continuing to trend downwards. The hoped for improvement in market sentiment and in the investment climate has not materialised." (The guardian December 13, 2011)

[4]Greece defaulted its sovereign debt in 2012. Around 200 billion dollars debt exchanged and buyback. The haircut is around 65%. See Cruces and Trebesch (2013)

even when the government declares default, foreign investors can expect to get high debt recovery rates for any given amount of debt. As a result, the risk premium required for foreign investors to hold risky government debt decreases with more precise information about the future fundamentals. This means that the government can rely more on foreign borrowing and less on tax revenues conditional on not defaulting. Then tax rates are lower in countries with more precise news about future fundamentals. Moreover, low tax rates increases output since tax policy is distortionary and households supply less labor to produce goods. This amplification mechanism caused by endogenous tax policy decreases the risk of default further, making more room for foreign borrowing, which in turn dampens the correlations of tax rates and government spending.

We calibrate the baseline model of no news case with the empirical regularities of Argentina. Argentina's experience is an ideal case study because it exhibited high procyclical fiscal policy and volatile default risk during 1990s, leading to a severe sovereign debt crisis in 2001. Moreover, the degree of news precision is low compared with developed countries. We assume that news in the developed country is highly informative in the model. We, then, vary the parameter which controls the precision of information content to see whether high news precision can create fiscal policy and business cycle statistics closer to that of developed countries.

We find out that news-related shocks can push the correlation between output and government expenditure in the right direction. Without news shocks, the correlation between output and government expenditure is 0.93, which means that they are highly correlated with each other. However, as we increase the news precision, the correlation of government expenditure with output decreases monotonically down to 0.75. This is still high compared with the data, but it is moving in the right direction.[5] The tax policy cyclicality in the simulation also delivers more realistic differences between developing and developed countries. As documented by Vegh and Vuletin (2012), developed countries tend to have an acyclical

[5] Iletzki (2010) decomposes government expenditure into government consumption and transfer to generate low correlation of government expenditure with output in a political friction economy.

tax policy while developing countries tend to have a procyclical tax policy. In the no news economy, the cyclicality of tax policy with output is -0.47. However, as we move towards a very accurate news economy, the correlation is -0.19.

As for the business cycle, we can match the difference in fluctuations in real variables between developing and developed countries. In our model, sovereign default risk and bond spreads are lower and recovery rates are higher in an economy with more precise information for a given level of current debt holding. This enables the government to accumulate a high debt level. Debt to output ratio varies from 10% to 12.6% as we increase the precision of news. The cyclicality of the trade balance also falls from -0.46 to -0.18 as the precision of news improves. This implies that there is more room for foreign borrowing when the country is hit by a negative productivity in a precise economy. Private consumption and government spending volatility are reduced as a government effectively smoothes consumption streams because they can more accurately anticipate future fundamentals. Output volatility also decreases because the resulting low correlation between the (distortionary) tax rate and output makes the household's labor supply decisions less volatile, contributing to less volatility of output.

Our paper is most closely related to Durdu, Nunes, Sapriza (2013) in that we investigate the role of news precision on business cycles features between developing and developed economies. They show that more precise news can generate lower volatility in private consumption and lower cyclicality in the trade balance. We differ with their paper since we study fiscal policy dynamics as well as business cycle features. Since we deliver endogenous fiscal policy in the model, we can investigate the effect of news shock on tax policy and the feedback effect of tax policy on business cycle variables.

The rest of the paper is organized as follows. Section 2.2 reviews related literature. Section 2.3 presents empirical evidence of fiscal policy dynamics and news shock. Section 2.4 provides a theoretical model. Section 2.5 defines recursive equilibrium. The calibration and quantitative implications will be discussed in section 2.6. Section 2.7 provides conclusions.

2.2 Literature Review

This paper is related to the emerging market fiscal policy literature. Kaminsky, Reinhart, and Vegh (2004) document that fiscal policy is procyclical for the majority of developing countries. As for tax policy, Vegh and Vuletin (2012) provide evidence that tax policy is acyclical in industrial countries but mostly procyclical in developing countries. One strand of literature studies a political economy explanation. Alesina et al. (2008) develop a political agency model to investigate the conflict between governments and voters over political rents which leads to procyclical fiscal policy. Ilzetzki (2011) explores a dynamic political model to show that successive governments which disagree on the desired distribution of public spending can generate procyclical fiscal policies. Frankel et al. (2013) focus on the quality of institutions and show that strong institutions can cause smaller procyclical fiscal policies.[6]

The other strand of literature focuses on fiscal policy in an endogenous sovereign default model by looking at the importance of incomplete markets in international financial markets. Following Arellano (2008) and Aguiar and Gopinath (2006)[7], Cuadra, Sanchez, and Sapriza (2010) combine endogenous fiscal policy with endogenous sovereign default risk. The risk of default in recession increases the cost of foreign credit and makes governments rely more heavily on tax policy. Pouzo and Presno (2014) study the possibility of sovereign default affecting tax policy and bond prices. The high risk of default generates a lower level of debt and high volatile tax revenues in emerging economies. Hatchondo, Martinez, and Roch (2013) implement a fiscal rule which prevents high debt levels and find out that a fiscal rule can generate a less procyclical fiscal policy. Tsyrennikov (2014) introduces pessimism coming from model misspecification. In this environment, the government manages the adverse state by implementing countercyclical fiscal policy.[8] What is distinctive in our

[6]See also Woo (2009), Azzimonti (2013), and Talvi and Vegh (2005) for political economy explanation.

[7]Quantitative sovereign default literature: Amador (2003), Cuadra and Sapriza (2008), Hatchondo, Martinez, and Sapriza (2009), Borri and Verdelhan (2011), Lizarazo (2005), Gilchrist, Yue, and Zakrajsek (2013), Mendoza and Yue (2012), Hatchondo and Martinez (2009), Chatterjee and Eyigungor (2009), Arellano and Ramanarayanan (2012)

[8]Several papers investigate the role of incomplete market on fiscal policy. Gavin and Perotti (1997), Aizenman et al. (2000), Riascos and Vegh (2003), Mendoza and Oviedo (2006), Parmasiz (2010), Doda (2007), Suzuki (2010), Froemel (2014)

paper is that we introduce news-related shocks, which are unrelated to contemporaneous TFP to explain the cyclicality of fiscal policy.

Lastly, we adapt the information structure from the news shock literature. Beaudry and Portier (2006) explore news about future technology opportunities which is captured in stock prices and can explain booms in consumption, investment and hours worked. Jaimovich and Rebelo (2008, 2009) propose several mechanisms to explain the comovement among business cycles variables caused by news driven shocks in closed and open economies. Schmitt-Grohe and Uribe (2012), Boz, Durdu, and Daude (2011) explore the learning process between permanent and transitory shocks and find out that severe informational frictions can account for high volatility of private consumption relative to output and a strong countercyclicality trade balance in emerging market economies. Our paper differs from this literature in that we concentrate on fiscal policy dynamics based on news precision or forecasting precision.

2.3 Stylized Facts

In this section, we show that fiscal policy cyclicality is related with precision of news about future economic growth rates.

2.3.1 Fiscal Policy and News Precision

In this section, we document the relationship between fiscal policy cyclicality and precision of news for each country.

Figure 2.2 shows the relationship between income levels and the degree of news precision. Following Durdu et al. (2013), we use forecast errors as a measure of news precision. By using Consensus Forecast's one quarter ahead forecast errors for quarterly GDP growth, we get forecast errors using Theil (1961) U indicator.

$$U_i = \sqrt{\frac{\frac{1}{N}\sum(e_{i,t} - \bar{e})^2}{\frac{1}{N}\sum(y_{i,t} - \bar{y})^2}} \tag{2.1}$$

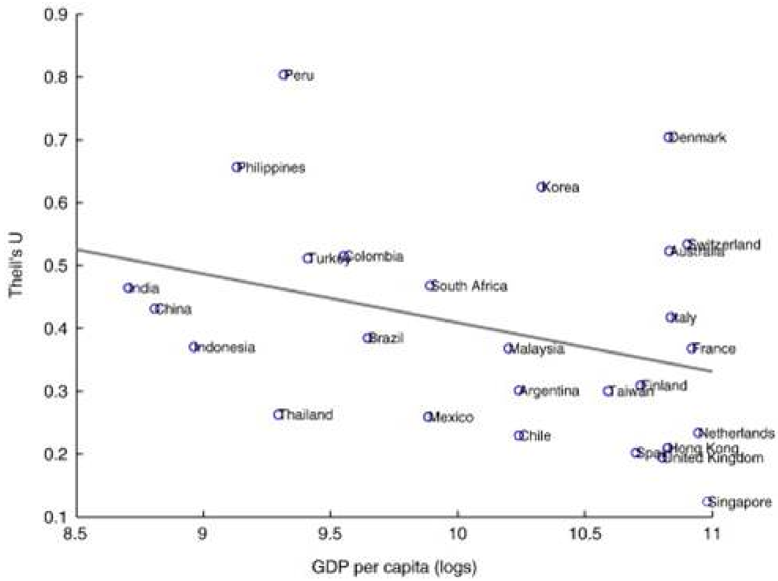


Figure 2.1: Income Level and Forecast Error, Source: Durdu et al. (2013)

The more precise the news, the closer Theil's index comes to 0. Therefore, the figure 2.2 shows that the degree of news precision about GDP growth is more accurate in developed countries than developing countries.

Based on the index of news precision, we provide the relationship between cyclicality of government expenditure and news precision about the future GDP growth.

The root Mean Square Error (RMSE) of Consensus Forecasts' one quarter ahead forecast errors, $(y_{t+1} - E_t y_{t+1})$, for quarterly GDP growth (at annualized rates) for a set of developed and emerging market countries. RMSE is a numerator in Theill's U index. The diamond indicates the developing countries and the square represents the developed countries.

Figure 2.3 and 2.4 show that the more precise the news, the less fiscal policy is correlated with output. Moreover, the developing countries tend to exhibit procyclical fiscal policy.

2.3.2 General Points

The model considers sovereign default and fiscal policy in a stochastic dynamic small open economy model. There are three agents in our economy: a risk averse household, a risk

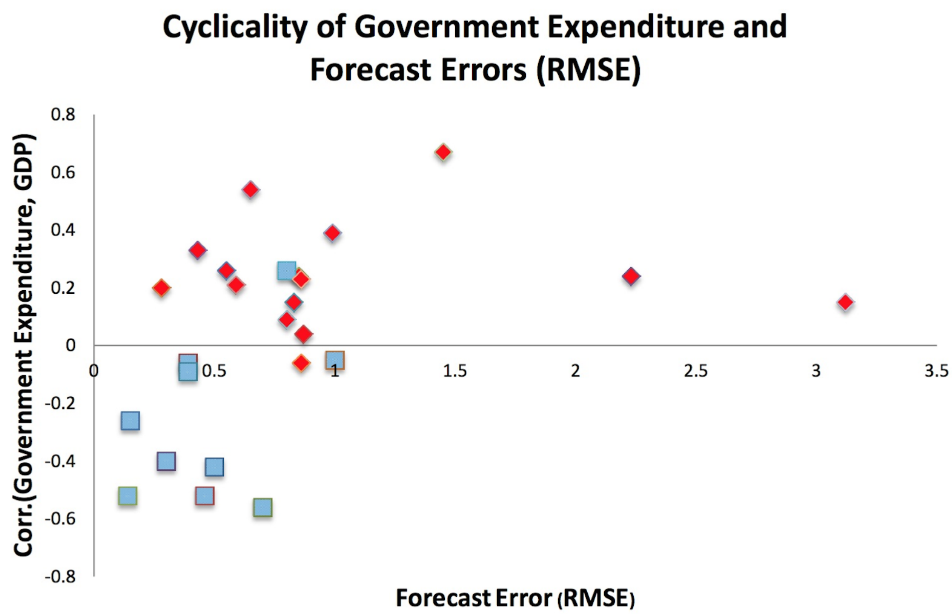


Figure 2.2: Cyclicality of government expenditures and forecast errors. HP filtered cyclicality components of total real central government expenditures and Root of Mean Square Error, using data set from Frankel, Vegh, and Vuletin (2013, JDE) and Durda, Nunes, and Sapriza (2013, JIE)

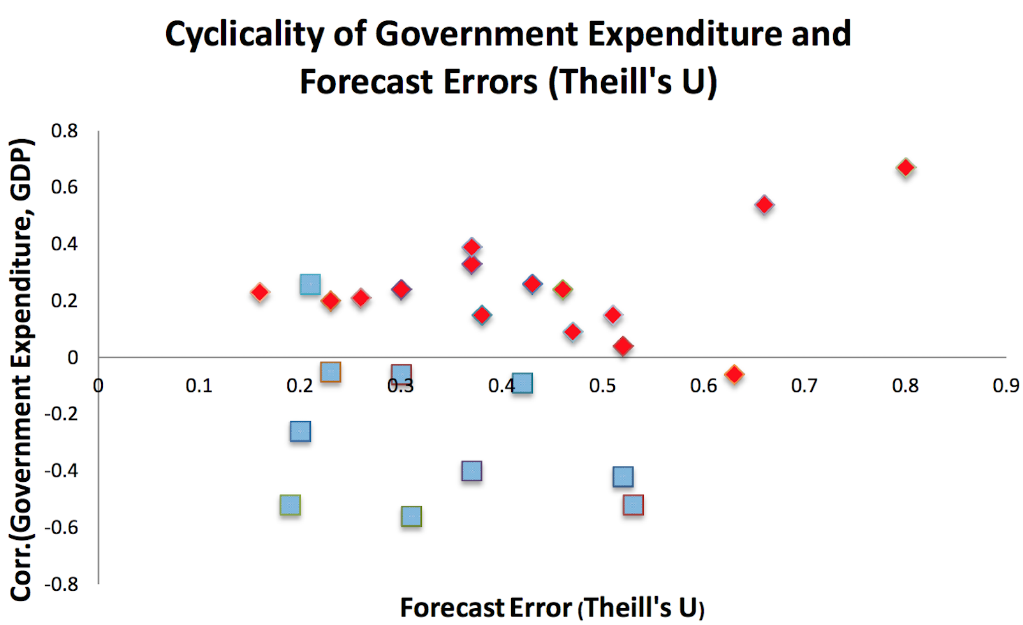


Figure 2.3: Cyclicality of government expenditures and forecast errors. HP filtered cyclicality components of total real central government expenditures and Root of Mean Square Error, using data set from Frankel, Vegh, and Vuletin (2013, JDE) and Durda, Nunes, and Sapriza (2013, JIE)

averse government, and a risk neutral foreign investor.

First, we assume that the household's preference is defined by the following utility function.

$$E_0 \sum_{t=0}^{\infty} \beta^t U(c_t, 1-l_t, g_t) = E_0 \sum_{t=0}^{\infty} \beta^t (u(c_t, 1-l_t) + v(g_t)) \tag{2.2}$$

where $0 < \beta < 0$ is a discount factor, c_t denotes private consumption, l_t is the labor supply, g_t is government consumption in period t. $u(c_t, 1-l_t)$ and $v(g_t)$ are one period private and public utility functions, which is strictly concave, continuous, and differentiable.

The country receives two shocks: Total factor productivity (TFP) shock and signals about the future TFP. The TFP shock is drawn from a compact set of $A = [a_{\min},\ a_{\max}] \subset R_+$. We assume a simple AR(1) TFP process as following:

$$\ln(A_t) = \rho \ln(A_{t-1}) + \epsilon_t \tag{2.3}$$

with $E(\epsilon) = 0$ and $E(\epsilon^2) = \sigma_\epsilon^2$. The process is approximated using a discrete one-period Markov chain with probability distribution, $\mu(a_{t+1}|a_t)$. Now we characterize the information structure regarding future TFP states of the economy. Following Jaimovich and Rebelo (2008) and Durdu et al (2013), we introduce the signal (s_t) regarding future TFP state (a_t). Denoting the probability space of TPF as Θ and signal space as Ξ, we assume that the probability space of TFP and the signal coincides. i.e Θ=Ξ. The precision of the signal regarding future TFP can be summarized by the following equation.

$$p(s_t = i \mid z_{t+1} = l) = \begin{cases} \eta & \text{if } i = l \\ \frac{1-\eta}{|\Xi|-1} & \text{if } i \neq l \end{cases} \tag{2.4}$$

This probability function implies that the probability of a correct signal is observed regarding future TFP states are given by η and the probabilities of incorrect signals are equally assigned. The higher the η is assigned, the more precise the current signals about future states of the economy. We vary the value of η from $\eta=\frac{1}{|\Xi|}$ to 1. When $\eta=\frac{1}{|\Xi|}$, then signal (s_t) do not contain any information about future TFP whereas if η=1, then signal (s_t) perfectly predicts future TFP states. Following this Bayesian updating, we can forecast future TFP states a_{t+1} given current signal s_t and current TFP state a_t.

$$p(a_{t+1} = l \mid s_t = i, a_t = j) = \frac{p(s_t = i \mid a_{t+1} = j)p(a_{t+1} = l \mid a_t = j)}{\sum_n p(s_t = i \mid a_{t+1} = n)p(a_{t+1} = n \mid a_t = j)} \tag{2.5}$$

The joint evolution of TFP shock and the signal can be expressed in the following Markov chain:

$$\Pi(z', s' \mid z, s) = p(s_{t+1} = \kappa, z_{t+1} = l \mid s_t = i, z_t = j)$$

$$=\text{p}(\text{z}_{t+1} = l \mid s_t = i, z_t = j) \sum_m [p(z_{t+2} = m \mid z_{t+1} = l)p(s_{t+1} = \kappa \mid z_{t+2} = m)], (2.6)$$

The international capital markets are incomplete. The government and foreign investors can borrow and lend only via one-period zero-coupon bonds, where b_{t+1} denotes the amount of bonds to be repaid next period. When the government purchases bonds, $b_{t+1} > 0$, and when it issues new bonds, $b_{t+1} < 0$. The set of the amount of bonds is $B = [b_{\min},\ b_{\max}] \subset R$, where $b_{\min} \leq 0 \leq b_{\max}$. The upper bound is the highest level of assets that the government can accumulate and the lower bound is the highest level of debts that the government can hold. We assume $q(b_{t+1}, a_t, s_t)$ is the bond price with asset position (b_{t+1}),TFP shock (a_t), and signal (s_t). The bond price will be determined in equilibrium.

We assume that foreign investors always commit to repay their debt. However, the government is free to decide whether to repay its debt or to default. If the government chooses to repay its debt, it will preserve access to international capital markets next period. If the government chooses not to pay its debt, it is subject to both exclusion at that period from the international capital markets and direct productivity cost. However, the government and the foreign creditor renegotiate for recovery rates.

