Trend Shocks and Financial Frictions in Small Open Economies´ Modeling

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Motivation

Which are the main sources of economic fluctuations, at business cycles frequencies, of small open economies?

Aguiar and Gopinath (JPE 2007) show that emerging market economies exhibit frequent policy regime switches, which could be captured by extending a standard RBC model with trend technology shocks. Using data from Canada and Mexico, they show that shocks to trend, rather than transitory fluctuations around a stable trend – are the primary source of fluctuations in emerging markets.

Garcia-Cicco, Pancrazi and Uribe (AER 2010) show that the RBC model driven by trend and transitory productivity shocks does a poor job at explaining observed business cycles in emerging markets. They show that departing from the frictionless financial market assumption greatly improves the characterization of economic fluctuations for Argentina and Mexico.

This paper studies the relative importance of including trend shocks and financial frictions when characterizing economic fluctuations in a set of 12 emerging and 12 developed small open economies.

The Model

Standard stochastic growth model with a single good and single asset. In the benchmark RBC model, a country can borrow at the world interest rate, while as a short-hand to add financial frictions we assume that a country's borrowing rate is a function of its level of indebtedness. Both models follow the same setup that is based on Aguiar and Gopinath (2007):

Technology yields output, Y_t, from capital, K_t, and labor, N_t, according to

$$Y_t = e^{z_t} K_t^{1-\alpha} \left(\Gamma_t N_t\right)^{\alpha}$$

Output is affected by two innovations, a transitory one, z_t, that follows the AR(1) process

$$z_t = \rho_z z_{t-1} + \varepsilon_t^z,$$

and the cumulative product of permanent innovations, Γ_t, that evolves according to:

$$\Gamma_t = e^{g_t}\Gamma_{t-1} = \prod_{s=0}^{t} e^{g_s} \quad \text{with} \quad g_t = \left(1-\rho_g\right)\mu_g + \rho_g g_{t-1} + \varepsilon_t^g$$

Households choose consumption, C_t, leisure, $L_t=1-N_t$, next period debt, B_{t+1}, and investment, X_t, to maximize

$$\sum_{t=0}^{\infty} \beta^t \left[\frac{C_t^{\gamma}\left(1-N_t\right)^{1-\gamma}}{1-\sigma}\right]^{1-\sigma}$$

subject to the sequence of budget constraints where output and newly acquired debt (non-contingent one-period discount bonds), at price q_t, must be enough to finance consumption, investment and previously contracted debt obligations:

$$Y_t + q_t B_{t+1} = C_t + X_t + B_t,$$

and the capital accumulation process: $K_{t+1} = X_t + \left(1-\delta\right)K_t - \frac{\phi}{2}\left(\frac{K_{t-1}}{K_t} - e^{\mu_g}\right)^2 K_t.$

Net exports, NX_t, are defined as the difference between production and absorption

$$NX_t = Y_t - C_t - X_t.$$

Finally, as a short hand to capture financial frictions, we assume that the price of bonds is an inverse function of the level of indebtedness according to

$$\frac{1}{q_t} = 1 + r_t = \frac{1 + r^* + \psi\left[e^{\left(\frac{B_{t+1}}{\Gamma_t} - b\right)} - 1\right]}{e^{\varepsilon_t^f}}.$$

Where RBC: $\psi \cong 0$ and Financial Frictions: $\psi >> 0$.

Estimation Strategy

- Bayesian maximum likelihood estimation of the two DSGE models (RBC and FF).
- **Key identification assumption**: the economy, using its external accounts, responds differently to trend technology, transitory technology and cost of borrowing shocks.
- Model as log-deviation from the detrended steady-state.
- Sample: 12 emerging and 12 developed countries small open economies, from 1980 to 2003.
- Data is quarterly Hodrick-Prescott-filtered cycle of the logarithms of gross domestic product, private consumption and investment.

Figure 1: Model impulse response functions to the three innovations: a) 1% increases the transitory component of technology; b) 1% increase in the permanent component of technology; and c) 1% reduction to the cost of borrowing.

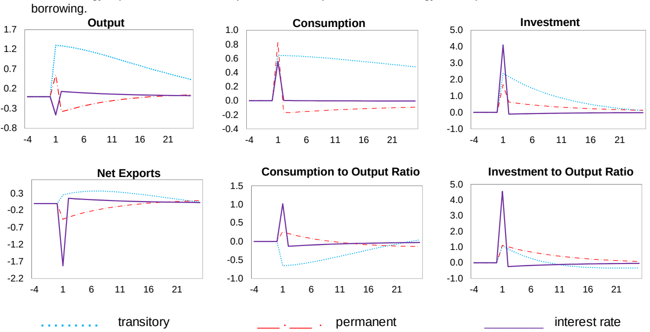


Table 1: Benchmark Parameter Values

Description	Symbol	Value
Time preference rate	β	0.980
Elasticity of substitution between consumption and labor (utility)	γ	0.360
Steady-state normalized debt	b	0.100
Elasticity of the borrowing interest rate to changes in indebtedness*	ψ	0.001
Labor share (production)	α	0.680
Inverse of the elasticity of intertemporal substitution	σ	2.000
Depreciation rate	δ	0.050
Productivity's long-run mean growth rate	μ_g	1.006

Note. Benchmark parameters used in all specifications unless otherwise specified

* This paramter is estimated in the model with financial frictions.

