Financial Integration, Excess Consumption Volatility, and the World Real Interest Rate*

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Abstract

This study investigates the reason for increased consumption volatility with deeper financial integration in emerging market economies by developing a small open, endowment economy model with an occasionally binding borrowing constraint, accompanied by a time-varying world real interest rate. Calibration exercises show that a deeper financial integration provides a better opportunity for smoothing consumption against income shocks. Meanwhile, the foreign borrowing limit becomes more sensitive to changes in the world real interest rate, resulting in higher foreign debt and consumption volatility. Thus, financial integration would make consumption more vulnerable to the world real interest rate changes in emerging market economies.

Keywords: Financial Integration, Excess Consumption Volatility, Emerging Market Economy, World Real Interest Rate, Occasionally Binding Borrowing Constraint

JEL codes: E21, E41, E44, F62

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1 Introduction

Can financial integration contribute to economic stability through reducing consumption volatility? The standard macroeconomic theory suggests that financial integration (hereafter, FI) facilitates international financial transactions and thus allows households to smooth their consumption, which results in less consumption volatility relative to income volatility. Previous theoretical exercises have also shown that consumption volatility and its ratio to income volatility decrease as the degree of FI increases (Mendoza 1994, and Baxter and Crucini 1995). However, empirical studies uncover that contrary to these theoretical predictions, in emerging market economies (hereafter, EMEs), consumption is excessively volatile than income. This empirical finding is called excess consumption volatility (ECV, Aguiar and Gopinath 2007). Moreover, the degree of the ECV is much worse in EMEs with higher FI degrees (Kose et al. 2003, and Prasad et al. 2005).

A natural question is; why does deeper FI lead to worse ECV in EMEs? To answer this question, this paper investigates a small-open economy (SOE) endowment model with an occasionally binding borrowing constraint accompanied by a time-varying world real interest rate (hereafter, R-dependent borrowing constraint). A key assumption is that the foreign borrowing limit depends negatively on the world real interest rate (WRI). This assumption makes the shadow price of the borrowing constraint, which is the country-specific risk premium of SOE, depend positively on the WRI. This theoretical property of the R-dependent borrowing constraint is consistent with Uribe and Yue (2006)'s finding that fluctuations in the U.S. real interest rate affect the EMEs' business cycles mainly through changing risk premiums.

This paper emphasizes the sensitivity of the foreign borrowing limit of the SOE to the WRI as the key to explain the question why the ECV increases in the degree of FI. Several papers, including Levchenko (2005), Leblebiciougluglu (2009), Pancaro (2010), Bhattacharya and Patnaik (2016), and Sapci (2017), approach this question differently from our study; most of them are abstract from the crucial effects of the WRI on international financial transactions. The central mechanisms proposed by these studies highlight how deepening FI changes the response of consumption to domestic shocks (e.g., productivity shock or growth shock) or alters the role of domestic financial market imperfections (i.e., limited risk sharing across domestic agents).

In this study, we focus on the crucial role of the WRI in EMEs' business cycles, motivated by numerous past studies advocating the importance of WRI movements to business cycles in SOEs. Previous exercises with small open economy real business cycle (SOE-RBC) models reveal the role of the WRI shock in business cycle fluctuations of developed SOEs (Blankenau et al. 2001 and Kano 2009). Moreover, other past studies show that the WRI shock has large effects on business cycles in the EMEs (Uribe and Yue 2006, Sarquis 2008, and Muhanji and Ojah 2011), sudden stops (Arellano and Mendoza 2002, and Mendoza 2010), and default risks (Foley-Fisher and Guimaraes 2013).

Our calibrated model successfully accounts for the ECV and volatility of the trade balance-output ratio observed in postwar quarterly data of Argentina. The model also implicates that a deeper FI, represented by a relaxed borrowing constraint, causes a higher ECV. These successful outcomes of our model steam from the following novel mechanism that this paper proposes. Because a higher degree of FI lowers the probability of binding the borrowing constraint, foreign borrowing increases on average and the households can smooth their consumption more easily. However, as foreign borrowing increases, the foreign debt repayment also becomes larger, and therefore consumption must be reduced more when the borrowing constraint will bind. Because the WRI significantly affects the tightness of the borrowing constraint, foreign borrowing and consumption will be more vulnerable to a change in the WRI. Hence, the ECV increases in the degree of FI.