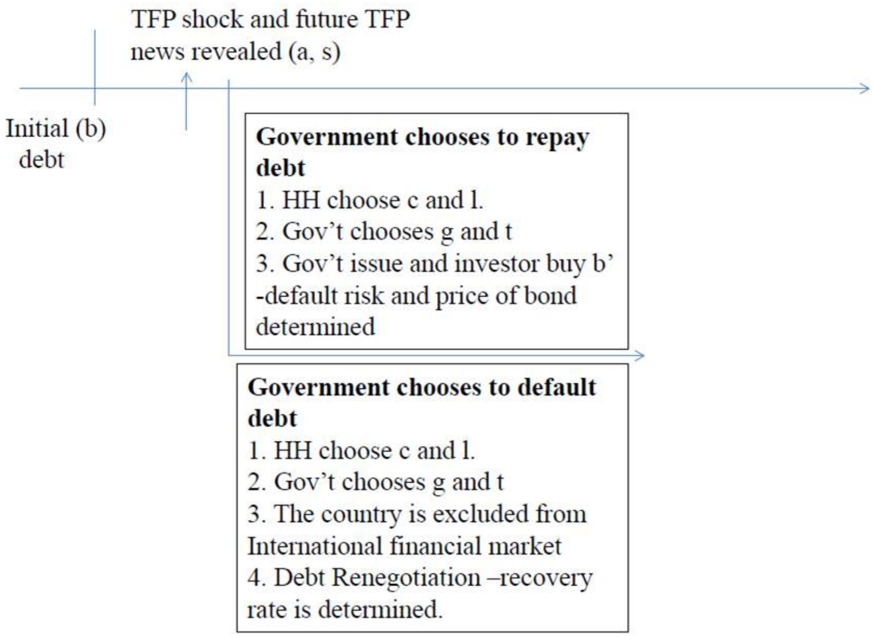


Figure 2.4: Timing of the model

2.3.3 Timing of the model

Timing of decisions is summarized in Figure 2.5.

1. Period t starts. TFP shock (a_t) and signal (s_t) for one period ahead TFP shock are observed.

2. Given that the country is not excluded from the international credit markets, the government enters the period with a level of sovereign debt (b_t). The pay-off relevant state variables are the level of debt, the TFP shock, and the signal for future TFP: (b_t, a_t, s_t)

3. The government makes a default decision : $d_t \in \{0, 1\}$

   (a) If it chooses to repay,

      i. Household makes private consumption (c_t) and labor supply (l_t) decisions for given government policies of government consumption (g_t) and tax policies (τ).

ii. The firm maximizes profits

iii. The government chooses new borrowing (b_{t+1}), government consumption (g_t), and tax rates policy (τ_t), given optimal private sector's decisions.

iv. The default probability and bond price are determined in equilibrium and the foreign investor issue (b_{t+1}) with this belief.

(b) If the government chooses to default, the country is excluded from the international credit markets and suffer productivity loss ($h(A)$)

i. Household makes consumption (c_t) and labor supply (l_t) decisions for given current government policies of government consumption (g_t) and tax policies (τ)

ii. Firm maximizes profit maximization.

iii. The government chooses government consumption (g_t) and tax rate policy (τ_t) given the optimal private sector's decisions.

iv. At the end of period t, the government and the foreign investor renegotiate for the recovery rates (α_t), the government repays the renegotiated debt to the creditor and can access the international financial markets next period.

2.3.4 Household's problem

The representative household chooses consumption (c_t) and labor supply (l_t) to maximize expected lifetime utility, given current government polices (g_t, τ, T).

$$\max_{c_t, l_t} E_0 \sum_{t=0}^{\infty} \beta^t U(c_t, g_t, 1 - l_t) \ , \tag{2.7}$$

$$s.t. \quad (1 + \tau_t)c_t = w_t l_t \tag{2.8}$$

The per-period utility function is concave, strictly increasing, and twice differentiable. The household earns an income from supplying labor to firms. The discount factor is $\beta \in (0, 1)$ and the household gets utility from private consumption, government consumption, and leisure.

The private component and public component are separable in the utility function with weight λ on government consumption.

$$U(c_t, g_t, 1 - l_t) = (1 - \lambda)u(c_t, l_t) + \lambda v(g_t) \tag{2.9}$$

We assume Greenwood, Hercowitz, and Huffman (GHH) per-period utility function to exclude the effect of wealth on labor supply decision. We will provide a more detailed specification in the calibration section. The household's problem in this setting is static in that the household is not allowed to access the international financial markets to smooth consumption. The household provides labor supply, given consumption tax rates.

The household's first order condition is

$$\frac{u_l}{u_c} = (\frac{w}{1 + \tau}) \tag{2.10}$$

Applying GHH utility specification assumption, we get

$$l_t = (\frac{w}{1 + \tau})^{\frac{1}{\psi}} \tag{2.11}$$

As seen in the optimality conditions, the labor supply decision depends on the consumption tax τ. A high consumption tax rate induces less labor supply and, therefore, lower output.

2.3.5 Firm's Problem

Final goods production is subject to productivity shocks A_t. Labor supply from household is the only input in this economy. Output is divided between private consumption and public consumption. Production technology follows the Cobb-Douglas form.

$$A_t F(l_t) = A_t l_t. \tag{2.12}$$

Given this production function, a firm's profit maximization problem is

$$\max_{l_t} \Pi_t = A_t F(l_t) - w_t l_t \tag{2.13}$$

2.3.6 Government Decision

The government's problem is to maximize the households' expected lifetime utility. The government makes a default decision and determines asset positions for the next period (b_{t+1}), government consumption (g_t), and tax rates (τ_t), given its current asset position (b_t), TFP shock (a_t), and news (or signal) (s_t) for one period ahead TFP states, and the household's optimal decision. The value function of the government is denoted by $V(b_t, a_t, s_t)$.

For $b_t > 0$, the government has savings. The government receives payment from foreign investors and determines its next period's bond holdings (b_{t+1}), government consumption (g_t), and tax rates (τ_t). The value functions is

$$V(b, a, s) = \max_{g, b', \tau} u(c^*, g, 1 - l^*) + \beta \int V(b', a', s') d\mu(a', s' | a, s) \tag{2.14}$$

$$s.t. \quad g = \tau c + b - q(b', a) b' \tag{2.15}$$

$$\frac{u_l}{u_c} = \frac{A F_l(l^*)}{(1 + \tau)} \tag{2.16}$$

$$c^* = \frac{A F(l^*)}{(1 + \tau)} \tag{2.17}$$

Equation 2.15 is the government budget constraint. Government expenditure (g) is financed by consumption tax revenues (τc) and foreign borrowings ($b - q(b'(b', a, s)b')$. Equation 2.16 refers to the household's optimal labor supply decisions. The resource constraint is given by equation 2.17.

For $b_t < 0$, the government has debt. The country has the option to default on its debt. If the government decides to pay its debt, it chooses its next-period asset position b_{t+1}, government consumption (g_t), and tax rates (τ_t). If it chooses to default, it will be excluded from international financial markets and the government chooses only government consumption (g_t) and consumption tax rate (τ_t).

Given the option to default, $V(b_t, a_t, s_t)$ satisfies

$$V(b_t, a_t, s_t) = \max\left[V^R(b_t, a_t, s_t), V^D(b_t, a_t, s_t)\right] \tag{2.18}$$

where $V^R(b_t, a_t, s_t)$ is the value associated with paying debt and $V^D(b_t, a_t, , s_t)$ is the value with defaulting debt.

The optimal default decision of the government, then, is characterized by:

$$D(b_t) = \left\{(a_t, s_t) \in \Lambda : V^R(b_t, a_t, s_t) < V^D\left(a_t, s_t\right)\right\} \tag{2.19}$$

The default set is the set of TFP and signals such that the value of default is higher than the value of repayment given the current debt holdings.

The value of repayment , V^R, is as following:

$$V^R(b_t, a_t, s_t) = \max_{g, b^{'}, \tau} u(c^*, g, 1 - l^*) + \beta \int V(b^{'}, a^{'}, s^{'}) d\mu(a^{'}, s^{'}|a, s) \tag{2.20}$$

$$s.t. \quad g = \tau c + b - q(b^{'}, a) b^{'} \tag{2.21}$$

$$\frac{u_l}{u_c} = \frac{AF_l(l^*)}{(1+\tau)} \tag{2.22}$$

$$c^* = \frac{AF(l^*)}{(1+\tau)} \tag{2.23}$$

$V^D(a_t, s_t)$ is the value associated with default.

$$V^D(b, a, s) = \max_{g, \tau} u(c^*, g, 1 - l^*) + \beta \int V(0, a^{'}, s^{'}) d\mu(a^{'}, s^{'}|a, s) \tag{2.24}$$

$$s.t. \quad g_d = \tau_d c_d + \alpha(b, a, s) b \tag{2.25}$$

$$\frac{u_l}{u_c} = \frac{h(A) F_l(l_d^*)}{(1+\tau_d)} \tag{2.26}$$

$$c_d^* = \frac{h(A) F(l_d^*)}{(1+\tau_d)} \tag{2.27}$$

When the government decides to default on its debt, it is excluded from financial markets and suffers productivity loss $h(A) < A$. Debt renegotiation is initiated at the time of default and recovery rates are determined. When the government repays the recovered debt ($\alpha(b,a,s)b$) to investors, it can re-access the international financial markets no debt in the next period.

2.3.7 Debt Renegotiation Problem

The debt renegotiation takes the form of a generalized Nash bargaining problem. When the government decides to default on its debt, it is excluded from international financial markets and initiates a debt restructuring process to determine the recovery rates. We assume that debt renegotiation takes places only once for each default. Furthermore, there is no delay in debt renegotiation in that it takes only one period to determine. The government can re-access international financial markets in the next period.[9] Under Nash bargaining, the value of the debt renegotiation agreement is follows:

$$V^d(b,a,s) = \max_{g,\tau} u(c^*, g, 1-l^*) + \beta \int V(0, a^{'}, s^{'}) d\mu(a^{'}, s^{'}|a,s) \tag{2.28}$$

$$s.t. \quad g = \tau c_d^* + \alpha(b,a,s)b \tag{2.29}$$

$$\frac{u_l}{u_c} = \frac{h(A)F_l(l_d^*)}{(1+\tau_d)} \tag{2.30}$$

$$c_d^* = \frac{h(A)F(l_d^*)}{(1+\tau_d)} \tag{2.31}$$

The value of the debt renegotiation agreement takes into account two costs of default, the productivity loss ($h(A)$) and the one period financial exclusion. However, they can reaccess the international financial markets next period with no debt obligations attached as seen by $b^{'} = 0$ in the value of next period, $V(0, a^{'}, s^{'})$. Now we characterize the threat point of debt renegotiation when both parties cannot resolve the debt renegotiation process. When

[9] Delays in debt renegotiatioin: Benjamin and Wright (2008), Bi (2008), Bai and Zhang (2013), Asonuma and Trebesch (2014), Asonuma and Joo (2014)

the government does not reach an agreement on recovery rates with foreign creditors, it is forced to stay in financial autarky forever with associated productivity loss.[10] Foreign creditors also receive nothing.

The value of financial autarky is as follows:

$$V^{aut}(a,s) = \max_{g,\tau} u(c^{*}, g, 1-l^{*}) + \beta \int V^{aut}(a^{'}, s^{'}) d\mu(a^{'}, s^{'}|a,s) \tag{2.32}$$

$$s.t. \quad g = \tau c_d^{*} \tag{2.33}$$

$$\frac{u_l}{u_c} = \frac{h(A)F_l(l_d^{*})}{(1+\tau_d)} \tag{2.34}$$

$$c_d^{*} = \frac{h(A)F(l_d^{*})}{(1+\tau_d)} \tag{2.35}$$

For any debt recovery rate, the surplus for the country, Δ^B, is defined by the difference between the value of debt renegotiation, $V^d(b,a,s)$ and the value of financial autarky, $V^{aut}(a,s)$ such that,

$$\Delta^B(b,a,s) = V^d(b,a,s) - V^{aut}(a,s) \tag{2.36}$$

The surplus to the risk-neural foreign investor, Δ^L, is the recovered debt from the debt renegotiation.

$$\Delta^L(b,a,s) = -\alpha(b,a,s)b \tag{2.37}$$

We follow Yue (2010) in assigning bargaining power in that the government has a bargaining power θ and foreign investors have bargaining power $1-\theta$. The bargaining power parameter summarizes the institutional arrangement or outside option for investors during debt renegotiation process.[11] We define the bargaining set $\Theta \in [0,1]$ such that the renego-

[10]The enforcement of financial autarky is discussed Bulow and Rogoff (1989), Kletzer and Wright (2001), Wright (2005)

[11]Benjamin and Wright (2009) emphasize the time-varying bargaining power to derive the delays in debt renengotiation outcomes

tiation joint surplus has a unique optimum for any given amount of debt (b), TFP shock (a), and news shock (s). Then the recovery rate $\alpha(b,a,s)$ solves following Nash bargaining problem:

$$\alpha(b,a,s) = arg\max_{\alpha}[((\Delta^B(b,a,s))^{\theta}(\Delta^L(b,a,s))^{1-\theta}] \tag{2.38}$$

$$s.t. \quad \Delta^B(b,a,s) > 0 \tag{2.39}$$

$$\Delta^L(b,a,s) > 0 \tag{2.40}$$

Since the debt recovery schedule that maximizes the joint surplus depends on the government's level of debt, the TFP shock, and the news shock, the renegotiation provides better insurance to the country if it chooses to default.

2.3.8 Foreign Investor's Problem

Risk neutral foreign investors choose next period's debt to maximize the expected profits for a given sovereign bond price schedule. Given the expected default probability $\lambda(b^{'},a,s)$ and the expected recovery rates $\alpha(b^{;},a,s)$ that foreign investors can expect to recover in times of default, the expected profits are as follows:

$$\pi(b^{'},a,s) = \begin{cases} q(b^{'},a,s)b^{'} - \frac{1}{1+r}b^{'} & \text{if } b^{'} \geq 0 \\ \frac{[1-\lambda(b^{'},a,s)+\lambda(b^{'},a,s)\alpha(b^{'},a,s)]}{1+r}(-b^{'}) - q(b^{'},a,s)(-b^{'}) & \text{if } b^{'} > 0 \end{cases} \tag{2.41}$$

Since we assume completely competitive sovereign debt markets, we impose a zero profit condition to derive the following price function.

$$q(b^{'},a,s) = \begin{cases} \frac{1}{1+r} & \text{if } b^{'} \geq 0 \\ \frac{1-\lambda(b^{'},a,s)}{1+r} + \frac{\lambda(b^{'},a,s)\alpha(b^{'},a,s)}{1+r} & \text{if } b^{'} > 0 \end{cases} \tag{2.42}$$

When the government has savings ($i.e.$ $b^{'} > 0$), the government is guaranteed to get repayment from the foreign investors. When the government has debt to repay, the foreign investors should take into account the fact that the government strategically chooses to default if the economy goes bad. The second term of equation 2.42 takes this possibility into account with the expected recovered debt.

The bond price function lies in $[0, \frac{1}{1+r}]$ since $0 < \lambda(b^{'}, a, s) < 1$ and $0 < \alpha(b^{'}, a, s) < 1$. The sovereign bond spread is defined as the difference between the country interest rate and risk-free rate, $s(b^{'}, a, s) = r^s(b^{'}, a, s) - r$.

2.3.9 Recursive Equilibrium

We define a stationary recursive equilibrium.

Definition 2.3.1. A recursive equilibrium is a set of value functions for (i) the country's value function $V^*(b, a, s)$ (together with $V^{*R}(b, a, s)$ and $V^{*D}(a, s)$), (ii) a set of policy functions for government default decision set $D^*(b, s)$, optimal asset holdings $b^{'*}(b, a, s)$, optimal government consumptions $g^*(b, a, s)$, $g^{*D}(b, a, s)$ consumption tax rate $\tau^*(b, a, s)$, $\tau^{*D}(b, a, s)$, (iii) a set of policy functions for household's private consumption $c^*(b, a, s)$ and household's labor supply $l^*(b, a, s)$, (iv) bond pricing functions $q^*(b^{'}, a, s)$, (v) recovery rate $\alpha^*(b, K_g, a)$

such that

[1] Given the government policies of government consumption $g^*(b, a, s)$ and consumption tax policy $\tau^*(b, a, s)$, and bond price function $q^*(b^{'}, a, s)$, the household policies of private consumption $c^*(b, a, s)$ and labor supply decisions $l^*(b, a, s)$ solve the household's problem.

[2]. Given the bond price function $q^*(b^{'}, a, s)$, and household consumption $c^*(b, a, s)$ and labor supply decision $l^*(b, a, s)$, the value function $V^*(b, a, s)$, asset positions $b^{*'}(b, a, s)$, government consumption $g^*(b, a, s)$, and consumption tax rates $\tau(b, a, s)$, and default set $D^*(b, s)$ satisfy the country's optimization problem.

[3]. Given the bond price function $q^*(b^{'}, a, s)$, the country's value function $V^*(b, a, s)$, the recovery rates $\alpha^*(b, a, s)$ solve the debt renegotiation problem.

[4]. Given the recovery rate $\alpha^*(b,a,s)$, the bond price function $q^*(b^{'},a,s)$ satisfies the zero expected profit function for foreign investors.

In equilibrium default probability $\lambda^*(b^{'},a,s)$ is defined by using the country's default decision:

$$\lambda^*(b^{'},a,s) = \int_{D^*(b^{'},a,s)} d\mu(a^{'},s^{'}|a,s), \tag{2.43}$$

The expected recovery rate $\alpha^*(b,a,s)$ in equilibrium is given by

$$\begin{aligned} \gamma^*(b,a,s) &= \frac{\int_{D^*(b,a,s)} \alpha^*(b,a,s) d\mu(a^{'},s^{'}|a,s)}{\int_{D^*(b,a,s)} d\mu(a^{'},s^{'}|a,s)} \\ &= \frac{\int_{D^*(b,a,s)} \alpha^*(b,a,s) d\mu(a^{'},s^{'}|a,s)}{\lambda^*(b^{'},a,s)} \end{aligned} \tag{2.44}$$

The numerator is the expected proportion of debt that the country pays to the foreign investor and the denominator is the default probability.

2.4 Quantitative Analysis

This section provides calibrations, solves the model numerically, and analyzes the quantitative implications of the sovereign default and fiscal polices. We first calibrate the parameters with the Argentina data. Then we use the no news case as a baseline model. The baseline simulation results resemble the emerging market business cycles and fiscal policy dynamics. Then as we increase the degree of news precision, we derive the equilibrium outcomes that resemble that of the advanced economy. We define one period as a quarter.