Table 2: Prior Parameter Values

Description	Symbol	Prior Mean	Prior Std. Deviation	Prior Distribution
Elasticity of the borrowing interest rate to changes in indebtedness*	ψ	0.06	0.02	Normal
Elasticity of the price of capital with respect to the investment-capital ratio	ϕ	4.00	1.50	Normal
Autoregressive coefficient temporary technology shock	ρ_z	0.50	0.20	Beta
Autoregressive coefficient permanent technology shock	ρ_g	0.10	0.05	Beta
Standard deviation of the temporary technology shock	σ_z	1.00	4.00	Inverse Gamma
Standard deviation of the permanent technology shock	σ_g	1.00	4.00	Inverse Gamma
Standard deviation of the bond price shock	σ_f	1.00	4.00	Inverse Gamma

Note. Benchmark prior parameters used in all specifications unless otherwise specified

* This parameter is calibrated to 0.001 in the model without financial frictions.

Results

- There is great heterogeneity in the observed business cycle fluctuations. This translates to heterogeneity in the estimated parameters of a common mode, which in turn tries to capture fluctuations in such diverse economies.
- There is some clustering of parameter estimates between emerging an developed small open economies.
- Trend stationary technology shocks are relatively more important in emerging market economies.

Table 3: Elasticity of the country's borrowing interest rate with respect to changes in indebtedness (ψ)
Estimated Mean and 90% Confidence Intervals

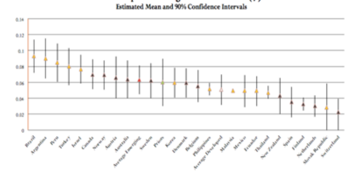
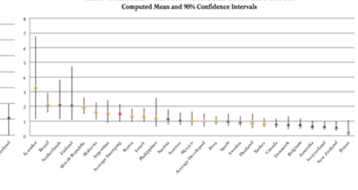


Table 4: Random Walk Solow Residuals in the RBC Model
Computed Mean and 90% Confidence Intervals



- Including financial frictions improves the fit of the model in all the studied emerging market economies. However, it only improves the fit in five of the small open economies, while in three cases, the extended real business cycles model matches the data better.

Table 5: Real Business Cycles and Financial Frictions Model Comparison: Posterior Model Probability

Emerging Market Economies			Developed Small Open Economies		
Country	RBC	FF	Country	RBC	FF
Argentina	0% (-356.86)	100% (-340.73)	Australia	64% (-548.93)	36% (-549.54)
Brazil	0% (-402.58)	100% (-363.99)	Austria	40% (-279.50)	60% (-279.10)
Ecuador	0% (-404.50)	100% (-394.16)	Belgium	0% (-471.83)	100% (-450.92)
Israel	0% (-782.73)	100% (-719.65)	Canada	100% (-413.69)	0% (-447.49)
Korea	0% (-708.89)	100% (-678.42)	Denmark	0% (-412.77)	100% (-391.82)
Malaysia	0% (-451.01)	100% (-426.47)	Finland	100% (-573.61)	0% (-585.55)
Mexico	0% (-730.68)	100% (-719.69)	Netherlands	1% (-517.13)	99% (-512.36)
Peru	0% (-465.24)	100% (-443.81)	New Zealand	46% (-419.98)	54% (-419.81)
Philippines	0% (-749.18)	100% (-727.38)	Norway	0% (-710.29)	100% (-665.76)
Slovak Republic	0% (-336.47)	100% (-329.30)	Spain	75% (-488.61)	25% (-489.72)
Thailand	0% (-358.04)	100% (-344.34)	Sweden	0% (-646.82)	100% (-624.40)
Turkey	0% (-553.59)	100% (-531.42)	Switzerland	99% (-334.78)	1% (-339.83)

Note: The table shows the posterior model probability between the real business cycle and financial frictions models. The log marginal density is reported in parentheses.

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Abstract

This paper studies the relative importance of including trend shocks and financial frictions when characterizing economic fluctuations in a set of 12 emerging and 12 developed small open economies. We find that, on average, trend shocks are relatively more important to characterize economic fluctuations of emerging market than of developed small open economies expanding the two-country (Canada and Mexico) evidence in Aguiar and Gopinath (2007). We also find that adding financial frictions improves the fit of the model in all the studied emerging market economies, but only in 5 developed small open economies, expanding the two-country (Argentina and Mexico) evidence in García-Cicco et al. (2010). In the process of comparing models, we provide a set of parameter estimates for a large set of countries that could serve as a guide for future studies.

Keywords: Small Open Economy Models, Economic Fluctuations, Trend Shocks, Financial Frictions, Structural Estimation.

JEL Classification: C32 – E32 – F41.

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1 Introduction

The quest to characterize the sources of economic fluctuations is a continuous endeavor where economists are providing novel evidence aided by the tools of model estimation. Changes in technology, preferences, news/expectations, policies, international factors and financial conditions are some of the sources of disturbance commonly proposed. In most cases, to account for a new source of fluctuations the analysis requires departing from a baseline Real Business Cycles (RBC) model by introducing imperfections relative to the functioning of a frictionless environment.