The remainder of the paper is organized as follows. Section 2 describes the model. Section 3 conducts the quantitative analysis and evaluates the model. Section 4 concludes.

2 A SOE endowment model with an R-dependent borrowing constraint

2.1 The household problem

Consider a SOE with a single good. An infinitely lived representative household receives exogenous income y_t which varies stochastically. 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

$$y_t + b_{t+1} = (1 + r_{t-1})b_t + c_t, \tag{1}$$

where c_t is consumption and b_{t+1} is the foreign debt level in period $t+1$.

The household also faces the following R-dependent borrowing constraint

$$b_{t+1} \leq \max\left\{\bar{b}, \frac{\tau}{r_t} E_t y_{t+1}\right\}, \tag{2}$$

where $\bar{b} > 0$ is the minimum borrowing limit and $\tau \geq 0$ is a parameter that determines the tightness of the borrowing constraint, as we will discuss bellow.[3]

The second term in the bracket of the R-dependent borrowing constraint (2) implies that (i) the foreign borrowing limit depends negatively on the WRI, and (ii) a higher τ makes the foreign borrowing limit more sensitive to the WRI; a lower (higher) r_t tightens (relaxes) the borrowing constraint.

More precisely, the R-dependent borrowing constraint is derived from foreign lenders' assessment of the borrower's default risk evaluated based on the interest coverage ratio (ICR), $\frac{y_t}{r_{t-1}b_t}$. We assume that foreign investors lend out to the SOE under the following condition on the ICR

$$\frac{y_t}{r_{t-1}b_t} \geq \bar{\tau}, \tag{3}$$

where $\bar{\tau}$ is the threshold value imposed by foreign lenders. The condition (3) implies

[3] It is necessary to set this minimum borrowing $\bar{b}$ for the existence of the optimal solution. Intuitively, if the initial b 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).

that foreign debt level b_t needs to satisfy that the ICR ($\frac{y_t}{r_{t-1}b_t}$) exceeds the threshold value $\bar{\tau}$.

We relay the economic rationale behind the condition on practical and empirical facts. The financial covenant with ICR is one of the common covenants in corporate firms (Private Placement Enhancement Project 1996, and Dothan 2006). 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 then derive the R-dependent borrowing constraint by rearranging eq.(3) and with setting $\tau \equiv 1/\bar{\tau}$. Here, the parameter τ can be interpreted as the degree of FI. A deeper FI reflected in, for example, enhancement of information disclosure to foreign investors and/or many 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 $\bar{\tau}$, thus increasing τ. As a result, a higher degree of FI can increase the foreign borrowing limit, as eq.(2) implies.

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

$$b_{t+1} \leq \max\left\{\tilde{b}, ME_t y_{t+1}\right\}, \tag{4}$$

where $\tilde{b} > 0$ 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 (4) is independent of r_t.

Given the exogenous income y_t, the WRI r_t and initial foreign debt level b_0, the household chooses the sequence of consumption c_t and the foreign debt level b_{t+1} by maximizing the following lifetime expected utility

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-\gamma} - 1}{1-\gamma}, \tag{5}$$

subject to the budget constraint (1) and the borrowing constraint (2) or (4).

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

$$r_t = (1-\rho^r)r^* + \rho^r r_{t-1} + e_t^r, \quad e_t^r \sim N(0, \sigma_r^2), \tag{6}$$

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

We also assume that the income follows the process

$$\ln y_t = \rho_y^y \ln y_{t-1} + \rho_r^y r_{t-1} + e_t^y, \quad e_t^y \sim N(0, \sigma_y^2). \tag{7}$$

where 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^y is on *i.i.d.* normal random variate with the zero mean and the standard deviation σ_y. The current income y_t depends on r_{t-1} 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.

2.2 Country-specific risk premiums and key channels of WRI shock

The Euler equation of the household's problem presented above is

$$\lambda_t^B = \lambda_t - \beta R_t E_t \lambda_{t+1}, \tag{8}$$

where λ_t^B is the Lagrange multiplier for the borrowing constraint (2) at period t, λ_t is the marginal utility for consumption at period t, and $R_t = (1 + r_t)$ is the gross WRI. Eq.(8) can be rewritten as

$$\frac{\lambda_t}{E_t \lambda_{t+1}} = \beta(R_t + S_t), \; S_t = \frac{\lambda_t^B}{\beta E_t \lambda_{t+1}}, \tag{9}$$

where S_t is the country-specific risk premium that depends on the Lagrange multiplier for the borrowing constraint λ_t^B and the expected discounted value of the marginal utility $\beta E_t \lambda_{t+1}$.

