Essays on Emerging Market Business Cycles

by

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Chapter 1

Introduction

1.1 Financial liberalization and vulnerability to external shocks

In recent years, financial crises originating in emerging market economies (hereafter, EMEs) have shaken the global economy; financial crises were observed in Latin America in 1982, in Mexico from 1994 to 1995, in the Asian financial crisis countries from 1997 to 1998, in Russia in 1998, in Brazil from 1998 to 1999 and from 2001 to 2002, in Turkey from 2001 to 2002, and in Argentina from 2001 to 2002. Such crises in EMEs have occurred since the 1980s when EMEs dramatically increased international capital transactions following international financial integration policy. In general, financial liberalization enables free capital transactions across borders and brings various benefits to EMEs. For example, countries with little domestic capital can achieve high economic growth by financing domestic investment from abroad. In addition, foreign capital transactions can also stabilize the economy by smoothing out consumption fluctuations caused by country-specific shocks. However, financial liberalization also has the adverse effect of making countries more vulnerable to external shocks.

Learning from past crises, EMEs and international economic institutions, such as the International Monetary Fund (IMF), the World Bank, and the Bank for International Settlements (BIS), have taken many steps to reduce their vulnerability to crises since the onset of financial crises. However, there are growing concerns about economic and financial crises in EMEs. The recent concern is the possibility of a debt crisis in EMEs due to the end of the low-interest rate policy in the U.S. since the global financial crisis and the fiscal deficits in EMEs accumulated during the COVID-19 pandemic. Natural but crucial questions are: Why does the EMEs' debt crisis occur, even if the EMEs have implemented policies to mitigate the vulnerability to external crisis? What is the potential cost of financial integration to the EMEs?

As the first step to answer these questions, this dissertation analyzes financial integration in EMEs and the effects on business cycles in EMEs. Specifically, we focus on how financial integration changes the impact of the world real interest rate shock, one of the most influential global shocks, on the EMEs' business cycles.

The remainder of this chapter is organized as follows. Section 1.2 reviews the related literature. Section 1.3 describes the structure of the dissertation.

1.2 Literature review

1.2.1 Definition and measurement of FI

Financial integration and financial liberalization There is no well-established definition of "financial integration" (hereafter, FI) (Rillo, 2018). We follow the view of Ho (2009): "Financial integration is the process through which financial markets in an economy become more closely integrated with those in other economies or with those in the rest of the world." "Financial liberalization" and "financial globalization" are referred to as the trend marked by the growing integration of capital markets and international financial transactions, according to Rillo (2018) and Ferrari Filho and Terra (2022).

We use the FI to reflect not only the abolition of regulation led by policy agencies but also various initiatives by private sectors. FI can be advanced through formal and informal ways (Ho, 2009). The formal way includes the eliminating restrictions on international financial transactions and multilateral policy coordination in response to financial instability. The informal way includes information sharing across borders, foreign investors' participation in domestic production, and innovation of financial services such as derivatives (Ho, 2009; Ferrari Filho and Terra, 2022). In Chapter 3, our model considers that the FI lowers the borrowing limit imposed by foreign lenders, especially through international information sharing.

Measurement of financial integration There are two major measurements of the degree of FI: *de facto* and *de jure* measures (Prasad et al., 2003a). The most common *de jure* measure is based on the Annual Report on Exchange Agreements and Exchange Restrictions (AREAER), published annually by the IMF. The AREAER includes various regulations on foreign exchange systems, international capital transactions, and international trades reported by public authorities in the member countries. The *de facto* measure captures the actual volume of international capital transactions, often called financial openness.[1]

Currently, there is no indicator that accurately measures the degree of FI in each country. On the one hand, the *de jure* measure exhibits only the existence of the regulation but cannot measure its strength. On the other hand, the *de facto* measure cannot account for the degree of free international capital transactions because the

[1] *De facto* measure also captures the degree of covered interest parity (CIP) condition holds. This measure is based on the fact that under free capital mobility, the CIP will hold. We use the actual volume of international capital transactions as the measurement of FI because our motivating fact, the ECV puzzle, introduced later, is based on the measurement.

number or strength of regulation does not necessarily correlate with the volume of external capital flows particularly in EMEs. According to Kose and Prasad (2012), Latin American countries imposed many capital controls during the crisis of the 1970s and 1980s, but they failed to prevent large capital outflows, resulting in a sharp increase in the gross capital flows to GDP ratio. Meanwhile, many African developing countries have no significant capital controls, yet their international capital transaction volumes are still low.

1.2.2 Economic stability and FI

Theoretical and empirical studies have reached no consensus on whether the FI stabilizes the economy. The standard neoclassical macroeconomic model predicts that the FI can contribute to the country's economic stability. Mendoza (1991) and Reinhart and Calvo (2000) provide theoretical explanations of how FI stabilizes the economy based on the households' behavior with concave utility. Under an economy with free capital mobility, a household can smooth its consumption intertemporally against the country-specific income shock by borrowing from or lending to other countries.

However, empirical studies cast doubt on the effect of the FI on consumption smoothing. We review two major empirical findings: the excess consumption volatility puzzle and the increased vulnerability of external shocks.

Excess consumption volatility puzzle In EMEs, the consumption is more volatile than income. This business cycle property is well known as the excess consumption volatility (ECV; Aguiar and Gopinath, 2007).[2] This is often interpreted as evidence of the failure of smoothing consumption in EMEs. Moreover, Kose et al. (2003b) and Prasad et al. (2003a) show that the ECV is worse in the EMEs with the higher levels of financial openness.[3] This finding is puzzling in relation to the theoretical prediction of the open economy real business cycle models of Mendoza (1991) and Baxter and Crucini (1995). In addition, Kose et al. (2003b) and Prasad et al. (2003a) also show a nonlinear relationship between the degree of financial openness and the ECV; a higher openness increases the ECV up to a threshold level.

Vulnerability of external shocks While international financial transactions have been active in EMEs since the 1980s, the financial crisis originating in EMEs has become more severe (Reinhart and Calvo, 2000). Major reasons behind the severe crisis in EMEs include the vulnerability of emerging markets' economic systems to external shocks and, importantly, the fact that the FI made countries more susceptible to external shocks. Barrot et al. (2018) empirically show that at the business cycle frequency, financial openness increases the vulnerability against external shocks, including international

[2] The size of ECV is measured by the relative volatility of consumption to real GDP.

[3] They showed that by the OLS and the IV. Even though they controlled other macroeconomic factors, the result was robust.

demand, supply, monetary, and commodity shocks. Georgiadis (2016) indicates that the FI is one of the factors that influence the magnitude of spillover effects of U.S. monetary policy on other countries' output. Pagliari and Hannan (2017) show that global factors significantly affect the volatility of EME capital flows, and argue that the EMEs suffer the economic instability due to the FI. Moreover, a large literature emphasizes that the international business cycle synchronization becomes stronger, especially during globalization periods (Kose et al., 2003a; Imbs, 2004; Kose et al., 2008; Felices and Wieladek, 2012).

1.3 Structure of dissertation

This dissertation first focuses on the EME business cycle. In Chapter 2, we revisit the Bayesian estimation exercise of the SOE real business cycle (SOE-RBC) model of García-Cicco et al. (2010) (GPU), a representative model of the EME business cycle. GPU, however, does not identify the world real interest rate (WRI) shock and the country-specific risk premium shock. In the first half of Chapter 2, we re-estimate the model using data from the real interest rates in the U.S. as an approximation of the WRI. The results show that the WRI shock mainly explains investment and trade balance, while in the GPU model, the country-specific shock explains investment and trade balance. Furthermore, we find that the Kalman smoother of the preference shocks obtained from the estimation correlates with the real interest rate in the U.S. since 1975. In the second half of Chapter 2, we discuss our hypothesis on what these correlations implies.

In Chapter 3, we describe the basic model used in the analysis in Chapters 4 and 5. The model can illustrate the ECV in EMEs and be consistent with our hypothesis described in Chapter 2. The key feature of the model is an occasionally binding borrowing constraint depending on the interest coverage ratio (ICR) by Yamada (2023). In this ICR-based borrowing constraint, the WRI has a larger effect on the foreign debt ceiling compared to the standard flow collateral constraint, such as in Bianchi, 2011 and Cuba-Borda et al., 2019. In this chapter, we compare the models with the ICR-based borrowing constraint and the standard borrowing constraint, addressing the equilibrium characteristics of the two models. The ICR model explains the mechanism of how the EMEs suffer the ECV.

Chapters 4 and 5 are the extensions of the basic model in Chapter 3. In Chapter 4, we approach the ECV puzzle, described in Section 1.2. We provide the economic mechanism behind which a deep FI worsens ECV by solving the model investigated in Chapter 3 with various degrees of the FI. In Chapter 5, we consider the effect of pecuniary externality on the EMEs and illustrate how sudden stops of international capital inflows happen in EMEs. We extend the basic model, allowing for the tradable and nontradable goods sectors and introducing the relative price of nontradable goods. We analyze how the FI affects the sudden stop by solving the model with various degrees of FI. In addition, we conduct a welfare analysis and show the opportunity of welfare improving policy interventions under different degrees of FI.

Finally, Chapter 6 concludes and discusses our future research agenda.

Chapter 2

Revisiting the source of emerging market business cycles: on empirical investigation

2.1 Introduction

Analysis of emerging market business cycles has been active since the seminal work by Aguiar and Gopinath (2007). They found the following three characteristics of the emerging market business cycles: (1) higher volatilities of GDP and trade balance-GDP ratio, compared to the advanced economies, (2) the ECV over income, and (3) the counter-cyclicality of the trade balance. Aguiar and Gopinath (2007) state that the permanent technology shock of emerging market economies (EMEs) creates the above three characteristics. Continued from Aguiar and Gopinath (2007), there has been active work on models representing these three characteristic: for example, Neumeyer and Perri (2005), Uribe and Yue (2006), and García-Cicco et al. (2010). Among them, GPU empirically identified the permanent technology shock with long historical annual data of Argentina and Mexico and found that the main driving source behind EMEs' business cycle features is not a growth shock. They showed that the risk premium shock, defined as the difference between the country's real interest rate and the fixed world real interest rate, explains the first and third characteristics; the preference shock, which is a shock on the stochastic discount factor, generates the second characteristic.

In this study, we revisit the source of EMEs' business cycles by re-estimating the GPU's model extended with a stochastic WRI. The GPU model assumes a constant WRI. Thus, the risk premium shock can be a mixture of shocks on the WRI and the country-specific risk premium. We separate the two shocks using the U.S. real interest rate data as a proxy of the WRI and re-estimate the extended model by a Bayesian method.

The resulting variance decomposition shows that the WRI shock, rather than country-specific risk premium shock, mainly explains investment growth and the trade balance-

GDP ratio. The source of ECV is the preference shock, regardless of the specification of the WRI process.

To dig deeper into the role of preference shock in the ECV, we conduct a rolling estimation of the correlation coefficient between the preference shock and the U.S. real interest rate. Surprisingly, we find that the correlation becomes much stronger after 1975. If the preference shock and the U.S. real interest rate are identified correctly, the correlation between them should be zero. The statistically significant positive correlation suggests that the preference shock includes some information related to the U.S. real interest rate shock. Since the main driver of the ECV is the preference shock, our empirical result infers that the U.S. real interest rate can cause the ECV in EMEs. Then, a question arises: Why did the correlation between them turn out to be significant after 1975?

This chapter is organized as follows. The first half of this chapter conducts the Bayesian estimation of the extended GPU model. Section 2.2 describes the model setting. Section 2.3 conducts the Bayesian estimation and reports the estimation results. Then, we raise a question about the identification of the preference shock and the real interest rate in the U.S. In Section 2.4, we introduce our hypothesis regarding why the non-zero correlation is observed, especially after 1975. We review the related literature in Section 2.5. Section 2.6 summarizes this chapter.

2.2 Model

2.2.1 Model environment

The model is basically the same as in GPU, except for the real interest rate process. Consider an SOE with a single good. The representative household can borrow for one period from foreign countries at the real interest rate r_t^c, which is defined as

$$r_t^c = r_t + \psi \left[\exp(\tilde{D}_{t+1}/X_t - \bar{d}) - 1 \right] + \exp(\mu_t^c - 1) - 1, \tag{2.2.1}$$

where r_t denotes the WRI in period t, which is exogenous to the SOE, $\tilde{D}_{t+1}$ is the aggregate level of foreign debt per capita acquired in period t, X_t is the labor productivity in period t, and μ_t^c is the country-specific risk premium shock in period t. The second term of Eq. (2.2.1) represents the foreign debt-elastic risk premium, and ψ is the parameter for the debt-elastic risk premium. If the aggregate foreign debt $(\tilde{D}_{t+1}/X_t)$ exceeds a threshold $\bar{d}$, the additional risk premium is imposed. The risk premium increases in the aggregate foreign debt. The representative household takes the aggregate debt level as exogenous. In equilibrium, $\tilde{D}_t = D_t$ holds.

Our model differs from the GPU model in the stochastic WRI as follows;

$$r_t = r^* + \exp(\mu_t - 1) - 1,$$

where r^* is the steady state value of the WRI and μ_t is the WRI shock in period t. In the GPU model, the WRI is assumed to be constant, and the risk premium shock μ_t^c can be regarded as both the WRI shock and the country-specific shock. Later, we use the U.S. real interest rate data as a good proxy for the WRI and identify the WRI shock and the other (country-specific risk premium) shock.

The production function of the SOE is as follows;

$$Y_t = A_t K_t^{\alpha} (X_t h_t)^{1-\alpha}, \tag{2.2.2}$$

where Y_t is output in period t, A_t is the total factor productivity in period t, K_t is capital holdings in period t, and h_t is labor force in period t. The labor augmenting productivity X_t grows at rate g_t,

$$g_t = \frac{X_t}{X_{t-1}}.$$

The household faces the following period-by-period budget constraint

$$Y_t + \frac{D_{t+1}}{1 + r_t^c} = C_t + D_t + I_t + S_t, \tag{2.2.3}$$

where C_t denotes consumption, I_t is investment in period t, and S_t is a domestic spending shock. We denote the transitory component of the domestic spending shock by

$s_t \equiv S_t/X_t$.

The law of motion for capital is

$$K_{t+1} = (1-\delta)K_t + I_t + \frac{\phi}{2}\left(\frac{K_{t+1}}{K_t} - g\right)^2 K_t, \tag{2.2.4}$$

where δ is the depreciation rate of capital, ϕ is the adjustment cost parameter and g is the steady-state growth rate of labor productivity.

The household's objective is to maximize the expected lifetime utility

$$E_0 \sum_{t=0}^{\infty} \beta^t \nu_t \frac{[C_t - \theta\omega^{-1} X_{t-1} h_t^{\omega}]^{1-\gamma} - 1}{1-\gamma}, \tag{2.2.5}$$

where ν_t is the preference shock.

Given the processes of $A_t, g_t, s_t, \mu_t, \mu_t^c, \nu_t$ and the initial conditions K_0 and D_{-1}, the household chooses $C_t, h_t, K_{t+1}, I_t, D_{t+1}$ to maximize the lifetime utility (2.2.5) subject to the budget constraint (2.2.3), the production technology (2.2.2), the law of motion for capital (2.2.4), and the no-Ponzi game conditions for the foreign debt and capital

$$\lim_{j\to\infty} E_t \left(\frac{D_{t+j}}{\Pi_{s=0}^{j}(1+r_s^c)}\right) \leq 0,$$

$$\lim_{j\to\infty} E_t \left(\frac{K_{t+j}}{\Pi_{s=0}^{j}(1+r_s^c)}\right) \geq 0.$$

Exogenous variables, $A_t, g_t, s_t, \mu_t^c, \mu_t$, and ν_t follow an AR(1) process in each;

$$\ln A_{t+1} = \rho_a \ln A_t + \epsilon_{t+1}^a, \quad \epsilon_t^a \sim \text{ i.i.d. } N\left(0, \sigma_a^2\right),$$

$$\ln\left(g_{t+1}/g\right) = \rho_g \ln\left(g_t/g\right) + \epsilon_{t+1}^g, \quad \epsilon_t^g \sim \text{ i.i.d. } N\left(0, \sigma_g^2\right),$$

$$\ln\left(s_{t+1}/s\right) = \rho_g \ln\left(s_t/s\right) + \epsilon_{t+1}^s, \quad \epsilon_t^s \sim \text{ i.i.d. } N\left(0, \sigma_s^2\right),$$

$$\ln \mu_{t+1}^c = \rho_c \ln \mu_t^c + \epsilon_{t+1}^c, \quad \epsilon_t^c \sim \text{ i.i.d. } N\left(0, \sigma_c^2\right),$$

$$\ln \mu_{t+1} = \rho_\mu \ln \mu_t + \epsilon_{t+1}^\mu, \quad \epsilon_t^\mu \sim \text{ i.i.d. } N\left(0, \sigma_\mu^2\right),$$

$$\ln \nu_{t+1} = \rho_\nu \ln \nu_t + \epsilon_{t+1}^\nu, \quad \epsilon_t^\nu \sim \text{ i.i.d. } N\left(0, \sigma_\nu^2\right),$$

where ρ_x is the AR(1) coefficient of the process x_t, and ϵ_t^x is the shock to x_t that is an *i.i.d.* normal random variate with the zero mean and the standard deviation σ_x.

2.2.2 Calibration

Table 2.1 reports the calibrated values of some of the model's structural parameters. The model is calibrated at an annual frequency. We use the same parameter values as in GPU. To calibrate the steady-state growth rate g, the AR(1) coefficient of growth shock ρ_g, and the standard deviation of growth shock σ_g, we use the estimation result

Table 2.1: Calibrated parameter values

Parameter		Value	Source
β	subjective discount factor	0.9224	from GPU
γ	risk aversion	2	
α	production share of capital	0.32	
δ	depreciation rate	0.1255	
ω	labor utility parameter	1.6	
θ	labor impact on utility	2.24	
$\bar{d}$	standard borrowing constraint	0.007	
g	steady-state growth rate	1.010	
ρ_g	AR(1) coefficient of growth shock	0.323	
σ_g	standard deviation of growth shock	0.011	

of GPU.

For comparison, we also consider the restrictive model to the same specification as in GPU, with the constant WRI assuming $\mu_t = 1$ and $r_t = r^*$.

We estimate the other parameters ψ, ϕ, r^* and exogenous shocks $A_t, \mu_t^c, \mu_t, \nu_t$ in Section 2.3.

2.2.3 Prior distribution

We estimate our model using the Bayesian method as in GPU. Table 2.2 shows the prior distributions of estimation parameters for two specifications. Specification (1) represents the benchmark model with a constant WRI, and specification (2) represents the extended model with a stochastic WRI described in Section 2.2. The parameters to estimate are the debt elastic risk parameter ψ, the adjustment cost parameter ϕ, the

Table 2.2: Prior distribution

	(1) Fixed WRI (GPU)			(2) Stochastic WRI		
	Distribution	Min.	Max.	Distribution	Min.	Max.
ψ	Uniform	0.00	5.00	Uniform	0.00	5.00
ϕ		0.00	8.00		0.00	8.00
ρ_a		-0.99	0.99		-0.99	0.99
ρ_s		-0.99	0.99		-0.99	0.99
ρ_c		-0.99	0.99		-0.99	0.99
ρ_μ		–	–		-0.99	0.99
ρ_ν		-0.99	0.99		-0.99	0.99
σ_a		0.00	0.20		0.00	0.20
σ_s		0.00	0.20		0.00	0.20
σ_c		0.00	0.20		0.00	0.20
σ_μ		–	–		0.00	0.20
σ_ν		0.00	1.00		0.00	1.00

Note: Prior distributions of estimation parameters for each specification (1) and (2). Specification (1) represents a model with fixed WRI, and specification (2) is a model with stochastic WRI described in section 2.2.