In an influential paper titled "Emerging Market Business Cycles: The Cycle is the Trend," Mark Aguiar and Gita Gopinath (2007) show that emerging market economies exhibit frequent policy regime switches, which could be captured by extending a standard RBC model with non-stationary (trend) technology shocks. Using Mexico, as a representative emerging market, and Canada, as an example of a developed small open economy, Aguiar and Gopinath (2007) show that shocks to trend growth — rather than transitory fluctuations around a stable trend — are the primary source of fluctuations in emerging markets. The first task of this paper is to extend this analysis by studying 12 emerging and 12 developed small open economies.[1] To anticipate our first result, we find partial support to the claim in Aguiar and Gopinath (2007) that, on average, shocks to trend growth are relatively more important in emerging market countries, but at a country-level there are some exceptions.

In another important paper titled "Real Business Cycles in Emerging Countries?" Javier Garcia-Cicco, Roberto Pancrazi, and Martin Uribe (2010) show that the RBC model driven by permanent and transitory productivity shocks does a poor job at explaining observed business cycles in emerging markets.[2] These authors give evidence that by departing from the frictionless financial market assumption the augmented model greatly improves in the characterization of economic fluctuations in Argentina and Mexico. The second task of this paper is to extend this analysis using our extended sample of 24 small open economies to compare the relative fit of the model when reduced-form financial market frictions are considered. To anticipate our second result, we find support to the claim in Garcia-Cicco et al. (2010) by allowing for financial frictions, the model fits the data better in all the studied emerging market economies. However, the model with financial frictions is only favored in five developed small open economies (Belgium, Denmark, Netherlands, Norway and Sweden). For the other seven developed small open economies, the extended Real Business Cycles model matches the data better in three countries (Canada, Finland and Switzerland), while there are no definite results in the remaining four countries (Australia, Austria, New Zealand and Spain).

To provide quantitative answers we use Bayesian Maximum Likelihood methods to first analyze the relative importance of non-stationary versus stationary technology shocks and later to compare the relative fit of models with and without financial frictions. In the process of model estimation and comparison we provide a set of parameter estimates for a large set of countries that could serve as a guide for future studies. There is great heterogeneity in the observed business cycle fluctuations, which translates into heterogeneity of the estimated parameters of a common model

[1] The sample corresponds to the countries originally selected by Aguiar and Gopinath (2007) to characterize economic fluctuations with the exception of South Africa (emerging) and Portugal (developed) due to unreliable estimation results. The emerging countries are: Argentina, Brazil, Ecuador, Israel, Korea, Malaysia, Mexico, Peru, Philippines, Slovak Republic, Thailand and Turkey. The developed small countries are: Australia, Austria, Belgium, Canada, Denmark, Finland, Netherlands, New Zealand, Norway, Spain, Sweden and Switzerland.

[2] Specifically, these authors point out that the extended RBC fails to capture the observed trade balance–to-output ratio autocorrelation and the observed excess volatility in consumption, it generates too much volatility of the trade balance, and it poorly matches the correlation of the trade balance with the domestic components of aggregate absorption.

that tries to capture fluctuations in such diverse economies. Though, in many cases, there are clear patterns separating the estimated parameters of emerging market countries from those of developed small open countries. For example, the elasticity of the country's borrowing interest rate with respect to changes in indebtedness, a measure of the degree of financial frictions, is on average larger for emerging market economies. Also, consistent with the empirical evidence of much larger perturbed volatility in emerging market economies, the standard deviations of the innovation are estimated to be larger in these economies relative to those of developed small open economies.

The outline of the paper is as follows. Section 2 presents the benchmark Real Business Cycle model and the extension to include financial frictions. Section 3 discusses the estimation strategy and the empirical implementation. Section 4 contains the results. Section 5 concludes.

2 Model

The model is a standard stochastic growth model with a single-good and a single-asset. Given that we are modeling a small-open economy we assume that the world interest rate is taken as given. In the benchmark model, labeled as Real Business Cycle, we assume that the country can borrow at this world interest rate. Meanwhile, in the Financial Frictions model the country's borrowing rate will be a function of its level of indebtedness. Given that a goal of the paper is to analyze the role of trend shocks in economic fluctuations, we follow Aguiar and Gopinath (2007) by presenting a small-open economy model augmented to include transitory and non-stationary (trend) shocks to productivity.

Technology yields output, Y_t, from capital, K_t, and labor, N_t, according to

$$Y_t = e^{z_t} K_t^{1-\alpha} (\Gamma_t N_t)^{\alpha} \tag{1}$$

where $\alpha \epsilon (0,1)$ is the labor share in output. Output is affected by two innovations, a transitory shock, z_t, that follows the AR(1) process

$$z_t = \rho_z z_{t-1} + \varepsilon_t^z \tag{2}$$

and the cumulative product of permanent innovations, Γ_t, that evolves according to

$$\Gamma_t = e^{g_t}\Gamma_{t-1} = \prod_{s=0}^{t} e^{g_0} \tag{3}$$

$$g_t = (1-\rho_g)\mu_g + \rho_g g_{t-1} + \varepsilon_t^g \tag{4}$$

where $|\rho_z| <, |\rho_g| < 1$ and ε_t^z and ε_t^g represents independently and identical distributed draws from two separate normal distributions with zero mean and standard deviations σ_z and σ_g, respectively, while μ_g represents productivity's long-run mean growth rate.