In this model, the WRI shock affects consumption through the two channels; changing interest rate payment and the borrowing limit. The first channel, named the "interest channel", directly changes R_t in the Euler equation (9). As seen in the standard SOE model without a borrowing constraint, a higher interest payment reduces borrowing (increases savings) and decreases consumption during the current period.

The second channel, named the "constraint channel", affects consumption through the Lagrange multiplier for the borrowing constraint, λ_t^B, and thus the risk premium S_t. Since the borrowing limit depends on the WRI negatively, an increase in the WRI can make the borrowing constraint tighter and raises λ_t^B. This higher λ_t^B affects consumption via the Euler equation (8).[4]

In contrast to the R-dependent borrowing constraint model, the WRI shock has only a small effect on λ_t^B in the standard borrowing constraint model. Thus, the WRI shock affects the marginal utility change mainly through the interest channel. The difference between the two models is through which channel the WRI shock primarily affects the marginal utility change.[5]

2.3 The steady state

We assume that the degree of FI in EMEs is sufficiently low that the borrowing constraint binds at the steady state. Lower τ leads to the smaller foreign borrowing limit and the tighter borrowing constraint. The sufficiently low τ then indicates that the borrowing constraint mostly limits foreign borrowing, resulting the borrowing constraint binds at the steady state.[6] Past studies assume the borrowing constraints unbind at the

[4]Moreover, the reduction in borrowing due to the tighter borrowing constraints also affects consumption through the budget constraint (1).

[5]The income shock effect may not generate sizable differences between the two models because it affects both λ_t^B and $E_t\lambda_{t+1}$ regardless of the form of borrowing constraints.

[6]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 a 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

Table 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	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^*

steady state to investigate the role of borrowing constraints in financial crises. Because our focus is on the effect of FI on the ECV as a whole business cycles, we analyze consumption in EMEs in the case that the borrowing constraint binds at the steady state.

The steady state of this model is characterized as follows:

$$y^{ss} = 1,\ r^{ss} = r^*,\ b^{ss} = \frac{\tau}{r^{ss}} y^{ss},\ tb^{ss} = r^{ss} b^{ss} = \tau y^{ss},$$

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

$$R^{*ss} = \frac{1}{\beta},\ S^{ss} = \frac{\lambda^{Bss}(c^{ss})^{\gamma}}{\beta}.$$

A higher τ increases the steady state foreign debt level b^{ss} and trade-balance tb^{ss}. Because this model is for an endowment economy, an increase in b^{ss} decreases the steady-state level of consumption c^{ss}. Since the Lagrange multiplier for the borrowing constraint λ^{Bss} does not depend on τ, a fall in c^{ss} decreases the risk premium S^{ss}.

2.4 Calibration

Table 1 reports the calibrated values of the model's structural parameters. The model is calibrated at 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 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 R-dependent 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 U.S. real interest rate for the period 1991Q1-2008Q3.[7]

We calibrate the stochastic processes of the two exogenous shocks by estimating eqs.(6) and (7) with the U.S. real interest rate and the deviation from the cubic trend of real GDP per capita in Argentina for 1991Q1-2008Q3, respectively. We obtain $\rho^r = 0.946$, $\rho^y_r = -0.108$, $\rho^y_y = 0.949$, $\sigma_r = 0.0051$, and $\sigma_y = 0.0194$ from the corresponding point estimates. We then approximate the bivariate vector autoregression (VAR), which is implied by eqs.(6) and (7), 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.

of borrowing constraints and foreign borrowing can be limited even in advanced economies.

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

3 Results of the quantitative analysis

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 b_t is chosen from equally spaced discrete grids, $\boldsymbol{B} = \{b_1 < b_2 < \cdots < b_{n^b}\}$. We set $\boldsymbol{B}$ with $n^b = 200$, $b_1 = 0.25b^{ss}$, $b_{200} = 1.75b^{ss}$ where b^{ss} is the deterministic steady state value of b_t. In the case of with τ smaller than the baseline value of 0.0328, we change the maximum value of $\boldsymbol{B}$ to $1.5b^{ss}$ with $n^b = 166$. 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.