AR(1) coefficients and standard deviations of the stationary technology shock ρ_a and σ_a, the domestic spending shock ρ_s and σ_s, the country-specific risk premium shock ρ_c and σ_c, and the preference shock ρ_ν and σ_ν. In specification (2), we also estimate the AR(1) coefficient and standard deviation of WRI shock ρ_μ and σ_μ. Following GPU, we use uniform distributions for all parameters' prior distribution. The supports of the uniform distributions follow those in GPU, as shown in Table 2.2.

2.3 Result of Bayesian estimation

2.3.1 Posterior inferences of the models

We use the same data as in GPU but adopt a different sample period. The data of GPU covers the period between 1900 and 2005, while our sample period is between 1934 and 2005. This is because the time series data of the U.S. real interest rate is only available after 1934. The sample country is Argentina. Our time series data contain the real GDP per capita, consumption, investment, and trade balance-GDP ratio in Argentina, as well as the real interest rate in the U.S.

We implement the Metropolis-Hastings algorithm using the Dynare 4.5.7 procedure on Matlab 2018b to simulate the posterior distributions of the structural parameters on the two specifications, respectively.

Table 2.3 shows the posterior distributions of estimation parameters and the estimated marginal log-likelihoods for the two specifications.[1] The first three columns correspond to the fixed WRI specification, and the last three correspond to the stochastic WRI specification. In each specification, the first column shows the posterior mean, and the second and the third columns are the lower and the upper ends of the 90% Bayesian credible interval of the corresponding structural parameter. The last row shows the logarithm of the estimated marginal log-likelihoods.

[1] See the result of the convergence test in Appendix 2A.

Table 2.3: Posterior distribution

	(1) Fixed WRI			(2) Stochastic WRI		
	Mean	90% interval		Mean	90% interval	
ψ	2.090	0.782	3.433	3.685	2.669	4.992
ϕ	3.466	2.123	4.892	4.906	3.519	6.321
ρ_a	0.936	0.895	0.989	0.923	0.871	0.979
ρ_s	0.790	0.675	0.910	0.792	0.681	0.908
ρ_c	0.927	0.874	0.989	0.926	0.873	0.984
ρ_μ	-	-	-	0.976	0.960	0.99
ρ_ν	0.920	0.867	0.968	0.913	0.858	0.964
σ_a	0.031	0.027	0.036	0.031	0.027	0.036
σ_s	0.120	0.103	0.134	0.118	0.102	0.133
σ_c	0.036	0.020	0.051	0.054	0.039	0.068
σ_μ	-	-	-	0.014	0.012	0.016
σ_ν	0.599	0.341	0.879	0.611	0.354	0.879
Log ML	481.939			659.96		

Note: posterior distribution of estimation parameters and marginal log-likelihoods for each specification. The first three columns are the case in the fixed WRI, and the last three are in the stochastic WRI. In each specification, the first column shows the mean of the posterior distribution, and the second and the third columns are the lower and the upper of the 90% confidence interval of the posterior distribution. The last row shows the marginal log-likelihood for each specification.

In Table 2.3, the risk premium parameter ψ and the adjustment cost parameter ϕ in the stochastic WRI model are higher than in the fixed WRI model. In addition, the standard deviation of country-specific risk premium shock σ_c in the stochastic WRI model is higher than in the fixed WRI model. The sizes of persistence of shocks are almost the same in the two specifications.

Table 2.4: Forecast error variance decompositions (in percent)
(1) Fixed WRI

	Technology	Growth	Preference	Country specific	Spending
Output growth	86.73	4.23	6.22	2.82	0.00
Cons. growth	49.18	1.91	44.06	4.84	0.01
Inv. growth	15.07	0.58	23.52	60.83	0.01
TB-GDP	0.96	0.23	20.64	78.11	0.07

(2) Stochastic WRI

	Technology	Growth	Preference	Country specific	Spending	US real R
Output growth	86.07	4.2	6.17	0.75	0.0	2.8
Cons. growth	48.54	1.89	43.5	1.29	0.01	4.78
Inv. growth	12.93	0.49	20.18	14.2	0.01	52.19
TB-GDP	0.79	0.19	17.08	17.24	0.05	64.65
US real R	0.0	0.0	0.0	0.0	0.0	100.0

Note: The variance decomposition for forecast errors (FEVD) under the fixed WRI model (1), and under the stochastic WRI model (2). Each variable, output growth, consumption growth, investment growth, and the trade balance-GDP ratio, are decomposed into the five shocks in specification (1) and the six in specification (2).

2.3.2 Source of business cycles

Table 2.4 shows the forecast error variance decompositions (FEVDs). Tables 2.4(1) and (2) represent the FEVDs under the fixed WRI model and the stochastic WRI model, respectively. We decompose the fluctuations of output growth, consumption growth, investment growth, and trade balance-GDP ratio into the five shocks in the fixed WRI and the six shocks in the stochastic WRI model.

Surprisingly, the U.S. real interest rate shock has a dominant role in investment growth and the trade balance-GDP ratio in the case of the stochastic WRI model. In the case of the fixed WRI model, the risk premium shock explains a large part of investment growth and trade balance-GDP ratio, as shown in GPU. However, when we identify the WRI shock ϵ^{μ} and the country-specific shock ϵ^{c}, the country-specific shock explains at most less than 20% of investment growth and trade balance-GDP, whereas the U.S. real interest rate shock explains over 50% of investment growth and almost 65% of trade balance-GDP ratio.

In the two specifications, the stationary technology shock and preference shock explain more than 90 percent of consumption growth. The domestic spending shock has only a small impact on the business cycles in the two specifications. The source of the ECV, the relative standard deviation of consumption to GDP, is the preference shock because the stationary technology shock explains not only consumption growth but also output growth. The preference shock explains about 45 percent of consumption growth but only about 6 percent of output growth. Hence, we can infer that the main source of the ECV is the preference shock in the two specifications.

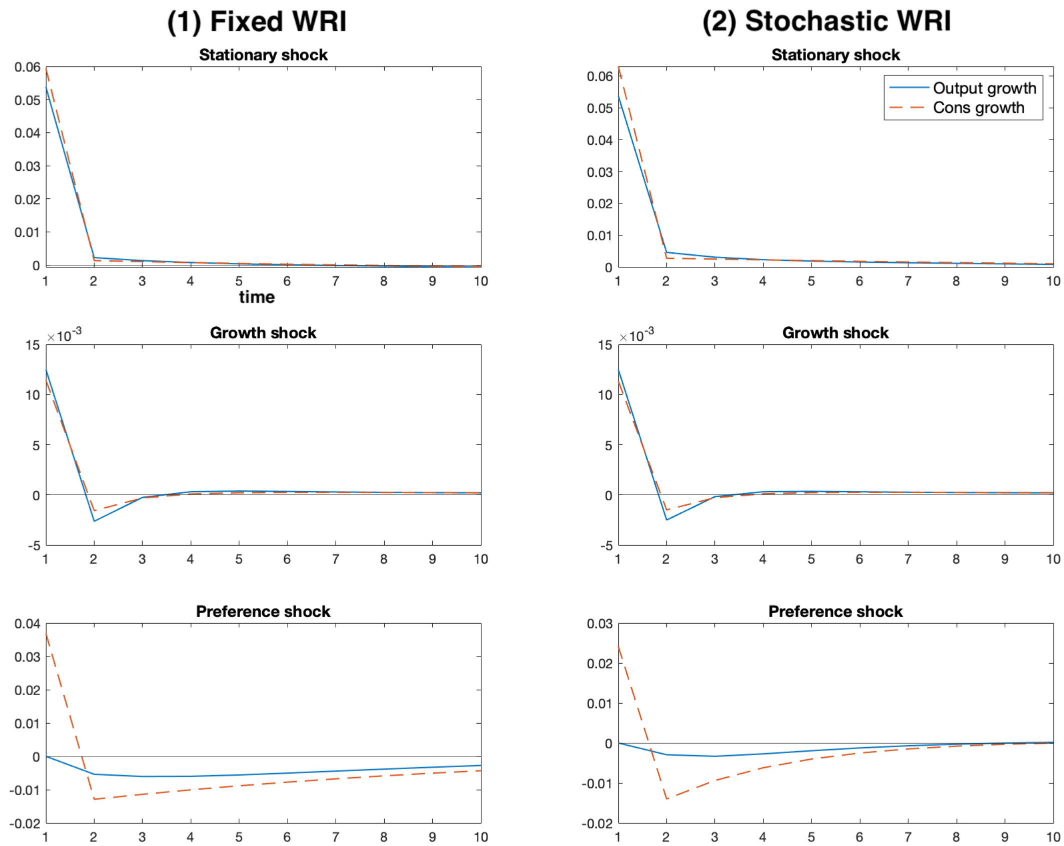
Figure 2.3.1 reports impulse responses of output and consumption growth, evaluated at the posterior mean. The solid blue lines represent the responses of output growth and the dashed orange lines represent those of consumption growth. The left panels are the fixed WRI case, and the right panels are stochastic WRI. The top panels are the responses against stationary shock, the middle ones ares the growth shock, and the bottom ones are the preference shock.

Figure 2.3.1 shows that consumption growth responds more than output growth against stationary and preference shocks, regardless of fixed and stochastic WRI cases. Notably, the consumption response against preference shock is much more than the output response. Thus, the source of ECV is preference shock. Against a positive preference shock, consumption growth increases about 2.5 to 3.5% on impact, then decreases about -1.5%, whereas output growth does not respond on impact and then decreases at most about -0.5%.

2.3.3 Correlation between the preference shock and the U.S. real interest rate

Now, we raise a question about the identification of the preference shock. Figure 2.3.2 plots the U.S. real interest rate (the left axis) and the Kalman smoothed inference of the preference shock, evaluated at the mean of the posterior distribution (the right axis). The first and second columns are for the fixed and the stochastic WRI models, respectively. The first row of each panel contains the plots for the full sample period (1934-2005), the second row is for the sub-sample period between 1934 and 1974, and the last one is for the sub-sample period between 1975 and 2005.

Figure 2.3.1: Impulse responses of output and consumption growth



Notes: Impulse responses of output and consumption growth are evaluated at the posterior mean. The solid blue lines represent the responses of output growth and the dashed orange lines represent those of consumption growth, respectively. The left panels are the fixed WRI case, and the right panels are stochastic WRI. The top panels are the responses against stationary shock, the middle ones are the growth shock, and the bottom ones are the preference shock.

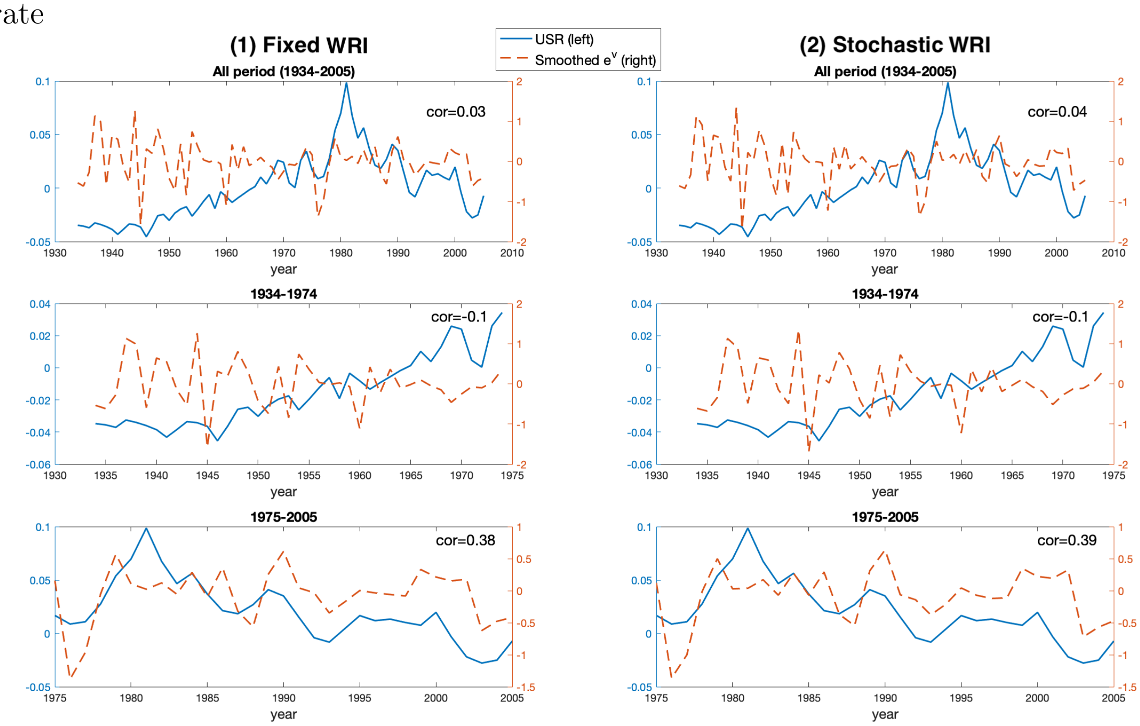
Figure 2.3.2 shows a positive correlation between the U.S. real interest rate and the smoothed preference shock after 1975, regardless of the model's specification. The estimated correlation coefficient in the second sub-sample period is 0.38 in the fixed WRI model and 0.39 in the stochastic WRI model. If the preference shock is correctly identified without miss-specification, the correlation should be zero. The positive correlation between the U.S. real interest rate and the smoothed preference shock revealed in Figure 2.3.2 indicates that none of the two specifications can identify the preference shock correctly. Since our FEVD result implies the source of ECV is the preference shock, if we correctly identify the preference shock, the ECV could result from the U.S. real interest rate shock.

The reason why the correlation still remains under the Stochastic WRI may be that the cross-equation restriction in the model has not been fully applied for some reason. One of the reasons for this may be that the data had a structural change around 1975, and the model has not been able to capture these changes, resulting in a poor fit for the post-1975 data.

2.4 Discussion

In the previous section, we observe a positive correlation between the smoothed preference shock and the U.S. real interest rate after 1975. A natural question is, why did the

Figure 2.3.2: Correlation between the smoothed preference shock & U.S. real interest rate



correlation occur? Why did the correlation become significant, especially after 1975? What is the economic mechanism behind this correlation? In this section, we offer our hypothesis behind this observation.

By construction, the preference shock ν_t can be considered as a shock to the Euler equation residual, a random variable that generates a deviation of the optimal consumption for the standard Euler equation. Then, a positive correlation between the U.S. real interest rate and the smoothed preference shock suggests the possibility that the Euler equation residual becomes correlated with the U.S. real interest rate after

1975. A reasonable candidate of the Euler equation residual is the Lagrange multiplier associated with a model subject to occasionally binding borrowing constraints. Such a model introduces an additional stochastic term, the Lagrange multiplier of the borrowing constraint, into the Euler equation. If the Lagrange multiplier becomes correlated with the U.S. real interest rate after 1975, it is consistent with our observation of a correlation between the smoothed preference shock and the U.S. real interest rate after 1975.

Therefore, to construct a model consistent with our observation and to seek the main mechanism behind ECV in EMEs more deeply, our study focuses on the role of the U.S. real interest rate in the tightness of the international financial market in the content of the financial openness of EMEs proceeded since the late 1970s. As we review in Section 2.5, the literature has pointed out that the U.S. interest rate has greatly impacts on the international financial market condition. In addition, previous studies also indicate that as EMEs promoted financial liberalization from the late 1970s, EMEs tended to be more vulnerable to foreign or world financial shocks. We consider that the correlation between the smoothed preference shock and the U.S. real interest rate reflects that consumption in EMEs becomes more sensitive to the tightness of the international borrowing condition, which largely depends on the U.S. real interest rate.

In the next section, we review previous studies discussing the effect of the U.S. real interest rate on EMEs and the financial liberalization of EMEs.

2.5 Related literature: the effect of U.S. interest rate on EMEs

Previous studies have pointed out that the WRI and the U.S. interest rate shocks significant affect on the EMEs' business cycles. Uribe and Yue (2006) construct an SOE business cycle model with a working capital constraint and show that the U.S. real interest rate shock explains about 20% of EME's business cycle fluctuations. Sarquis (2008) found a result similar to that of Uribe and Yue (2006) by using an SOE business cycle model with a binding credit constraint in Brazilian data. Muhanji and Ojah (2011) showed that the WRI shock leads to significant fluctuations in foreign debts in eleven African countries.

In addition, previous studies have shown that the global common factor, such as the WRI shock, has a significant effect on the EME capital flows and, in some cases, causes external crises. Koepke (2018) surveyed the large empirical literature on the drivers of international capital flows and concluded that push factors, including the world interest rates, global risk aversion, and the growth of the world economy, are the main drivers of capital flows in EMEs. Forbes and Warnock (2012) classify the extreme capital flow episodes in EMEs into four categories: surges, stops, flights, and retrenchments. The surges include a sharp increase in gross capital inflows; the stops include a sharp decrease in gross capital inflows; the flights include a sharp increase in gross capital outflows; and the retrenchment a sharp decrease in gross capital outflows. They show empirically that the WRI has a dominant effect on the retrenchments. In addition, under some regression specifications, the WRI significant affects on the stops. Moreover, many theoretical studies also argue the significant impact of global factors, including the WRI, on the sudden stops (Arellano and Mendoza, 2002; Mendoza, 2010; Davis et al., 2023) and EME sovereign defaults (Foley-Fisher and Guimaraes, 2013).

2.6 Summary of this chapter

In this chapter, we revisit the source of EMEs' business cycles by re-estimating the GPU model extended with a stochastic WRI. The resulting variance decomposition shows that the WRI shock, not the country-specific risk premium shock, dominantly explains investment growth and the trade balance-GDP ratio. The source of ECV is the preference shock, regardless of the specification of the WRI process.

In addition, we dig deeper into the role of preference shock in the ECV by conducting a rolling estimation of the correlation coefficient between the preference shock and the U.S. real interest rate. We find that the correlation becomes much stronger after 1975.

Since the main driver of the ECV is the preference shock, our empirical result infers that the U.S. real interest rate can cause the ECV in EMEs. By construction, the preference shock can be considered as a shock to the Euler equation residual. Then, a positive correlation between the U.S. real interest rate and the smoothed preference shock suggests the possibility that the Euler equation residual becomes correlated with the U.S. real interest rate after 1975. We discuss that the model with the borrowing constraint can be consistent with our findings of a correlation between the smoothed preference shock and the U.S. real interest rate. A possible candidate for the Euler residual is the Lagrange multiplier associated with a model subject to occasionally binding borrowing constraints. If the Lagrange multiplier becomes correlated with the U.S. real interest rate after 1975, it is consistent with our observation of the stronger correlation after 1975.

Chapter 3

ICR-based borrowing constraint

3.1 Introduction

In the previous chapter, we observe that the U.S. real interest rate and the smoothed preference shock correlated positively after 1975. We hypothesize that the positive correlation reflects that consumption in EMEs becomes more sensitive to the tightness of the international financial condition, which is largely affected by the real interest rate of the U.S. or the WRI.

To approach our hypothesis, this chapter introduces the ICR-based borrowing constraint. The key feature of this occasionally binding borrowing constraint is that its tightness depends strongly on the WRI, compared to the standard flow collateral constraint as in Bianchi (2011) and Cuba-Borda et al. (2019).

Since Bernanke and Gertler (1995) emphasized the role of interest rates on borrowing ability, many previous papers focused on how the interest rate affects foreign debt and the tightness of borrowing constraints in SOE models, such as Neumeyer and Perri (2005), Uribe and Yue (2006), Mendoza (2010), and Davis et al. (2023). Previous studies have considered the working capital constraints, stock collateral constraints *à* la Kiyotaki and Moore (1997), or flow collateral constraints as in Bianchi (2011) and Cuba-Borda et al. (2019). However, in the actual debt security market, it is not apparent whether the collateral is determined by the value of stock assets (physical capital) or (cash-)flow based. Lian and Ma (2020) show that 20% of debt in U.S. non-financial firms is valued by assets, but 80% is by cash flows.