Households choose consumption, C_t, leisure, $L_t = 1 - N_t$, next period debt, B_{t+1}, and investment, X_t, to maximize

$$\sum_{t=0}^{\infty} \beta_t u(C_t, 1-N_t) \tag{5}$$

where $\beta \epsilon (0,1)$ is a discount factor. We assume that the utility function take the Cobb-Douglas form

$$u(C_t, 1-N_t) = \frac{[C_t^{\gamma}(1-N_t)^{1-\gamma}]^{1-\sigma}}{1-\sigma} \tag{6}$$

where $\gamma \epsilon (0,1)$ and $\sigma > 0, \neq 1$ is the inverse of the elasticity of intertemporal substitution.

Assets are restricted to one-period non-contingent debt contracts with price $q_t = \frac{1}{1+r_t}$, where r_t is the interest rate. The per-period resource constraint requires that output and newly acquired debt must be enough to finance consumption, investment, and previously contracted debt obligations according to

$$Y_t + q_t B_{t+1} = C_t + X_t + B_t \tag{7}$$

Given the presence of capital depreciation, $\delta \epsilon (0, 1)$, and quadratic capital adjustment cost, capital accumulates according to

$$K_{t+1} = X_t + (1-\delta)K_t - \frac{\phi}{2}\left(\frac{K_{t-1}}{K_t} - e^{\mu_g}\right)^2 K_t \tag{8}$$

where the parameter $\phi \geq 0$ is the elasticity of the price of capital with respect to the investment-capital ratio.

Net exports, NX_t, are defined as the difference between production and absorption

$$NX_t = Y_t - C_t - X_t \tag{9}$$

Up to this point both models share identical elements, the only difference between the Real Business Cycle model and the Financial Frictions model will be the assumption about bond price determination. As a short-hand to capture financial frictions we assume that the price of bonds is an inverse function of the level of indebtedness according to

$$\frac{1}{q_t} = 1 + r_t = \frac{1 + r^* + \psi\left[e^{\left(\frac{B_{t+1}}{\Gamma_t} - b\right)} - 1\right]}{e^{\varepsilon_t^f}} \tag{10}$$

where r^* is the world interest rate, b represents the steady-state of normalized debt, and $\psi \geq 0$ captures the elasticity of the borrowing interest rate to changes in indebtedness. In the model without financial frictions $\psi \to 0$,[3] while if financial frictions are present $\psi \gg 0$.[4] In both versions we introduce an innovation ε_t^f to the price of bonds and assume that it represents independently and identical distributed draws from a normal distribution with zero mean and standard deviation σ_f. This extra innovation allows us to use a third data series, investment, and helps to ensure that we identify the elasticity of the borrowing interest rate with respect to indebtedness.

Before moving into the estimation strategy it could be useful to get intuition about the dynamics of the variables in the model in response to the three innovations. Figure 1, below, shows, the behavior of output, net exports, consumption, consumption to output ratio, investment and investment to output ratio in response to transitory

[3] Only for technical reasons, as explained in Schmitt-Grohe and Uribe (2003), ψ is not equal to zero in the benchmark model without frictions.

[4] This short hand to capture financial frictions was proposed by García-Cicco, Pancrazi, and Uribe (2010). Roberto Chang and Andres Fernandez (2010) points out to some limitations of this approach and introduce a richer structure to model financial frictions. We recognize that this version of financial frictions that we are considering is not micro founded and it is somewhat restrictive, as features like credit rationing or lack of commitment are not considered. Despite these limitations we decided to keep the comparison as simple as possible because our goal is to see how robust the finding in García-Cicco et al. (2010) is.

technology, permanent technology and cost of borrowing innovations, respectively. For illustration purposes, the charts report the response in the RBC model ($\psi \rightarrow 0$). The behavior with financial frictions ($\psi \gg 0$) is qualitatively similar, but the use of external accounts to smooth shocks is more limited given that the cost of borrowing is sensitive to changes in indebtedness.