3.1 Business cycle moments: standard vs R-dependent borrowing constraint

Table 2 shows the sample moments in Argentina for 1991Q1-2009Q3 (column 2) and the business cycle moments derived from the stationary distributions of b_t and policy functions. Column 3 displays the moments in the R-dependent constraint model, and column 4 displays those in the standard borrowing constraint models.[8]

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 sig-

[8] 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.

Table 2: Long-run business cycle moments

	Data	Model: R-dependent constraint	Model: 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 standard borrowing constraint, and the "R-dependent constraint" (column 4) refers to the model with the R-dependent borrowing constraint. The business cycle moments in models are calculated from the stationary distributions of b_t and policy functions.

nificantly, which means the ECV. These observations are consistent with findings of Aguiar and Gopinath (2007).

The model with the R-dependent borrowing constraint performs well at accounting 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.

Compared to the R-dependent 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 R-dependent 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.

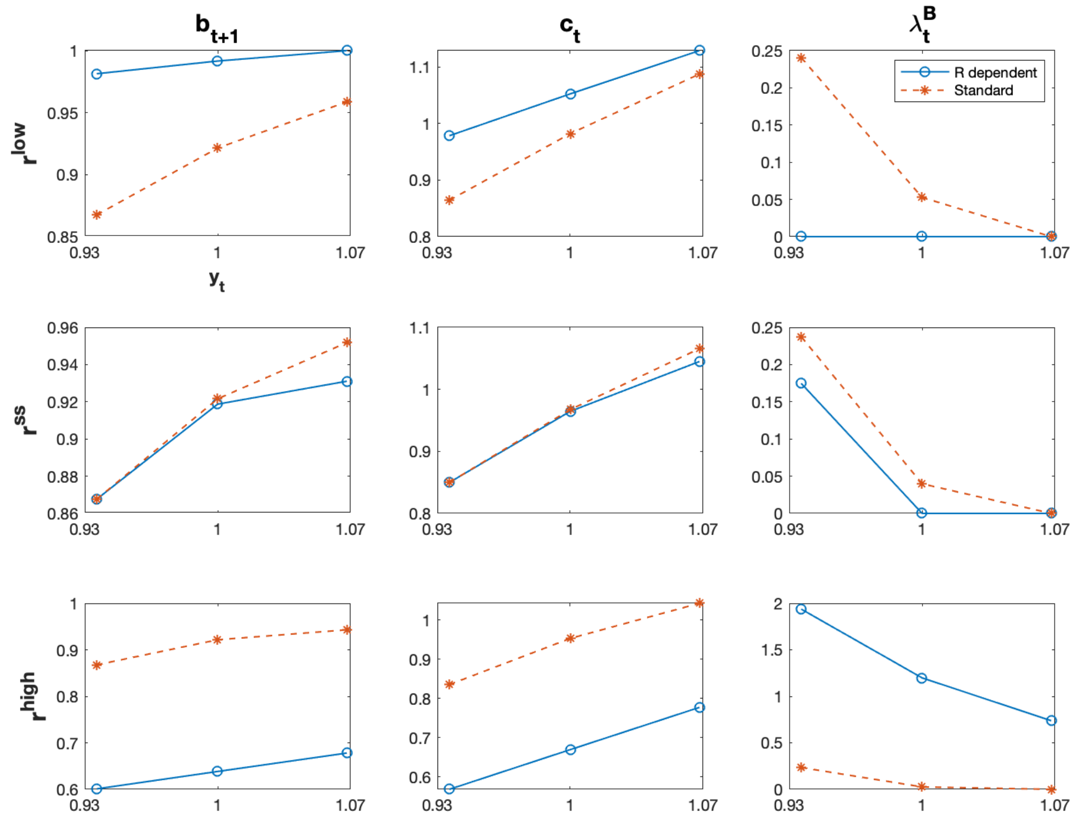
3.2 Policy function and simulation: the source of high volatility

This subsection explains why the R-dependent borrowing constraint model predicts higher volatilities of borrowing and consumption than does the standard borrowing constraints model.