The debt or interest ratio of cash flows is also a common type of borrowing constraint. According to Greenwald (2019), the ICR-based covenant, the borrower's ratio of interest payments to profit needs to exceed the threshold, is the most used covenant in non-financial firms in the U.S. In addition, he shows that the debt-ratio-based covenant, the borrower's total debt ratio to profit needs to be over the threshold, is the second most commonly used covenant, and the combination of ICR and debt-ratio is the most common covenant combination set.

Our ICR-based borrowing constraint is based on Greenwald (2019). which use the

ICR as borrowing constraint firstly. He uses the ICR-based borrowing constraint as a firm's constraint in a closed economy. Compared to his, we consider the ICR-based covenant as in the international financial markets. Almost half of the portfolio inflows to EMEs are by private sectors, and a quarter of debt inflows are by financial intermediaries (López and Stracca, 2021). Thus, we consider that such financial intermediaries make an ICR-based covenant with EMEs in the international financial market.

We show that the WRI affects consumption through the Lagrange multiplier attached to the borrowing constraint in the ICR-based borrowing constraint model more strongly than in the standard flow collateral constraint. As a result, consumption becomes more sensitive to the WRI shock in ICR-based borrowing constraints. The mechanism behind the ECV is different between the standard and the ICR-based models. In the case of the ICR-based borrowing constraint, the ECV reflects a significant consumption decline due to the binding borrowing constraint when the WRI is high. When the WRI is low, the borrowing constraint is slack, and consumption smoothing is possible. However, once the WRI increases, the borrowing constraint binds, and refinancing is limited. Thus, households must reduce consumption to a greater degree, resulting in the ECV. In the case of the model with the standard borrowing constraint, the source of the ECV is the amplification of the income shock due to the borrowing constraint. A low-income shock tightens the collateral constraint and reduces consumption more than the current income for the repayments. In contrast, a positive permanent income shock relaxes the collateral constraint and increases consumption more than the current income by borrowing from foreign countries. In the standard collateral constraint model, consumption responds to income shocks. Hence, consumption smoothing is not possible.

This chapter is organized as follows. Section 3.2 introduces the ICR-based borrowing constraint. Section 3.3 compares the model with the ICR-based borrowing constraint and the model with the standard borrowing constraint by Cuba-Borda et al. (2019). Section 3.4 shows the results of the quantitative analysis and discusses the difference between the ICR-based borrowing constraint model and the standard flow collateral constraint model. Finally, Section 3.5 summarizes the chapter.

3.2 ICR-based borrowing constraint

Consider the following ICR-based borrowing constraint

$$d_{t+1} \leq \max \left\{ \bar{d}, \frac{\tau}{r_t} E_t y_{t+1} \right\}, \tag{3.2.1}$$

where $\bar{d} > 0$ is the minimum debt limit and $\tau \geq 0$ is a parameter that determines the tightness of the borrowing constraint.[1] The second term in the bracket of the Eq.(3.2.1) implies that (i) the foreign borrowing limit depends negatively on the WRI and positively on the expected income, and (ii) a higher τ makes the foreign borrowing limit more sensitive to the WRI and the expected income. Note that a lower (higher) r_t relaxes (tightens) the borrowing constraint, whereas a lower (higher) expected income tightens (relaxes) the borrowing constraint.

We define the ICR by $y_t/(r_{t-1}d_t)$. The ICR-based borrowing constraint is derived from foreign lenders' assessment of the borrower's default risk evaluated by the ICR. We assume that foreign investors lend out to the SOE under the following conditions on the ICR;

$$ICR_t \equiv \frac{y_t}{r_{t-1}d_t} \geq \bar{\tau}, \tag{3.2.2}$$

where $\bar{\tau}$ is the threshold value imposed by foreign lenders. Condition (3.2.2) implies that foreign debt level d_t needs to satisfy that the ICR exceeds the threshold value $\bar{\tau}$. We then derive Eq.(3.2.1) by rearranging Eq.(3.2.2) and with setting $\tau \equiv 1/\bar{\tau}$. Here, the parameter τ can be interpreted as the degree of FI. A deeper FI, which is reflected in, for example, the enhancement of information disclosure to foreign investors and many

[1] It is necessary to set this minimum debt $\bar{d}$ for the existence of the optimal solution. Intuitively, if the initial d is small enough, there is no optimal solution depending on the realized value of shocks. For details, see Chapter 18 of Ljungqvist and Sargent (2012).

local branches of international banks, can reduce monitoring costs of foreign lenders and increase the credibility of the SOE. This higher credibility can lower the threshold value $\bar{\tau}$, and leads to a higher τ. As a result, a higher degree of FI can increase the foreign borrowing limit, as Eq.(3.2.1) implies.

The economic rationale behind the condition relies on practical and empirical facts. The financial covenant with ICR is one of the common covenants in corporate firms (Private Placement Enhancement Project 1996; Dothan 2006; Greenwald, 2019). According to Greenwald (2019), the ICR-based covenant is the most used type of index-based covenant in U.S. firms. He shows that $\bar{\tau}$ is almost stable over time. In addition, the ICR is used for default risk evaluations in firms. For example, rating agencies, such as Standard and Poor's, include the ICR in the construction of their ratings (Standard and Poor's 2013). Furthermore, Gray et al. (2006) show that the ICR has a dominant effect on credit ratings.

We suppose that in international lending, the ICR-based covenant is common and useful for evaluating potential default risks. According to López and Stracca (2021), almost half of the international portfolio inflows to EMEs come from the private sector. Especially in the international debt security market, financial intermediaries account for almost a quarter of the EMEs' inflow (López and Stracca, 2021). Thus, we believe that the ICR covenant is common even in international financial markets.

3.3 Comparison between ICR-based and standard borrowing constraints

Consider a SOE with a single good. An infinitely lived representative household receives exogenous stochastic income y_t. There is a state non-contingent bond traded in international financial markets. The representative household can borrow for one period from foreign countries at the time-varying WRI r_t, which is exogenous to the SOE.

The household faces the following period-by-period budget constraint

$$y_t + d_{t+1} = (1 + r_{t-1})d_t + c_t, \tag{3.3.1}$$

where c_t is consumption and d_{t+1} is the foreign debt level in period $t+1$. The household also faces the ICR-based borrowing constraint (3.2.1).

To make the important role of the ICR-based borrowing constraint clear, we also examine the standard borrowing constraint as in Cuba-Borda et al. (2019)

$$d_{t+1} \leq \max\left\{\tilde{d}, ME_t y_{t+1}\right\}, \tag{3.3.2}$$

where $\tilde{d} > 0$ is the minimum borrowing limit for this case and $M > 0$ is a parameter that determines the tightness of the standard borrowing constraint. Note that the foreign debt limit of the standard borrowing constraint (3.3.2) is independent of r_t.

Given the exogenous income y_t, the WRI r_t and initial foreign debt level d_0, the household chooses the sequence of consumption c_t and the foreign debt level d_{t+1} by maximizing the following expected lifetime utility

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-\gamma} - 1}{1 - \gamma}, \tag{3.3.3}$$

subject to the budget constraint (3.3.1) and the either of borrowing constraint (3.2.1) or (3.3.2).

We assume that the WRI follows an AR(1) process

$$r_t = (1 - \rho^r) r^* + \rho^r r_{t-1} + e_t^r, \quad e_t^r \sim N(0, \sigma_r^2), \tag{3.3.4}$$

where r^* and ρ^r are the mean and the AR root of r_t. The WRI shock e_t^r is an *i.i.d.* normal random variate with the zero mean and the standard deviation σ_r.

We also assume that the income follows the process

$$\ln y_t = (1 - \rho_y^y) \ln y^* + \rho_y^y \ln y_{t-1} + \rho_r^y r_{t-1} + e_t^y, \quad e_t^y \sim N(0, \sigma_y^2). \tag{3.3.5}$$

where y^* is the steady-state level of y, ρ_y^y is the AR root of y_t, and ρ_r^y is the sensitivity of the current income y_t to the one period past WRI, r_{t-1}. The country-specific income shock e_t^y is an *i.i.d.* normal random variate with the zero mean and the standard deviation σ_y. We specify that the current income y_t depends on r_{t-1}. This is because if we consider an AR(1) income process independent of r_t, consumption volatility, which depends on the multiple shocks in equilibrium, should exceed income volatility by construction. Thus, we consider a reduced-form income process, which is driven by the two shocks, to obtain the volatility ratio of consumption and income consistent with the data.

3.3.1 The WRI effect on consumption

The Euler equation of the household's problem is

$$\lambda_t = \beta R_t E_t \lambda_{t+1} + \lambda_t^B, \tag{3.3.6}$$

where $\lambda_t = c_t^{-\gamma}$ is the marginal utility of consumption at period t, λ_t^B is the Lagrange multiplier for the ICR-based borrowing constraint at period t or for the standard flow collateral constraint, and $R_t = (1 + r_t)$ is the gross WRI. If $\lambda_t^B = 0$, Eq.(3.3.6) is equivalent to the Euler equation in the standard SOE model without borrowing constraints.

λ_t^B represents the additional utility cost that the representative household needs to pay to increase current consumption through foreign borrowing when the borrowing constraint binds. When the borrowing constraint binds, the marginal utility gain from increasing consumption by foreign borrowing (λ_t) equals the marginal utility loss from reducing consumption associated with the increase in interest payments ($\beta R_t E_t \lambda_{t+1}$) and the additional cost due to the binding borrowing constraint ($\lambda_t^B > 0$). Thus, current consumption becomes smaller than in the standard case without borrowing constraints.

In the case of the model with the ICR-based borrowing constraint, the WRI affects consumption through two channels. The first channel is the intertemporal substitution effect, the first term in the Euler equation (3.3.6), which is the standard effect of real interest rate on consumption in the real business cycle model. The second channel is through the Lagrange multiplier for the borrowing constraint, λ_t^B. Since the borrowing constraint (3.2.1) assumes the borrowing limit depends negatively on the WRI, a higher WRI tightens the borrowing constraint and increases λ_t^B , which reduces the current consumption. In the case of the model with the standard flow collateral constraint (3.3.2), the WRI also affects consumption through the above two channels. However, the second channel would be modest compared to the ICR-borrowing constraint case because the debt ceiling of the standard flow collateral constraint does not depend on the WRI. In addition, a higher WRI has the opposite effect on consumption in the case of the ICR-based borrowing constraint. A higher WRI reduces foreign debt, relaxes the collateral constraint, and reduces λ_t^B, which results in higher consumption.

In the previous chapter, we find a correlation between the smoothed preference shock and the U.S. real interest rate. As discussed in Section 2.4, we hypothesize that the Euler equation has an additional term that correlates with the WRI, especially after 1975. Note that the SOE model with the ICR-based borrowing constraint introduced in this chapter is consistent with our hypothesis. In the case of ICR-based borrowing constraint, the Euler equation has an additional term, λ_t^B, that correlates strongly to the WRI, as described in Section 3.3.1. In Section 3.4, we will show that the WRI has a dominant effect on λ_t^B and, thus, consumption in equilibrium of the ICR-based borrowing constraint model by quantitative analysis. In the next chapter, we will show how the FI changes the effect of WRI on consumption through its effect on λ_t^B.

3.3.2 The steady state

We assume that the degree of FI in EMEs is sufficiently low so that the borrowing constraint binds at the steady states. Lower τ leads to a smaller foreign borrowing limit and the tighter borrowing constraints. The sufficiently low τ indicates that the borrowing constraint mostly limits foreign borrowing, resulting in the borrowing constraint binds at the steady state.[2] Past studies assume the borrowing constraints unbind at the steady state to investigate the role of borrowing constraints in financial crises. Because we focus on the effect of FI on the ECV, which is a business cycle feature of EMEs, we analyze consumption under the situation that the borrowing constraint binds at the steady state.

The steady state of this model is characterized as follows:

$$y^{ss} = y^*, \ r^{ss} = r^*, \ d^{ss} = \frac{\tau}{r^{ss}} y^{ss}, \ tb^{ss} = r^{ss} d^{ss} = \tau y^{ss},$$

$$c^{ss} = y^{ss} - r^{ss} d^{ss} = (1-\tau) y^{ss}, \ \lambda^{Bss} = [1 - \beta(1 + r^{ss})] > 0,$$

$$R^{*ss} = \frac{1}{\beta}.$$

A higher τ increases the steady state foreign debt level d^{ss} and trade-balance tb^{ss}. Because our model is an endowment economy model, an increase in d^{ss} decreases the steady-state level of consumption c^{ss}.

[2]Advanced economies can be considered as having sufficiently large τ the case that the borrowing constraint seldom binds. The probability of binding borrowing constraints is very low, so borrowing is not limited in normal times. Thus, consumption volatility will be lower than income volatility. In that sense, for business cycles in advanced economies, we can ignore the borrowing constraint and consider frictionless SOE models with bitty risk premiums that are imposed only for the stationarity of the model, as in Schmitt-Grohé and Uribe (2003). However, huge negative shocks can recall the existence of borrowing constraints, and foreign borrowing can be limited even in advanced economies.

Table 3.1: Calibrated parameter values (baseline case)

Parameter		Value	Source
β	subjective discount factor	0.9224	from García-Cicco et al. (2010)
γ	risk aversion	2	the common value of SOE models
r^*	steady-state value of WRI	0.0356	mean of U.S. real interest rate
τ	degree of FI	0.0328	mean of TB-GDP in Argentina
M	scale parameter of standard borrowing constraint	0.921	τ/r^*

3.3.3 Calibration

Table 3.1 reports the calibrated values of the model's structural parameters. The model is calibrated at a quarterly frequency. We set the parameter $\beta = 0.9224$ so that $\lambda^{Bss} > 0$, i.e., the borrowing constraint binds at the steady state. Since $\tau = tb^{ss}/y^{ss}$ at the steady state, τ is set to 0.0328, which equals the sample average of the trade balance-GDP ratio in Argentina for the period 1991Q1-2008Q3. The parameter M is set to $\tau/r^* = 0.921$ so that the marginal effect of income on the borrowing limit at the steady state is identical between standard and the ICR-based borrowing constraints. We assume that the WRI is approximated by the U.S. real interest rate. Hence r^* is set to the sample average of the real interest rate in the U.S. for the period 1991Q1-2008Q3.[3]

We calibrate the stochastic processes of the two exogenous shocks by estimating Eqs.(3.3.4) and (3.3.5) with the U.S. real interest rate and the deviation from the

[3]The U.S. real interest rate is constructed followed by Neumeyer and Perri (2005).

cubic trend of real GDP per capita in Argentina for 1991Q1-2008Q3, respectively. We assume that $y^* = 1$. We obtain $\rho^r = 0.946$, $\rho_r^y = -0.108$, $\rho_y^y = 0.949$, $\sigma_r = 0.0051$, and $\sigma_y = 0.0194$ from the corresponding point estimates. We then approximate the bivariate vector autoregression (VAR), which is implied by Eqs.(3.3.4) and (3.3.5), by a finite Markov process with three states of y_t and r_t, using the multi-Tauchen method developed by Tauchen and Hussey (1991). We construct the state space grids of $y = [0.963, 1(= y^{ss}), 1.068]$ and $r = [0.0198, 0.0356(= r^*), 0.0514]$, respectively.

3.3.4 Quantitative exercise

The model is solved using the fixed-point iteration method proposed by Mendoza and Villalvazo (2020), which is one of the nonlinear global solution methods with occasionally binding constraints. The endogenous state variable d_t is chosen from equally spaced discrete grids, $\mathbf{D} = \{d_1 < d_2 < \cdots < d_{n^d}\}$. We set $\mathbf{D}$ with $n^d = 200$, $d_1 = 0.25d^{ss}$, $d_{200} = 1.75d^{ss}$, where d^{ss} is the deterministic steady state value of d_t. In the case of with τ smaller than the baseline value of 0.0328, we change the maximum value of $\mathbf{D}$ to $1.5d^{ss}$ with $n^d = 166$. Because exogenous state variables r_t and y_t have nine states in total, there are 200×9 coordinates (or 166×9 if τ is smaller than the baseline value) in the state space of this model.

Table 3.2: Long-run business cycle moments

		Model	
	Data	ICR-based constraint	Standard constraint
Mean			
Foreign debt	-	0.89	0.92
TB-GDP ratio	0.03	0.03	0.03
Risk premium	-	4.69	4.64
Standard deviation (in percent)			
Foreign debt	-	20.25	4.18
TB-GDP ratio	5.40	5.56	1.91
Consumption	6.82	7.71	5.69
Real GDP	5.10	5.07	5.07
Risk premium	-	18.08	4.15
Std. relative to GDP			
Consumption	1.34	1.52	1.12
Probability of binding	-	36.29%	88.83%
Max Euler eq. error	-	$2.1E{-}06$	$1.9E{-}06$

Notes: The data sample is Argentina for 1991Q1-2008Q3, calculated from the replication data of Chapter 5 in Uribe and Schmitt-Grohé 2017, available at Marítn Uribe's homepage. The data for consumption and GDP are in real per capita terms, logged, and deviations from these cubic trends. The trade balance-output ratio is also in real per capita terms. The "standard constraint" (column 3) refers to the model with a standard borrowing constraint, and the "ICR-based constraint" (column 4) refers to the model with the ICR-based borrowing constraint. The business cycle moments in models are calculated from the stationary distributions of d_t and policy functions.

3.4 Results of the quantitative analysis

3.4.1 Business cycle moments: standard vs. ICR-based borrowing constraints

Table 3.2 shows the sample moments in Argentina for 1991Q1-2009Q3 (the second column) and the business cycle moments derived from the stationary distributions of d_t

and policy functions. The third column displays the corresponding moments simulated with the ICR-based constraint model, and the fourth column displays those with the standard borrowing constraint models.[4]

The sample moments in Argentina show high volatility and ECV. Instead, the standard deviations of trade balance, consumption, and income are over 5 percentage points. Moreover, the relative standard deviation of consumption to income exceeds one significantly, which means the ECV. These observations are consistent with the findings of Aguiar and Gopinath (2007).

The ICR-based borrowing constraint model accounts well for these observations. The standard deviations of trade balance, consumption, and the size of ECV are close to the data counterparts. These high volatilities result from the high standard deviation of the risk premium, which is almost 18 percentage points. By definition, the source of risk premium is λ_t^B, depending on whether the borrowing constraint binds or not. If the borrowing constraint binds infrequently, the average risk premiums will be small. Meanwhile, the volatility of the risk premium increases if λ_t^B varies significantly with the realized value of the shocks. As explained in detail in the next subsection, the high sensitivity of λ_t^B to the WRI raises the volatility of the risk premium.

[4] Since we calibrated the models with the mean value of the trade balance-output ratio, this value is identical for the data and the two models. We also calibrated the income process. Due to the approximation of VAR by the Markov process, the standard deviation of income is different between the data and the two models.

Compared to the ICR-based borrowing constraint model, the standard borrowing constraint model predicts much smaller volatilities of foreign borrowing, consumption, and risk premium. Moreover, the probability of binding borrowing constraint is nearly 50 percent higher than that in the ICR-based constraint model. Since the borrowing constraint binds at the steady state, the borrowing constraint is mostly binding if the shocks have small effects on the borrowing limits. Since the borrowing limit in the standard borrowing constraint depends only on income, the borrowing constraint almost always binds. Thus, the volatilities of foreign borrowing and trade balance are small in the standard borrowing constraint model.