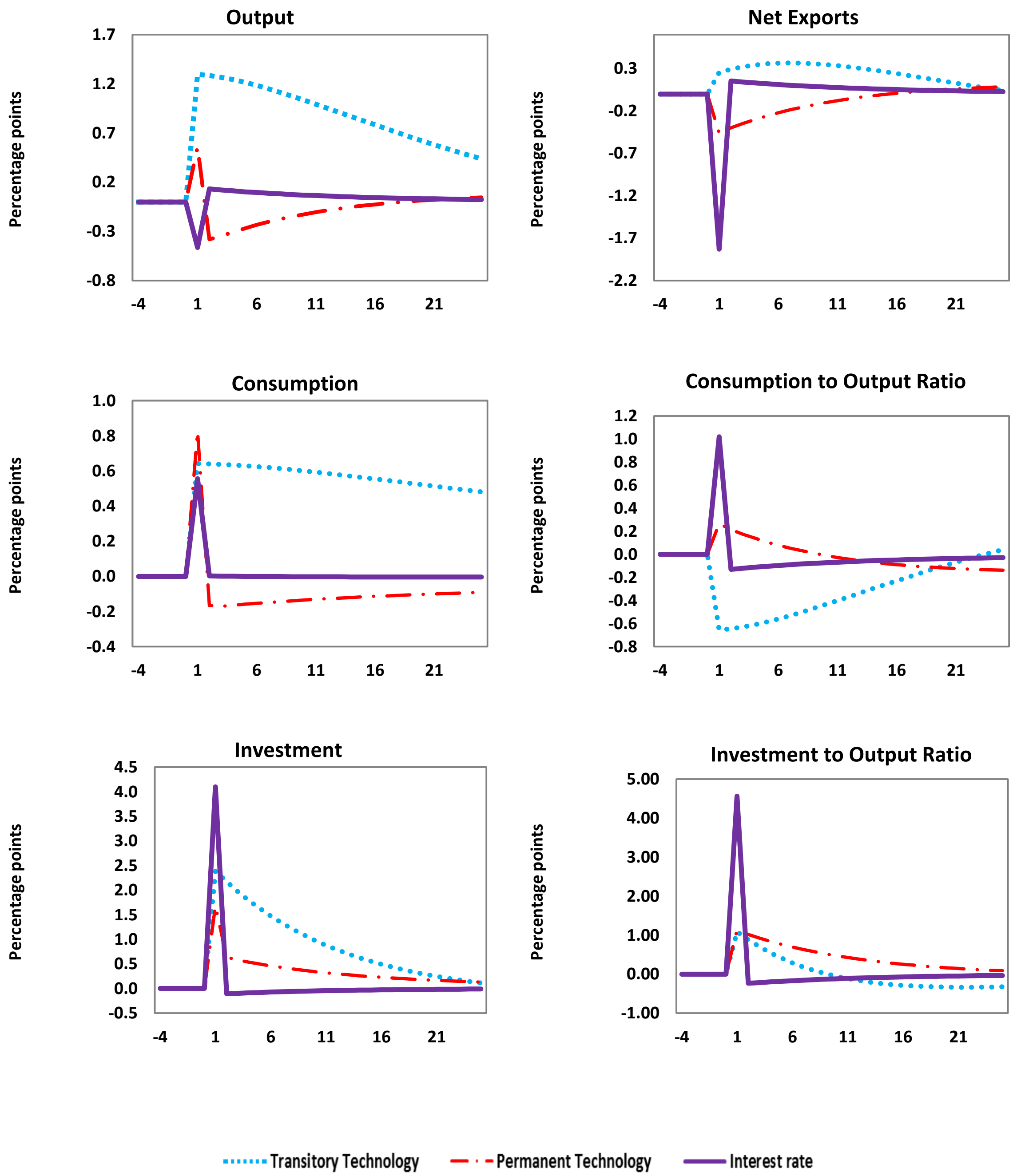
From the figure we see that a positive transitory technology shock increases output, consumption and investment. Given that this is a transitory windfall, consumption increases less than output as the economy saves part of this extra income through its net exports account that experiences a surplus.

In the case of a positive permanent technology shock, again, output, consumption and investment increase. Given that this is a permanent increase in income and it takes time to accumulate capital, upon impact consumption rises more than output and this imbalance is financed with a net export deficit. In this sense we can say that the economy smoothens temporary disturbances, but adjusts to permanent shocks.

Finally, a one-time drop in the international cost of borrowing leads to a sharp increase in borrowing to finance consumption and investment booms. Given the model´s specification of preferences, agents respond by temporarily increasing leisure, which causes a transitory decline of output. Note that a shock to the cost of borrowing is the only innovation that leads to contracyclical consumption and investment and to procyclical net exports responses.

Therefore, we have 3 shocks with contrasting effects in the model variables' behavior. We will impose data discipline into the model to identify these innovations.

Figure 1: Model responses to the three innovations: a) 1% increases the transitory component of technology; b) 1% increase in the permanent component of technology; and c) 1% reduction to the cost of borrowing.



NOTE: The impulse response functions are based on simulations that take the calibrated parameters and the priors to be described in subsection 3.3. The simulations take the elasticity of the borrowing interest rate to changes in indebtedness ψ almost zero. The figure shows the percentage deviations from steady.

3 Estimation Strategy and Empirical Implementation

The model presented above is estimated using Bayesian methods.[5] This section describes the methods, data, and parameters used for estimation. The estimation was computed using Dynare.

3.1 Bayesian estimation of the DSGE model

The object of interest is the vector of parameters

$$\theta = \{\psi, \phi, \rho_z, \rho_g, \sigma_z, \sigma_g, \sigma_f\}$$

where ψ captures the elasticity of the borrowing interest rate to changes in indebtedness, ϕ is the elasticity of the price of capital with respect to the investment-capital ratio, ρ_z and ρ_g represent the autoregressive parameters of the transitory and permanent technology shocks, respectively, while σ_z and σ_g represent their standard deviations and σ_f represents the standard deviation of the bond price shock.

Given a prior $p(\theta)$, the posterior density of the model parameters, θ, is given by

$$p(\theta \mid Y^T) = \frac{L(\theta \mid Y^T)\, p(\theta)}{\int L(\theta \mid Y^T)\, p(\theta)\, d\theta}$$

where $L(\theta \mid Y^T)$ is the likelihood conditional on observed data $Y^T = \{Y_1, \dots, Y_T\}$. In our case, as detailed below, $Y^T = [obs(y_t), obs(c_t), obs(x_t)]'$ for t = 1,…,T. The likelihood function is computed under the assumption of normally distributed disturbances by combining the state-space representation implied by the solution of the linear rational expectations model and the Kalman-Filter. Posterior draws are obtained using Markov Chain Monte Carlo methods. After obtaining an approximation to the mode of the posterior, a Random Walk Metropolis algorithm with 1,000,000 iterations is used to generate posterior draws. Point estimates and measures of uncertainty are obtained from the generated values.