2.4.1 Parameters and Functional Forms

The Greenwood, Hercowitz, and Huffman (GHH) per-period utility function is used in numerical simulations. One of the important features of this utility function is that the labor supply decision is independent of wealth of agents. In the news shock literature, these preferences are widely used to derive the comovement among consumption, investment, and hours worked (Jaimovich and Rebelo, 2008).

$$u(c_t, g_t, 1-l_t) = (1-\pi)\frac{(c_t - \frac{l_t^{1+\psi}}{1+\psi})^{1-\gamma}}{1-\gamma} + \pi_t \frac{g_t^{1-\gamma}}{1-\gamma} \tag{2.45}$$

The public expenditure g_t and private sector variables c_t, l_t are separable. We set γ equal to 2 to follow the real business cycles (RBC) literature. ψ is set to 0.455, implying a Frisch labor supply elasticity of 2.22, following Mendoza (1991) and Mendoza and Yue (2013). Since the Frisch labor supply elasticity affects the output cost, we will conduct sensitivity analysis by varying the degree of ψ.[12] The weight on the public sector π is set to 0.3 to generate a public spending to private consumption ratio, 16%, which is usually found in emerging economy in Latin America.

Total Factor Productivity (TFP) shock is assumed to follow a simple AR(1) process to capture the Argentina output process from 1970 to 2007.

$$\ln(A_t) = \rho_a \ln(A_{t-1}) + \sigma_a \epsilon_t \tag{2.46}$$

We set the persistence parameter ρ to be 0.94 and volatility σ_a equal to 0.015. We approximate this stochastic process as discrete Markov chains of 11 equally spaced grids by using the quadrature method of Tauchen and Hussey (1991)

The discount factor β=0.95 is calibrated to match the default probability of Argentina, 3 %.[13]

The cost of default is specified as in Arellano (2008). When the government defaults on its debt, the productivity of the country decreases. In the model, TFP is reduced by ϕ.

[12] Chetty, Guren, Manoli, and Weber (2011) investigate the importance of labor supply elasticity as a source of business cycles and the divergence between macro and micro analysis.

[13] Argentina defaulted three times from 1900 to 2005, matching 3 % of default risk annually. (Reinhart and Rogoff, 2010). In sovereign debt default literature, the discount factor ranges from 0.6 to 0.99. Low β is usually used to match high debt default probability with high interest rates which is very hard to match at the same time. Low value of β can be justified in emerging economy because they tend to experience high structural break in government policies, regime switches which contributes myopic perspective on government.

Parameter	Value	Sources
Risk aversion	$\gamma = 2$	RBC Literature
Discount factor	$\beta = 0.93$	default frequency 2.7%(Annual)
G weight	$\pi = 0.3$	Public and Private con ratio 16%
Labor elasticity	$1/\psi = 2.22$	Mendoza (1991)
Risk free rate	$r = 0.01$	U.S. quarterly interest rate
Default penalty	$\phi = 0.96$	Arellano (2008)
Bargaining power	$\theta = 0.72$	Yue (2010)
Autocorrelation of TFP	$\rho_a = 0.9$	Argentina, 1980Q1-2002Q4
Standard deviation of TFP	$\sigma_a = 0.01$	Argentina, 1980Q1-2002Q4
News shock	$\eta \in [1/\Xi, 0.95]$	

Table 2.1: Model Parameters

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

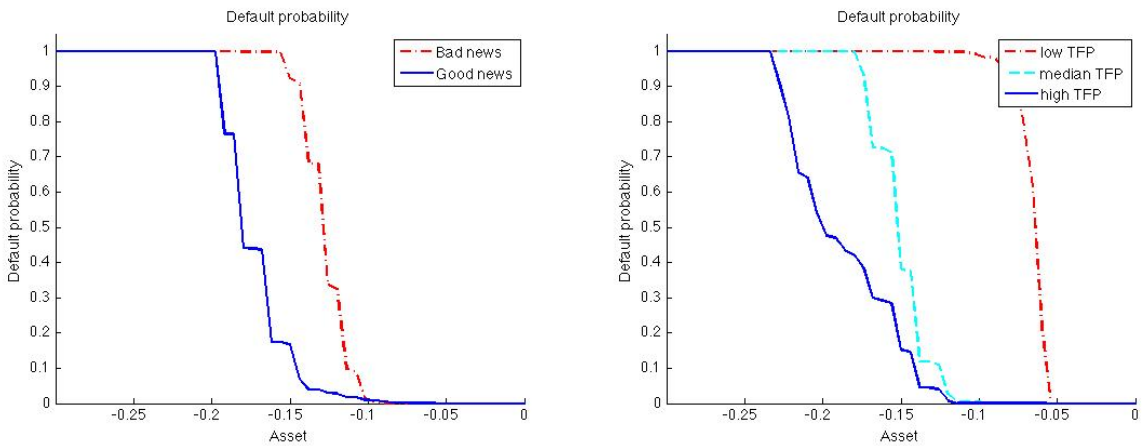
The specification of default cost is asymmetric. Since it is costly to default during good times whereas it is not costly to default during bad times, countercyclical interest rates can be delivered in the model. The risk-free interest rates are set to be 0.01 to match the U.S. annual interest rate.

2.5 Quantitative Work

2.5.1 The effects of news

In this section, we investigate the equilibrium properties of the model. Figure 2.6-(a) and 2.6-(b) show plots of the default probability as a function of current asset positions for two values of the TFP shock and news of future TFP states.

Figure 2.6-(a) shows that when bad news hit the economy, the risk of default increases for any level of current debt. Since the bad news contains information about future low realization of TFP, the risk of sovereign debt increases even though there is no change in TFP in the current period. Figure 2.6-(b) presents that risk of default is higher when a



(a) News and default probability

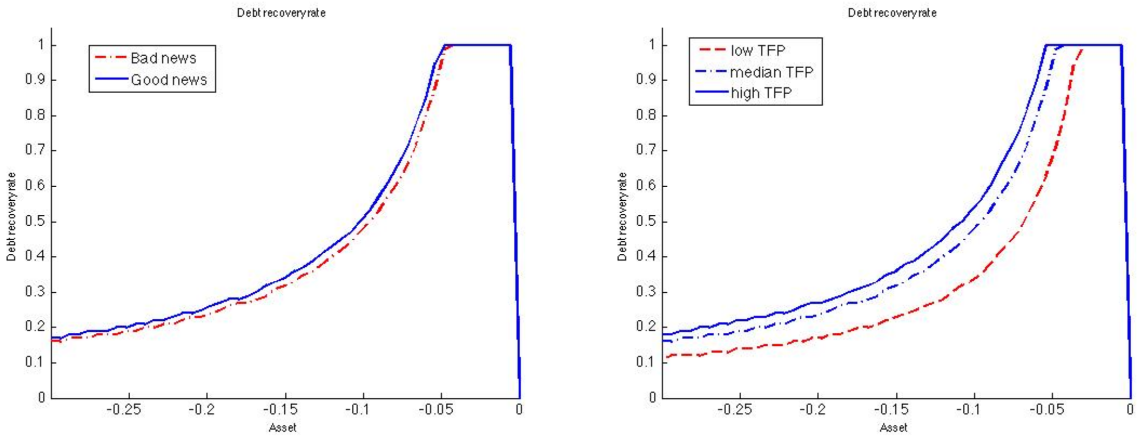
(b) TFP and default probability

Figure 2.5: The effect of precision of news and TFP on expected sovereign bond prices. Notes: In the plots, $\eta = 0.95$ *and the current TFP shock is at steady-state. Figure 1-(a), the good and bad news refers to a signal of an increase and decrease of 1.4% in the TFP shock. In the figure 1-(b), high and low TFP shock refers to lowest and highest TFP shock states, respectively.*

country is in a low TFP state. The high degree of persistence of the TFP shock makes it optimal for government to default on sovereign debt for a given level of debt. In sum, Figure 2.6-(a) and 2.6-(b) shows that risk of default increases as the country is hit by an anticipated future bad TFP shock (news) and an unanticipated current bad TFP shock (TFP). Moreover, default risk increases with respect to the current level of debt.

Figure 2.7-(a) and 2.7-(b) show the debt recovery schedule when the government chooses to default and renegotiates with foreign investors.

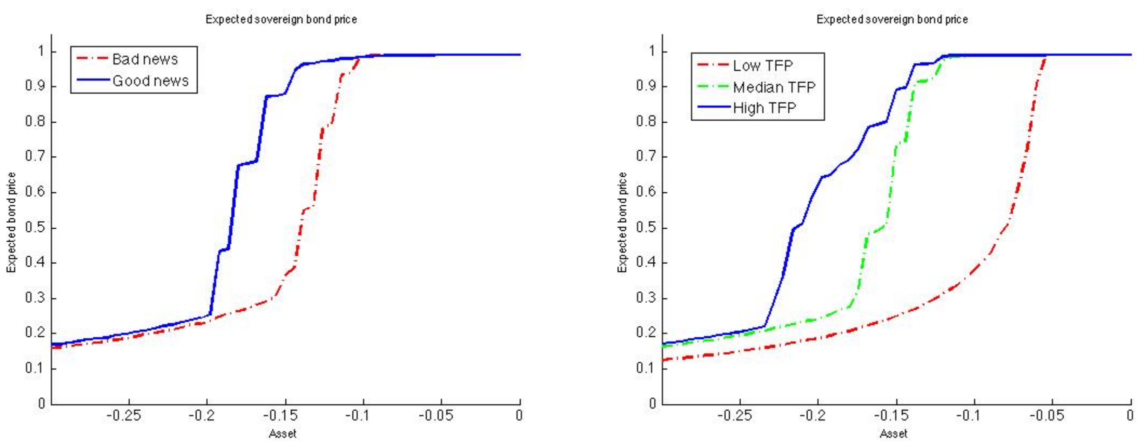
It is clear from the figures that when the amount of defaulted debt is high, it is more likely that renegotiated recovery rates will be low. As for the effect of news on debt recovery rates, figure 2.7-(a) shows that positive news on future TFP shock increases the recovery rates whereas negative news on future bad TFP decreases the recovery rates. The intuition for this result is that when it is expected that future TFP will become favorable, the government has an incentive to re-access the international financial markets to make use of good productivity opportunities and avoid the productivity loss. Therefore, the government may be eager to pay a higher cost in order to enter the international financial markets and



(a) News and recovery rate

(b) TFP and recovery rate

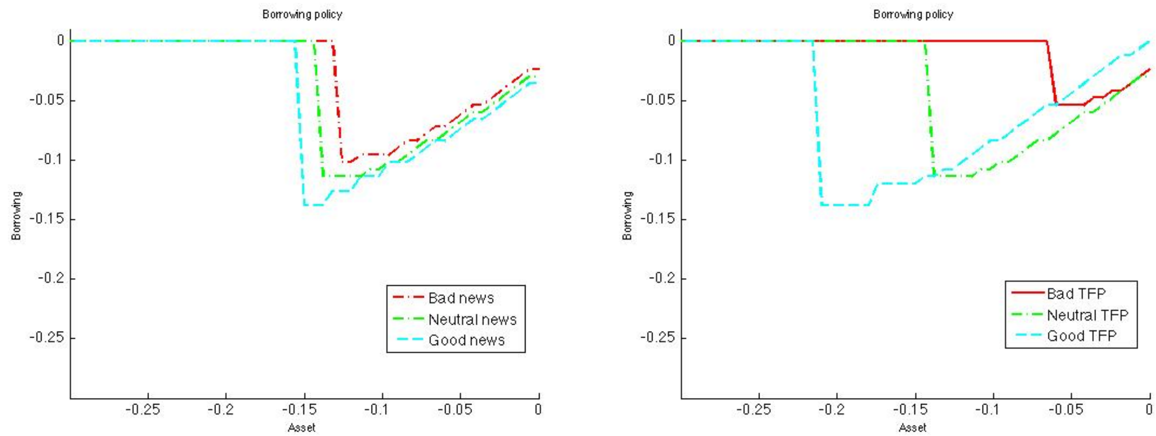
Figure 2.6: The effect of precision of news and TFP on recovery rates. See the notes in figure (1)



(a) News and bond price

(b) TFP and bond price

Figure 2.7: The effect of precision of news and TFP on bond prices. See the notes in figure (1)



(a) News and borrowing (b) TFP and borrowing

Figure 2.8: The effect of precision of news on borrowing. See the notes in figure (1)

investors can expect higher recovery rates. Figure 2.7-(b) also shows that debt recovery rates are higher when the government defaults in a good TFP state. Both figure 7-(a) and 7-(b) illustrate that as the level of the defaulted debt increase, the recovery rate tends to be low.

Based on the results from default risk and recovery rates, we can investigate the effects of news and TFP on bond prices. When the country receives positive news on its future TFP state, default risk decreases and recovery rates increase. The bond price increases for all levels of current bond holdings. The opposite argument is true when negative news hit the economy. As for the effect of TFP on the bond price, a positive TFP shock reduces the default incentive and the recovery rate increases. Consequently, bond prices increase.

The borrowing policy is shown in figure 2.9-(a) and 2.9-(b). Figure 2.9-(a) shows that when positive news about future TFP is revealed, the bond prices increase and the government can borrow a higher level of foreign credit for all current debt levels. Figure 2.9-(b) shows that when the government is highly indebted, the government borrows more in good TFP states but less in bad TFP states. On the other hand, when the country does not have much debt, it borrows less in a good TFP state compared with a bad TFP state. From this figure, we can anticipate countercyclical capital flows when the government is highly

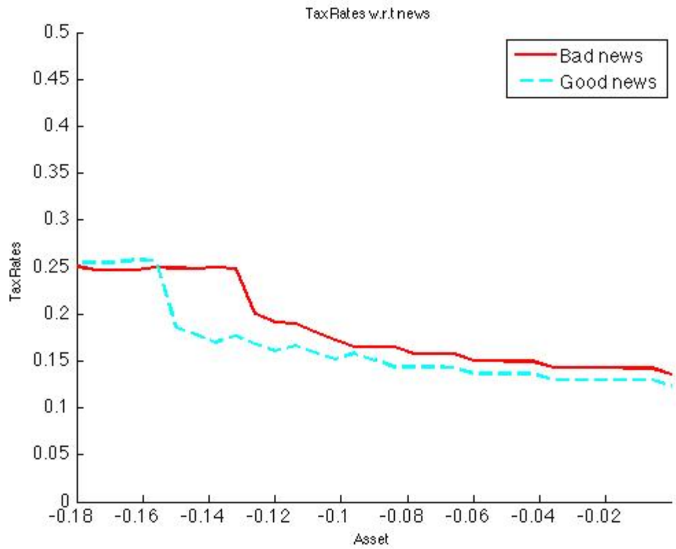


Figure 2.9: Tax Rates with respect to news. See notes in figure 1

indebted but procyclical capital flows when the government carries small amounts of debt.

Now we investigate the effect of news and TFP shocks on fiscal policies. When positive news shocks hit the economy, as seen above in figure 10, the government can borrow more than when negative news shocks hit the economy at all levels of debt. In this event, a government can rely less on tax rates to pay interest rate payments and government expenditures since the tax policy is distortionary. This leads to a reduction in tax rates for all levels of current bonds.

When a good TFP shock hits the economy, on the other hand, the change of a tax rate depends on the level of indebtedness, as seen in figure 2.11. When the government has a high debt level, the government increases a tax rate conditional on not defaulting on foreign debt because the government is restricted from accessing the international financial markets; it is thus exhibiting a procyclical tax policy. However, when the government has a low level of debt, the risk of default is low and the government can access the international financial markets even when hit by negative TFP shock. This leads to a counter-cyclical tax policy in the spirit of incomplete markets without default risk (Huggett, (1993))

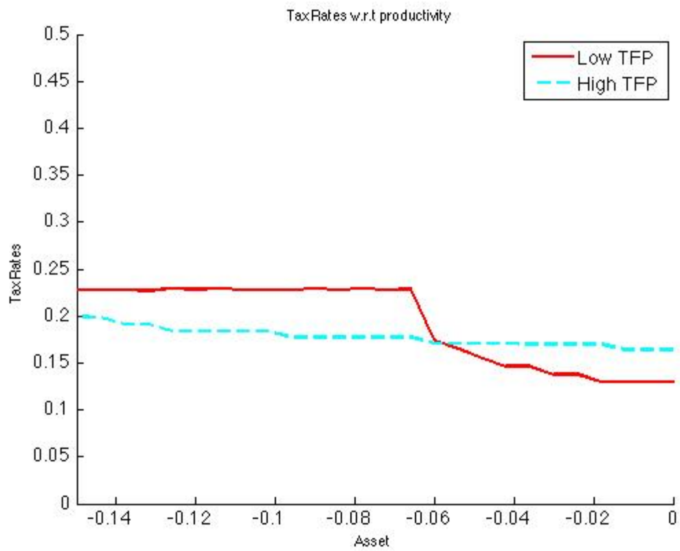


Figure 2.10: Tax Rates with respect to TFP. See notes in figure 1

2.5.2 Simulation results: long-run analysis

We conduct 1000 rounds of simulation with 2000 periods per round, and we extract 80 observations before and 25 observations after each default in stationary distribution to compute equilibrium statistics.[14]

In the baseline model, we present two results. The first one is the simulation results coming from the no news case ($s = \frac{1}{|\Xi|}$) in which the parameters are calibrated. Then we show another set of results where the agents can anticipate future TFP state very accurately, ($s = 0.95$). Then we compare the simulation results with Arellano (2008), Yue (2010), and Durdu et al. (2013).

[14] see Arellano (2008), Yue (2010), Asonuma (2012)

A: Business Cycles Statistics

	Data	Model $\eta = \{\frac{1}{\Xi}, 0.95\}$	Arellano (2008)	Yue (2010)	Durda et al. (2013)
Business Cycles					
Priv C Std./GDP Std.	1.03	{1.06, 1.06 }	1.10	1.04	{1.06, 0.99}
Trade Balance/GDP Std.	2.75	{0.80, 1.56 }	1.50	2.81	
Corr.(TB,GDP)	-0.39	{-0.46, -0.18}	-0.25	-0.16	[-0.27, 0.19]
Corr.(Private C,GDP)		{0.99, 0.97 }	-	-	-
Avg. Debt/GDP Ratio (%)	46.5/9.54	{10.0, 12.6 }	5.95	10.13	
Bonds Spreads and Debt Reduction					
Corr.(Spread, GDP)	-0.43	{-0.32, -0.14 }	-0.29	1.11	{-0.35, 0.17}
Avg Bond Spreads (%)	7.17	{3.90,3.14}	3.58	1.86	-
Bond Spread Std (%)	2.67	{7.73,7.02}	6.36	1.58	-
Average Exclusion (years)	3.5	0.25	0.89	0.25	-
Target Statistics					
Default Frequency (%)	2.7	{2.8,2.8}	3	2.67	3
Avg Recovery Rates (%)	27	{53,48}	-	27.31	-

Source: Arellano (2008), Yue (2010), Durdu et al. (2013), Datastream, IMF WEO

Table 2.2: Simulation results

The calibrated model matches with the business cycle statistics of developing countries (Neumeyer and Perri, (2005)). In an emerging market, private consumption volatility is larger than output volatility. We can capture this feature as previous studies. The cyclicality of the trade balance is negative in that when a country is a good state, it borrows from the financial markets whereas it is difficult to access the international financial markets when a country is in a bad state.