3.2.1 Policy function

Figure 1 shows policy functions sliced at the deterministic steady state value of the foreign borrowing, $b_t = b^{ss}$. The solid blue lines are the policy functions implied by the R-dependent borrowing constraint model, and the dashed orange lines are those implied by the standard borrowing constraint model. The left column plots, the policy

Figure 1: Policy function for income



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

functions of the 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 R-dependent borrowing constraint model (the solid blue lines), the upper-right panel of Figure 1 shows that when $r_t = r^{low}$, λ_t^B remains zero, no matter how much the income is. This means that the R-dependent borrowing constraint never binds in the low WRI period. Thus, during the r^{low} periods, the households can borrow from foreign countries freely and smooth their consumption against the income shock.

The tightness of the R-dependent borrowing constraint varies largely depending on the value of the WRI. As shown in the right panels, λ_t^B for the R-dependent borrowing constraint is highly volatile; it varies from zero to near two, depending on the level of 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 by the budget constraint (1).

In contrast to the R-dependent borrowing constraint model, the standard borrowing constraint model (orange dashed lines) never allows households to smooth their consumption; consumption in the standard borrowing constraint model is more responsive to income. In the standard borrowing constraint 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 constraint model, the WRI shock affects the marginal utility change only through the interest channel, as discussed in Section 2.2. 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 borrowing constraint model, households cannot smooth their consumption, and consumption changes largely depending on income level.

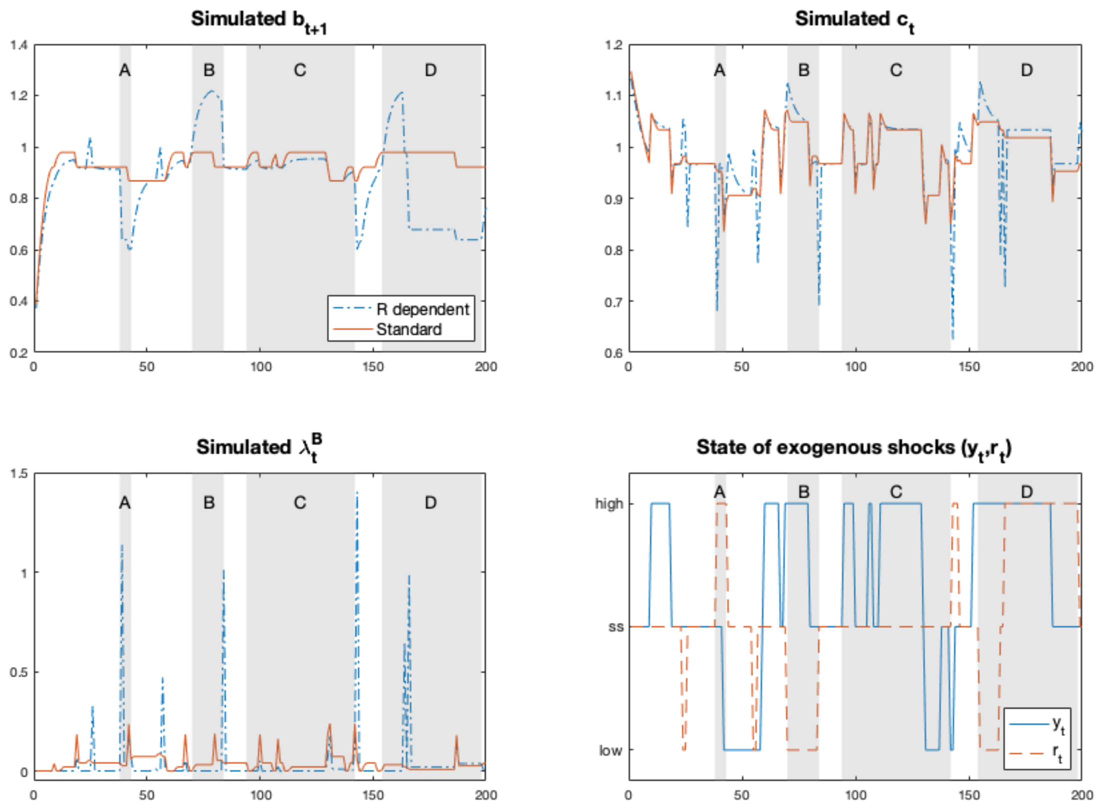
3.2.2 Simulation

To evaluate the size of volatility clearly, we simulate the both R-dependent borrowing constraint model and the standard borrowing constraint model. Figure 2 is the result. This simulation exercise is conducted by the following steps. First, we generate the Markov chains 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 policy functions. The top two panels in Figure 2 are the simulated responses to foreign borrowing and consumption, and the bottom-left panel is that to the Lagrange multiplier of the borrowing constraints. To illustrate the source of high volatility, we focus on the four notable episodes in the simulation. The episodes are named from A to D and displayed as the shadows in the figure.