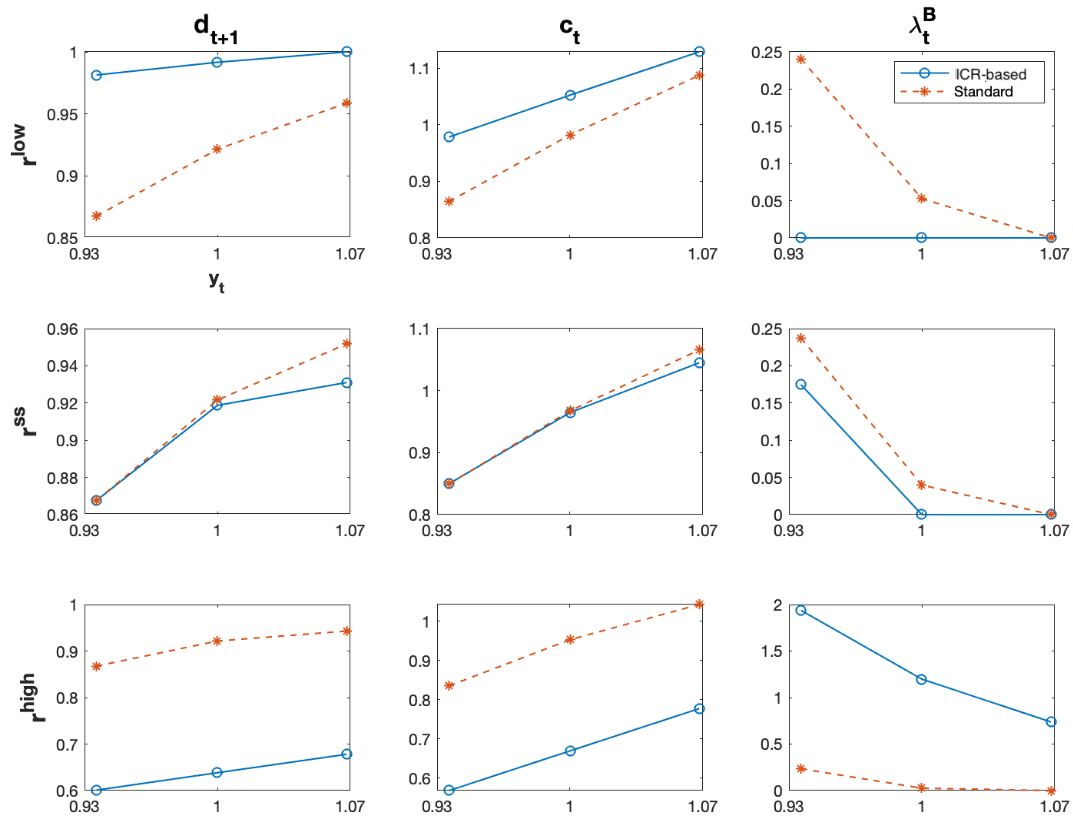
3.4.2 Policy function and simulation: the source of high volatility

This subsection explains why the ICR-based borrowing constraint model predicts higher volatilities of borrowing and consumption than the standard borrowing constraints model.

3.4.2.1 The policy functions

Figure 3.4.1 shows the policy functions sliced at the deterministic steady state value of the foreign borrowing, $d_t = d^{ss}$. The solid blue lines are the policy functions implied

Figure 3.4.1: Policy function for income



Notes: All policy functions are calculated with spline completion at $d_t = d^{ss}$ (the deterministic steady-state level of foreign borrowing). $r^{low}, r^{ss}, r^{high}$ mean the states (grids) for the WRI.

by the ICR-based borrowing constraint model, and the dashed orange lines are those implied by the standard borrowing constraint model. The left column plots the policy functions of foreign borrowing, the middle column plots those of consumption, and the right column plots those of the Lagrange multiplier for the borrowing constraints. We examine the policy functions under the different levels of the WRI. The upper row corresponds to the low value of r_t, the middle row corresponds to the steady state value of r_t, and the bottom row corresponds to the high value of r_t, respectively.

In the ICR-based borrowing constraint model, the upper-right panel of Figure 3.4.1 shows that when $r_t = r^{low}$, λ_t^B remains zero, no matter how much the income is. This means that the ICR-based borrowing constraint never binds in the low WRI period. Thus, during the r^{low} periods, households can borrow from foreign countries freely and smooth their consumption against the income shock.

The tightness of the ICR-based borrowing constraint varies largely depending on the value of the WRI. As shown in the right panels, λ_t^B for the ICR model is highly volatile; it varies from zero to near two, depending on the level of r_t. Such a high sensitivity of λ_t^B to the WRI makes foreign borrowing and consumption depend strongly on the WRI. A lower (higher) r_t relaxes (tightens) the borrowing constraint and facilitates (limits) foreign borrowing, which results in increasing (reducing) consumption by the budget constraint (3.3.1).

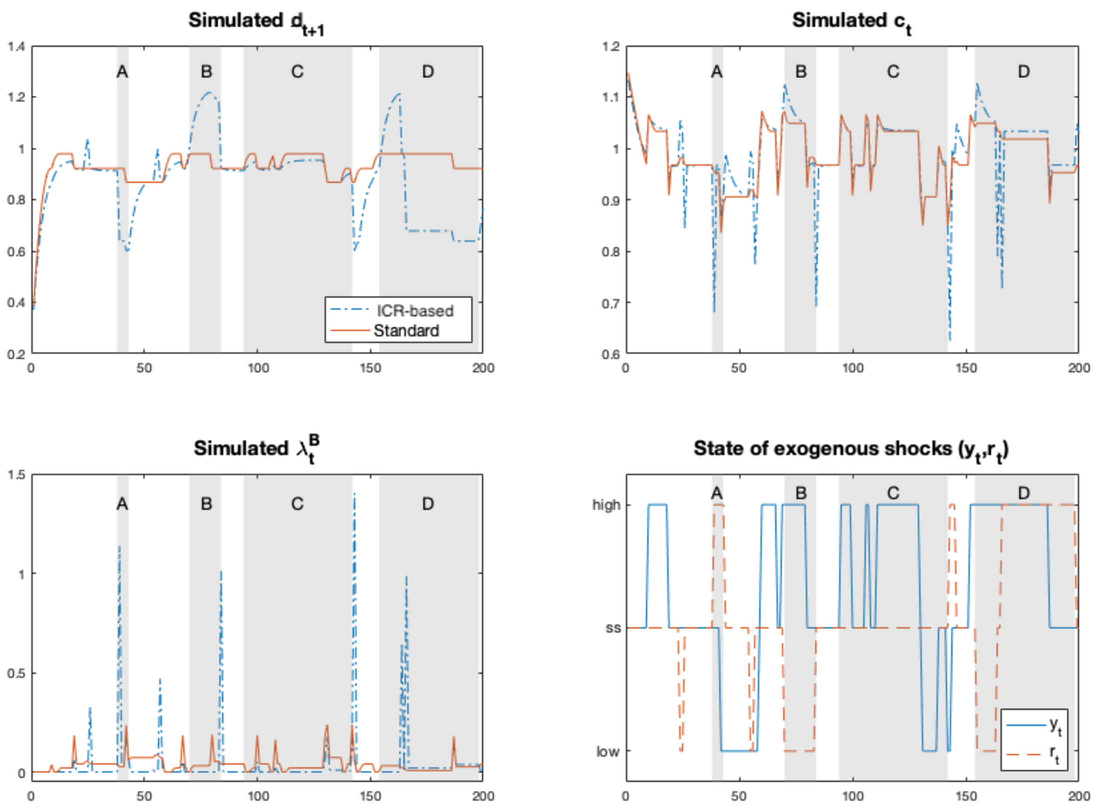
In contrast to the ICR model, the standard model never allows the household to smooth their consumption; consumption in the standard model is more responsive to income. In the standard model, λ_t^B is almost independent of r_t; it takes roughly the same values in the top to the bottom panels. This indicates that in the standard model, the WRI shock affects the intertemporal substitution of consumption only through the interest channel, as discussed in Section 3.3.1. Because the income level has a dominant effect on the tightness of the borrowing constraint, the amount of foreign borrowing largely depends on the income level (see the upper-right panel). Therefore, in the standard model, the household cannot smooth their consumption, and consumption changes largely depending on income level.

3.4.2.2 Simulation

To evaluate the size of volatility clearly, we simulate the ICR and the standard models. Figure 3.4.2 reports the result of the simulation. This simulation exercise is conducted in the following steps. First, we generate the Markov chain simulations of the income and the WRI with 200 periods. The bottom-right panel shows the simulated paths for y_t (the solid blue line) and r_t (the dashed orange line). We then calculate responses of endogenous variables from the policy functions. The top-two panels and the bottom-left in Figure 3.4.2 plot the simulated responses to foreign borrowing, consumption, and the Lagrange multiplier of the borrowing constraints. To illustrate the source of high volatility, we focus on the four notable episodes in the simulation. They are displayed as the shadows A, B, C, and D in the figure.

Notably, there are some events in λ_t^B (the bottom-left panel) that take huge values in the ICR model. Such high λ_t^B events are triggered by the change in the WRI;

Figure 3.4.2: Simulation result



Notes: The simulation is conducted by the following steps: (1) Generate Markov chain simulations of exogenous shocks (y, r) with 200 periods, (2) Calculate responses of d, c, λ^B from policy functions with spline completion. We start the simulation at $d_0 = d^{ss}, y_1 = y^{ss}, r_1 = r^{ss}$.

specifically when (i) the WRI takes the higher value in period t, and (ii) the WRI was low before period t and then raise in period t. Episode A in Figure 3.4.2 corresponds to case (i); a large increase in λ_t^B reflects tighter borrowing constraints due to a high WRI. Because the higher WRI decreases borrowing limits, borrowing and consumption also decline.

Episode B corresponds to case (ii); breaking away from the low WRI causes the tighter ICR-based borrowing constraint. As seen in Figure 3.4.1, the ICR-based borrowing constraint never binds when $r_t = r^{low}$. Thus, foreign debt (upper-left panel) increases, and foreign borrowing is remarkably accumulated during episode B. Once the WRI increases, the borrowing constraint binds, then the new borrowing is limited. As a result, the large repayment of borrowing acquired in the low WRI period requires a huge reduction in consumption. The downward spike in consumption (the upper-right panel) at the end of episode B reflects the decline in consumption for the repayments.

In episode C, r_t remains at a steady state, and the only income changes. The income shock does not generate sizable spikes of λ_t^B in the ICR model. Thus, foreign borrowing and consumption are relatively stable.

In episode D, the WRI stays at a high value soon after the low WRI period. At the beginning of episode D, the relaxed borrowing constraint contributes to a sizable accumulation of foreign borrowing in the ICR model. Then a rise in r_t makes the borrowing constraint tighter, resulting in huge reductions in foreign borrowing and consumption. However, when the WRI rises up and only income fluctuates, the volatilities of foreign borrowing and consumption stay low.

In the standard model, λ_t^B is more stable than in the ICR model. This stability of λ_t^B leads to the smaller volatilities of foreign borrowing and consumption in Episodes

A, B, and D. In Episode C, which is the period when the only income shock occurs, the ICR and the standard models predict similar fluctuations of foreign borrowing and consumption. This implies that the WRI shock generates a sizable difference between the two models.

To summarize, in the ICR model, the WRI shock has stronger effects on the volatilities of borrowing and consumption than does the income shock. The ICR-based borrowing constraint is relaxed during the low WRI periods and tightened in the high WRI periods. Thus, borrowing increases during the low WRI periods and falls once the WRI increases. High consumption volatility results mainly from the large spikes in consumption at the end of the low WRI period. When r_t becomes higher than r^{low}, the household needs to repay a large amount of foreign borrowing accumulated in r^{low} periods, but the binding borrowing constraint prevents the household from refinancing. Therefore, consumption will fall and be more volatile than income.

3.5 Summary of this chapter

This chapter introduces the ICR-based borrowing constraint. The key feature of the ICR-based borrowing constraint is that the WRI has a large effect on the foreign debt ceilings compared to the standard flow collateral constraint. The ICR model can explain the correlation between the smoothed preference shock and the WRI in the previous chapter.

The results of our calibration exercises show that the WRI has dominant effects on the tightness of the borrowing constraint, foreign debt, and consumption in the ICR model. During low-WRI periods, the borrowing constraint does not bind, and consumption smoothing is possible. As a result, foreign debt is accumulated. Once the WRI increases, the borrowing constraint binds, and refinancing is limited. The household reduces consumption sharply for repayments. This large decline in consumption is the source of the ECV.

Chapter 4

Financial integration and excess consumption volatility in emerging market economies

4.1 Introduction

In the previous chapter, we introduce the ICR-based borrowing constraint. In the ICR model, the WRI has a dominant effect on the tightness of the borrowing constraint, resulting in the correlation between the WRI and λ_t^B. Hence, the ICR model can explain our findings in Chapter 2.

A remaining question is: why did the correlation between the smoothed preference shock and the WRI become significant after 1975? In section 2.5, we reviewed the ECV puzzle: a deeper FI associated with a higher ECV. We consider the stronger correlation that emerged after 1975 because the EMEs started liberalizing their financial markets in the late 1970s; for example, Argentina conducted a financial reform in 1976 and removed restrictions regarding international financial transactions. As FI in EMEs deepens, the EMEs become more sensitive to external shocks, such as the WRI shock. Thus, we consider that λ_t^B started to correlate with the WRI after 1975 due to the FI, which causes the observed strong correlation between the U.S. real interest rate and the smoothed preference shock.

This view also implies that the ECV puzzle is associated with the sensitivity to the WRI. Then, this chapter provides a new mechanism of the ECV puzzle focusing on how the sensitivity of foreign borrowing capacity to the WRI changes the FI. Theoretically, we show the ECV puzzle using an SOE endowment model with the ICR borrowing constraint introduced in the previous chapter. Solving the model with various degrees of FI, τ, we show how the effect of WRI on the tightness of the borrowing constraint changes in τ. We emphasize the sensitivity of the foreign borrowing limit of the SOE to the WRI as a key to explain the past empirical observations that the extent of the ECV increases in the FI.

In addition, we illustrate that the ECV is associated with a negative skewness of consumption in EMEs. The size of the ECV is larger in EMEs with a large negative skewness of consumption. This fact indicates that consumption decreases sharply in an occasional fashion. The large previous literature has pointed out the business cycle asymmetry: an occasional sharp drop in business cycles (Neftci, 1984; Hamilton, 1989; Sichel, 1993; Van Nieuwerburgh and Veldkamp, 2006; Morley and Piger, 2012; Jensen et al., 2017). We contribute to this literature by showing that the ECV in EMEs results in an asymmetric consumption response both empirically and theoretically. Theoretically, we illustrate the negative consumption skewness by solving the occasionally binding ICR constraint with a nonlinear method developed by Mendoza and Villalvazo (2020).

Our calibrated ICR model successfully accounts for the ECV observed in Argentina's postwar quarterly data. The model also implies that a deeper FI, which is represented by a looser borrowing constraint, causes a higher ECV and larger negative skewness of consumption. The successful outcomes of our model stem from the novel mechanism proposed in this study. A higher degree of FI lowers the probability of binding borrowing constraints. Then, the household can smooth their consumption more through international financial transactions. As a result, foreign debt increases, on average. However, as foreign debt increases, foreign debt repayment increases; therefore, consumption decreases more sharply when the borrowing constraint binds. Because the

WRI significantly affects the tightness of the borrowing constraint, foreign debt, and consumption will become more vulnerable to a change in the WRI. Hence, the ECV increases in the degree of FI.

Our calibration results suggest that a deeper FI facilitates international financial transactions and makes consumption-smoothing easier. The possibility of consumption-smoothing depends on the level of WRI. Previous studies, including Pancaro (2010) and Faia (2011), approached the puzzling relationship between the FI and ECV differently from our research; they considered collateral constraints á la Kiyotaki and Moore (1997) and ignored the crucial effects of the WRI on international financial transactions. Contrary to our calibration results, their results indicate that a deeper FI (i.e., the relaxation of collateral constraints) does not promote the consumption-smoothing behavior. The central mechanisms proposed by these studies highlight how deepening the FI amplifies the consumption response to country-specific productivity shocks. A positive country-specific productivity shock increases demand for collateral for production. Thus, it increases the price of capital, which results in a relaxed collateral constraint and a further increase in production, inducing a greater increase in the permanent income. As the permanent income hypothesis predicts, consumption increases more than the current income does. Hence, the ECV emerges.

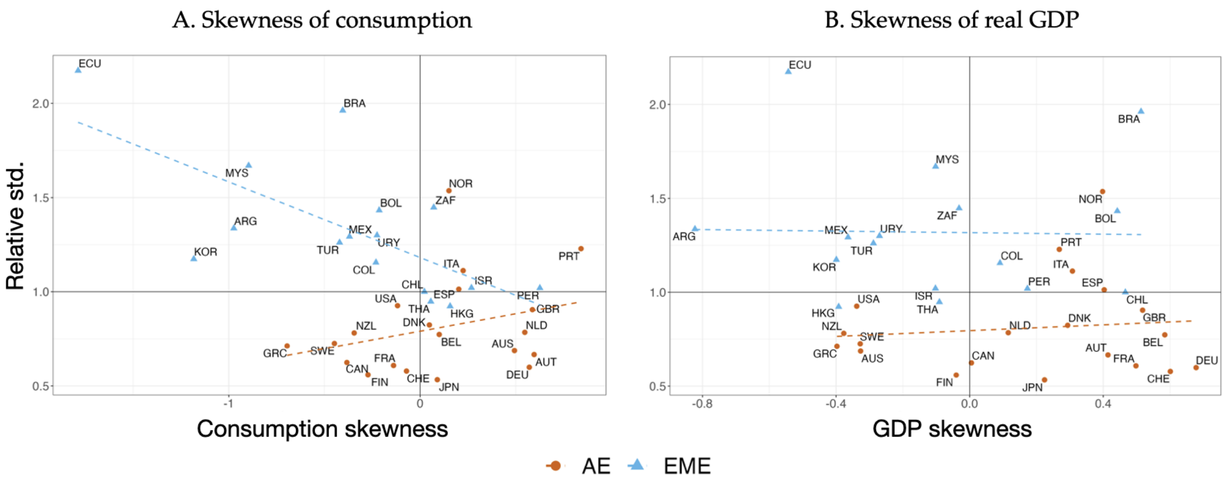
Other studies have examined the impact of the FI on the ECV by modeling the FI as the opening of a closed country to the international financial market (Levchenko, 2005; Leblebiciouglu, 2009; Bhattacharya and Patnaik, 2016; Evans and Hnatkovska, 2007, 2014). These studies illustrate how the FI worsens the ECV, relaying on the permanent income hypothesis. The FI allows consumption to respond to an increase in permanent income more than the current income does. Thus, consumption is more volatile than income.

This chapter is organized as follows. Section 4.2 empirically discusses the relationship between the ECV and a negative skewness of consumption. Section 4.3 describes the ICR model. Section 4.4 presents the quantitative analysis and evaluates the model. Finally, Section 4.5 summarizes the chapter.

4.2 ECV and negative skewness of consumption

Figure 4.2.1 shows the cross-country scatter plots of the relative standard deviation of consumption to real GDP, the measurement of ECV, and the negative skewness of consumption and real GDP. In panels A and B of Figure 4.2.1, the y-axis represents the relative standard deviation of consumption to real GDP for each country. The x-axis represents the skewness of consumption in Panel A and the skewness of real GDP in Panel B. The blue triangle points represent the EMEs, and the orange circles indicate

Figure 4.2.1: The relative standard deviation of consumption to real GDP and skewness of consumption and of real GDP



Note: The y-axis represents the relative standard deviation of consumption to real GDP. The x-axis represents the skewness of consumption in Panel A and the skewness of real GDP in Panel B. The blue triangle points represent EMEs, and the orange circles indicate advanced economies. The list of sample countries and sample periods is in the Appendix.

the advanced economies.[1]

Figure 4.2.1 shows that in EMEs, the relative standard deviation is associated negatively with the skewness of consumption but not with the skewness of real GDP. In other words, consumption must be more volatile than GDP because it drops significantly in an occasional fashion, indicating that the distribution of consumption has a long tail to the left. The ECV is caused by the occasional significant decline in consumption in the EMEs.

[1]Sample countries are listed in Appendix 4A.