The average debt to output ratio is not reasonable to compare with the data. In the data, it is around 45% whereas we only can generate around 10%. Since we assume one period debt, it is hard to get a high level of debt. Previous papers show similar results as Arellano (2008) generate 5.59% and Yue (2010) 10.03% which is 4-8 times less than realistic debt levels of Argentina. [15]

Countercyclical interest rates are generated by our baseline model. High default risk

[15] Achieving a high debt to output ratio with reasonable default frequency is hard work in a quantitative sovereign default model. Various attempts are exercised. D'Erasmo (2008) introduced asymmetric information regarding political states and multi-period debt reneogtiation process to generate 50% of empirical relevant debt to output ratio. Chatterjee and Eyigungor (2012) introduced multi-period sovereign bonds to generate relevant debt to output ratio but with very high default frequency.

	Model with no news	Model with high pecision
Fiscal Variables		
Government Exp Std./GDP Std.	1.16	1.30
Corr.(Government Exp,GDP)	0.9	0.81
Consumption Tax Std.	0.9	1.50
Corr.(Consumption Tax,GDP)	-0.51	-0.22

Table 2.3: Fiscal Policy

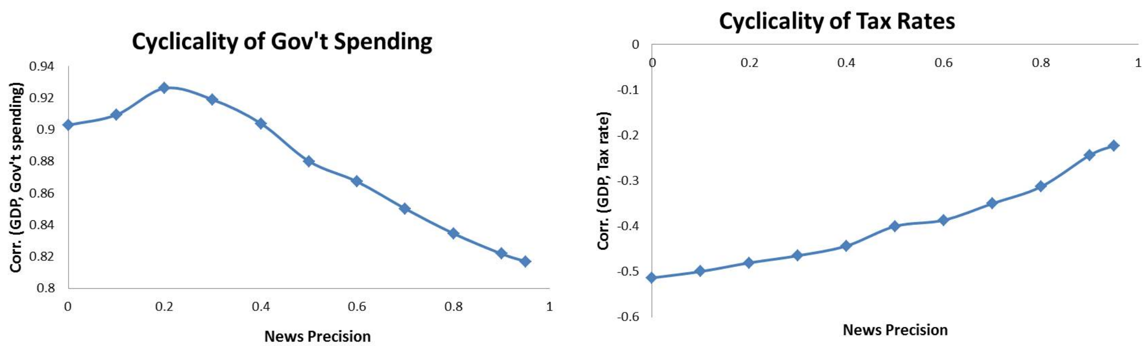
and low recovery rates increase the cost of credit in bad times. Furthermore, asymmetric default costs (Arellano (2008)) makes it less costly to default in bad times. As a result, the government cannot borrow much during bad times.[16] Average bond spreads are 3.9% with default frequency 2.8%. Bond spread volatility is 7.73% which is higher than reported in the data but is similar to the findings of Arellano (2008). The average exclusion period is one quarter since we assumed that the government is excluded only one period and can access the international financial markets in the next period.[17] Average recovery rate is 53%. This is high compared to the Argentina case where the recovery rates are around 30%. The average recovery rates for all default cases from 1980 to 2000 are 60% [18]

Now we investigate the simulation results of fiscal policy dynamics. The average tax rates are lower in transparent economies. This can be justified by the fact that a more accurate economy can accumulate a high debt and can rely less on tax revenues to repay debt payments and government expenditures. The correlation between government expenditure and output is high in the model of no news. In this model, the TFP shock drives the economy, and when it is hit by the positive TFP shock, government consumption also tends to increase at the same rate. However, when the news shock is introduced, government expenditures can increase even though there is no current TFP shock, therefore, leading to low correlation between government spending and output. Likewise, the correlation between tax rates and output follows the same logic in that when negative TFP shock is

[16]Mendoza and Yue (2013) introduced incomplete complementarities between domestic and foreign intermediate goods and successful in endogenizing asymmetric default cost caused by efficiency loss.

[17]Benjamin and Wright (2008), Cruces and Trebesch. (2013)

[18]Gelos (2013), Benjamin and Wright (2009), Cruces and Trebesch (2013)



(a) Correlation between GDP and Government Expenditure

(b) Correlation between GDP and Tax rates

Figure 2.11: Cyclicality of Government Spending and Tax Policy

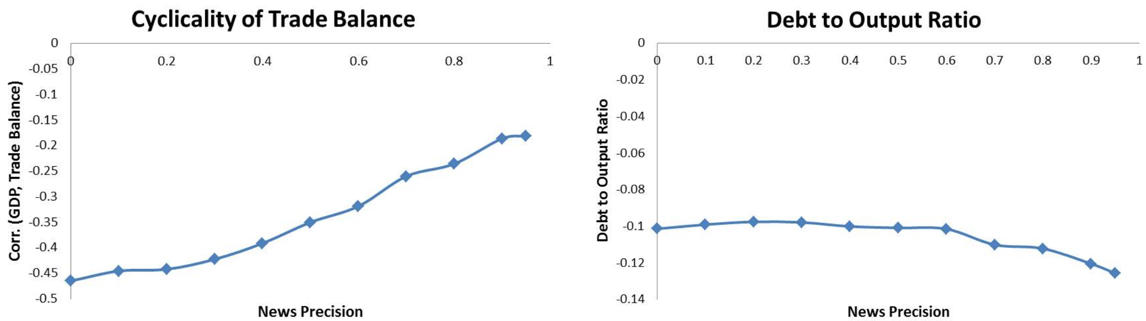
revealed in the current period, the risk of default increases and prevents the government from borrowing from foreign investors. Thus high procyclical tax policy is generated within less accurate economies. The degree of procyclicality, however, is reduced from -0.51 to -0.22 as the precision of news improves.

2.5.3 News precision and development of economy

In this subsection, we provide equilibrium properties of business cycles and fiscal policies with respect to a degree of news precision. The degree of news precision is captured by the η in the model. $\eta = \frac{1}{|\Xi|}$ implies no information content from the signal and $\eta=1$ stands for perfect information about one-period ahead TFP state.

The fiscal policy exhibits patterns in that tax rates tend to be lower in a high precision news economy than in a low precision news economy. The reason for this result is that the government can borrow foreign credit more cheaply for any given amount of debt. This implies that a government can rely less on tax revenues conditional on not defaulting. Therefore, the tax rate in a high precision news economy tends to be lower than in a low precision news economy.

Now we investigate how the precision of news affects business cycle and fiscal policies as we vary the degree of η.



(a) Cyclicaltiy of Trade Balance

(b) Cyclicality of Debt to Output ratio

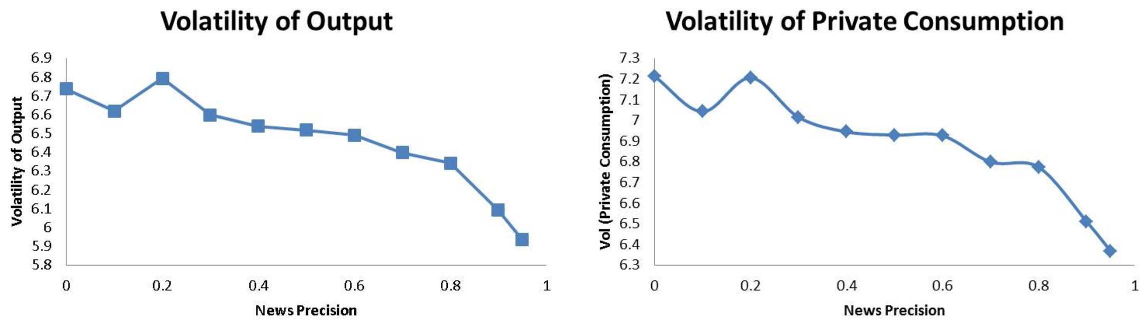
Figure 2.12: Cyclicality of Trade Balance and Debt to Ouptput Ratio

Figure 2.12 (a) shows that as news precision increases, the correlation between government spending and output decreases and thus creates less procyclical government spending. When a signal does not contain any information about the future TFP, the correlation between government expenditure and output is almost 1 whereas it is close to .0.8 in a very precise economy. This is still high compared to the data, but it is moving in the right direction of a developed economy.

The cyclicality of tax policy also exhibits a difference between developing and developed countries in the figure 2.12 (b). When precision of news is very precise, it is almost acyclical and even countercyclical which resembles the pattern of developed countries. As precision of news decreases, the correlation between tax rate and GDP monotonically increases.

Figure 2.13 shows the cyclicality of trade balance and debt to output ratio. As the precision of news improves, so the correlation of trade balance with output decreases. This implies that the government can access the international financial markets more easily during recessions. Debt to output ratio also increases as news precision increases. As the risk of default decreases, the government can accumulate a high level of debt.

The volatility of output decreases as the precision of news increases. Since the correlation of tax rates with output decreases close to zero, tax rates do not increase as much in a less precise news economy in bad states. Labor supply, then, does not decrease much in time of recession, making output less volatile. The volatility of the private consumption and public



(a) Volatility of Output (b) Volatility of Private Consumption

Figure 2.13: Volatility of Output and Private Consumption

consumption are also decreased as a government can rely more on foreign borrowing to smooth consumption. In Durdu et al. (2013), the volatility of consumption relative to the volatility of output decreases monotonically as the news precision improves. However, in our setting, it depends on a relative change in volatility between output and consumption. This is caused by endogenous feedback from distortionary tax on output which Durdu et al. (2013) does not have.

2.6 Sensitivity Analysis

2.6.1 The role of labor supply elasticity

We examine the effect of changing Frisch wage elasticity on equilibrium outcomes. High Frisch wage elasticity implies that labor supply is highly sensitive to shock. When a negative shock hits the economy, the labor supply decrease significantly, resulting in an abrupt output drop. The volatility of the output, the private consumption, and the government consumption are high compared to the low Frisch wage elasticity case. Then the risk of default increases for any given amount of debt. Therefore, the debt sustainability decreases, generating less debt to output ratio. As a result, default probability decreases by a general equilibrium effect.

	Baseline	$1/\psi = 1$	$1/\psi = 4$
Business cycles			
Output Std.		{4.32,3.74}	{9.94,8.69}
Corr.(Trade Balance,Output)	{-0.46, -0.18}	{-0.48,-0.19}	{-0.31,0.03}
Corr.(Private Consumption,Output)	{0.99, 0.97 }	{0.98,0.93}	{0.99,0.99}
Debt and Bond spreads			
Average Debt to Output Ratio (%)	{10.0, 12.6 }	{-12.4,15}	{6.8,8}
Corr.(Spread, Output)	{-0.32, -0.14 }	{-0.29,-0.16}	{-0.29,-0.19}
Average Bond Spreads. (%)	{3.90,3.14}	{3.71,3.37}	{3.21,1.74}
Bond Spread Std. (%)	{7.73,7.02}	{6.01,6.33}	{7.60,4.88}
Fiscal Variables			
Government Exp Std.		{5.68,5.53}	{10.10,9.40}
Corr.(Government Exp,Output)	{0.9, 0.81}	{0.83,0.73}	{0.95,0.88}
Corr.(Consumption Tax,Output)	{-0.51, -0.22}	{,-0.23}	{,0.003}

Table 2.4: Sensitive analysis:labor supply elasticity

2.7 Conclusion

Developing countries tend to have procyclical fiscal policies whereas developed countries exhibit acyclical or countercyclical fiscal policies. This paper explains this stylized fact within the dynamic stochastic general equilibrium model that explicitly incorporates endogenous fiscal policy and news shock in a small open economy of limited commitment. Quantitative analysis shows that news shock can explain the difference in fiscal policy cyclicality. As precision of news improves, a government can rely more on foreign borrowing in recession, dampening a correlation of government expenditure and tax policy with output similar to that of developed countries. Furthermore, this model can generate different business cycle dynamics between developing and developed countries in that the consumption and the output volatility is reduced and the correlation of trade balance with the output decreases as the news precision improves.

Bibliography

[1] Aguiar, M., Gopinath, G., 2006, "Defaultable debt, interest rates and the current account," *Journal of International Economics*, Vol.69, pp.64-83.

[2] Alesina, A., Campante, F., and G. Tabellini, "Why is fiscal policy often procyclical?," *Journal of the European Economic Association*, 6 (5) (2008), pp. 10061036

[3] Arellano, C., 2008, "Default risk and income fluctuations in emerging economies,"

[4] Asonuma, T., 2012, "Serial Default and Debt Renegotiation," forthcoming IMF Working Paper.

[5] Asonuma, T., and C. Trebesch, 2014 "Sovereign Debt Restructuring: Pre-emptive and Post Default ," manuscript, IMF.

[6] Azzimonti, M., 2013, "The Dynamics of Public Investment under Persistent Electoral Advantage," Federal Reserve Bank of Philadelphia, Working Paper.

[7] Bai, Y., and J, Zhang., 2012, "Duration of Sovereign Debt Renegotiatio," *Journal of International Economics*, Vol.86(1), pp.252-268.

American Economic Review, Vol.98(3), pp.690-712.

[8] Beaudry, Paul, Portier, F., 2006, "Stock pries, news, and economic fundamentals," *American Economic Review*, Vol.96(4), pp.1293-1307.

[9] Benjamin, D., and M, Wright., 2008, "Recovery Before Redemption? A Theory of Delays in Sovereign Debt Renegotiation," Manuscript, UCLA.

[10] Bi, R., 2008, "Beneficial Delay in Debt Restructuring Negotiation,"IMF working paper No. WP/08/38, International Monetary Fund.

[11] Borri, N, and A. Verdelhan, 2012, "Sovereign Risk Premia," Working Paper, MIT Sloan.

[12] Boz, E., C.B., Durdu, Daude, C., 2011, "Emerging market business cycles: learning about the trend," *Journal of Monetary Economics*, Vol.58(6-8), pp.616-631.

[13] Chatterjee, Satyajit and Burcu Eyigungor, Maturity, Indebtedness, and Default Risk, *American Economic Review*, 2012, 102, 267499.

[14] Chetty, R., Guren, A., Manoli, D., and Weber, A., 2011, " Are Micro and Macro Labor Supply Elasticities Consistent? A Review of Evidence on the Intensive and Extensive Margins," *American Economic Review*, 101(3): 471-75.

[15] Cruces, J., and Trebesch, C., 2011, "Sovereign Defaults: The Price of Haircuts," *American Economic Journal: Macroeconomics,* 2013, 5(3), pp. 85117.

[16] Cuadra, G., Sanchez, M., and Sapriza, H., 2010, "Fiscal Policy and default Risk in Emerging Markets," *Review of Economic Dynamics*, 13 (2010), pp.452-469.

[17] D'Erasmo, P., 2011, "Government Reputation and Debt Repayment in Emerging Economies," manuscript, University of Maryland.

[18] Doda, B ., 2010, "Optimal Fiscal Policy with Sovereign Default," Working Paper, University of Toronto.

[19] Durdu, C. Bora Nunes, Ricardo Sapriza, Horacio, 2013. "News and sovereign default risk in small open economies," *Journal of International Economics*, Vol.91(1), pp.1-17.

[20] Eaton, J., Gersovitz, M., 1981, "Debt with potential repudiation: theoretic and empirical analysis," *Review of Economic Studies*, 48, pp.289-309.

[21] Foemel, M ., 2014, "Imperfect Financial Markets and the Cyclicality of Social Spending," Konstanz Working Paper 2014-11.

[22] Frankel, J., Vegh, C., and Vuletin, G., 2013, "On Graduation from Fiscal Procyclicality," *Journal of Economic Development*, Vol. 100 (1), pp.32-47.

[23] Gavin, M., and Perotti, R., 1997, "Fiscal policy in Latin America," NBER Macroeconomics Annual (1997), pp. 1161

[24] Gelos, R.G., and Wei, Shang-Jin., 2005, "Transparency and International Portfolio Holdings," *Journal of Finance*, 60(6), pp.2987-3020.

[25] Gilchrist, S., Yue, V. and E. Zakrajsek, "Sovereign Risk and Financial Risk," Working Paper, Federal Reserve of Board.

[26] Hatchondo, J., Martinez, L., and Roch, F., 2012, "Fiscal Rules and the Sovereign Default Premium," Working Paper, Federal Reserve Bank of Richmond.

[27] Hatchondo, J., Martinez, L., and Roch, F., 2012, "Fiscal Rules and the Sovereign Default Premium," Working Paper, Federal Reserve Bank of Richmond.

[28] Ilzetzki, E., 2010, ""Rent-seeking distortions and fiscal procyclicality," *Journal of Development Economics*, Vol.96(1), pp.30-46.

[29] Jaimovich, Nir, Rebelo, S., 2008, "Can news about the future drive the business cycle?," *American Economic Review*, 99 (4) (2009), pp. 1097-1118.

[30] Jaimovich, Nir, Rebelo, S., 2008, "News and business cycles in open economies," *Journal of Money, Credit, and Banking*, 40 (8) (2008), pp. 16991711

[31] Kaminsky, G., Reinhart, C. and C. Vegh, "When It Rains, It Pours: Procyclical Macro policies and Capital Flows," in Mark Gertler and Kenneth S. Rogoff (eds.), NBER Macroeconomics Annual 2004, (lead article), 11-53.

[32] Lizarazo,. S, 2013 "Default Risk and Risk Averse International Investors," *Journal of International Economics*, Volume 89, Issue 2, 317-330

[33] Mendoza, G. and M. Oviedo, " Public Debt, Fiscal Solvency and Macroeconomic Uncertainty in Latin America The Cases of Brazil, Colombia, Costa Rica and Mexico," NBER Working Papers 10637, National Bureau of Economic Research, Inc.

[34] Mendoza, Enrique G. and Vivian Z. Yue, " General Equilibrium Model of Sovereign Default and Business Cycles," *Quarterly Journal of Economics*, Forthcoming.

[35] Neumeyer, P., and F, Perri., 2005, "Business Cycles in Emerging Economies: the Role of Interest Rates" *Journal of Monetary Economics*, Vol.52(2), pp.345-380

[36] Parmasiz, O ., 2010, "Fiscal Policy, Default and Emerging Market Business Cycles," Dissertation, University of Pennsylvania.