Notably, there are some events that λ_t^B (the bottom-left panel) takes huge values in the case of R-dependent borrowing constraint. Such high λ_t^B events are triggered by the change in the WRI; specifically when (i) the WRI takes the higher value in period t, and (ii) the WRI was low before period t and then raises in period t. Episode A in Figure 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 R-dependent borrowing constraint. As seen in Figure 1, the R-dependent borrowing constraint never binds when $r_t = r^{low}$. Thus foreign debt (upper-left panel)

Figure 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 b, c, λ^B from policy functions with spline completion. We start the simulation at $b_0 = b^{ss}, y_1 = y^{ss}, r_1 = r^{ss}$.

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 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 the steady state, and the only income changes. The income shock does not generate sizable spikes of λ_t^B in the R-dependent borrowing constraint 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 R-dependent borrowing constraint model. Then a rise in r_t makes the borrowing constraint tighter and results 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 borrowing constraint model, λ_t^B is more stable than in the R-dependent borrowing constraint 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, both the R-dependent borrowing constraint model and the standard borrowing constraint model 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 model with the R-dependent borrowing constraint, the WRI shock has more effects on the volatilities of borrowing and consumption than does the income shock. The R-dependent borrowing constraint relaxes during the low WRI periods and tights 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

Table 3: Long-run moments: effect of τ change

	$0.5\tau^*$	$0.75\tau^*$	τ^*	$1.25\tau^*$
Mean				
Foreign debt	0.48	0.69	0.89	1.07
TB-GDP ratio	0.02	0.02	0.03	0.04
Risk premium	4.75	4.72	4.69	4.63
Standard deviation (in percent)				
Foreign debt	15.14	17.64	20.25	22.77
TB-GDP ratio	4.43	5.01	5.56	5.89
Consumption	6.87	7.3	7.71	7.98
Real GDP	5.07	5.07	5.07	5.07
Risk premium	13.54	15.30	18.08	19.77
Relative std. to GDP				
Consumption	1.36	1.44	1.52	1.57
Probability of binding	61.61%	56.48%	36.29%	28.83%

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

than income.

3.3 The effect of financial integration

Now to answer our question why the degree of ECV increases as the FI deepens. We calculate the stationary distributions of the R-dependent model with various calibrated values of the degree of FI, τ. Table 3 shows long-run moments predicted by the model with R-dependent borrowing constraints under four different values of τ. Here, $\tau^* = 0.0326$ is the baseline value of τ.

The size of ECV, reported as the relative standard deviation of consumption to GDP in Table 3, increases in τ. The mechanism how a larger τ worse the ECV as follows. A larger τ reduces the probability of binding borrowing constraint 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.[9] If τ is small (i.e., the FI level is low), the borrowing constraint mostly 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 and results in the smaller volatilities of borrowing and consumption.

3.4 Key channels of WRI shock

As discussed in Section 2.2, the WRI shock can affect the marginal utility through the two channels; the interest channel and the constraint channel. To discuss which channel of the WRI shock has a more significant impact on consumption volatility, we decompose the unconditional variance of the marginal utility change into the above two channels following the Euler equation (9)

$$Var(\frac{\lambda_t}{E_t\lambda_{t+1}}) = Var(\beta R_t) + Var(\beta S_t) + 2Cov(\beta R_t, \beta S_t), \tag{10}$$

where $\lambda_t = c_t^{-\gamma}$ is the marginal utility in period t and $\beta S_t = \frac{\lambda_t^B}{E_t\lambda_{t+1}}$. The first term on the right-hand side of eq.(10) corresponds to the interest channel, i.e., the channel considered in the canonical SOE model without a borrowing constraint. The constraint channel corresponds to the second and third terms, specific to models with borrowing constraints.