Previous empirical studies, such as Aguiar and Gopinath (2007) and Kose et al. (2003a), have not pointed out the relationship between the ECV and skewness of consumption. Such previous studies have focused only on up to second-order moments. Our finding indicates the importance of examining higher-order moments, as shown by the extensive literature pointing out the business cycle asymmetry (Neftci, 1984; Hamilton, 1989; Sichel, 1993; Van Nieuwerburgh and Veldkamp, 2006; Morley and Piger, 2012; Jensen et al., 2017).

Previous studies did not consider the negative relationship between the relative standard deviation and consumption skewness (Pancaro, 2010; Faia, 2011). They ignore the population skewness of consumption because they solve their model by linear approximation around the steady state with a binding borrowing constraint. To simulate the population consumption skewness, we solve the ICR model using a nonlinear method developed by Mendoza and Villalvazo (2020).

4.3 An SOE endowment model with ICR-based borrowing constraint

4.3.1 The household problem

The model and the steady state are the same as in Chapter 3.

Table 4.1: Calibrated parameter values (baseline case)

Parameter		Value	Source/target
β	subjective discount factor	0.95	Pancaro (2010)
γ	risk aversion	2	Mendoza (2010)
τ	degree of FI	0.0408	std. ratio of consumption to real GDP per capita in Argentina
r^*	steady-state value of WRI	0.0356	mean of U.S. real interest rate
$\ln y^*$	steady-state value of income (logarithm)	4.460	mean of per capita real GDP in Argentina

4.3.2 Calibration

Table 4.1 reports the calibrated values of the model's structural parameters. The model is calibrated at a quarterly frequency. The parameter values are the same as in the previous chapter, except for τ and $\ln y^*$. τ is set to 0.0408 so that the standard ratio of consumption to real GDP per capita obtained from the model fits its data in Argentina for the period 1993Q1-2008Q3. $\ln y^*$ is set to the sample average of real GDP per capita in Argentina, 4.46.[2]

We calibrate the stochastic processes of the two exogenous shocks by estimating Eqs.(3.3.4) and (3.3.5) with the U.S. real interest rate and the deviation from the cubic trend of real GDP per capita in Argentina for 1993Q1-2008Q3, respectively. We obtain $\rho^r = 0.937$, $\rho^y_r = -0.100$, $\rho^y_y = 0.9485$, $\sigma_r = 0.0055$, and $\sigma_y = 0.0194$ from the corresponding point estimates. Subsequently, we approximate the bivariate vector autoregression (VAR) by a finite Markov process with nine states of y_t and r_t, using

[2]The real GDP per capita is the deviation from the cubic trend.

the multi-Tauchen method developed by Tauchen and Hussey (1991). In this chapter, we consider nine discrete grids for each y and r. The generated discrete grids of y have a minimum value of 79.93 and a maximum value of 93.51, while r has a minimum value of 0.0165 and a maximum value of 0.0547 to improve the solution accuracy.

We investigate the effect of FI on the SOE by changing the value of τ. We recalibrate the model with the four different values of $\tau = [0.5\tau^*, 0.75\tau^*, \tau^*, 1.25\tau^*]$, where τ^* is the baseline value of τ set above.

4.3.3 Quantitative exercise

We solve the ICR model using the fixed-point iteration method proposed by Mendoza and Villalvazo (2020). In this chapter, we set $\boldsymbol{D}$ with $n^d = 200$, $d_1 = -0.3d^{ss}$, and $d_{200} = 2.1d^{ss}$ for the baseline τ^* case, where d^{ss} is the deterministic steady state value of d_t. In case τ is smaller than the baseline value of 0.0408, we change d_1 to $-0.8d^{ss}$. The maximum value of $\boldsymbol{D}$, d_{200}, is set to different values depending on τ value. For $\tau = 0.5\tau^*$, $d_{200} = 1.5d^{ss}$; for $\tau = 0.75\tau^*$, $d_{200} = 1.9d^{ss}$; for $\tau = 1.25\tau^*$, $d_{200} = 2.45$.[3] Because each exogenous state variables r_t and y_t has nine states, there are 200×81 coordinates in the state space of this model.

[3]The minimum and maximum values of D are chosen so that the Euler equation error is sufficiently small.

4.4 Results of the quantitative analysis

4.4.1 Effect of financial integration on the SOE

Table 4.2 shows the sample moments in Argentina for 1993Q1-2008Q2 in the second column and the corresponding moments simulated from the ICR model with four different values of τ in the third to sixth columns. Here, $\tau^* = 0.0408$ is the baseline value of τ.

The sample moments in Argentina show high volatility and the ECV. Indeed, the standard deviations of trade balance, consumption, and income are over five percentage points. Moreover, the relative standard deviation of consumption to income exceeds one. These observations are consistent with the characteristics of emerging market business cycles. Most importantly, consumption in Argentina is characterized by a large negative skewness of -0.97. Hence, the ECV is associated with a large negative consumption skewness in Argentina.

Our ICR model explains these statistical properties well. In the baseline τ^* case shown in the fifth column in Table 4.2, the standard deviation of consumption, the size of the ECV, and the consumption skewness are close to the data counterparts. Moreover, the size of the ECV increases in τ. This calibration result shows that a deeper FI worsens the ECV, which is consistent with the findings of Kose et al. (2003b) and Prasad et al.

Table 4.2: Business cycle moments: effect of τ change

		Model			
	Data	$0.5\tau^*$	$0.75\tau^*$	τ^*	$1.25\tau^*$
Mean					
Foreign debt	-	45.52	65.53	84.58	102.92
TB-GDP ratio	0.02	0.02	0.03	0.03	0.04
Consumption (log)	4.26	4.44	4.43	4.42	4.42
Real GDP (log)	4.46	4.46	4.46	4.46	4.46
Standard deviation (in percent, except for foreign debt)					
Foreign debt	-	10.96	13.85	16.10	17.87
TB-GDP ratio	5.40	3.18	3.75	4.18	4.52
Consumption (log)	6.82	5.94	6.42	6.83	7.19
Real GDP (log)	5.10	5.10	5.10	5.10	5.10
Relative std. to GDP					
Consumption (log)	1.34	1.17	1.26	1.34	1.41
Skewness					
Foreign debt	-	0.39	0.36	0.33	0.30
TB-GDP ratio	1.00	1.80	1.91	1.96	1.98
Consumption (log)	−0.97	−0.69	−0.94	−1.13	−1.29
Probability of binding (%)	-	16.28	12.04	9.56	8.22
Euler eq. error (log10)					
Max. value	-	−7.86	−7.87	−7.92	−7.87
Mean. value	-	−9.50	−9.59	−9.67	−9.73

Note: Moments are calculated from the stationary distribution in Appendix 4B. The probability of binding borrowing constraint means intuitively how many positive grids, which can be the solution with the positive probability, are in λ_t^B.

(2003b). Besides, a higher consumption volatility is associated with a larger negative skewness of consumption. A larger τ reduces the probability of binding borrowing constraints and increases the average amount of foreign debt. These calibration results indicate that a deeper FI allows more international borrowing, whereas it increases the volatility and the negative skewness of consumption.

4.4.2 The source of high volatility

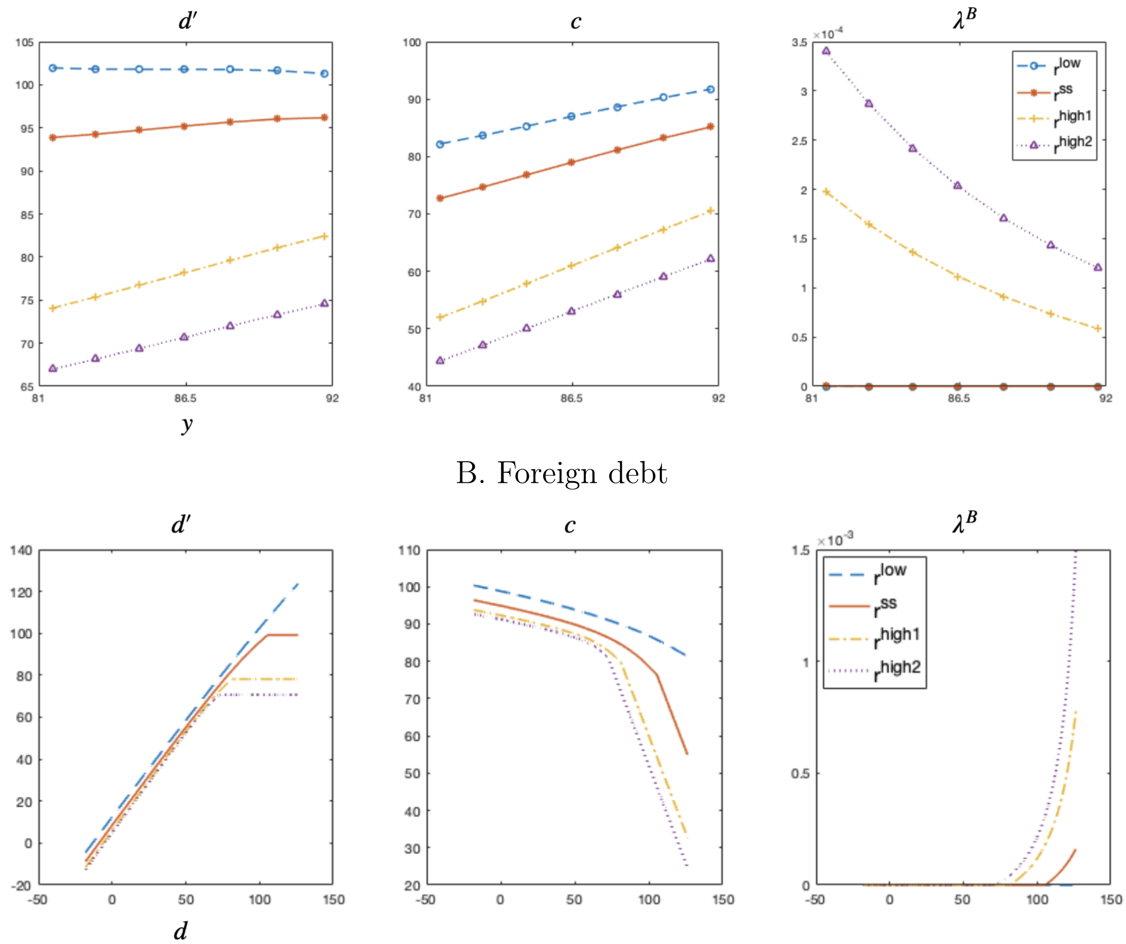
This subsection explains why our model predicts higher consumption volatility as the FI deepens.

Figures 4.4.1A and B show the policy functions of our model sliced at the steady state value of income, $y_t = y^{ss}$ and $d_t = d^{ss}$, respectively. The left panels plot the policy functions for foreign borrowing, the middle panels plot those for consumption, and the right panels plot those for the Lagrange multiplier for the borrowing constraints. We examine the policy functions under different levels of the WRI. The blue dashed lines depict the policy functions under the low value of r_t, the solid red lines are under the steady-state value of r_t, and the yellow dashed-dotted lines and the purple dotted lines are under the high r_t.

The right panel of Figure 4.4.1(A) shows that when $r_t = r^{low}$, λ_t^B remains zero, no matter how much the income is. It indicates that the borrowing constraint never binds in low WRI periods. Thus, during periods with r^{low}, the representative household can borrow from foreign countries freely and smooth consumption against the income shock. Because the income shock is temporal, the representative household increases

Figure 4.4.1: Policy functions

A. Income



Note: Policy functions in subplot A are calculated with spline completion and sliced at $d = d^{ss}$ (the deterministic steady-state level of foreign borrowing), and those in subplot B are sliced at $y = y^{ss}$ (the deterministic steady-state level of income). In subplot A, both ends of the income grid are dropped. $r^{low}, r^{ss}, r^{high1}$, and r^{high2} mean the states (grids) for the WRI in both subplots A and B. r^{low} is the second level from the bottom of WRI. r^{high2} and r^{high1} are the second and third levels from the top of WRI, respectively.

foreign debt to smooth consumption in low-income periods and reduce foreign debt in high-income periods, as shown in the left panel of Figure 4.4.1(A).

The tightness of the borrowing constraint varies notably depending on the value of the WRI. As shown in the right panel of Figure 4.4.1(A), λ_t^B is highly volatile; it varies from zero to near 0.15%, depending on r_t. Such a high dependence of λ_t^B on the WRI makes foreign borrowing and consumption depend on the WRI. A lower (higher) r_t relaxes (tightens) the borrowing constraint and facilitates (limits) foreign borrowing, which results in increasing (reducing) consumption through the budget constraint (3.3.1).

Figure 4.4.1(B) indicates that if the foreign debt in the previous period, d_t, is high enough, then the foreign debt and consumption will fluctuate significantly with changes in the WRI. When the WRI is lower than r^{ss}, the borrowing constraint never binds ($\lambda_t^B = 0$), regardless of states of d, as shown in the right panel in Figure 4.4.1(B). As the WRI increases, λ_t^B varies significantly depending on states of d; higher d increases λ_t^B. The more foreign debt in the previous period, the more likely the current foreign debt will be severely limited when the WRI is high. As a result, a larger d with a high WRI reduces consumption more than with a low WRI. The WRI has a dominant effect on whether the borrowing constraint binds at the high d states,

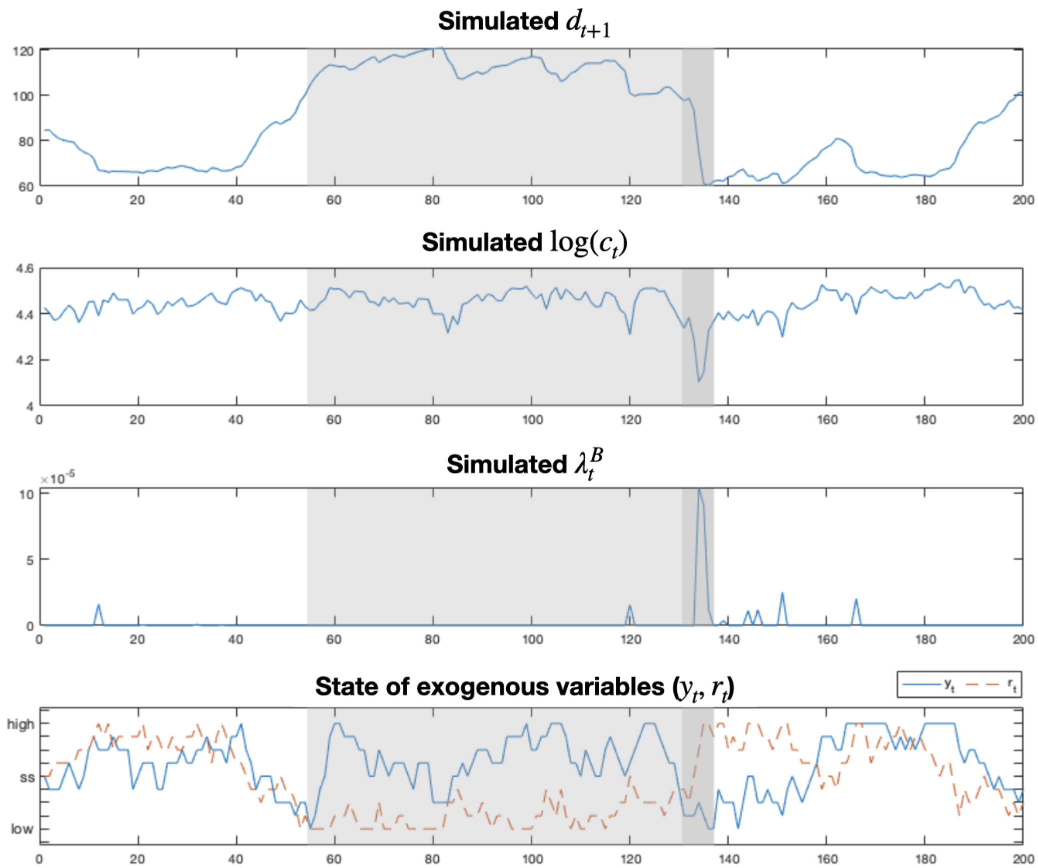
The simulated path reported in Figure 4.4.2 illustrates a large d_t and a high WRI generate a downward spike in consumption under the binding borrowing constraint. During the low-WRI period, highlighted by the gray shadow, the borrowing constraint does not bind; foreign borrowing is accumulated. Then, if the WRI rises sharply, the borrowing constraint binds, and the foreign debt is limited. However, the household must repay the foreign debt accumulated during the low-WRI period. As a result, consumption decreases significantly to repay the foreign debt, leading to a large negative skewness of consumption and a higher consumption volatility than income volatility.

Now we answer the question, why does the degree of the ECV increase as the FI deepens? A larger τ reduces the probability of binding borrowing constraints and increases the average amount of foreign borrowing. However, it also makes borrowing and consumption more volatile because a larger τ amplifies the effect of the WRI on the borrowing limit.[4] If τ is small (i.e., the FI level is low), the borrowing constraint almost always binds even if the WRI is low. The implied higher probability of binding constraint does not allow foreign borrowing to adjust fully against the income shock, resulting in the smaller volatilities of foreign debt and consumption.

The standard constraint presented in the previous chapter cannot predict such a large negative consumption skewness. In the standard constraint, the borrowing constraint is slack when the income is high. However, since the income shock is temporally,

[4]Recall that the borrowing constraint forms $d_{t+1} \leq \frac{\tau}{r_t} E_t y_{t+1}$.

Figure 4.4.2: Simulation result



Note: The simulation is conducted through the following steps: (1) Generate Markov chain simulations of exogenous shocks (y, r) with 200 periods, (2) Calculate responses of d, c, λ^B from policy functions with spline completion. We start the simulation at the mean value of the stationary distribution of b and the deterministic steady state value of y and r.

households reduce rather than increase their borrowing. Since the binding borrowing constraints makes repayment more difficult, households have less incentive to increase foreign debt. When income is low and the borrowing constraint binds, the borrowing is limited. Households must repay the foreign debt during the high income period, but the amount of foreign debt is less compared to the ICR constraint. As shown in Figure 3.4.2, the standard constraint has the less drop in consumption compared to the ICR constraint. Therefore, the standard constraint cannot replicate the large negative consumption skewness.

4.5 Summary of this chapter

This chapter investigates why deeper FI increases the ECV in EMEs. First, we show that the ECV is associated with a negative skewness of consumption. Then, we construct the ICR model in which the borrowing limit depends on expected future income and the WRI. The quantitative analysis shows that the model fits better with the consumption volatility and the relative volatility of consumption to income in Argentina. In addition, our model can illustrate our motivating facts; the ECV increases in the FI and is associated with a negative skewness of consumption.

The mechanism presented in this chapter is as follows. Under the baseline calibration, the borrowing constraint does not bind when the WRI is low. Hence, foreign borrowing increases. Large repayments reduce consumption if the WRI increases and the borrowing constraint becomes tight. Consumption-smoothing against the income shock is possible when the borrowing constraint binds. Consumption becomes more sensitive to the WRI shock, which has a crucial influence on whether the borrowing constraint binds.

A higher degree of FI reduces the probability of binding the borrowing constraint and increases the average amount of foreign borrowing. However, it also makes foreign borrowing and consumption more volatile because the higher degree of FI amplifies the effect of the WRI on the foreign debt limit. A large amount of foreign debt reduces consumption significantly once the borrowing constraint binds, and this consumption fall leads to its negative skewness. Consequently, foreign debt and consumption become more volatile at higher FI levels, even if the FI increases the average amount of foreign debt and provides a better opportunity for consumption-smoothing against income shocks. The FI would make consumption and foreign borrowing more vulnerable to the WRI shock.

Chapter 5

Financial integration and emerging market crises

5.1 Introduction

In the previous chapter, we consider the social planner's case. However, it is weird that individuals take into account the effect of their effect on price. In this chapter, we extend the ICR model in Chapter 3 by considering the pecuniary externality.