3.2 Data

To identify the nature of the shocks, we use data on output, consumption and investment. Given that the model is presented as log deviations from the detrended steady-state we use quarterly data of Hodrick-Prescott-Filtered cycle of the log gross domestic product, log private consumption, and log investment. We perform estimations for 12 emerging and 12 developed small open economies. The emerging countries are: Argentina, Brazil, Ecuador, Israel, Korea, Malaysia, Mexico, Peru, Philippines, Slovak Republic, Thailand and Turkey. The developed small countries are: Australia, Austria, Belgium, Canada, Denmark, Finland, Netherlands, New Zealand, Norway, Spain, Sweden and Switzerland. The data was originally compiled by Aguiar and Gopinath and for most countries the sample starts in 1980 and spans up to 2003.[6] South Africa and Portugal were excluded from the sample, as we were not satisfied with their estimation results given that some parameter estimates seemed unrealistic.

[5] A detailed description of the methods is found in An and Schorfheide (2007).

[6] Ideally, the analysis should be performed with a larger sample due to the limited number of cycles in the post 1980´s as emphasized by García-Cicco, Pancrazi and Uribe (2010). We decided to directly use the data compiled by Aguiar and Gopinath to limit the factors modified in the analysis.

3.3 Parameters

In the quantitative analysis we fix a subset of the parameters and estimate those related to the technology and financial processes. Below we provide details about the subset of calibrated and estimated parameters.

3.3.1 Calibration

The calibrated parameter values are standard and follow those used by Aguiar and Gopinath (2007). The quarterly discount rate β is set to 0.98, and the world interest rate, r^*, is set to satisfy the condition that $\beta(1+r^*) = e^{\mu_g[1-\gamma(1-\sigma)]}$, which is required for well-behaved consumption. The consumption coefficient in the Cobb-Douglas utility function γ is set to 0.36 to get steady-state labor of one-third of the available time, while the inverse of the elasticity of intertemporal substitution σ is set to 2.0. The capital depreciation rate δ is set to 0.05. The steady-state normalized debt $b \equiv \frac{B}{Y}$ is approximated using the net foreign asset position reported by Philip R. Lane and Gian Maria Milesi-Ferretti (2007). In the benchmark RBC model the elasticity of the borrowing interest rate to changes in indebtedness ψ is set to 0.001. In the model with financial frictions this elasticity will be estimated. The labor share in production α is set to 0.68, while the productivity's long-run mean growth rate μ_g is set to 1.006 implying a 2.4% annual growth rate. Table 1, below, summarizes these values.

Table 1: Benchmark Parameter Values

Description	Symbol	Value
Time preference rate	β	0.980
Consumption coefficient in Cobb-Douglas utility function	γ	0.360
Steady-state normalized debt*	b	varies
Elasticity of the borrowing interest rate to changes in indebtedness**	ψ	0.001
Labor share (production)	α	0.680
Inverse of the elasticity of intertemporal substitution	σ	2.000
Depreciation rate	δ	0.050
Productivity's long-run mean growth rate	μ_g	1.006

Note. Benchmark parameters used in all specifications unless otherwise specified
* Country's average net foreign asset position to GDP.
** This parameter is estimated in the model with financial frictions.

3.3.2 Priors

As previously explained, the only difference between a model with and without financial frictions is that in the model with financial frictions the elasticity of the borrowing interest rate to changes in indebtedness ψ is different from zero. In the financial frictions´ version we assume that this elasticity follows a normal distribution with a prior mean of 0.06 and a standard deviation of 0.02. In the case of the elasticity of the price of capital with respect to the investment-capital ratio ϕ we assume a normal distribution with a prior mean of 4 and a standard deviation of 1.5. For the autoregressive coefficients of the temporary and permanent technology shocks we assume Beta distributions with prior means of 0.5 and 0.1 and standard deviations of 0.2 and 0.05, respectively. Finally for the standard deviations of the three shocks we assume that they have Inverse Gamma distributions with prior mean of 1 and standard deviation of 4. Table 2, below, summarizes these values.

Table 2: Prior Parameter Values

Description	Symbol	Prior Mean	Prior Std. Deviation	Prior Distribution
Elasticity of the borrowing interest rate to changes in indebtedness*	ψ	0.06	0.02	Normal
Elasticity of the price of capital with respect to the investment-capital ratio	ϕ	4.00	1.50	Normal
Autoregressive coefficient temporary technology shock	ρ_z	0.50	0.20	Beta
Autoregressive coefficient permanent technology shock	ρ_g	0.10	0.05	Beta
Standard deviation of the temporary technology shock	σ_z	1.00	4.00	Inverse Gamma
Standard deviation of the permanent technology shock	σ_g	1.00	4.00	Inverse Gamma
Standard deviation of the bond price shock	σ_f	1.00	4.00	Inverse Gamma

Note. Benchmark prior parameters used in all specifications unless otherwise specified

* This parameter is calibrated to 0.001 in the model without financial frictions.