[37] Pouzo, D., and I. Presno, 2014, "Optimal Taxation with Endogenous Default under Incomplete Market," Working Paper, UC Berkeley.

[38] Pouzo, D., and I. Presno, 2012, "Sovereign Default Risk and Uncertainty Premia," Working Paper, Federal Reserve Bank of Boston.

[39] Reinhart, C., and Rogoff, K., 2010, "Growth in a time of Debt," *American Economic Review,* American Economic Association, vol. 100(2), pages 573-78, May.

[40] Riascos, M., and Vegh, C., 1997, "Procyclical government spending in developing countries: The role of capital market imperfections.," Working Paper, UCLA

[41] Schmitt-Grohe, S., and Uribe. M "What's news in business cycles," Econometrica, 80 (2012), pp. 2733-2764 (November)

[42] Suzuki, Y., 2014, "Sovereign Risk and Procyclical Fiscal Policy in Emerging Market Economies," *The Journal of International Trade Economic Development,*

[43] Tsyrennikov, V., 2014, "Fiscal Policy, Sovereign Debt and Default with Model Misspecification," Working Paper, Cornell University.

[44] Vegh, C. and Vuletin. G, " How is tax policy conducted over the business cycle?," NBER Working Paper, Vol.17753 (2012).

[45] Woo, J., 2009, "Why Do More Polarized Countries Run More Procyclical Fiscal Policy?," *The Review of Economics and Statistics*, Volume (91 (2009), 4 (November), pp: 850-870

[46] Yue, V., 2010, "Sovereign Default and Debt Renegotiation," *Journal of International Economics*, Vol.80(2), pp.176-187.

Chapter 3

Sovereign Debt Restructurings: Delay in Renegotiation and Risk-Averse Creditors

3.1 Introduction

Foreign creditors' behavior can influence the process and outcome of sovereign debt restructurings. We compile a new dataset on foreign creditors' risk aversion during restructurings and show that when foreign creditors are highly risk-averse, restructurings are solved quickly and with smaller haircuts. To explain these stylized facts, we develop a stochastic general equilibrium model of defaultable debt that explicitly embeds multi-round debt negotiations between a risk-averse sovereign and risk-averse creditors. The quantitative analysis shows that high creditors' risk aversion results in shorter restructuring duration and smaller haircuts. When foreign creditors are highly risk-averse, being less patient, they opt to settle the negotiations in the current period and demand higher recovery rates, equivalent to lower haircuts since their outside option associated with not proposing the offer also remains high due to the high risk-aversion.

First, the paper introduces a new comprehensive dataset on creditors' risk aversion during sovereign debt restructurings. We use two existing datasets on the duration of restructurings at a monthly frequency in Asonuma and Trebesch (2014) and on creditor losses (haircuts) in Cruces and Trebesch (2013) both which cover the same 178 episodes of restructurings on private external debt over 1978-2010. Our new creditor risk aversion measures comprise mainly two indicators: (1) the term premium on the US and German government bonds and (2) the credit spread and excess bond premium for US financial firms in Gilchrist and Zakrajsek (2012). For all debt restructuring episodes and for each risk aversion measure, we compute a monthly average creditor risk aversion during restructuring from the announcement to the completion of restructurings as in Asonuma and Trebesch (2014)

Two new stylized facts on the foreign creditors' risk aversion and outcomes of debt restructurings emerge from our compiled dataset. When the foreign investors are highly risk-averse, (i) restructurings tend to be completed quickly, and (ii) result in smaller haircuts (higher recovery rates). These findings are obtained from the panel regressions controlling other macroeconomic and financial market variables.

These new empirical findings pose important questions in the literature of sovereign debt restructurings. Why are restructurings solved more quickly when the foreign creditors are highly risk-averse? In a similar vein, why are agreed haircuts (recovery rates) at restructurings high (low) when the sovereign debtor is negotiating with highly risk-averse creditors?

In order to answer two important questions in debt restructuring literature, we build a stochastic general equilibrium model with the debtors endogenous default choice that embeds explicitly a multi-round debt renegotiation between a sovereign debtor and creditors. The fundamental structure of the model builds on recent quantitative analysis of sovereign debt such as Aguiar and Gopinath (2006), Arellano (2008), and Tomz and Wright (2007), which is based on classical setup of Eaton and Gersovitz (1981).

3.2 Literature Review

The theoretical parts of model is in line with theoretical work on sovereign debt restructurings that model the outcome of default and debt renegotiation as a bargaining game between a sovereign debtor and its creditors.[1] In particular, paper contributes to the literature by explaining an additional degree of delays arise to risk-averse behavior of creditors. In par-

[1]For example, Bulow and Rogoff, (1989), Benjamin and Wright, (2009), Kovrijnykh and Szentes (2007), Bi (2008), Bai and Zhang (2010), D'Erasmo (2010), Yue (2010), Pitchford and Wright (2012), Asonuma (2012), Hatchondo et al. (2014) and Asonuma and Trebesch (2014).

ticular, the paper relates to Benjamin and Wright (2009), Bi (2008), and Bai and Zhang (2010) which embed a multi-round bargaining game to analyze delay in debt renegotiations. Benjamin and Wright (2009) explain that delays arise due to the same commitment issues such as the borrowers limited ability to repay the newly issued debt, while Bi (2008) finds that delays can be beneficial for both parties in that they allow the economy to recover from a crisis first and make more resources available to settle the renegotiation. In a different set-up, Bai and Zhang (2010) show that secondary market plays an information revelation role to shorten the costly delays. This paper contributes to the literature by explaining an additional degree of delays arise to risk-averse behavior of creditors.

The second stream of literature studies sovereign debt and risk-averse creditors. Borri and Verdelhan (2009), Lizarazo (2013), Pouzo and Presno (2011), and Asonuma (2014). Gilchrist et al. (2012) analyze the case of risk-averse lenders and show that risk aversion allows the model to generate spreads larger than default probabilities, as observed in emerging markets. Borri and Verdelhan (2009) consider risk aversion with external habit preference, while Lizarazo (2013) assumes decreasing absolute risk aversion (DARA) and Asonuma (2014) presumes constant relative risk aversion (CRRA).[2] On the contrary, Pouzo and Presno (2011) introduce fears about model misspecification for the lenders. What distinguishes this current paper with these work is that we explore how creditors risk aversion influences debt restructuring process.

The paper also contributes to empirical literature on sovereign debt restructurings[3] Benjamin and Wright (2009) first document a new perspective on the relationship between restructuring delay and haircut size and Asonuma and Trebesch (2014) show that preemptive restructurings have much lower haircuts and shorter durations. Cruces and Trebesch (2013) shows that restructurings involving higher haircuts are associated with significantly higher subsequent bond yield spreads and longer periods of capital market exclusion. On

[2]Gilchrist et al. (2012) examine theoretically and quantitatively the relationship between sovereign bond spreads, local economic activity, and global financial risk.

[3]There are some work on sovereign debt restructurings which apply detailed case studies such as Sturzenegger and Zettelmeyer (2006, 2008), Finger and Mecagni (2007), Diaz-Cassou et al. (2008), Panizza et al. (2009), Das et al. (2012), and Erce (2013).

the contrary, Gelos et al. (2011) show that probability of market access after a default is not influenced by a country's frequency of defaults, and that a default, if resolved quickly, does not reduce significantly the probability of tapping the markets.[4] The current paper differs from the existing literature in that we find newly that restructurings tend to be finalized and are associated with low haircuts if completed when liquidity at the global financial markets is limited, i.e. global interest rates are high.

3.3 Stylized Facts and Empirical Analysis

In this section, we find two new stylized facts on sovereign debt restructurings: restructurings tend to be protracted when creditors income is high . Moreover, haircuts are smaller (recovery rates are higher) if creditors are facing high income.

Our empirical analysis uses two sets of data. One of them is data on duration and haircuts from Asonuma and Trebesch (forthcoming) and Cruces and Trebesch (2013).[5] As defined in Sturzenegger and Zettelmeyer (2007), haircuts measure the market value of the new instruments, plus any cash payment received, to the net present value (NPV) of the remaining contractual payments on the old instruments (inclusive of any principal or interest arrears) using the yield of the new instrument.[6] Duration corresponds to the number of months from the start of distress (default or announcement of a restructuring) until the completion of the debt restructuring process (debt exchange) as specified in Asonuma and Trebesch (forthcoming).

The other is monthly data on creditors GDP growth rate and risk aversion indicators. These are (i) US GDP growth rate from Bureau of Economic Analysis (US), (ii) German GDP growth rate from Federal Statistical Office (Germany), (iii) Gilchrist and Zakrajsek

[4] Trebesch (2013) suggests that sovereigns factors such as political instability, weak institutions and strategic government behavior influence delays in restructurings more than and creditor characteristics.

[5] Asonuma and Trebesch (forthcoming) compile two separate datasets on haircuts by Cruces and Trebesch (2013) and the monthly data on restructuring by Trebesch (2013). They also provide classified data on preemptive and post-default restructurings.

[6] In contrast, financial market participants use haircut measures which compare the market value of the new debt and cash received to the sum of outstanding face value of the old debt and past due interest.

	Observation	Mean	Median	Std. Dev.	**Ave. 1978-2010** [3/]
Duration of Restructurings (# of months)	179	39.6	18.7	49.4	-
Haircuts (%)	178	36.7	31.7	27.2	-
Investors' GDP Growth Rate Ave. [1/]					
US GDP Growth (%)	177	3.38	3.42	1.8	2.83
Germany GDP Growth (%)	177	2.07	2.23	1.5	1.86
Investors' Risk Aversion Ave. [2/]					
US Credit Spread (GZ) (%)	104	1.7	1.7	0.8	-
Germany Corporate Bond Yield (%)	177	7.3	7.3	1.3	-

Table 3.1: Duration, Haircuts and Investors' Risk Aversion for Restructuring in 1978-2010. Sources: Asonuma and Trebesch (2014), Board of Governors of the Federal Reserve System, Cruces and Trebesch (2013), Deutsche Bundesbank, and Gilchrist and Zakrajsek (2012) 1/ Term premium is defined as a difference between 1-year and 10-year bonds yields

(2012) credit spread for financial firms, and (iv) German corporate bond yields from Bundesbank.[7][8][9]

Table 3.1 reports duration and haircuts of the restructurings, investors' GDP growth rate and risk aversion which are average over duration of the restructurings. One new evidence emerges from Table 3.1: average investors' GDP growth rate during debt restructuring is higher than average over 1978-2010 (for the US by 0.6 percent and for Germany by 0.2 percent).

With our combined sample of restructurings over 1978-2010, it is apparent in Figure 3.1 that restructurings are protracted when investors income is high. This is clearly the case for both average US and German GDP growth rate during restructurings shown in Panel A and B. Regression lines highlighted in red correspond to estimated lines from regression results reported in Table 3.2 below. Creditors are willing to avoid a quick resolution and

[7]GZ Credit spread (CS) measures the disruption of the financial market by exploiting the prices of individual US corporate bonds in the secondary markets. Their credit spread can be decomposed into a component capturing the movements in usual expected defaults and a component representing the cyclical changes in the relationship between measured default risk and credit spread. The latter is called GZ excess bond premium (EBP) which reflects the effective risk-sharing capacity of the financial sector and a contraction in the supply of credit.

[8]Gilchrist and Mojon (2014) also construct credit risk indicators for euro area over 1999-2013, i.e., credit spread and excess bond premium.

[9]The Chicago Board Options Exchange Market Volatility Index (VIX) which is a key measure of market expectations of near-term volatility conveyed by SP 500 stock index option prices. Given that this index was introduced in 1993, we have even more smaller sample of restructuring episodes.

opt to postpone the negotiation when they have high income during the restructuring.

In a similar vein, haircuts are smaller (recovery rates are larger) when creditors' income is high as shown in Figure 3.2. Both GDP growth rate for the US and Germany at end of restructuring is negatively associated with haircuts (panel A and B in Figure 3.2). Creditors facing high income demand lower haircuts (higher recovery rates), while creditors with low income are willing to accept higher haircuts (lower recovery rates).

With our combined sample of 177 episodes, cross-sectional analysis attempts to confirm how creditors income process influences duration and haircuts. We have following two specifications using our indicators for creditors income process $(CreditorIncome_i)$:

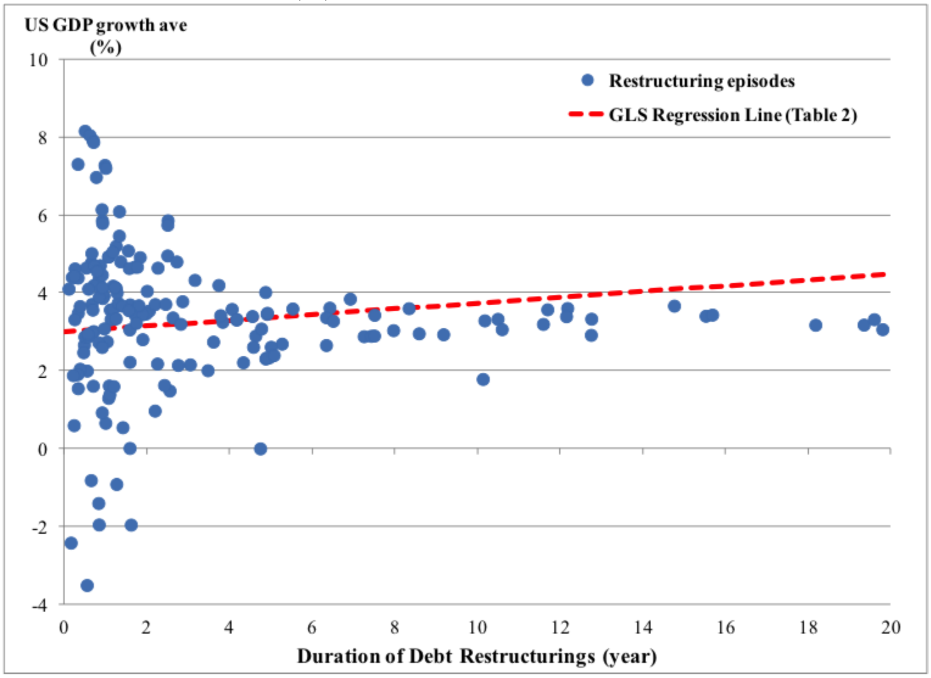
$$Duration_i = c + \beta_1 CreditorIncome_i + Z_i\gamma^{'} + \epsilon_{i,1} \tag{3.1}$$

$$Haircut_i = c + \beta_1 CreditorIncome_i + Z_i\gamma^{'} + \epsilon_{i,2} \tag{3.2}$$

where $Duration_i$ and is $Haircuti$ are duration and haircut of debt restructuring i. Z_i is a vector of other explanatory variables. To reflect influence over the whole duration of restructurings, average creditors income is used for specification (3.1). On the contrary, to capture effect at the settlement, creditors income at end of restructurings is used for specification (3.2). On a choice of other control variables, we follow the empirical literature on sovereign defaults and restructurings, particularly Kohlscheen (2009), Asonuma (2012) and Trebesch (2013). We have debtors' GDP deviation from the trend and growth rate of GDP trend obtained from applying a Hodrick-Prescott (H-P) filter, external debt-to-GDP ratio and export-to-debt service ratio at the end of restructurings, which are considered to be key factors in debt renegotiation. To capture the influence of global liquidity, we also include LIBOR (London Interbank Offered Rate).

On duration of restructuring, baseline regression results (2nd and 3rd columns in Table 3.2) show that high average creditors' income during negotiation, measured by average GDP growth rate for the US and Germany, leads to longer duration of restructuring. When credi-

(A): US GDP Growth Rate



(B): German GDP Growth Rate

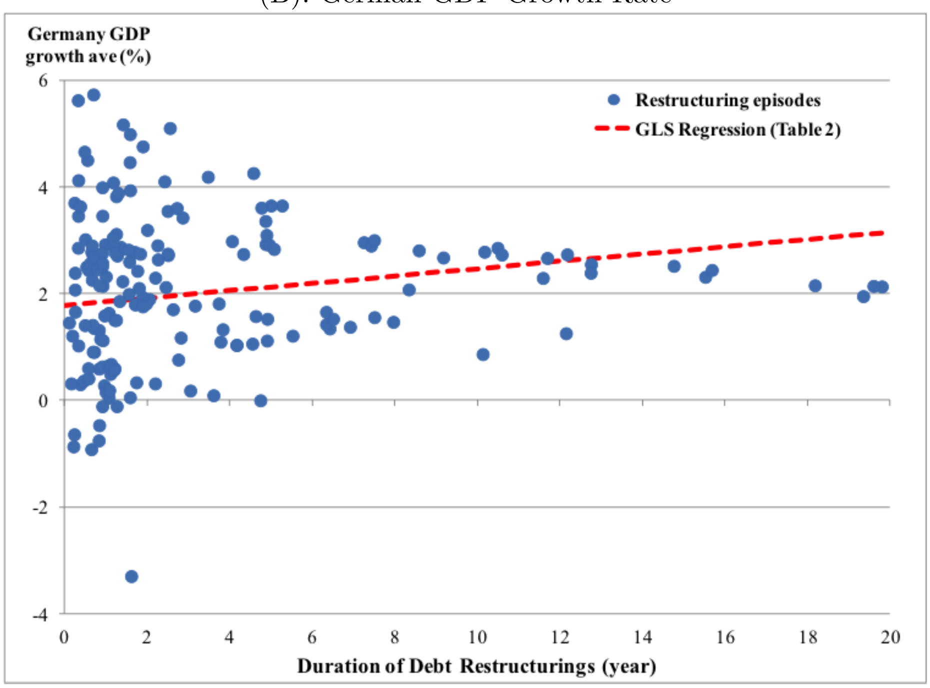
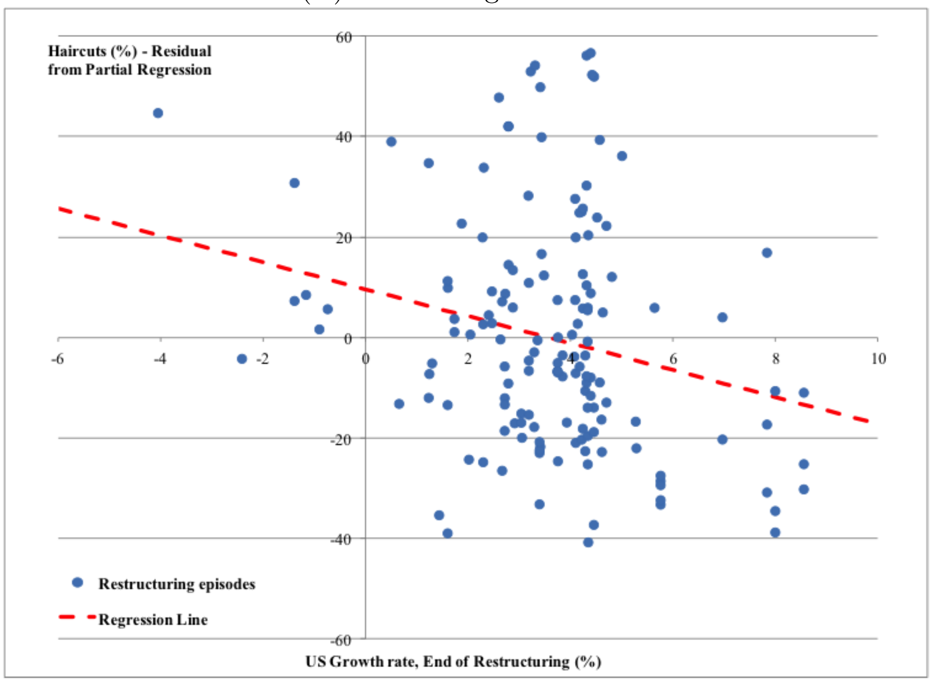


Figure 3.1: Duration and Creditors GDP Growth Rate for Restructurings in 1978-2010. Sources: Asonuma and Trebesch (forthcoming), Bureau of Economic Analysis (US), Federal Statistical Office (Germany).