Bianchi (2011) shows that under the two-sector SOE borrowing constraint model with pecuniary externality, the private agent borrows more than the social planner does. The social planner internalizes the changes in the tightness of the borrowing constraint reflecting the relative price changes, whereas the private agent does not internalize it because they take the relative price changes as given. The overborrowing causes the sudden stop to be more likely and severe. Following this hypothesis, preventing overborrowing will make sudden stops less likely, and improve economic welfare.

This chapter theoretically investigates the characteristics of overborrowing and sudden stops under various FI levels. Specifically, we analyze the following questions: (1) Does the impact of a sudden stop crisis differ among economies with different levels of FI? (2) Does a change in the WRI cause overborrowing or sudden stops? and (3) If so, how does the change in the WRI cause sudden stops?

To answer the above questions, we extend the ICR model in Chapter 3 by introducing tradable and nontradable goods endowments. Our extended two-sector ICR model is the same as in Bianchi (2011), except for the borrowing constraint; while Bianchi (2011) uses the standard flow collateral constraint, we use the ICR-based borrowing constraint. As we introduced in Chapter 3, the key feature of the ICR-based borrowing constraint is that a change in the WRI has a greater impact on external borrowing availability than the standard flow collateral constraint. Different from the ICR-based borrowing constraint in Chapter 3, this chapter's ICR borrowing constraint depends not only on the WRI and endowments changes but also on the relative price of non-tradable goods to tradable goods. Hence, a change in the relative price due to tradable or nontradable goods shocks will affect the tightness of the borrowing constraint.

We compare the social planner's allocation and the decentralized rational expectations equilibrium , like in Bianchi (2011). We illustrate how overborrowing occurs and induces sudden stops, conduct welfare analysis, and provide simple policy implications for preventing sudden stops.

Our calibration exercises show that a deeper degree of the FI, represented by a looser borrowing constraint, reduces the probability of sudden stops. Meanwhile, the impact of sudden stops on the SOE becomes more severe. The FI makes a sudden stop less likely to occur, but once a crisis occurs, there would be a significant decline in consumption and welfare. Consequently, the business cycles become more volatile, resulting in higher consumption volatility and a more severe ECV puzzle (Kose et al., 2003b and Prasad et al., 2003a).

We also show that there is an overborrowing problem behind rare but severe crises in high FI-level economies, especially during low WRI periods. Our model incorporates pecuniary externality; private agents do not internalize the price effects on the tightness of the borrowing constraint. Consequently, the private agent borrows more than expected in the first best allocation. In our calibration results, overborrowing occurs in states with low probabilities of binding the borrowing constraints, due to low WRIs. Once the borrowing constraint binds, consumption decreases greatly for repayment.

The probabilities of binding borrowing constraint and a sudden stop are remarkably high in high WRI periods. In high WRI periods, the occurrence of a sudden stop depends on tradable goods shock and the amount of foreign debt; large foreign debt and low tradable goods shock tighten the borrowing constraint.

Moreover, our results infer that the welfare gain of internalizing the pecuniary externality increases in the FI because the impact of a sudden stop is larger in the high-FI countries having large foreign debts. In addition, policies preventing overborrowing, for example, Tobin taxes on capital inflows, would be particularly effective under the low-WRI periods with active overborrowing. Under the high-WRI periods with the high risk of sudden stops, it is effective for reducing the probability of sudden stops not only to control capital flows with capital tax but also to raise the supply of tradable goods and the relative price of nontradable goods by policies, such as lowering tariffs and raising subsidies for tradable goods sectors.

This study contributes to the literature by focusing on how the FI and the WRI affect sudden stops. Previous studies showing the mechanism of how sudden stops occur in EMEs, including Arellano and Mendoza (2002), Mendoza (2010), and Bianchi (2011), did not illustrate the relationship between the WRI and sudden stops explicitly. For example, Bianchi (2011) assumed a constant WRI and did not consider the effect of the WRI on sudden stops. Mendoza (2010) investigated sudden stops by an SOE model with a stock collateral constraint under a stochastic WRI. He showed that a rise in the WRI results in a sudden stop but did not analyze how much the higher WRI increases the sudden stop probability or how crucial changes in the WRI are for causing sudden stops, compared to the other structural shocks. Recently, Davis et al. (2023) investigated the role of the WRI on sudden stops using a self-fulfilling equilibrium model. They show that the WRI can be a trigger for the sudden stop. Our study is different from their study in two aspects. The first difference is the equilibrium concept; we use the standard rational expectations equilibrium, whereas they use the self-fulfilling equilibrium developed by Schmitt-Grohé and Uribe (2020). Hence, our model is easy to solve with little computational effort. Secondly, we consider two types of exogenous shocks: endowment shocks and the WRI shock, whereas they consider only the WRI shock. Our model can discuss which domestic or external shock has a dominant effect on the EMEs. This is important for policy discussion. Furthermore, none of these previous studies analyzed the effect of FI on the sudden stop and welfare.

The remainder of this chapter is organized as follows. Section 5.2 describes the model. Section 5.3 presents the quantitative exercise that evaluates the model and discusses the welfare. Finally, Section 5.4 summarizes the chapter.

5.2 The Model

5.2.1 The economic environment

Consider an SOE endowed with tradable and nontradable goods. The infinitely lived representative household receives tradable goods y_t^T and nontradable goods y_t^N as endowments. y_t^T and y_t^N vary stochastically. There is a state non-contingent bond traded in international financial markets. The representative household can borrow from and lend to the rest of the world for one period at the time-varying WRI r_t, which is exogenous to the SOE.

The household faces the following period-by-period budget constraint

$$y_t^T + p_t y_t^N + d_{t+1} = (1 + r_{t-1})d_t + c_t^T + p_t c_t^N, \tag{5.2.1}$$

where p_t is the relative price of nontradable goods in terms of tradable goods, c_t^T is tradable goods consumption, c_t^N is nontradable goods consumption, and d_{t+1} is the foreign debt level in period $t + 1$.

The household faces the augmented ICR-based borrowing constraint;

$$d_{t+1} \leq \max\left\{\bar{d}, \frac{\tau}{r_t}(y_t^T + p_t y_t^N)\right\}, \tag{5.2.2}$$

where $\bar{d} > 0$ is the minimum debt limit and $\tau \geq 0$ is the degree of FI, which is a parameter that determines the tightness of the borrowing constraint. The Eq. 5.2.2 has two differences from the ICR-based borrowing constraint in Chapter 3. First, for simplicity, we assume that the foreign debt limit depends on the current total income, not the expected value of the next period's income. Second, a change in the relative price affects the foreign debt limit. Thus, the foreign debt limit relies on changes in four factors: the WRI, tradable and nontradable goods endowments, and the relative price.[1] An increase in the relative price raises the total income and relaxes the ICR-based borrowing constraint.

Our borrowing constraint (5.2.2) respectfully takes after imitating the previous work by Bianchi (2011): a collateral constraint depending on the current income and relative price of nontradable goods. This specification is an easy extension form from the ICR constraint in the previous chapter. In addition, it makes it easier to compare the large amount of previous studies using the standard flow type collateral constraints *à* la Bianchi (2011).[2]

[1]Theoretically, nontradable goods can be collateral because it is possible for foreign lenders to sell nontradable goods in the domestic market and get funds (Bianchi, 2011).

[2]Extending this model to the production economy, the borrowing constraint becomes dependent on the capital stock and labor demand. It is one of our future research, but we believe that in the production economy, our ICR-based borrowing constraint generates the dominant effect of the WRI on the SOE. In the production economy, two additional channels of the WRI change exist: changing capital demand and tightness of the borrowing constraint through the Euler equation for capital. As shown in the Chapter 3, the WRI has a dominant effect on the borrowing constraint channel, and effects through intertemporal substitution are modest. Thus, we believe that in the Euler equation for capital, the borrowing constraint effect of WRI is dominant. We expect that our mechanism, in

Given the exogenous sequences of tradable goods y_t^T, nontradable goods y_t^N, the WRI r_t, the relative price p_t and initial foreign debt level d_0, the household maximizes the following expected lifetime utility function

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-\gamma}}{1-\gamma}, \tag{5.2.3}$$

by choosing the sequence of tradable consumption c_t^T, nontradable consumption c_t^N and the foreign debt level d_{t+1}, subject to the budget constraint (5.2.1) and the borrowing constraint (5.2.2) and exogenous stochastic process of y_t^T, y_t^N, r_t. c_t is the consumption basket given by $c_t = (\omega(c_t^T)^{-\eta} + (1-\omega)(c_t^N)^{-\eta})^{-\frac{1}{\eta}}$ with $\eta > -1, \omega \in (0,1)$.

5.2.2 Optimality conditions

The household's first-order conditions are:

$$\lambda_t = U_1(c_t^T, c_t^N) = \omega(c_t^T)^{-(1+\eta)} c_t^{(1-\gamma)(\frac{1}{\eta}-1)}, \tag{5.2.4}$$

$$\lambda_t = U_2(c_t^T, c_t^N) p_t = (1-\omega)(c_t^N)^{-(1+\eta)} c_t^{(1-\gamma)(\frac{1}{\eta}-1)} p_t, \tag{5.2.5}$$

$$\lambda_t = \beta(1+r_t) E_t \lambda_{t+1} + \lambda_t^B, \tag{5.2.6}$$

which the WRI has a dominant effect on borrowing tightness, which in turn affects consumption, is also largely valid in the production economy.

$$d_{t+1} = \frac{\tau}{r_t}(p_t y_t^N + y_t^T) \text{ if } \lambda_t^B > 0. \tag{5.2.7}$$

Eqs. (5.2.4) and (5.2.5) show the marginal utility of tradable and nontradable consumption, where λ_t is the Lagrange multiplier associated with the budget constraint (5.2.1). Eq. (5.2.6) represents the Euler equation where λ_t^B is the Lagrange multiplier for the ICR-based borrowing constraint (5.2.2). If the ICR-based borrowing constraint binds, $\lambda_t^B > 0$ and the borrowing constraint holds with equality, as in Eq. (5.2.7).

By combining Eqs. (5.2.4) and (5.2.5), we obtain the equilibrium relative price of nontradable goods as a function of the ratio of tradable to nontradable goods consumption:

$$p_t = \frac{1-\omega}{\omega}\left(\frac{c_t^T}{c_t^N}\right)^{\eta+1}. \tag{5.2.8}$$

The equilibrium relative price p_t increases in tradable goods consumption, and decreases in nontradable goods consumption.

Market clearing conditions are given by:

$$c_t^N = y_t^N, \tag{5.2.9}$$

$$y_t^T + d_{t+1} = c_t^T + (1 + r_t)d_t. \tag{5.2.10}$$

Eq. (5.2.9) states that nontradable goods must be consumed domestically in equilibrium. Substituting Eq. (5.2.9) into the budget constraint Eq. (5.2.1), we obtain Eq. (5.2.10), the market clearing condition of tradable goods.

5.2.3 Recursive competitive equilibrium

The above household's dynamic optimization problem can be rewritten in a recursive form:

$$V(d, D, s) = \max_{d', c^T, c^N} u(c(c^T, c^N)) + \beta E_{s'|s} V(d', D', s')$$

$$\text{s.t.} \quad d' + y^T + p(D, s)y^N \geq c^T + p(D, s)c^N + (1 + r)d,$$

$$d' \leq \frac{\tau}{r}[y^T + p(D, s)y^N],$$

$$D' = \Gamma(D, s),$$

where d is the household's foreign debt in t, D is the aggregate foreign debt in the current period, s is the state of exogenous variables (y^T, y^N, r), Γ is the household's belief of aggregate foreign debt in the next period, and the prime symbol denotes the next period's value. $V(d, D, s)$ is the optimal value of the objective function with states of foreign debt d, the aggregate foreign debt D, and exogenous variables s.

We use the recursive competitive equilibrium as the equilibrium concept of the above model.[3] The recursive competitive equilibrium for this economy is defined

[3]See also Section 7.3 of Ljungqvist and Sargent (2012).

by a pricing function $p(D, s)$, a perceived law of motion $\Gamma(D, s)$, and decision rules $\{\hat{d'}(d, D, s),\ \hat{c^T}(d, D, s),\ \hat{c^N}(d, D, s)\}$ with associated value function $V(b, D, s)$ satisfying the following conditions:

1. *Household optimization:* given $p(D, s)$ and $\Gamma(D, s)$, the decision rules and the value function solve the recursive optimization problem of the household.

2. *Rational expectation condition:* $\Gamma(D, s) = \hat{d}'(d, D, s)$.

3. *Markets clear:* market clearing conditions $y^N = \hat{c^N}(b, D, s)$ and $\Gamma(D, s) + y^T = \hat{c^T}(d, D, s) + (1 + r)D$ hold.

5.2.4 Social planner's problem

Unlike private agents, the social planner chooses foreign debt and consumption by internalizing the effects of price changes on borrowing constraints and maximizing the social welfare of the SOE. The social planner faces the following ICR-based borrowing constraint internalizing the pecuniary externality:

$$d' \leq \frac{\tau}{r}\left[y^T + \frac{1-\omega}{\omega}\left(\frac{c^T}{y^N}\right)^{\eta+1} y^N\right], \tag{5.2.11}$$

which is obtained by substituting the optimal relative price (5.2.8) and equilibrium condition (5.2.9) into the ICR-based borrowing constraint (5.2.2).

Since the nontradable goods must be consumed domestically in equilibrium (Eq. (5.2.9)), the social planner chooses only tradable consumption c^T, and foreign debt d'. Overall, the social planner's optimization problem in recursive form can be written as follows:

$$V(d,s) = \max_{d',c^T} u(c(c^T, y^N)) + \beta E_{s'|s} V(d', s')$$

$$\text{s.t.} \quad d' + y^T = c^T + (1+r)d,$$

$$d' \leq \frac{\tau}{r}\left[y^T + \frac{1-\omega}{\omega}\left(\frac{c^T}{y^N}\right)^{\eta+1} y^N \right],$$

where $V(d,s)$ is the value function with foreign debt d and exogenous variables s.

5.2.5 Difference between the first best allocation and the decentralized equilibrium

The Euler equations of the social planner's problem and of the private agent's problem are:

$$\text{Social Planner: } u_1(c_t^T, c_t^N) + \Psi_t \lambda_t^{Bsp} = \beta(1+r_t)E_t\left[u_1(c_{t+1}^T, c_{t+1}^N) + \lambda_{t+1}^{Bsp}\Psi_{t+1}\right] + \lambda_t^{Bsp}, \tag{5.2.12}$$

$$\text{Private Agent: } u_1(c_t^T, c_t^N) = \beta(1+r_t)E_t u_1(c_{t+1}^T, c_{t+1}^N) + \lambda_t^B, \tag{5.2.13}$$

where λ_t^B is the Lagrange multiplier for the borrowing constraint of the private agent's problem, λ_t^{Bsp} is that of the social planner, and $\Psi_t = (\eta+1)\frac{\tau}{r_t}\frac{1-\omega}{\omega}\frac{(c_t^T)^\eta}{(y_t^N)^{\eta+1}} > 0$. Suppose the social planner increases a unit of tradable consumption by increasing foreign debt. An increases in c_t^T and d_{t+1} have four effects on the SOE through the Euler equation (5.2.12). The left-hand side of Eq. (5.2.12) implies the benefit of increasing c_t^T: the additional marginal utility, $u_1(c_t^T, c_t^N)$, and the marginal benefit from relaxed borrowing constraint evaluated in terms of utility, $\Psi_t \lambda_t^{Bsp}$. The right-hand side of Eq. (5.2.12) indicates the cost of increasing foreign debt, d_{t+1}: the lower expected discounted value of the marginal utility $\beta(1+r_t)E_t u_1(c_{t+1}^T, c_{t+1}^N)$ for repayments, increasing λ_t^{Bsp} by tightening borrowing constraint, and a tighter borrowing constraint in the next period $\beta(1+r_t)E_t[\lambda_{t+1}^{Bsp}\Psi_{t+1}]$ due to increasing repayments and decreasing c_{t+1}^T.

The private agent does not internalize the marginal benefit from the relaxed borrowing constraint evaluated in terms of utility, $\Psi_t \lambda_t^{Bsp}$, and a tighter borrowing constraint in the next period, $\beta(1+r_t)E_t[\lambda_{t+1}^{Bsp}\Psi_{t+1}]$. Under the binding borrowing constraint ($\lambda_t^B > 0$ or $\lambda_t^{Bsp} > 0$), both the private agent and the social planner will reduce current tradable consumption, but the size of reduction differs between their choices. On the one hand, the social planner considers the expected utility loss of binding borrowing constraint in the next periods, while the private agent does not. Thus, the social planner reduces the current tradable consumption more than the private agent does. On the other hand, the social planner takes into account the marginal utility gain of relaxed borrowing constraint. Overall, the private agent consumes more than the social planner if the variable $\Delta_t^B \equiv \left\{(1-\Psi_t)\lambda_t^{Bsp} + \beta(1+r_t)E_t[\lambda_{t+1}^{Bsp}\Psi_{t+1}]\right\} - \lambda_t^B$ is positive.

To understand this condition, suppose λ_t^B and$\lambda_t^{Bsp} = 0$. In this case, the borrowing constraint does not bind both in the decentralized equilibrium and the social planner's solution. Then we obtain

$$\Delta_t^B = \beta(1+r_t)E_t[\lambda_{t+1}^{Bsp}\Psi_{t+1}] \geq 0.$$

Therefore, if the current borrowing constraint is slack, the private agent always consumes and borrows more than the social planner. This implies "overborrowing" in the decentralized equilibrium (Bianchi, 2011). Note that Δ_t^B increases in the degree of FI, τ. Hence, the degree of overborrowing gets worse in τ. Because a higher foreign debt in the current period increases refunding demands of foreign debt and tightens the future borrowing constraint, once the borrowing constraint binds, equilibrium consumption in the decentralized economy decreases more for debt repayments when sudden stops as τ increases.

5.2.6 Stochastic process of exogenous variables

We assume that y_t^T and y_t^N follow the vector auto-regressive process with order one (VAR(1)). Let X_t denote the column vector $[\ln y_t^T, \ln y_t^N]'$. Then X_t follows

$$X_t = \begin{bmatrix} \rho_T^T & \rho_N^T \\ \rho_T^N & \rho_N^N \end{bmatrix} X_{t-1} + \begin{bmatrix} e_t^T \\ e_t^N \end{bmatrix}. \tag{5.2.14}$$

The tradable and nontradable endowment shocks, e_t^T and e_t^N, follow a bivariate normal distribution with the zero mean and the following variance-covariance matrix,

$$V = \begin{bmatrix} \sigma_T^2 & \sigma_{TN} \\ \sigma_{TN} & \sigma_N^2 \end{bmatrix},$$

where σ_T and σ_N are the standard deviations of the tradable and nontradable endowment shocks, respectively, and σ_{TN} is the covariance between the tradable and nontradable shocks.

We assume that r_t follows an AR(1) process;

$$r_t = (1-\rho^r)r^* + \rho^r r_{t-1} + e_t^r,\ e_t^r \sim N(0, \sigma_r^2),$$

where r^* is the steady state level of r_t, and ρ^r is the AR(1) coefficient. The WRI shock

Table 5.1: Calibrated parameter values (baseline case)

Parameter		Value	Source/target
β	subjective discount factor	0.906	Bianchi (2011)
γ	risk aversion	2	Bianchi (2011)
η	price elasticity parameter	0.2048	Bianchi (2011)
ω	tradable consumption share	0.2989	share of tradable consumption in Argentina
τ	degree of FI	0.023	probability of being sudden stop in Argentina
r^*	steady-state value of WRI	0.055	mean of U.S. real interest rate

e_t^r is an *i.i.d.* normal random variate with the zero mean and the standard deviation σ_r.