Table 4 shows the result of the decomposition at the grid $b = b^{ss}$ under the four degrees of FI τ. The "MU change" refers to the marginal utility change. The standard

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

Table 4: Variance decomposition of marginal utility change under various τ

	$0.5\tau^*$	$0.75\tau^*$	τ^*	$1.25\tau^*$
Variance				
MU change	12.01	1.99	0.44	0.05
	(0.6)	(1.52)	(4.06)	(14.89)
βR_t		$1.6E-04$		
βS_t	11.91	1.96	0.42	0.05
	(0.59)	(1.5)	(4.03)	(14.84)
$2Cov(\beta R_t, \beta S_t)$	0.1	0.04	0.02	0.01
	(0.01)	(0.02)	(0.03)	(0.05)
Share in *Var(MU change)* (%)				
βR_t	0.002	0.01	0.05	0.04
	(0.001)	($3.6E{-}04$)	($1.2E{-}04$)	($2.7E{-}05$)
βS_t	99.17	98.01	96.22	89.13
	(19.83)	(21.17)	(22.31)	(21.55)
$2Cov(\beta R_t, \beta S_t)$	0.83	1.98	3.73	10.46
	(10.47)	(10.51)	(10.23)	(9.92)

Notes: "MU change" refers to the marginal utility change $\frac{\lambda_t}{E_t \lambda_{t+1}}$. All values are calculated at the grid $b = b^{ss}$ with Spline interpolation. Variations across grids b are shown as standard deviations listed in parentheses. Since the variance of βR_t is common across grids b, no standard deviations are displayed.

deviations reported in the parentheses show variations of variance across grid b. A larger standard deviation means larger variation in volatility depending on borrowing acquired in the previous period b_t.

The baseline case with $\tau = \tau^*$ as reported in the fourth column in Table 3 shows that the constraint channel, which is given by the sum of second and third terms of eq.(10), accounts for more than 99 percent of the total variance of the marginal utility change. In contrast, the interest channel (the variance of βR_t) accounts for only 0.05 percent. The WRI shock affects the marginal utility change by the constraint channel.

The constraint channel has the dominant effect on the variance of the marginal utility regardless of the value of τ, but the share decreases as τ increases. As shown in Table 3, a higher τ reduces the probability of binding borrowing constraint and increases the average amount of foreign borrowing. Thus, the average risk premium becomes smaller, which results in a smaller share of the constraint channel.

Meanwhile, the higher τ increases the sensitivity of the borrowing limit to the WRI, which cause a higher share of the covariance terms. Moreover, as τ increases, the variance of the marginal utility change depends more on the level of the previous foreign debt b_t, as shown in the higher standard deviations in the brackets. In the largest τ case (the rightest column in the figure), the variation across b_t in the variance of marginal utility is about 25 times higher than that in the lowest case. A higher τ allows a larger amount of foreign borrowing, but it leads to a huge decline in consumption for the repayment when the WRI raises and the borrowing constraint binds. When the borrowing constraint binds in the previous period, b_t is small, and the households do not have to reduce consumption for the repayment. As a result, the variance of marginal utility change depends more on the past foreign debt level b_t.

4 Concluding remarks

This paper investigates why deeper FI increases the ECV in EMEs. We construct a small open, endowment economy model with a occasionally binding borrowing constraint in which the borrowing limit depends on expected future income and the WRI. The quantitative analysis shows that, compared to the model with a standard borrowing constraint in which borrowing limit depends only on income, the R-dependent borrowing constraint model fits better to the actual volatilities of consumption and trade balance-output ratio in Argentina.

The mechanism presented in this paper is as follows. Under the baseline calibration, the R-dependent 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. This reduction in consumption is much larger than that under the standard borrowing constraint model. Consumption smoothing is possible when the R-dependent borrowing constraint does not bind, but only against income shocks. As a result, consumption under the R-dependent borrowing constraint model depends more on the WRI shock, which determines whether the borrowing constraint binds or not.

A higher degree of FI reduces the probability of binding the R-dependent 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 borrowing limit. A large amount of foreign borrowing can reduce consumption greatly once the borrowing constraint binds. Consequently, foreign borrowing and consumption will be more volatile at higher FI levels, even if the FI increases the average amount of foreign borrowing 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.

Future research should consider the production side of this economy. Our focus would be on the ratio of consumption volatility to output volatility. Borrowing constraints will also affect output volatility. Intuitively, if borrowing constraints bind, firms have to reduce investments because they cannot borrow from foreign countries to the desired level. As a result, tighter borrowing constraints will reduce output. This reduction in output level will decrease consumption. Thus, we expect that the overall effect of the FI on the ECV this paper shows may be valid even in a production economy.

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