(A): US GDP growth rate



(B): German GDP Growth Rate

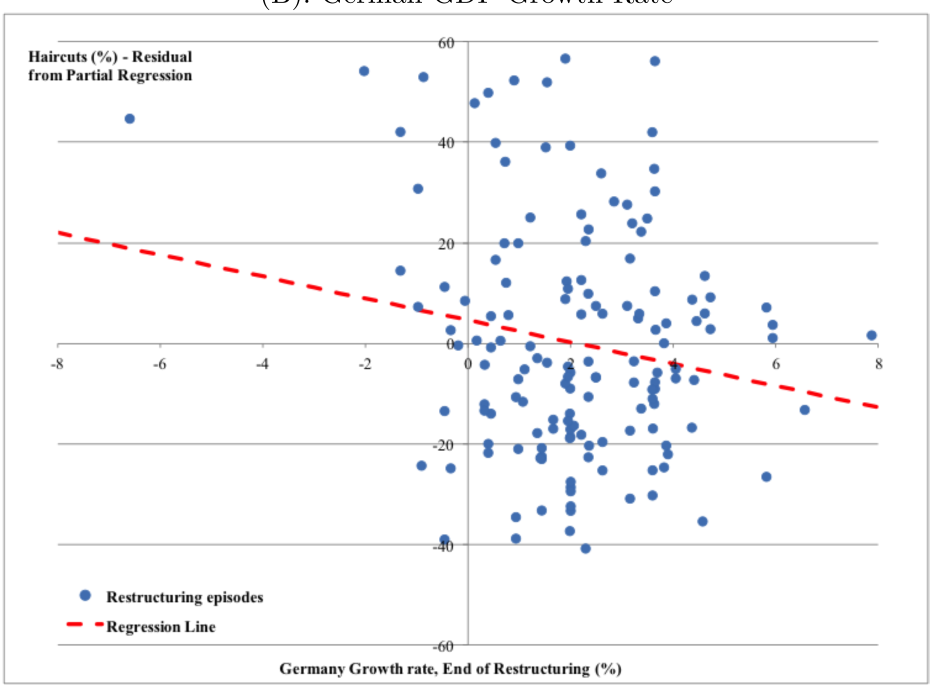


Figure 3.2: Haircuts and Creditor's GDP Growth Rate for Restructurings in 1978-2010. Sources: Asonuma and Trebesch (2014), Deutsche Bundesbank, Gilchrist and Zakrajsek (2012)

tors are facing high income, they are willing to postpone the settlement to later periods. As in previous studies on the sovereign debt restructuring, i.e., Trebesch (2010), restructurings tend to be protracted when external debt is large, sovereigns have ample liquidity (high export-to-debt service ratio). Both GDP deviation from trend and growth rate of GDP trend at end of restructurings are shown to positively influence duration of restructuring, but this is possibly due to that fact that restructurings are completed after economic recovery (Bi, 2008). Similarly, lower average risk aversion of creditorshighly correlated with creditors high income processis highly associated with long length of restructurings as shown in 4th and 5th columns in Table 3.2.

Next, haircuts are substantially reduced by an increase in average creditors' income (the US and German GDP growth rate) reported in the 2nd and 3rd columns in Table 3.3. Creditors receiving high income demand lower haircuts (higher recovery rates), while accept higher haircuts (lower recovery rates) when their income is low. In line with empirical findings in the sovereign debt restructuring and crisis literature, haircuts are high if external debt is large. Export-to-debt service ratio enters with a positive sign possibly because sovereigns with high liquidity (high exports-to-debt service ratio) are less reluctant to accept low haircuts in exchange for regaining market access. Despite insignificance, haircuts are lower with per capita US dollar GDP since countries which are highly developed in the US dollar term, have higher capacity to repay debt. GDP deviation from trend at restructurings enters as a counter-intuitive sign insignificantly, but this is possibly due to that fact that restructurings are completed after economic recovery as aforementioned. Moreover, when creditors are less risk-averse highly correlated with creditors' high income process, they demand lower haircuts (higher recovery rates) reported in 4th and 5th columns in Table 3.3.

Two stylized facts are confirmed by Figure 3.1, 3.2 and Table 3.2 3.3:

- Stylized fact 1: Restructurings tend to be protracted when foreign creditors' income is high. Duration of restructurings is extended by about 3.5-4.8 years due to a 1-percent increase in creditors average GDP growth rate.

- Stylized fact 2: Haircuts are smaller (recovery rates are high) when foreign creditors are facing high income. A 1-percent increase in creditors' GDP growth rate at end of restructuring reduces haircuts by 2.2-3.2 percent.

Explanatory variable: Duration (month)	(1) US Term Premium	(2) GER Term Premium	GZ Credit Spread	GZ Excess Spread
US GDP Growth rate average (%) 1/	3.46* (1.95)	-	-	-
Germany GDP Growth average (%)1/	-	4.80** (2.38)	-	-
US GZ credit spread average1/	-	-	-10.8** (5.04)	-
GER Corporate Bonds average1/	-	-	-	-2.65** (1.17)
GDP deviation from trend2/ 3/ (%)	1.23** (0.44)	1.22*** (0.44)	1.21** (0.51)	1.05** (2.14)
Growth rate of GDP trend2/ 3/ (%)	5.67*** (2.15)	5.50*** (2.15)	6.70** (2.83)	10.00*** (2.14)
External debt/GDP ratio (%)2/	0.24*** (0.07)	0.24*** (0.074)	0.23** (0.11)	0.36*** (0.08)
Export-to-debt service ratio2/	3.09*** (0.78)	3.04*** (0.78)	2.92*** (0.85)	3.87*** (0.86)
LIBOR 12-month (%) average1/	11.37*** (2.25)	8.84*** (2.31)	8.32*** (2.41)	-3.45** (1.64)
LIBOR 12-month (%) end of restructuring 2/	-13.65*** (1.91)	-12.51*** (1.84)	-10.24*** (2.11)	-
GER term premium (%) average 1/ 4/	-	-	-	-5.93* (3.39)
Constant	0.47 (18.4)	17.18*** (17.3)	29.40 (21.9)	-
Sample	152	152	93	156
Adj-R^2	0.43	0.43	0.4	0.55
Root MSE	39.7	39.6	39.8	43.3

*Table 3.2: Regression Results on Duration of Restructuring. Asonuma and Trebesch (forthcoming), Bank of England, Bureau of Economic Analysis (US), Deutsche Bundesbank, Federal Statistical Office (Germany), Gilchrist and Zakrajsek (2012), IMF WEO, and authors calculation. Note: Standard errors are in parentheses. ***, **, * show significance at 1, 5, and 10 percent levels respectively.*
/1 Monthly average over duration of restructurings.
/2 Levels at end of restructurings.
/3 GDP deviation from the trend and growth rate of GDP trend are a percentage deviation from the trend and annual change in the trend obtained by applying a Hodrick-Prescott (H-P) filter to quarterly GDP series.
/4 Term premium on the government bonds is a difference between 1-year and 10-year bond yields.

Explanatory variable: Haircut (%)	(1) US Term Premium	(2) GER Term Premium	GZ Credit Spread	GZ Excess Spread
US Growth rate	-3.22***	-	-	-
(%) 1/	(0.96)			
German growth rate	-	-2.20**	-	-
(%)1/		(1.04)		
US Credit Spreads (GZ)	-	-	6.86**	-
(%)1/			(2.99)	
GER corporate bonds	-	-	-	3.40**
(%)1/				(1.64)
GDP deviation from trend	0.18	0.26	0.40	0.44
(%)1/2/	(0.26)	(0.26)	(0.30)	(0.28)
Per Capita US$ GDP 1/	-1.52	-1.05	-0.09	0.39
(thousand US$)1/	(1.32)	(1.34)	(1.29)	(1.24)
External debt/GDP ratio	0.26***	0.25***	0.33***	0.31***
(%)1/	(0.04)	(0.04)	(0.04)	(0.04)
Export-to-debt service ratio	2.20***	2.25***	2.45***	2.39***
1/	(0.42)	(0.43)	(0.44)	(0.44)
LIBOR 12-month (%) 1/	-	-	-0.63	-2.14**
(%)1/			(0.59)	(1.01)
Constant	24.13***	16.69***	-	-
	(6.36)	(5.78)		
Sample	148	148	114	148
Adj-R^2	0.33	0.30	0.78	0.75
Root MSE	22.7	23.1	24.1	23.5

*Table 3.3: Regression Results on Haircut. Sources: Bank of England, Bureau of Economic Analysis (US), Deutsche Bundesbank, Federal Statistical Office (Germany), Gilchrist and Zakrajsek (2012), IMF WEO, and authors calculation. Note: Standard errors are in parentheses. ***, **, * show significance at 1, 5, and 10 percent levels respectively. All regression results are based on least square estimations.*

/1 Levels at end of restructuring.

/2 GDP deviation from the trend and growth rate of GDP trend are a percentage deviation from the trend and an annual change in the trend obtained by applying a Hodrick-Prescott (H-P) filter to quarterly GDP series.

3.4 Model

3.4.1 Timing of the Model

Figure 3.4 summarizes the timing of decisions within each period.

1. The sovereign starts current period with initial debt b_t, and creditors' risk-free assets b_t^{*f}. We are in node (A).

2. A vector of income y_t realizes. The sovereign decides whether to pay its debt or to default after observing its income.

3. (a) In node (B) (payment node), if payment is chosen, we move to the upper branch of a tree. The sovereign maintains market access ($h_{t+1} = 0$) and chooses its consumption (c_t) and level of assets/debt in next period (b_{t+1}). Default risk is determined and creditors also choose next-period sovereign bonds (b_{t+1}^*) and risk-free assets b_{t+1}^{*f}. Bond prices are determined in the market. We proceed to node (A) next period.

   (b) In node (C) (default node), if default is chosen, we move on to the lower branch of a tree. The sovereign suffers output costs $\lambda_d y_t^h$ and also loses access to the international capital market ($h_{t+1} = 1$). Creditors choose next-period risk-free assets b_{t+1}^{*f} and its price is determined in the market.

4. A vector of income y_{t+1} realizes.

5. In node (D) (default node), with probability ϕ, the sovereign has an opportunity to propose an offer to its creditors. Otherwise, the creditors do. The proposer, i.e. either the sovereign or its creditors who has an option to propose decides whether to propose an offer to other party. The creditors choose next-period risk-free assets b_{t+1}^{*f}.

6. (a) In node (E) (propose node), if the proposer chooses to propose, the other party decides whether to accept or reject the offer. If the other accepts the offer, the sovereign regains market access ($h_{t+2} = 0$). We move back to node (A) next

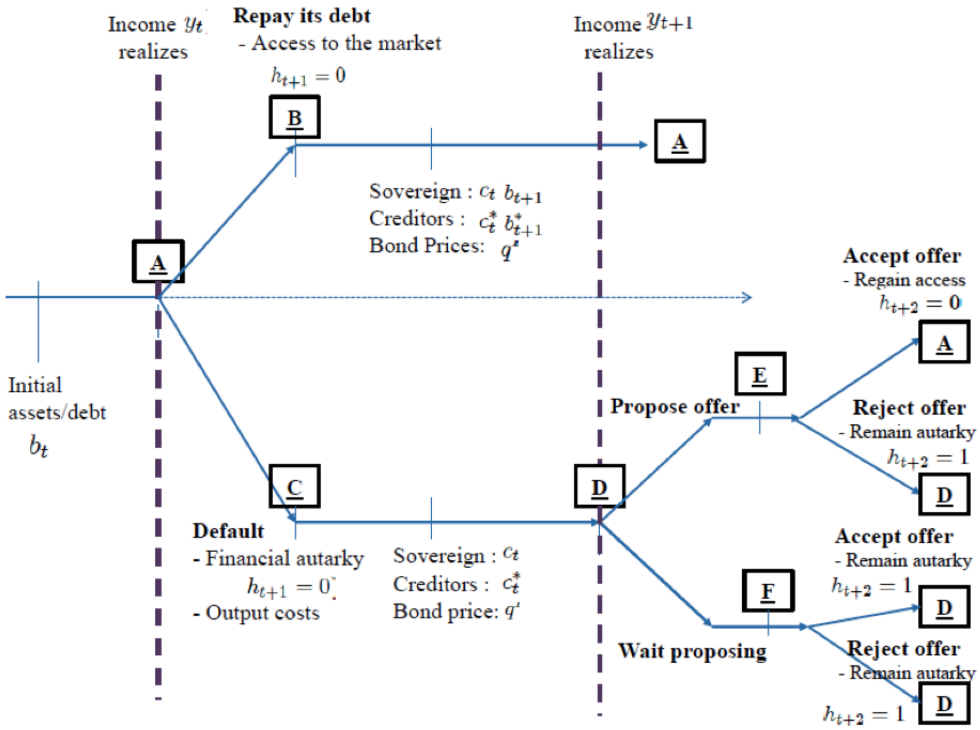


Figure 3.3: Timing of the model

period. On the contrary, if the other rejects the offer, the sovereign remains autarky ($h_{t+2} = 1$). We again move to node (D). The creditors choose next-period risk-free assets b^{*f}_{t+1}.

(b) In node (F) (wait node) if the proposer opts to wait proposing, the sovereign remains autarky ($h_{t+2} = 1$). The other party decides whether to accept or reject the offer. If the other accepts the offer, the sovereign remain autarky ($h_{t+2} = 1$). We again move to node (D). Similarly, if the other rejects the offer, the sovereign remains autarky ($h_{t+2} = 1$). We again move to node (D). The creditors choose next-period risk-free assets b^{*f}_{t+1}.

3.5 Recursive Equilibrium

In this section, we define the stationary recursive equilibrium of our model.

3.5.1 Sovereign's problem

The sovereign maximize its expected lifetime utility. It makes default/repayment decision and determines next-period assets (b_{t+1}), given its current asset position (b_t), credit history (h_t), and a vector of two income shocks ($y_t \equiv (y_t^h, y_t^f)$), and the value function is denoted by $V(b_t, b_t^{*f}, h_t, y_t)$. First, we start with its problem when the sovereign has a good credit record ($h_t = 0$). For $b_t \geq 0$ ($h_t = 0$), the sovereign has savings. The sovereign receives payments from its creditors and determines its next period assets/debt position b_{t+1} and consumption c_t given price of bond $q(b_{t+1}, b_{t+1}^{*f}, 0, y_t)$. Thus the value function is

$$V(b_t, b_t^{*f}, 0, y_t) = \max_{c_t, b_{t+1}} u(c_t) + \beta \int V(b_{t+1}, b_{t+1}^{*f}, 0, y_{t+1}) d\mu(y_{t+1}|y_t) \tag{3.3}$$

$$s.t. \quad c_t + q(b_{t+1}, b_{t+1}^{*f}, 0, y_t) b_{t+1} = y_t^h + b_t \tag{3.4}$$

For $b_t < 0$ ($h_t = 0$), the sovereign has debt. The sovereign has its option to default its debt. If the sovereign decides to pay its debt, its chooses its next-period asset/debt position b_{t+1} receives payments from its creditors and determines its next period assets/debt position and consumption c_t. If it chooses to default, it will be excluded from the international capital market and its credit record deteriorates to $h_{t+1} = 1$ with unpaid debt $(1+r_t^*)b_t$ next period where r_t^* is the world interest rate. Given an option to default,

$$V(b_t, b_t^{*f}, 0, y_t) = \max[V^R(b_t, b_t^{*f}, 0, y_t), V^D(b_t, b_t^{*f}, 0, y_t)] \tag{3.5}$$

where $V^R(b_t, b_t^{*f}, 0, y_t)$ is the value associated with paying debt:

$$V^R(b_t, b_t^{*f}, 0, y_t) = \max_{c_t, b_{t+1}} u(c_t) + \beta \int V(b_{t+1}, b_{t+1}^{*f}, 0, y_{t+1}) d\mu(y_{t+1}|y_t) \tag{3.6}$$

$$s.t. \quad c_t + q(b_{t+1}, b_{t+1}^{*f}, 0, y_t) b_{t+1} = y_t^h + b_t \tag{3.7}$$

and $V^D(b_t, b_t^{*f}, 0, y_t)$ is the value associated with default:

$$V^D(b_t, b_t^{*f}, 0, y_t) = u((1-\lambda_d)y_t^h) + \beta \int \Gamma((1+r_t^f)b_t, b_t^{*f}, y_{t+1})d\mu(y_{t+1}|y_t) \tag{3.8}$$

Next we consider the problem with $b_t < 0$ ($h_t = 1$) expressing that the country has unpaid debt appears and a bad credit record. The country is currently excluded from the international market, is suffering the output cost and may settle the defaulted debt through renegotiation with foreign investors. The renegotiation process is a dynamic game that may last more than one period. In equilibrium, this bargaining game pins down an endogenous recovery rate $\delta(b_t, b_t^{*f}, 0, y_t) \in [0, 1]$ and the length of financial autarky. The value of staying financial autarky and continuing renegotiation from period t, $V^D(b_t, b_t^{*f}, 0, y_t)$ is equal to the expected payoff that the borrower can get from the bargaining which starts from period t. We denote this payoff as

$$V^D(b_t, b_t^{*f}, 1, y_t) = \Gamma(b_t, b_t^{*f}, y_t) \tag{3.9}$$

The countrys default policy can be characterized by default sets $D(b_t, b_t^{*f})$, defined as the set of income shocks for y_t which default is optimal given the sovereigns debt b_t, the creditors risk-free assets b_t^{*f} and good credit history ($h_t = 0$).