4 Results

In this section we present the estimation results. First, we report the estimated parameters. Second, we analyze the importance of relaxing the frictionless financial markets assumption by presenting a Maximum Likelihood comparison of both models for each country to extend the evidence in García-Cicco et al. (2010). Finally, we explore the relative importance of trend shocks, as captured by non-stationary technology shocks, as drivers of economic fluctuations to extend the evidence in Aguiar and Gopinath (2007).

4.1 Estimation

Tables 3 and 4, presented in the next two pages, summarize the estimation results for the Real Business Cycles and Financial Frictions models, respectively. In the table we repeat the priors and report the posterior means and 90% confidence intervals (in parenthesis) of the estimated parameters.

Table 3: Estimations of Real Business Cycles Model Augmented with Permanent Technology Shocks

Emerging Market Economies

Country	ψ	Φ	ρ_z	ρ_g	σ_z	σ_g	σ_f	RWSR
Priors	-	4.00	0.50	0.10	1.00	1.00	1.00	0.28
		(1.53, 6.47)	(0.17,0.82)	(0.03,0.19)	(0.19,2.47)	(0.19,2.47)	(0.19,2.47)	(0.02 , 1.08)
Argentina	-	5.27	0.83	0.49	1.34	2.03	3.65	1.57
		(4.08, 6.37)	(0.70, 0.97)	(0.40, 0.60)	(1.02, 1.64)	(1.39, 2.62)	(2.84, 4.45)	(0.90, 2.41)
Brazil	-	4.42	0.71	0.51	1.39	3.14	1.95	2.18
		(3.26, 5.58)	(0.53, 0.89)	(0.44, 0.59)	(0.98, 1.79)	(2.46, 3.79)	(1.49, 2.40)	(1.56, 2.92)
Ecuador	-	2.94	0.97	0.76	1.33	1.21	1.92	3.33
		(1.71, 4.09)	(0.94, 0.99)	(0.67, 0.84)	(0.97, 1.69)	(0.62, 1.72)	(0.83, 2.84)	(1.15, 6.78)
Israel	-	4.07	0.71	0.53	1.41	1.69	2.50	1.36
		(3.40, 4.75)	(0.61, 0.8)	(0.48, 0.59)	(1.21, 1.60)	(1.38, 1.99)	(2.10, 2.89)	(0.95, 1.88)
Korea	-	5.34	0.80	0.51	1.10	1.40	1.86	1.38
		(4.61, 6.08)	(0.70, 0.91)	(0.45, 0.57)	(0.95, 1.25)	(1.16, 1.64)	(1.59, 2.12)	(0.97, 1.88)
Malaysia	-	3.64	0.88	0.55	1.67	2.09	2.41	1.65
		(2.96, 4.30)	(0.77, 0.98)	(0.50, 0.59)	(1.28, 2.04)	(1.68, 2.51)	(1.90, 2.94)	(1.10, 2.29)
Mexico	-	3.71	0.91	0.50	1.09	1.11	2.28	1.09
		(3.16, 4.25)	(0.86, 0.96)	(0.41, 0.59)	(0.92, 1.26)	(0.88, 1.33)	(1.90, 2.64)	(0.69, 1.66)
Peru	-	3.67	0.87	0.26	1.43	2.77	1.42	1.04
		(2.94, 4.41)	(0.82, 0.92)	(0.19, 0.32)	(1.16, 1.69)	(2.28, 3.25)	(1.14, 1.70)	(0.79, 1.33)
Philippines	-	1.11	0.78	0.61	1.19	1.02	1.24	1.26
		(1.00, 1.23)	(0.72, 0.84)	(0.49, 0.73)	(1.02, 1.36)	(0.75, 1.29)	(1.05, 1.43)	(0.63, 2.55)
Slovak Republic	-	1.89	0.73	0.49	0.67	1.45	1.43	2.00
		(1.26, 2.48)	(0.58, 0.88)	(0.43, 0.56)	(0.52, 0.82)	(1.14, 1.75)	(1.00, 1.84)	(1.48, 2.60)
Thailand	-	3.17	0.97	0.46	1.72	1.67	1.71	0.94
		(2.44, 3.90)	(0.95, 0.98)	(0.38, 0.54)	(1.35, 2.09)	(1.24, 2.10)	(1.23, 2.17)	(0.53, 1.52)
Turkey	-	4.52	0.86	0.31	1.81	2.42	2.11	0.85
		(3.75, 5.30)	(0.75, 0.95)	(0.24, 0.39)	(1.44, 2.16)	(1.99, 2.84)	(1.75, 2.46)	(0.58, 1.20)
Average Emerging	**-**	**3.65**	**0.84**	**0.50**	**1.35**	**1.83**	**2.04**	**1.56**
		(2.88, 4.41)	(0.74, 0.93)	(0.42, 0.57)	(1.07, 1.62)	(1.41, 2.25)	(1.57, 2.51)	(0.94, 2.17)