5.2.7 Calibration

Table 5.1 reports the calibrated values of the model's structural parameters. The model is calibrated at an annual frequency. Following Bianchi (2011), the subjective discount factor, β, is set to 0.906, the CRRA parameter, γ, is set to 2.0, and the price elasticity parameter, η, is set to 0.2048. The share of tradable consumption is 0.2989, which comes from the mean value for our sample period between 1980 and 2007 in Argentina. We calibrate the degree of FI, $\tau = 0.023$, so that the probability of sudden stop is consistent with the data in Argentina, 5.05%.[4] We use the U.S. real interest rate as the proxy of

[4]In the model, a sudden stop event is defined as the period satisfying the two conditions following Bianchi (2011): (1) the borrowing constraint binds, (2) the current account to GDP ratio deviates from its one standard deviation. Empirically, we define a sudden stop event as the period in which the current account to GDP ratio deviates from its one standard deviation.

the WRI, r_t. We estimate the AR(1) process of r_t with the U.S. real interest rate from 1980 to 2007, and obtained $r^* = 0.055$, $\rho^r = 0.3996$, $\sigma_r = 0.0125$. We estimate the VAR(1) process of X_t, Eq. (5.2.14), with the HP-filtered cycle component of tradable goods and non-tradable goods in Argentina.[5] We obtain $\rho_T^T = 0.2425$, ρ_N^T =-0.1984, $\sigma_T = 0.0052$, $\rho_T^N = 0.3297$, $\rho_N^N = 0.7576$, $\sigma_N^2 = 0.0059$, and σ_{TN} = -0.002. Subsequently, we approximate the VAR(1) by a finite Markov process with each three states of y_t^T, y_t^N, and r_t. To derive the finite Markov process for r_t, we use the Tauchen method. For the VAR process of X_t, we use the multi-Tauchen method developed by Tauchen and Hussey (1991). The generated discrete grids of y_t^T have a minimum value of 0.91 and a maximum value of 1.099, those of y_t^N have a minimum value of 0.88 and a maximum value of 1.13, while those of r have a minimum value of 0.041 and a maximum value of 0.069.

We scrutinize the effect of FI on the SOE by changing the value of τ. We recalibrate the model with the four different values of $\tau = [0.9\tau^*, 0.95\tau^*, \tau^*, 1.05\tau^*]$, where τ^* is the baseline value of τ set above.

[5]For y^T, we use the value added of agriculture, fishing, mining, and manufacturing, following Schmitt-Grohé and Uribe (2016).

5.2.8 Quantitative exercise

We solve our model using the time iteration method. The endogenous state variable is d, which is chosen from evenly spaced discrete grids with size n_d, $\mathbf{D} = \{d_1 < d_2 < \cdots < d_{n^d}\}$. The state space of the model is defined as $(d, s) \in \mathbf{D} \times \mathbf{S}$. We set $\mathbf{D}$ with $n^d = 100$, $d_1 = 0.2$, and $d_{100} = 1.1$ for the baseline τ^* case. Because each of the three exogenous state variables r_t, y_t^T, and y_t^N has three grids, there are 100×27 coordinates in the state space of this model.

5.3 Result of the quantitative analysis

5.3.1 FI and business cycle moments

Figure 5.3.1 shows business cycle moments simulated by the model with various degrees of FI, τ. In all panels, the horizontal axis represents the values of τ. Figure 5.3.1A shows, from the left to right panels, the ensemble averages of the unconditional means of foreign debt, tradable consumption, price, and the sudden stop probability (in percent) for each τ. The aggregate real consumption and the aggregate real GDP are calculated based on national accounts definition, using the value in the base year as the steady-state value:

$$x_t^{real} = (p_t x_t^N + x_t^T)\left(W^N \frac{p_t}{p^*} + W^T\right), \ x = \{c, y\}, \tag{5.3.1}$$

where $W^N = p^* x^{N*} / \left(p^* x^{N*} + x^{T*}\right)$ and $W^T = x^{T*} / \left(p^* x^{N*} + x^{T*}\right)$ are the weights for nontradable and tradable goods, and p^* is the steady-state level of the relative price, x^{N*} is that of the nontradable goods, and x^{T*} is that of the tradable goods. For the steady-state values, we use the mean values of the variables. A sudden stop event is defined as a period that satisfies the following two conditions: (1) the borrowing constraint binds, and (2) the current account to GDP ratio drops more than one standard deviation.[6] Figure 5.3.1B shows that from left to right panel, the averages of the standard deviations of foreign debt and real consumption, the relative standard deviations of consumption to real GDP, and the standard deviation of the relative price for each τ. Standard deviations are in percentage.

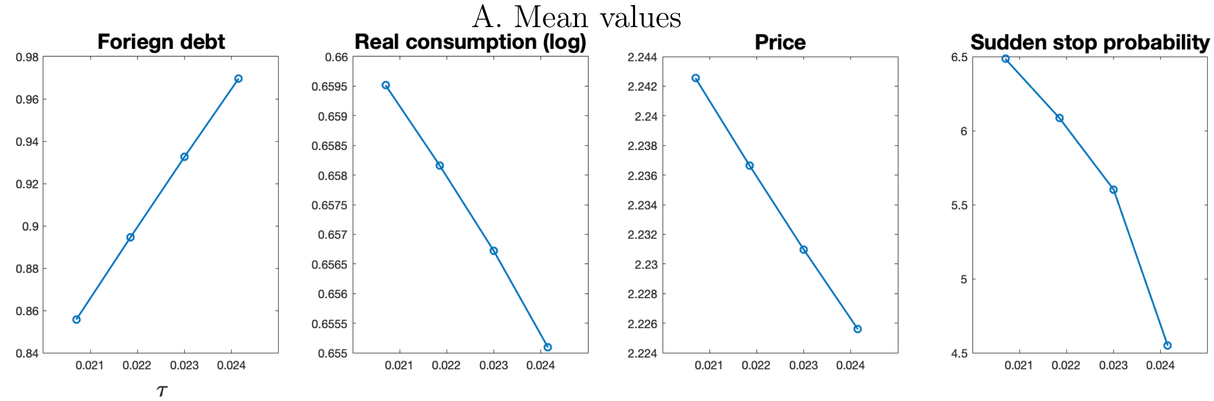
Figure 5.3.1A illustrates how a deeper FI reduces the probability of sudden stops. As τ increases, the average amount of foreign debt increases because a higher τ relaxes the borrowing constraint. As a result, the probability of sudden stops decreases from about 6.5% in the lowest τ to almost 4.5% in the highest τ. Real consumption and price decrease in τ, but to a lesser extent. At most, consumption declines by about 0.7% and the price by only 0.4%.

FI reduces the sudden stop probability but increases business cycle volatilities. In Figure 5.3.1B, the standard deviations of foreign debt, real consumption, the relative

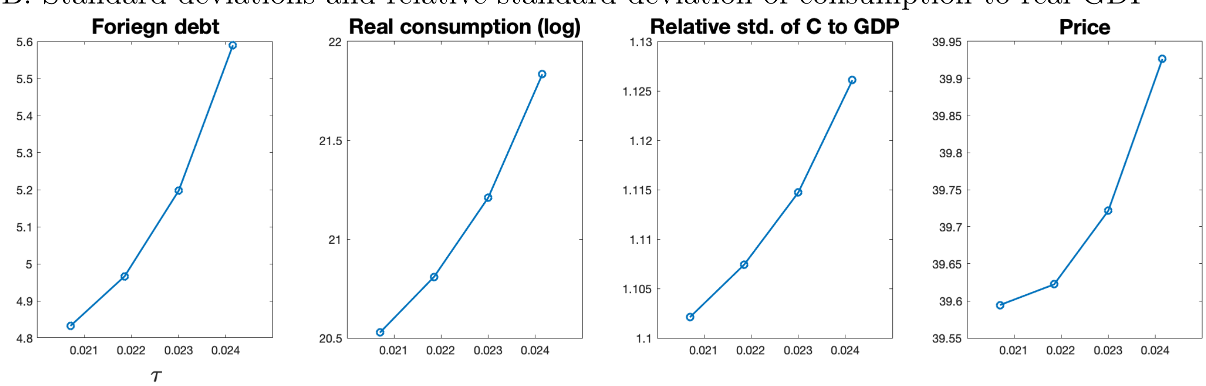
[6] Under the baseline τ case, the mean of the current account to GDP ratio is 0.0013 for the decentralized economy and 0.000 for the social planner's economy.

Figure 5.3.1: Business cycle moments under various degrees of τ

A. Mean values



B. Standard deviations and relative standard deviation of consumption to real GDP



Note: Business cycle moments under various degrees of $\tau = [0.9, 0.95, 1.0, 1.05]\tau^*$, where τ^* is the baseline $\tau = 0.023$. All moments are calculated based on a simulation of 51,000 periods with 1,000 burn-in. In all panels, the horizontal axis is the value of τ. Figure A shows, from left to right panel, the averages of the means of foreign debt, real consumption, price, and the sudden stop probability (in percent) for each τ. A sudden stop event is defined as the time that satisfies following two conditions: (1) the borrowing constraint binds, and (2) the current account to GDP ratio exceeds more than one standard deviation. Figure B shows that from left to right panel, the averages of the standard deviations of foreign debt and real consumption, the relative standard deviations of consumption to real GDP, and the standard deviation of relative price for each τ. Standard deviations are shown in percentage.

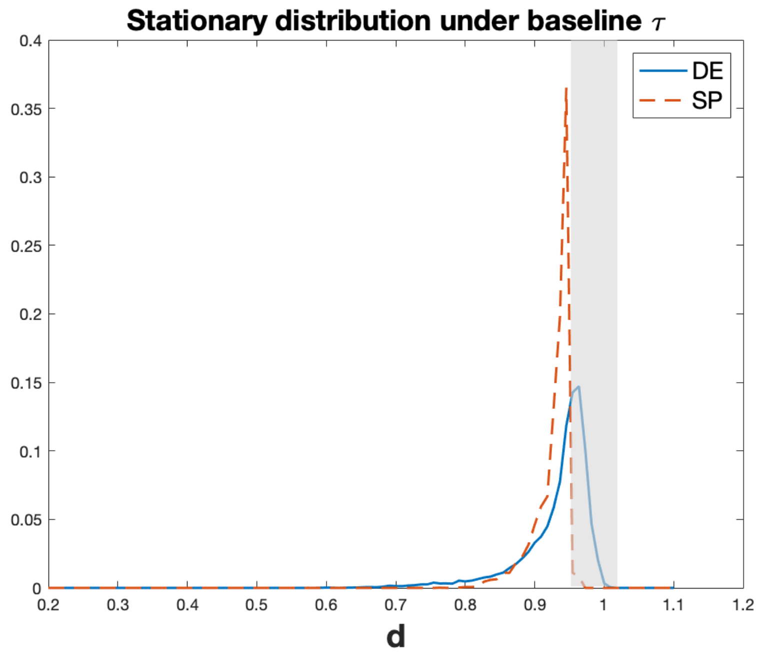
price, and the relative standard deviation of consumption to real GDP increase in τ. In addition, the relative standard deviation of consumption to real GDP exceeds one regardless of the value of τ, which implies the ECV. Therefore, a deeper FI increases business cycle volatility and worsens the ECV, even though it reduces the sudden stop probability.

5.3.2 FI and overborrowing of private agents

As we mentioned in Section 5.2.5, the private agent tends to borrow more than the social planner under certain conditions. Figure 5.3.2 reveals this overborrowing of the private agent, showing the stationary distribution of decentralized economy and social planner's economy at baseline τ. In Figure 5.3.2, the horizontal axis represents foreign debt d. The solid blue line represents the stationary distribution of the decentralized economy, and the dashed orange line represents that of the social planner's solution.

As shown in Figure 5.3.2, the stationary distribution of the decentralized economy has longer upper and lower tails than that of the social planner. Hence, foreign debt of the private agent is more volatile than that of the social planner. The region colored with a gray shadow in Figure 5.3.2 represents a high d region. In this region, the decentralized economy has a higher probability of d in equilibrium than the social planner's economy. Moreover, the mode of the social planner's distribution is lower

Figure 5.3.2: Stationary distribution of decentralized economy and social planner's economy at baseline τ

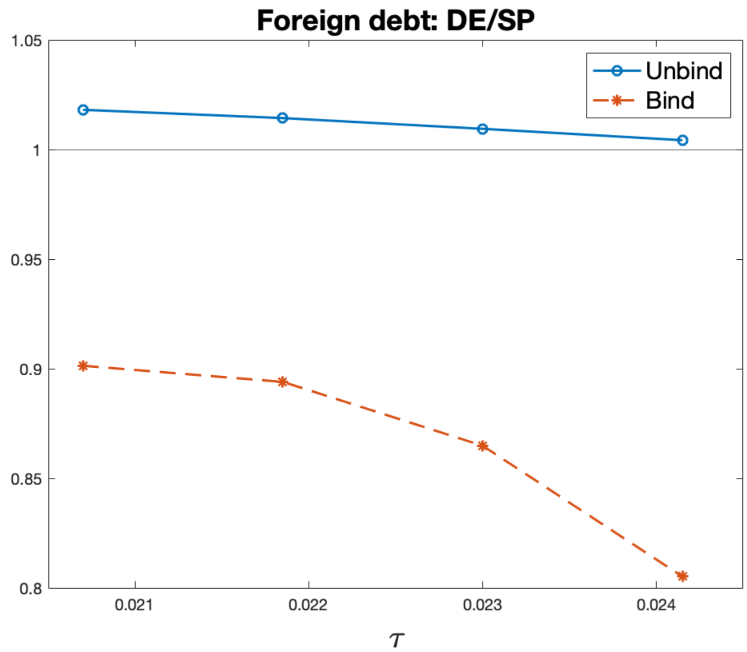


Note: The horizontal axis is foreign debt d, and the vertical axis is the probability of being the stationary equilibrium solution. The solid blue line represents the stationary distribution of a decentralized economy, and the dashed orange line represents that of a social planner's economy.

than that of the private agent's. The private agent borrows even at a higher level than the social planner would, implying overborrowing of the private agent.

Figure 5.3.3 shows the degree of overborrowing of the private agent under different levels of τ. The horizontal axis reports the level of τ, and the vertical axis shows the ratio of foreign debt in the decentralized economy to that in the social planner's allocation. The solid blue line depicts the average ratio conditional on the current

Figure 5.3.3: The ratio of foreign debt in the decentralized economy to that in the social planner's economy under different τ



Note: The horizontal axis is the level of τ, and the vertical axis is the ratio of foreign debt in the decentralized economy to that in the social planner's economy. The blue solid line is the ratio averaged over the case when the borrowing constraint is slack in the decentralized economy, and the orange dashed line is the ratio averaged over the case when the borrowing constraint binds in the decentralized economy.

state of unbinding constraints in the decentralized economy, and the dashed orange line displays the average ratio conditional on the current state of binding borrowing constraints in the decentralized economy. If the ratio exceeds one, the private agent borrows more than the social planner does.

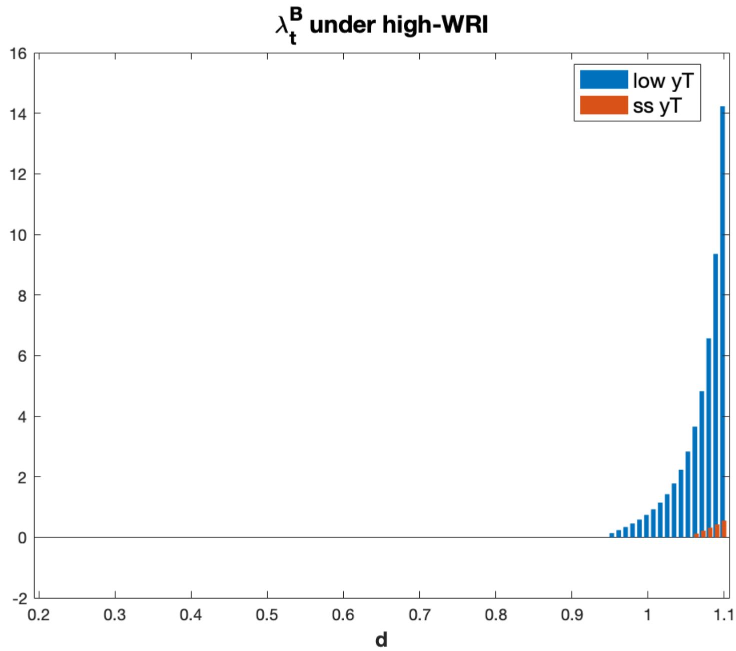
On the one hand, the private agent borrows more than the social planner when the borrowing constraint does not bind, regardless of τ. However, the ratio of foreign debt in the decentralized economy to that in the social planner in unbinding borrowing constraint decreases in τ, implying a higher FI reduces overborrowing. On the other hand, under the binding borrowing constraint, the private agent borrows less than the social planner; "underborrowing" occurs. In addition, the ratio d^{DE}/d^{SP} decreases in τ. Once the borrowing constraint binds, the private agent needs to reduce foreign debt more than the social planner because the private agent borrows more than the social planner during periods with an unbinding borrowing constraint. Since the average foreign debt in the decentralized economy increases in τ, as Figure 5.3.1 shows, a higher τ makes the borrowing constraint tighter, and the private agent must reduce the foreign debt much more than the social planner when the borrowing constraint binds.

5.3.3 FI and crisis impact

Figure 5.3.4 shows the Lagrange multiplier of the ICR constraint of the private agent λ_t^B under high-WRI periods.[7] The horizontal axis represents current foreign debt d, and the vertical axis is λ_t^B. The blue and orange bars represent λ_t^B under low-y^T and steady-state y^T, respectively. Notably, λ_t^B increases in the foreign debt d. As foreign debt increases, the borrowing constraint binds and becomes tighter. In addition, low y^T makes the borrowing constraint much tighter. In Figure 5.3.4, λ_t^B under low y^T grows

[7] In this calibration, λ_t^B takes positive values only in high-WRI periods. Hence, we show λ_t^B under high-WRI.

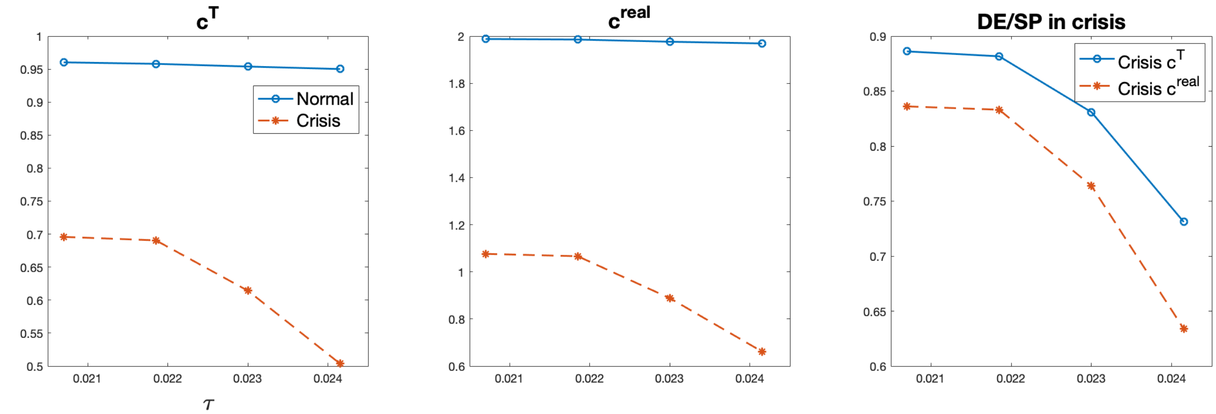
Figure 5.3.4: Lagrange multiplier of ICR constraint under high-WRI



Note: λ_t^Bunder high-WRI. The horizontal axis represents current foreign debt d, and the vertical axis is λ_t^B. The blue and orange bars represent λ_t^B under low-y^T and steady state y^T, respectively.

much faster than that under steady-state level of y^T. On the contrary, under high y^T, the borrowing constraint never binds regardless of d. This indicates that a high y^T relaxes the borrowing constraint both directly and indirectly; a high y^Tincreases the relative price p_t. Moreover, λ_t^B takes positive values only under the high-WRI periods; when the WRI is less than steady-state level, the borrowing constraint slacks, not depending on the foreign debt, y^T and y^N. Under high WRI periods, the borrowing constraint binds and becomes tighter depending on the amount of foreign debt and

Figure 5.3.5: Consumption in normal time and crisis period under various degrees of τ



Note: In all panels, the horizontal axis is the value of τ. The left and middle panel shows the averages of the tradable consumption and real consumption for each τ. In both panels, blue solid lines are the mean values in the normal (non-crisis) periods, and orange dashed lines are in the sudden stop crisis periods. The right panel shows that the averages of c^{DE}/c^{SP} in crisis periods for each τ, where c^{DE} refers to consumption under the decentralized economy and c^{SP} is that under the social planner's economy. The blue solid line is for tradable consumption, and the orange dashed line is for real consumption.

the state of y^T. The nontradable endowments y^N does not affect the tightness of the borrowing constraints.