$$D(b_t, b_t^{*f}) = \left\{ y_t \in A : V^R(b_t, b_t^{*f}, 1, y_t) < V^D(b_t, b_t^{*f}, 1, y_t) \right\} \tag{3.10}$$

3.5.2 Foreign Creditors' Problem

If the countrys credit record is good ($h_t = 0$), foreign investor optimally chooses its consumption c_t^*, sovereign bonds b_{t+1}^* and risk-free assets saving b_{t+1}^{*f}. The value function of foreign investor is

$$V^*(b_t, b_t^{*f}, 1, y_t) = 1_{Non-Default} V^{*R}(b_t, b_t^{*f}, 1, y_t) + (1 - 1_{Non-Default}) V^{*D}(b_t, b_t^{*f}, 1, y_t) \tag{3.11}$$

where $1_{Non-Default}$ is indicator function showing 1 if sovereign does not default and 0 otherwise and $V^{*R}(b_t, b_t^{*f}, 0, y_t)$ is the value when sovereign opts to repay its debt

$$V^{*R}(b_t, b_t^{*f}, 0, y_t) = \max_{c_t^*, b_{t+1}^*, b_{t+1}^{*f}} u(c_t^*) + \beta^* \int V^*(b_{t+1}, b_{t+1}^{*f}, 0, y_{t+1}) d\mu(y_{t+1}|y_t) \tag{3.12}$$

$$s.t. \quad c_t + q(b_{t+1}, b_{t+1}^{*f}, 0, y_t) b_{t+1}^* + q^f(b_{t+1}, b_{t+1}^{*f}, 0, y_t) b_{t+1}^{*f} = y_t^h + b_t^* + b_t^{*f} \tag{3.13}$$

$V^{*D}(b_t, b_t^{*f}, 0, y_t)$ is the value when sovereign decides to default

$$V^{*D}(b_t, b_t^{*f}, 0, y_t) = \max_{c_t^*, b_{t+1}^{*f}} u(c_t^*) + \beta^* \int V^*((1 + r_t^*) b_t, b_{t+1}^{*f}, 1, y_{t+1}) d\mu(y_{t+1}|y_t) \tag{3.14}$$

$$s.t. \quad c_t + q^f(b_{t+1}, b_{t+1}^{*f}, 0, y_t) b_{t+1}^{*f} = y_t^h + b_t^{*f} \tag{3.15}$$

Given the expected default choice of sovereign and expected recovery rates, we obtain the following bond price functions.

$$q(b_{t+1}, b_{t+1}^{*f}, 0, y_t) = \beta^* \int \frac{u'(c_{t+1}^*)}{u'(c_t^*)} \left[\begin{array}{l} 1_{Non-Default} + \\ (1 - 1_{Non-Default}) \gamma(b_{t+1}, b_{t+1}^{*f}, y_{t+1}) \end{array} \right] d\mu(y_{t+1}|y_t) \tag{3.16}$$

$$q^f(b_{t+1}, b_{t+1}^{*f}, 0, y_t) = \beta^* \int \frac{u'(c_{t+1}^*)}{u'(c_t^*)} d\mu(y_{t+1}|y_t) \tag{3.17}$$

where $\gamma(b_{t+1}, b_{t+1}^{*f}, y_{t+1})$is the expected recovery rates at time $t+1$ conditional on sovereigns default.

If the countrys credit record is bad ($h_t = 1$), the value function of foreign investor is

$$V_L(b_t, b_t^{*f}, 1, y_t) = \Gamma^*(b_t, b_t^{*f}, y_t) \tag{3.18}$$

Bond price function for risk-free asset for creditor is the same;

$$q^f(b_{t+1}, b_{t+1}^{*f}, 1, y_t) = \beta^* \int \frac{u^{'}(c_{t+1}^*)}{u^{'}(c_t^*)} d\mu(y_{t+1}|y_t) \tag{3.19}$$

3.5.3 Renegotiation Game

As in Bi (2008), we model the debt renegotiation problem as a two-player stochastic bargaining game with complete information based on Merlo and Wilson (1995). This is a stochastic bargaining game in that both the endowment process and the identity of the proposer are stochastic. In each period, a state is realized and the proposer is randomly selected. For simplicity, we assume that each player has a constant probability of being selected as proposer in each period. That is, the identity of the proposer is independent of a vector of income shock. Let ϕ denote the probability that the borrower, B, can propose in a period, and $(1 - \phi)$ is the probability that the lender, L, proposes in each period. The frequency with which a player is selected as proposer is a parsimonious way to capture the bargaining power acquired through ones ability to enjoy the first-mover advantage. The proposer may either propose a debt recovery rate or pass. If she proposes, then the remaining party chooses to accept or to reject the proposal. If the proposal is accepted, then the defaulting country immediately repays its reduced debt arrears, and then enters the next period with an upgraded credit standing of $h_{t+1} = 0$ without any outstanding debt. If the proposal is rejected, a new output state is realized and the game repeats until an agreement is reached. In the case that the proposer chooses to pass, both players enter the next period and continue the game. We now define some basic concepts of the game. A stochastic bargaining game may be indexed by (C, β_B, β_L), where for each endowment state vector $y \in Y$, $C(y)$ is the set of feasible utility vectors that may be agreed upon in that state. β_B

and β_L are the discount factors for B and L, respectively[10]. A payoff function is an element $\Delta(y) \in C(y)$, where $\Delta_i(y)$ is the utility to player i, $i = B, L$. As in Merlo and Wilson (1995), we focus on a game with stationary strategies, that is, the players actions depend only on the current state and the current offer. In equilibrium, the proposers strategy is to propose when the proposal would be accepted for sure and to pass otherwise. The other player acts passively: she accepts when a proposal is made and waits if the proposer passes. Therefore, we can denote the proposer is equilibrium strategy as a simple stopping function τ, τ^* with $\tau = 0$ when i proposes and $\tau = 1$ when i passes; the other player accepts or waits accordingly. A stationary subgame perfect (SSP) equilibrium is then defined as the players equilibrium stationary strategies B and L, and the payoff functions, Γ and Γ^*, associated with these strategies for player B and L.

We then proceed to characterize the SSP strategies and payoffs. The expected payoff for the borrower B and lender L in period t, shown as:

$$\Gamma(b_t, b_t^{*f}, y_t) = \phi\Gamma^B(b_t, b_t^{*f}, y_t) + (1-\phi)\Gamma^L(b_t, b_t^{*f}, y_t) \tag{3.20}$$

$$\Gamma^*(b_t, b_t^{*f}, y_t) = \phi\Gamma^{*B}(b_t, b_t^{*f}, y_t) + (1-\phi)\Gamma^{*L}(b_t, b_t^{*f}, y_t) \tag{3.21}$$

Here the superscript denotes the identity of the proposer. So Γ^B represents the borrowers payoff when the borrower himself is the proposer, and Γ^L refers to the borrowers payoff when the lender is the proposer. Similarly, Γ^{*B} denotes the lenders payoff when the borrower proposes, and Γ^{*L} shows the lenders payoff when the lender itself is the proposer.

First consider the case when the borrower B is the proposer. We refer the proposed debt recovery rate as δ_t^B and the value of proposing as V_B^{PRO} . When B proposes and the proposal is accepted, the sovereign repays the agreed amount of debt, $\delta_t^B b_t$, immediately

[10]Merlo and Wilson (1995) assume that the players have the same discount factor. But they also mention that there is no real restriction implied by the assumption that players discount utility at a common constant rate. So long as the discounted size of the cake converges uniformly to 0. player dependent discount factors can always be represented by a different cake process with a common fixed discount factor. So in our model we allow the borrower and the lender to have different discount factors .

and enters the next period with a good credit standing and no outstanding debt. Thus, V_B^{PRO} is given by

$$V^{PRO}(b_t, b_t^{*f}, y_t) = u((1-\lambda_d)y_t^h + \delta_t^B b_t) + \beta \int V(b_{t+1}, b_{t+1}^{*f}, 0, y_{t+1}) d\mu(y_{t+1}|y_t) \quad (3.22)$$

$$V^{*ACT}(b_t, b_t^{*f}, y_t) = \max_{c_t^*, b_{t+1}^*} u(c_t^L) + \beta \int V(0, b_{t+1}^{*f}, 0, y_{t+1}) d\mu(y_{t+1}|y_t) \quad (3.23)$$

$$s.t. \quad c_t^L - q^f(b_{t+1}, b_{t+1}^{*f}, 0, y_t) b_{t+1}^{*f} = y_t^h - \delta_t^B b_t - b_t^{*f} \quad (3.24)$$

When B proposes to pass

$$V^{PASS}(b_t, b_t^{*f}, y_t) = u((1-\lambda_d)y_t^h) + \beta \int V((1+r_t^*)b_t, b_{t+1}^{*f}, y_{t+1}) d\mu(y_{t+1}|y_t) \quad (3.25)$$

$$V^{*REJ}(b_t, b_t^{*f}, y_t) = \max_{c_t^*, b_{t+1}^{*f}} u(c_t^L) + \beta \int \Gamma^*((1+r_t^*)b_t, b_{t+1}^{*f}, y_{t+1}) d\mu(y_{t+1}|y_t) \quad (3.26)$$

$$s.t. \quad c_t^L - q^f(b_{t+1}, b_{t+1}^{*f}, 0, y_t) b_{t+1}^{*f} = y_t^h - b_t^{*f} \quad (3.27)$$

In equilibrium,

$$\delta_t^{B*} = argmax V_B^{PRO}(b_t, b_t^{*f}, y_t) \quad (3.28)$$

$$V^{PRO}(b_t, b_t^{*f}, y_t) \geq V^{PASS}(b_t, b_t^{*f}, y_t) \quad (3.29)$$

$$V^{*ACT}(b_t, b_t^{*f}, y_t) \geq V^{*REJ}(b_t, b_t^{*f}, y_t) \quad (3.30)$$

Two parties payoff if $\delta_t^{B*}(b_t, b_t^{*f}, y_t)$ exists,

$$\Gamma(b_t, b_t^{*f}, y_t) = V^{PRO}(b_t, b_t^{*f}, y_t) \quad (3.31)$$

$$\Gamma^*(b_t, b_t^{*f}, y_t) = V^{*ACT}(b_t, b_t^{*f}, y_t) \tag{3.32}$$

Otherwise,

$$\Gamma(b_t, b_t^{*f}, y_t) = V^{PASS}(b_t, b_t^{*f}, y_t) \tag{3.33}$$

$$\Gamma^*(b_t, b_t^{*f}, y_t) = V^{*REJ}(b_t, b_t^{*f}, y_t) \tag{3.34}$$

The renegotiation settlement can be characterized by settlement sets $R^B(b_t, b_t^{*f})$, defined as the set of income shocks for y_t which both parties agree on renegotiation when the borrower is the proposer given the sovereigns debt b_t^B, the creditors debt b_t^L.

$$R^B(b_t, b_t^{*f}) = \left\{ \begin{array}{l} y_t \in Y : V^{PRO}(b_t, b_t^{*f}, y_t) \geq V^{PASS}(b_t, b_t^{*f}, y_t) \\ V^{ACT}(b_t, b_t^{*f}, y_t) \geq V^{REJ}(b_t, b_t^{*f}, y_t) \end{array} \right\}. \tag{3.35}$$

Similar, the lender is a proposer and we refer the proposed debt recovery rate as δ_t^L and the value of proposing as V^{*PRO}

$$V^{*PRO}(b_t, b_t^{*f}, y_t) = \max_{c_t^*, b_{t+1}^*} u(c_t) + \beta \int V(0, b_{t+1}^{*f}, 0, y_{t+1}) d\mu(y_{t+1}|y_t) \tag{3.36}$$

$$s.t. \quad c_t^* - q^f(b_{t+1}, b_{t+1}^{*f}, 0, y_t) b_{t+1}^{*f} = y_t^h - \delta_t^L b_t - b_t^{*f} \tag{3.37}$$

$$V^{ACT}(b_t, b_t^{*f}, y_t) = u((1-\lambda_d) y_t^h + \delta_t^L b_t) + \beta \int V(0, b_{t+1}^{*f}, 0, y_{t+1}) d\mu(y_{t+1}|y_t) \tag{3.38}$$

When B proposes to pass

$$V^{*PASS}(b_t, b_t^{*f}, y_t) = \max_{c_t^*, b_{t+1}^{*f}} u(c_t) + \beta \int \Gamma^*((1+r_t^*) b_t, b_{t+1}^{*f}, y_{t+1}) d\mu(y_{t+1}|y_t) \tag{3.39}$$

$$s.t. \quad c_t^L - q^f(b_{t+1}, b_{t+1}^{*f}, 0, y_t)b_{t+1}^{*f} = y_t^h - b_t^{*f} \tag{3.40}$$

$$V^{REJ}(b_t, b_t^{*f}, y_t) = u((1-\lambda_d)y_t^h) + \beta \int \Gamma((1+r_t^*), b_{t+1}^{*f}, y_{t+1})d\mu(y_{t+1}|y_t) \tag{3.41}$$

In equilibrium, In equilibrium,

$$\delta_t^{L*} = argmax V_L^{PRO}(b_t, b_t^{*f}, y_t) \tag{3.42}$$

$$V^{PRO}(b_t, b_t^{*f}, y_t) \geq V^{PASS}(b_t, b_t^{*f}, y_t) \tag{3.43}$$

$$V^{*ACT}(b_t, b_t^{*f}, y_t) \geq V^{*REJ}(b_t, b_t^{*f}, y_t) \tag{3.44}$$

Two parties payoff if $\delta_t^{L*}(b_t^B, b_t^L, y_t)$ exists,

$$\Gamma^*(b_t, b_t^{*f}, y_t) = V^{*PRO}(b_t, b_t^{*f}, y_t) \tag{3.45}$$

$$\Gamma(b_t, b_t^{*f}, y_t) = V^{ACT}(b_t, b_t^{*f}, y_t) \tag{3.46}$$

Otherwise,

$$\Gamma^*(b_t, b_t^{*f}, y_t) = V^{*PASS}(b_t, b_t^{*f}, y_t) \tag{3.47}$$

$$\Gamma(b_t, b_t^{*f}, y_t) = V^{REJ}(b_t, b_t^{*f}, y_t) \tag{3.48}$$

The renegotiation settlement can be characterized by settlement sets $R^L(b_t^B, b_t^L)$, defined as the set of income shocks for y_t which both parties agree on renegotiation when the borrower is the proposer given the sovereigns debt b_t^B, the creditors debt b_t^L.

$$R^L(b_t, b_t^{*f}) = \left\{ \begin{array}{l} y_t \in Y : V^{*PRO}(b_t, b_t^{*f}, y_t) \geq V^{*PASS}(b_t, b_t^{*f}, y_t) \\ V^{*ACT}(b_t, b_t^{*f}, y_t) \geq V^{*REJ}(b_t, b_t^{*f}, y_t) \end{array} \right\}. \tag{3.49}$$

3.5.4 Market Clearing Conditions

Goods - Repayment

$$c_t + c_t^* = y_t^h + y_t^f \tag{3.50}$$

Goods - Default

$$c_t = (1 - \delta_d)y_t^h, c_t^* = y_t^f \tag{3.51}$$

Bonds

$$\pi b_t + (1 - \pi)b_t^* = 0 \tag{3.52}$$

3.5.5 Equilibrium

Definition 3.5.1. A recursive equilibrium is defined as by a set of (A) sovereigns value function $V(b_t, b_t^{*f}, h_t, y_t)$, consumption $c_t(b_t, b_t^{*f}, h_t, y_t)$, asset position $b_{t+1}(b_t, b_t^{*f}, h_t, y_t)$, default set $D(b_t, h_t)$; (B) investors consumption $c_t^*(b_t, b_t^{*f}, h_t, y_t)$, asset position $b_{t+1}^*(b_t, b_t^{*f}, h_t, y_t)$, (C) the sovereigns and creditors decision function $\tau(b_t, b_t^{*f}, y_t)$ and $\tau^*(b_t, b_t^{*f}, y_t)$, recovery rates $\delta_t^B(b_t, b_t^{*f}, h_t, y_t)$ and $\delta_t^L(b_t, b_t^{*f}, h_t, y_t)$, and the payoffs $\Gamma(b_t, b_t^{*f}, y_t)$ and $\Gamma^*(b_t, b_t^{*f}, y_t)$ (D) bond price functions $q(b_t, b_t^{*f}, 0, y_t)$ and $q^f(b_t, b_t^{*f}, h_t, y_t)$ such that:

[1]. Given the price function and the renegotiation outcomes, the sovereigns consumption, asset position, and default set satisfy the sovereigns optimization problem.

[2]. Given the price function and the debt renegotiation outcomes, the investors consumption and asset position satisfy the creditors optimization problem.

[3]. Given the bond price function, the debt recovery rates and the strategies of both players solve the post-default renegotiation problem.

[4]. Market clearing conditions for bonds and goods are satisfied.

In equilibrium, default probabilities$p^*(b_{t+1}, b_{t+1}^{*f}, 0, y_t)$ is defined by using the sovereign's default decision;

$$p^D(b_{t+1}, b^{*f}_{t+1}, 0, y_t) = \int_{D^*(b_{t+1}, b^{*f}_{t+1})} d\mu(y_{t+1}|y_t), \tag{3.53}$$

Similarly, probability of settling renegotiation is defined by using two settlement sets:

$$p^R(b_{t+1}, b^{*f}_{t+1}, y_t) = \phi \int_{R^{B*}(b_{t+1}, b^{*f}_{t+1})} d\mu(y_{t+1}|y_t) + (1-\phi) \int_{R^{L*}(b_{t+1}, b^{*f}_{t+1})} d\mu(y_{t+1}|y_t), \tag{3.54}$$

Expected recovery rates conditional on default choice,

$$\gamma(b_{t+1}, b^{*f}_{t+1}, y_{t+1}) = \left[\begin{array}{c} \phi 1_{y_{t+1} \in R^B(b_{t+1}, b^{*f}_{t+1})} \delta^{B*}_t(b_{t+1}, b^{*f}_{t+1}, y_{t+1}) \\ +(1-\phi) 1_{y_{t+1} \in R^L(b_{t+1}, b^{*f}_{t+1})} \delta^{B*}_t(b_{t+1}, b^{*f}_{t+1}, y_{t+1}) \end{array} \right]$$

$$+ \left(\begin{array}{c} \phi 1_{y_{t+1} \in R^B(b_{t+1}, b^{*f}_{t+1})} \\ +(1-\phi) 1_{y_{t+1} \in R^L(b_{t+1}, b^{*f}_{t+1})} \end{array} \right) \int_Y \beta^* \frac{u(c^*_{t+2})}{u^*(c_{t+1})} \gamma((r+r^*_{t+1})b_{t+1}, b^{*f}_{t+2}, y_{t+2}) d\mu(y_{t+2}|y_{t+1}) \tag{3.55}$$

Risk-free interest rate is defined as

$$1 + r^*(b_{t+1}, b^{*f}_{t+1}, h_t, y_t) = \frac{1}{q^f(b_{t+1}, b^{*f}_{t+1}, h_t, y_t)} \tag{3.56}$$

Spreads for sovereign bonds is defined as follow:

$$s(b_{t+1}, b^{*f}_{t+1}, h_t, y_t) = \frac{1}{q(b_{t+1}, b^{*f}_{t+1}, 0, y_t)} - 1 - r^*(b_{t+1}, b^{*f}_{t+1}, 0, y_t) \tag{3.57}$$

3.6 Qunatitative Analysis

This section provides quantitative analysis of model. Our major findings can be summarized as follows. First, at the steady state distribution, we show that there exist region of passing offer in the state of both sovereign and the creditors income process. Delay in debt restructuring, i.e., passing proposing . Second, our simulation exercise uses Argentine default in 2001 and replicates both business cycle, non-business cycle regularities, and delay in debt restructurings.