The tighter borrowing constraint limits foreign debt and decreases tradable consumption and, thus, real consumption. From Section 5.3.2, since the decline in foreign debt during a tight borrowing constraint increases in τ, consumption can decrease greatly in τ. This larger consumption decline in a higher τ can be confirmed in Figure 5.3.5. The left and middle panels of Figure 5.3.5 show the ensemble mean of the tradable consumption and the aggregate real consumption over simulations for each τ. In the three panels, solid blue lines represent the mean values in the normal (non-crisis) periods, and dashed orange lines represent the sudden-stop crisis periods. The right panel of Figure 5.3.5 shows the averages of c^{DE}/c^{SP} in crisis periods for each τ, where c^{DE} and c^{SP} denote consumption under the decentralized economy and the social planner's allocation. The solid blue line represents tradable consumption, and the dashed orange line represents the aggregate real consumption.

The left and middle panels of Figure 5.3.5 show that as τ increases, tradable and real consumption decline more severely during crises, and the deviations from normal times increase. The impact of a crisis on consumption worsens as the degree of FI increases. Moreover, the deeper the FI, the greater the drop in consumption during a crisis in the decentralized economy compared to that in the social planner's allocation. In the right panel of Figure 5.3.5, tradable and real consumption in the decentralized economy are smaller than in the social planner's economy, regardless of τ. In addition, as τ increases, the private agent reduces consumption more than the social planner during the crises. This severe impact on the decentralized economy implies that the potential effectiveness of policy interventions is higher as FI deepens.

In summary, the FI prevents sudden stops but worsens the impact of crises on the SOE. Once the crisis happens, it severely impacts on the high FI countries.

5.3.4 FI and room for policy interventions

Following Bianchi (2011), the welfare gain for removing the externality, $W(d,s)$, is calculated as

$$(1+W(d,s))^{1-\gamma} = \left(\frac{V^{sp}(d,s)}{V^{de}(d,d,s)}\right), \tag{5.3.2}$$

where $V^{sp}(d,s) = u(\hat{c^T}, \hat{c^N}) + \beta E_{s'|s} V^{sp}(\hat{d}', s')$ is the optimal value under the social planner's problem with state (d,s) and $V^{de}(d,d,s) = u(\tilde{c^T}, \tilde{c^N}) + \beta E_{s'|s} V^{sp}(\tilde{d}', \tilde{d}', s')$ is that under the decentralized economy with state (d,d,s). $\hat{x}$ is the optimal value of variable x for the social planner, whereas $\tilde{x}$ is for the decentralized equilibrium. If we start the economy from $t = 0$, the optimal values $V^{de}(d_0, s_0)$ and $V^{dp}(d_0, s_0)$ can be written as the expected discounted value of permanent utility;

$$V^{sp}(d_0, s_0) = E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{\hat{c_t}^{1-\gamma}}{1-\gamma}\right),$$

$$V^{de}(d_0, d_0, s_0) = E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{\tilde{c_t}^{1-\gamma}}{1-\gamma}\right).$$

Since the expected lifetime utility function is homothetic,

$$(1+W(d_0,s_0))^{1-\gamma} V^{de}(d_0,d_0,s_0) = (1+W(d_0,s_0))^{1-\gamma} E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{\tilde{c_t}^{1-\gamma}}{1-\gamma}\right)$$

$$= E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{[\tilde{c}_t(1 + W(d_0, s_0)]^{1-\gamma}}{1-\gamma} \right).$$

Thus, the welfare gain $W(d, s)$ refers to the increase in consumption required across all states of the decentralized economy so that private agents are indifferent between the social planner's allocation and the decentralized equilibrium. If $W(d, s) = 0$, there is no difference in the expected discounted value of permanent consumption between the two, implying no welfare gains. If $W(d, s) > 0$, the social planner has higher social welfare than the decentralized economy, so there are gains for removing the pecuniary externality.

Table 5.2 shows welfare gains from correcting pecuniary externalities under various degrees of τ. In Table 5.2, under the baseline τ, the average welfare gain is only 0.094 percent of permanent consumption. The small welfare gain is consistent with the result of Bianchi (2011). Meanwhile, the average welfare gain increases in τ. As we mentioned in Section 5.3.3, a higher τ exacerbates the impact of the crisis on consumption, especially in the decentralized economy, which results in higher consumption volatility. Therefore, correcting the externality would increase private agents' consumption, especially during crisis periods, and mitigate the impact of a sudden stop on the SOE.

The result that the welfare gain of correcting the externality increases in τ implies policy interventions would be more beneficial in high FI countries. Capital taxes for preventing capital inflows will be effective in preventing overborrowing during the unbinding periods, underborrowing during the binding periods, and mitigating the impact of sudden stops, as many previous studies (e.g., Reinhart and Calvo, 2000; Bianchi, 2011; Forbes and Warnock, 2012; Chun-Che Chi, 2022; Ma and Matsumoto, 2023) have shown.

Furthermore, our results suggest that imposing capital taxes during periods of low WRIs can be more effective for preventing overborrowing and, thus, sudden stops. From the discussion in Section 5.3.3, the overborrowing is active, especially during the low-WRI period. The gain for preventing the sudden stop is large, especially high FI countries having a large average amount of debt. Similarly, macro-prudential capital controls can lower the sudden stop probability, as discussed in Bianchi and Lorenzoni (2022). In addition, when the WRI is high and sudden stop probability is high, an effective policy in reducing the risk of sudden stops should raise y^T and the equilibrium relative price p_t. Since our calibration result shows that y^N does not affect on the tightness of the borrowing constraints, raising p_t through increasing y_T is more effective for preventing the sudden stops. Such policies include lowering tariffs or raising subsidies to promote tradable goods sector production. Such policies can increase y^Tmore than y^N and make the equilibrium price higher, resulting in a relaxed borrowing constraint.

Table 5.2: Welfare gains under various degrees of τ

τ	0.021	0.022	0.023 (τ^*)	0.024
Welfare gains (%)	0.069	0.079	0.094	0.115

5.4 Summary of this chapter

This chapter theoretically investigates the characteristics of sudden stops under various FI levels. We extend the model described in Chapter 3 to the SOE model with tradable and nontradable goods as in Bianchi (2011).

The quantitative analysis indicates that a deeper FI reduces the probability of sudden stops, but once the sudden stop occurs, it causes a severe impact on the SOE. The reason behind the rare but severe crises is as follows. A deeper FI, represented by the looser borrowing constraint, increases the average amount of foreign debt and reduces the probability of sudden stops. Meanwhile, the overborrowing is severe, especially during the low WRI periods. Once the borrowing constraint binds, consumption must fall greatly for repayments of accumulated borrowing.

As FI deepens, the welfare gain from correcting the pecuniary externality increases. In other words, the policy intervention to reduce market failure will effectively prevent sudden stops, particularly in high-FI countries. Moreover, our results suggest that during low WRI periods, when private agents accumulate large amounts of foreign debt, we require active policy intervention that prevents overborrowing. Also, in high WRI periods with a large amount of debt, when the probability of sudden stops is high, policy intervention is effective for preventing sudden stops. Such policies include lowering tariffs and raising subsidies to increase the supply of tradable goods and equilibrium price, and they can relax the borrowing constraint.

Chapter 6

Conclusion

This dissertation analyzes FI in EMEs and the possible effects on their business cycles. Specifically, we focus on how FI changes the effect of the WRI shock, one of the most influential external shocks, on the EMEs' business cycles.

In chapter 2, we revisit the GPU model of EME business cycles by allowing for a stochastic WRI. We estimate the extended model and show that the main driver of investment growth and trade balance-GDP ratio is the WRI shock. Moreover, we dig deeper into the role of the preference shock, which is the main driver of the ECV. We conducted a rolling estimation of the correlation coefficient between the preference shock and the U.S. real interest rate and found that the correlation became much stronger after 1975. We scrutinize an SOE endowment model with an occasionally binding borrowing constraint to explain this observation. If the Lagrange multiplier of the borrowing constraint strongly depends on the U.S. real interest rate after 1975, the model can explain our observation.

In chapter 3, we construct an SOE endowment model with the ICR-based borrowing constraint (ICR model). The key assumption of the ICR borrowing constraint is that the SOE's debt ceiling depends on the WRI. We compare the ICR model and the standard borrowing constraint model. The calibration exercise shows that in the ICR model, the WRI has a greater effect on the tightness of borrowing constraint, foreign debt, and consumption than in the standard model. During the low-WRI periods, the ICR constraint does not bind, and foreign debt increases. Once the WRI increases and the ICR constraint binds, the borrowing is limited. However, the household must repay the large amount of foreign debt accumulated in the low-WRI periods. Thus, consumption decreases for repayments, resulting in the ECV.

Chapter 4 investigates the ECV puzzle: a deeper FI results in a worse ECV. We empirically show that the ECV is associated with the negative skewness of consumption. To explain our motivating facts, we use the ICR model with various degrees of the FI. Our calibrated model can replicate our motivating facts: a deeper FI worsens ECV and results in negative consumption skewness. As the FI deepens, the ICR constraint becomes looser, and, as a result, the average amount of foreign debt increases. Once the WRI rises, the ICR constraint binds, and the household must repay a large amount of foreign debt. The amount of repayment is larger when the FI deepens. Hence, the household must reduce consumption more under a deep FI. This huge reduction in consumption causes a larger negative skewness and worsens the ECV.

In chapter 5, we extend the ICR model by introducing tradable and nontradable endowment goods to illustrate the sudden stops. We compare the social planner's allocation and the decentralized rational expectations equilibrium. Our calibration exercises show that a deeper degree of the FI reduces the probability of sudden stops but worsens the impact of sudden stops on the SOE once a sudden stop occurs. We also show an overborrowing problem behind rare but severe crises in high FI-level economies, especially during low WRI periods. The private agent borrows more than the first best allocation due to the pecuniary externality. Our calibration results show that overborrowing occurs in the states with the low probability of binding borrowing constraints due to the low WRIs. Once the borrowing constraint binds, consumption decreases greatly for repayment. Moreover, our results infer that the welfare gain of internalizing the pecuniary externality increases in the FI because the impact of sudden stops is larger in the high-FI countries with large foreign debts.

Future research should evaluate the empirical validation of our ICR model's implication; the WRI has a dominant effect on the tightness of international borrowing and consumption in EMEs. Classical Conventional exercises based on linear vector autoregressive (VAR) models are not appropriate for validating our implication because the WRI has nonlinear effects on the tightness of borrowing and consumption. One possible validation method is a nonlinear VAR method, such as a threshold VAR and a smoothed transition VAR. The other method estimates our ICR model directly.

In addition, future research should also seriously consider the decision-making of the international lenders and investors behind the borrowing constraint. Previous studies have considered the international borrowing restrictions based on the borrower's collateral value. However, among capital flows, the risk that portfolio flows cause a sudden stop is particularly increasing (López and Stracca, 2021). Therefore, we should consider the borrowing (investment) constraint for the international portfolio flows. Our ICR constraint can also be considered as a simplified reflection of the investment behavior of portfolio investors; the ICR constraint can be interpreted as a constraint that investees in EMEs must satisfy their ICRs above a certain level to obtain bond investment from investors every period. However, the ICR is not a unique financial condition that international investors refer to. What kind of decisions do portfolio investors make to terminate investments and withdraw funds? We leave the construction of more realistic borrowing constraints as an important future research agenda.

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Appendix for Chapter 2

Appendix 2A. Convergence test

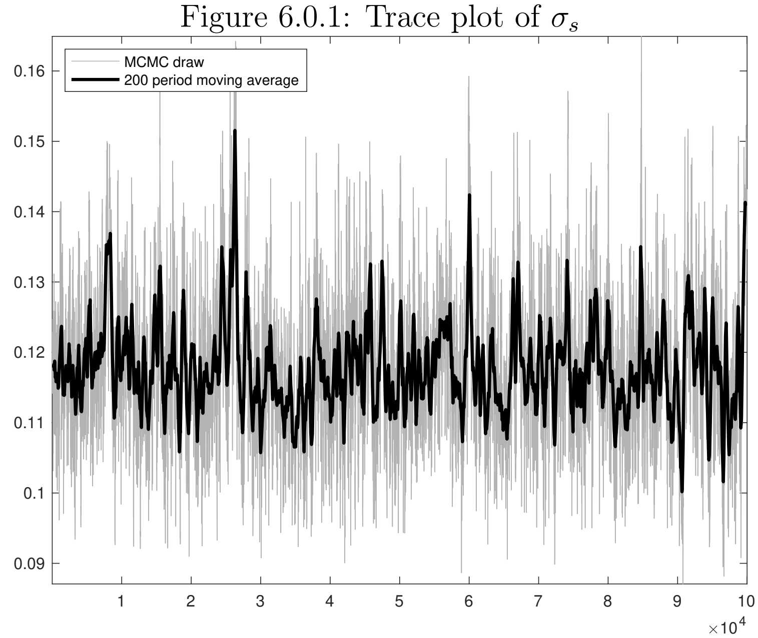
Table 6.1 shows the P-values of Geweke's convergence test. Under the fixed WRI model, all parameters pass the test; the null hypothesis is that the equality of the first 10% and the last 75% of the sample cannot be rejected with a 5% probability. Under the stochastic WRI model, the standard deviation of spending shock, σ_s, cannot pass the test. Thus, we confirmed the stability of the sample of σ_s by checking the trace plot shown in Figure 6.0.1.

Table 6.1: Geweke's convergence test

	(1) Fixed WRI	(2) Stochastic WRI
ψ	0.2530	0.2660
ϕ	0.1170	0.0530
ρ_a	0.3300	0.0990
ρ_ν	0.0130	0.5740
ρ_s	0.5410	0.8190
ρ_μ	-	0.6480
ρ_c	0.0280	0.4190
σ_a	0.4760	0.2460
σ_ν	0.0380	0.4850
σ_s	0.5210	0.0000
σ_μ	-	0.5420
σ_c	0.3100	0.1770

Notes: P-values of Geweke's convergence tests. The first column shows the fixed WRI model, and the second shows the stochastic WRI model. The null hypothesis is that the first 10% and the last 75% of the samples have the same mean values.

Figure 6.0.1: Trace plot of σ_s



Notes: Trace plot for σ_s. The gray line represents the MCMC draw, and black line represents the moving averages for the 200 period.

Appendix for Chapter 4

Appendix 4A. Data source and sample countries

A1. Data source and sample countries

Table 6.2 and Table 6.3 are the list of sample countries in emerging market economies and in advanced economies, respectively. The end of the sample is 2009Q4.

A2. Source of Argentine data and construction of U.S. real interest rate

The sample period is from 1993Q1 to 2008Q3. The Argentine quarterly dataset is by Martín Uribe and is available on his homepage. For the real GDP per capita and consumption, we use the deviations from the cubic trend.

The U.S. real interest rate is constructed by following Neumeyer and Perri (2005).

Table 6.2: Sample countries: emerging market economies

		Beginning of the sample	
Country	Iso3c	Annual	Quarterly
Bolivia	BOL	1991	1991Q1
Ecuador	ECU	1991	1991Q1
Uruguay	URY	1983	1983Q1
Argentina	ARG	1993	1993Q1
Brazil	BRA	1991	1991Q1
Chile	CHL	1996	1996Q1
Colombia	COL	1994	1994Q1
Hong Kong SAR, China	HKG	1980	1980Q1
Israel	ISR	1980	1980Q1
Korea, Rep.	KOR	1980	1980Q1
Mexico	MEX	1980	1980Q1
Malaysia	MYS	1991	1991Q1
Peru	PER	1980	1980Q1
Thailand	THA	1993	1993Q1
Turkey	TUR	1980	1980Q1
South Africa	ZAF	1980	1980Q1
Bulgaria	BGR	1994	1994Q1
Cyprus	CYP	1995	1995Q1
Hungary	HUN	1995	1995Q1

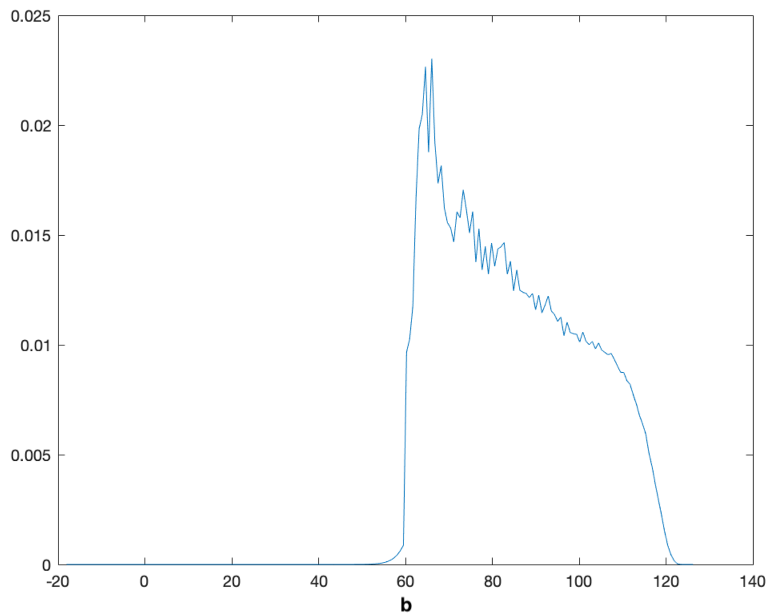
Table 6.3: Sample countries: advanced economies

		Beginning of the sample	
Country	Iso3c	Annual	Quarterly
Australia	AUS	1980	1980Q1
Austria	AUT	1980	1980Q1
Belgium	BEL	1980	1980Q1
Canada	CAN	1980	1980Q1
Switzerland	CHE	1980	1980Q1
Germany	DEU	1980	1980Q1
Denmark	DNK	1980	1980Q1
Spain	ESP	1980	1980Q1
Finland	FIN	1980	1980Q1
France	FRA	1980	1980Q1
United Kingdom	GBR	1980	1980Q1
Greece	GRC	2000	2000Q1
Italy	ITA	1980	1980Q1
Japan	JPN	1980	1980Q1
Netherlands	NLD	1980	1980Q1
Norway	NOR	1980	1980Q1
New Zealand	NZL	1980	1980Q1
Portugal	PRT	1980	1980Q1
Sweden	SWE	1980	1980Q1
United States	USA	1980	1980Q1

First, construct the monthly real interest rate = nominal interest rate - expected inflation. For the nominal interest rate, we use a 3-month U.S. treasury bill. The expected inflation is calculated as the average of the past 3 month's realization of CPI-based inflation. Then, we take an average of quarterly, obtaining the quarterly U.S. real interest rates.

Appendix 4B. Stationary distribution under baseline calibration

Figure 6.0.2: Stationary distribution under the baseline calibration



Note: Ergodic distribution under the baseline calibration. The x-axis is foreign debt, b. Moments shown in Table 4.2 are calculated using this distribution.