3.6.1 Parameters and Functional Forms

We use most of the parameters and functional forms speci.ed in previous work. There is only one new element in the model associated with a two-country set-up: (i) relative size of the sovereign. The following constant relative risk averse (CRRA) utility functions are used in numerical simulation:

$$u(c_t) = \frac{c_t^{1-\sigma}}{1-\sigma}, u(c_t^*) = \frac{c_t^{*1-\sigma}}{1-\sigma} \tag{3.58}$$

where σ expresses degree of risk aversion. We set σ equal to 2, which is commonly used in real business cycle analysis for advanced economy and emerging markets. The creditors discount factor is set to $\delta^f = 0.98$ to replicate the risk-free interest rate of 1.7%. Output loss parameter λ_d is assumed to be 2% following Sturzenegger (2004)'s estimates.

The endowment processes are calibrated to match Argentine and the US quarterly GDP over 1980Q3-2013Q3 from the Ministry of Finance of Argentina (MECON) and over 1970Q2-2015Q1 from the US Bureau of Economic Analysis (BEA). We assume each exogenous process stream y_t^i for $i = h, f$ follows a log normal AR(1) process.

$$log(g_t) = log(\mu^i) + \rho_g^i(log(g_{t-1}^i) - log(\mu^i)) + \epsilon_g^i \tag{3.59}$$

where growth rate $g_t^i = \frac{y_t}{y_{t-1}}$ and growth shock ϵ_g^i is $i.i.d$ $N(0, \sigma_t^{i^2})$, and $log(\mu^i)$ is the expected log gross growth rate of the borrowers and lenders endowment. Each shock is then discretized into a finite state Markov chain by using a quadrature procedure in Hussey and Tauchen (1991) from their joint distribution. We obtain estimated auto-coefficients such as $\rho^h = 0.26$ for Argentina and $\rho^f = 0.87$ for the US.

Parameter	Value	Sources
Risk aversion	$\sigma = 2$	RBC Literature
Output cost	$\lambda_d = 0.02$	Sturzenegger (2004)
Bargaining power	$\phi = 0.5$	Computed
Discount factor (creditor)	$\beta^f = 0.98$	Computed
Autoreg. of income (creditor)	$\rho^f = 0.87$	Computed-US BEA
Autoreg. of income growth (creditor)	$\mu^f = 0.0069$	Computed-US BEA
S.D of income growth shock (creditor)	$\epsilon^f = 0.0154$	Computed-US BEA
Autoreg. of income (sovereign)	$\rho^h = 0.26$	Computed-MECON
Autoreg. of income growth (sovereign)	$\mu^h = 0.0067$	Computed-MECON
S.D of income growth shock (sovereign)	$\epsilon^h = 0.0561$	Computed-MECON
Relative size of sovereign	$\pi = 0.025$	IMF-WEO
Discount rate (sovereign)	$\beta = 0.85$	Computed

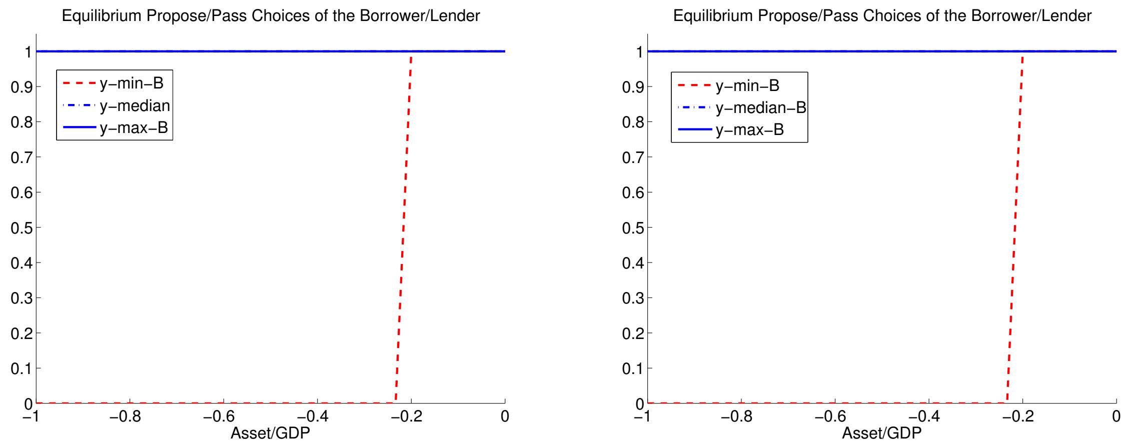
Table 3.4: Model parameters

For remaining country-specific parameters, size of the sovereign relative to that of the creditors is set to 0.025 to re.ect the ratio of US dollar GDP of Argentina to that of the US over 1993-2012. Sturzenegger and Zettelmeyer (2006) report that Argentina experienced 6 defaults in 1820-2004. We specify the sovereigns discount factor β^h=0.85 and bargaining power $\phi = 0.5$ (Argentina) to replicate the average annual default frequency of 3.26% and a recovery rate of 25.0% (Argentina 2001-5 restructuring). Table 3 summarizes the model parameters.

3.6.2 Numerical Results on Equilibrium Properties

In this subsection, we report the equilibrium properties of the model. We first present in Figure 3.5 the equilibrium propose/pass choices made for borrwer's income state and defaulted debt-to-mean output ratio. On the vertical axes, "Propose" (equivalent to 1) represents the case that a proposal is made and accepted, i.e., an agreement is reached. "Pass" equivalent to 0, on the contrary, implies waiting and hence one period of delay.

As in Bi (2008), the two panel charts in Figure 3.5 are identical, meaning that for a given endowment of borrower and a defaulted debt-to-mean output ratio, the borrower and the lender would make the same propose/pass choice no matter who is selected as proposer.



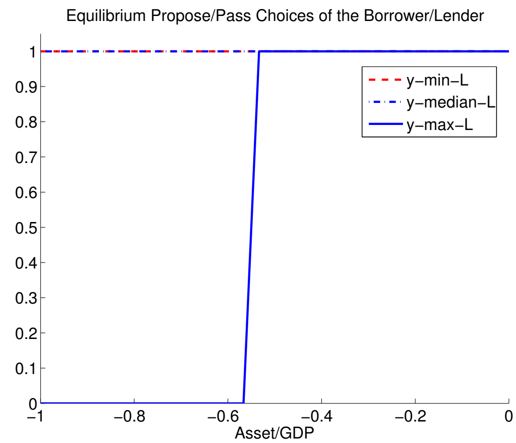
(a) Borrowers decision (b) Lenders decision

Figure 3.4: Decision of proposing offer and passing given borrowers income

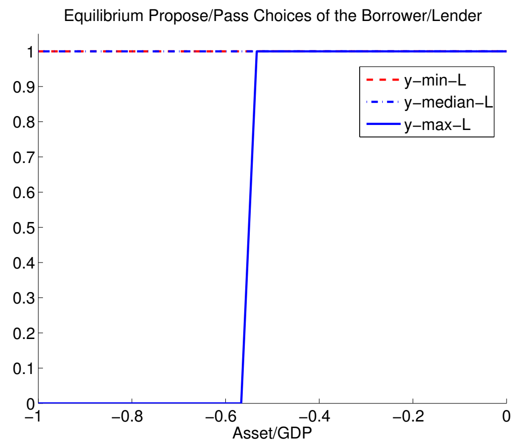
Proposers always opt to propose when income is high, while they prefer to pass at some debt level (above 95 percent of GDP) when income is low.

On the contrary, Figure 3.6 displays the equilibrium propose/pass choices made for lenders income state and defaulted debt-to-mean output ratio. Proposers always opt to propose when creditors income is low, while they prefer to pass at some debt level (above 75 percent of GDP) when creditors income is high. When the creditors are facing low income shock, they are facing limited liquidity and willing to settle the debt renegotiation to receive recovered debt payment in current period. On the contrary, when creditors income is high, they are having enough liquidity and willing to postpone the debt restructuring anticipating higher payments upon borrowers high income realization in future.

We now plot the equilibrium debt recovery rates agreed at each state (Figure 3.7 and 3.8). In this figure, a zero debt recovery rate implies that the proposer chooses to pass" in the particular state. In general, the debt recovery rates agreed by both parties are decreasing respect to level of debt and increasing respect to borrowers income as documented in Benjamin and Wright (2009), Bi (2008), Yue (2010) and Asonuma (2012). On the contrary, recovery rates do not vary much depending on creditors income process. Creditors income influence significantly on settlement of debt restructurings, but not much on recovery



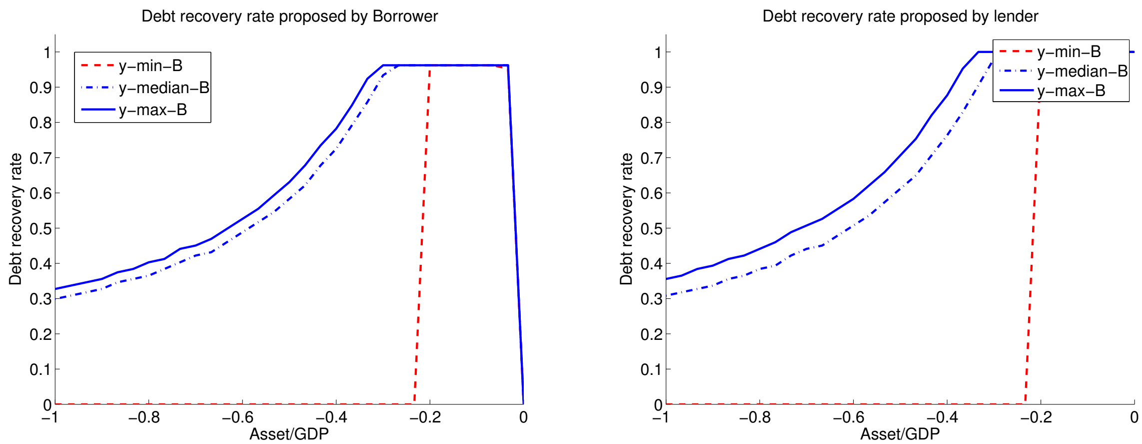
(a) Borrowers decision



(b) Lenders decision

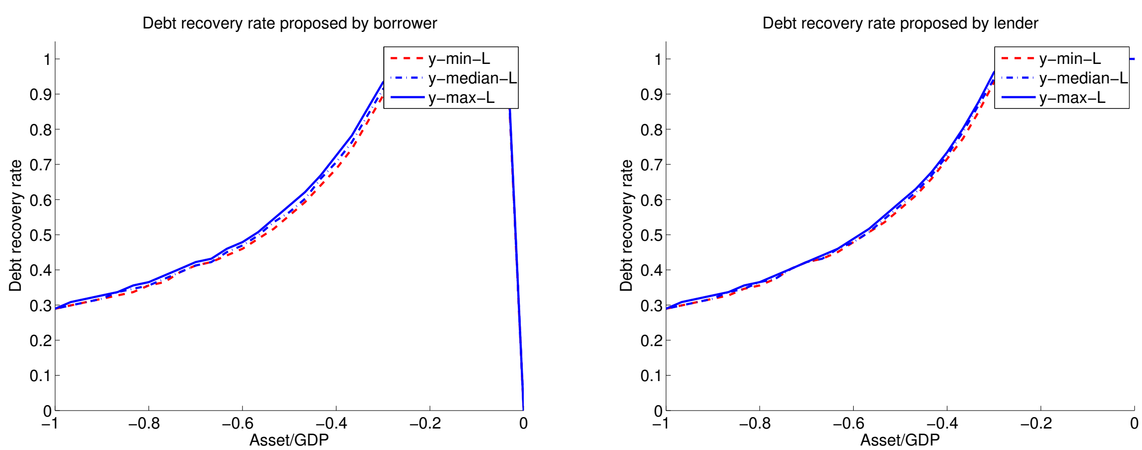
Figure 3.5: Decision of proposing offer and passing given lenders income

rates at restructurings as they are technically recipients of payments, not payers.



(a) Borrowers decision (b) Lenders decision

Figure 3.6: Recovery Rates Agreed with respect to borrower's income



(a) Borrowers decision (b) Lenders decision

Figure 3.7: Recovery Rates Agreed with respect to lender's income

3.7 Conclusion

Creditor's income affects the outcomes of debt renegotiation. Empirical analysis reveals that high (low) creditors' income results in longer (shorter) restructuring duration and smaller (larger) haircuts. Quantitative analysis explains these stylized facts within the dynamic stochastic general equilibrium model with risk averse investor and multi-period bargaining framework. Creditors with high income, being more patient, postpone the negotiations and demand higher recovery rates (lower haircuts) since their outside option with not proposing an offer remains high.

Bibliography

[1] Aguiar, M., Gopinath, G., 2006, “Defaultable debt, interest rates and the current account,” *Journal of International Economics*, Vol.69, pp.64-83.

[2] Arellano, C., 2008, “Default risk and income fluctuations in emerging economies,”

[3] Asonuma, T., 2012, “Serial Default and Debt Renegotiation,” forthcoming as IMF Working Paper.

[4] Asonuma, T., 2012, ”Sovereign Defaults, External Debt, and Real Exchange Rate Dynamics,” forthcoming as IMF Working Paper.

[5] Asonuma, T., and C. Trebesch, 2014 “Sovereign Debt Restructuring: Pre-emptive and Post Default ,” manuscript, IMF.

[6] Bai, Y., and J, Zhang., 2012, “Duration of Sovereign Debt Renegotiatio,” *Journal of International Economics*, Vol.86(1), pp.252-268.

[7] Benjamin, D., and M, Wright., 2008, “Recovery Before Redemption? A Theory of Delays in Sovereign Debt Renegotiation,” Manuscript, UCLA.

[8] Bi, R., 2008, “Beneficial Delay in Debt Restructuring Negotiation,”IMF working paper No. WP/08/38, International Monetary Fund.

[9] Borri, N, and A. Verdelhan, 2012, “Sovereign Risk Premia,” Working Paper, MIT Sloan.

[10] Cruces, J., and Trebesch, C., 2011, “Sovereign Defaults: The Price of Haircuts,” *American Economic Journal: Macroeconomics,* 2013, 5(3), pp. 85117.

[11] Das, U., Papaioannou, M., and C. Trebesch, 2012, “Sovereign Debt Restructuring 1950-2010: Literature Survey, Data and Stylized Facts,” IMF Working Paper 12/203

[12] D'Erasmo, P., 2011, "Government Reputation and Debt Repayment in Emerging Economies," manuscript, University of Maryland.

[13] Diaz-Cassou, J., Erce-Dominquez., and J. Vazquez-Zamora, 2008, "The Role of the IMF in Recent Sovereign Debt Restructurings: Implications for the Policy of Lending into Arrears," Occasional Paper, Banco de Espana.

[14] Eaton, J., Gersovitz, M., 1981, "Debt with potential repudiation: theoretic and empirical analysis," *Review of Economic Studies*, 48, pp.289-309.

[15] Finger H., and M. Mecagni, 2007,"Sovereign Debt Restructuring and Debt Sustainability An Analysis of Recent Cross-Country Experience," IMF Occasional Paper No. 255.

[16] Gelos, R.G., Sahay, R., and G. Sandleris, 2011, "Sovereign Borrowing by Developing Countries: What Determines Market Access?," *Journal of Economic Development*, Vol.83, pp.243-254.

[17] Gilchrist, S., Yue, V. and E. Zakrajsek, 2013, "Sovereign Risk and Financial Risk," Working Paper, Boston University.

[18] Gilchrist, S., Yue, V. and E. Zakrajsek, 2014, "US Monetary Policy and Foreign Bonds Yields," Working Paper, Boston University.

[19] Hatchondo, J., Martinez, L., and C. S. Padilla, 2014, "Voluntary Sovereign Debt Exchanges," *Journal of Monetary Economics*,Vol(61), pp 32-50

[20] Kohlscheen, E., 2009, "Sovereign Risk: Constitutions Rule," *Oxford Economic Papers*, Vol. 62(1) pp. 62-85

[21] Kovrijnykh, N., and B. Szentes, 2007, "Equilibrium Default Cycles," *Journal of Political Economics*, Vol.93(3), pp. 621-639

[22] Lizarazo,. S, 2013 "Default Risk and Risk Averse International Investors," *Journal of International Economics*, Volume 89, Issue 2, 317-330

[23] Panizza, U., Sturzenegger, F,. and J. Zettelmeyer, 2009, “ The Economics and Law of Sovereign Debt and Default,” *Journal of Economic Literature*, Vol. 47(3), pp 651-698.

[24] Pitchford, R., and M. Wright, 2007, “Restructuring the Sovereign Debt Restructuring Mechanism,” *Journal of Monetary Economics*, UCLA Working paper.

[25] Pouzo, D., and I. Presno, 2012, “Sovereign Default Risk and Uncertainty Premia,” Working Paper, Federal Reserve Bank of Boston.

[26] Trebesch, C., 2010 “Delay in Sovereign Debt Restructurings,”manuscript, Free University of Berlin.

[27] Sturzenegger, F., and J. Zettelmeyer, 2008, “Haircuts: Estimating Investors Losses in Sovereign Debt Restructurings, 1998-2005,” Journal of International Money and Finance Vol. 27(5), pp.780-805

[28] Yue, V., 2010, “Sovereign Default and Debt Renegotiation,” *Journal of International Economics*, Vol.80(2), pp.176-187.

Curriculum Vitae

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