Developed Small Open Economies

Country	Ψ	Φ	ρ_z	ρ_g	σ_z	σ_g	σ_f	RWSR
Priors	-	4.00	0.50	0.10	1.00	1.00	1.00	0.28
		(1.53, 6.47)	(0.17,0.82)	(0.03,0.19)	(0.19,2.47)	(0.19,2.47)	(0.19,2.47)	(0.02 , 1.08)
Australia	-	2.00	0.83	0.52	0.57	0.41	0.87	0.67
		(1.60, 2.40)	(0.78, 0.88)	(0.45, 0.59)	(0.49, 0.64)	(0.33, 0.49)	(0.70, 1.02)	(0.42, 1.04)
Austria	-	2.83	0.81	0.44	0.38	0.51	0.47	1.19
		(2.25, 3.41)	(0.72, 0.90)	(0.35, 0.54)	(0.30, 0.45)	(0.41, 0.61)	(0.38, 0.56)	(0.76, 1.78)
Belgium	-	2.55	0.81	0.41	0.44	0.45	0.78	0.78
		(2.08, 3.01)	(0.75, 0.87)	(0.32, 0.51)	(0.38, 0.50)	(0.35, 0.54)	(0.65, 0.90)	(0.49, 1.19)
Canada	-	3.24	0.94	0.40	0.51	0.52	0.51	0.81
		(2.84, 3.66)	(0.92, 0.96)	(0.32, 0.48)	(0.43, 0.59)	(0.43, 0.60)	(0.44, 0.59)	(0.54, 1.17)
Denmark	-	2.23	0.61	0.40	0.85	0.98	0.81	0.78
		(1.74, 2.72)	(0.48, 0.75)	(0.29, 0.52)	(0.69, 1.00)	(0.75, 1.19)	(0.65, 0.96)	(0.44, 1.31)
Finland	-	2.09	0.77	0.84	0.83	0.35	0.50	2.12
		(1.67, 2.50)	(0.74, 0.81)	(0.79, 0.89)	(0.73, 0.93)	(0.28, 0.42)	(0.39, 0.61)	(1.06, 4.71)
Netherlands	-	2.18	0.81	0.86	0.57	0.20	0.43	2.13
		(1.64, 2.74)	(0.73, 0.89)	(0.83, 0.89)	(0.50, 0.63)	(0.16, 0.25)	(0.30, 0.55)	(1.15, 3.82)
New Zealand	-	2.07	0.84	0.39	0.82	0.72	0.89	0.59
		(1.59, 2.54)	(0.76, 0.92)	(0.28, 0.49)	(0.67, 0.96)	(0.57, 0.86)	(0.69, 1.09)	(0.34, 0.98)
Norway	-	2.28	0.59	0.52	0.89	1.00	1.44	1.10
		(1.91, 2.66)	(0.48, 0.71)	(0.46, 0.59)	(0.77, 1.00)	(0.80, 1.18)	(1.22, 1.66)	(0.73, 1.57)
Spain	-	3.93	0.90	0.53	0.50	0.44	1.06	1.02
		(3.33, 4.53)	(0.85, 0.95)	(0.47, 0.59)	(0.42, 0.57)	(0.36, 0.52)	(0.88, 1.23)	(0.68, 1.49)
Sweden	-	3.35	0.81	0.34	0.90	1.29	1.36	0.95
		(2.79, 3.89)	(0.76, 0.86)	(0.25, 0.43)	(0.77, 1.02)	(1.04, 1.53)	(1.15, 1.57)	(0.66, 1.31)
Switzerland	-	2.71	0.90	0.53	0.33	0.22	0.43	0.66
		(2.27, 3.13)	(0.88, 0.93)	(0.47, 0.59)	(0.29, 0.37)	(0.18, 0.25)	(0.35, 0.50)	(0.42, 0.99)
Average Developed	**-**	**2.62**	**0.80**	**0.51**	**0.63**	**0.59**	**0.80**	**1.07**
		(2.14, 3.10)	(0.74, 0.87)	(0.44, 0.59)	(0.54, 0.72)	(0.47, 0.71)	(0.65, 0.94)	(0.64, 1.50)

Note: The table shows the mean and 90% confidence intervals of the estimated parameters and the shocks' standard deviations. The estimation uses Bayesian Likelihood Methods and HP filtered data for output, consumption and investment. Posterior statistics are based on one-million MCMC chain from which the first 20% were discarded.

Table 4: Estimations of Financial Frictions Model Augmented with Permanent Technology Shocks

Emerging Market Economies

Country	**ψ**	**ϕ**	**ρ_z**	**ρ_g**	**σ_z**	**σ_g**	**σ_f**	**RWSR**
Priors	0.06	4.00	0.50	0.10	1.00	1.00	1.00	0.28
	(0.03, 0.09)	(1.53, 6.47)	(0.17,0.82)	(0.03,0.19)	(0.19,2.47)	(0.19,2.47)	(0.19,2.47)	(0.02 , 1.08)
Argentina	0.09	3.96	0.77	0.47	1.65	2.05	2.46	1.17
	(0.06, 0.12)	(2.88, 5.07)	(0.68, 0.88)	(0.36, 0.58)	(1.25, 2.06)	(1.50, 2.60)	(1.80, 3.09)	(0.63, 1.99)
Brazil	0.09	2.75	0.71	0.75	1.06	2.73	0.88	5.89
	(0.07, 0.11)	(1.85, 3.65)	(0.57, 0.85)	(0.71, 0.79)	(0.84, 1.26)	(2.18, 3.25)	(0.61, 1.14)	(4.67, 7.45)
Ecuador	0.05	2.06	0.86	0.80	1.06	1.59	1.51	6.31
	(0.03, 0.07)	(1.20, 2.86)	(0.76, 0.95)	(0.76, 0.84)	(0.85, 1.26)	(1.23, 1.95)	(0.89, 2.10)	(4.56, 8.48)
Israel	0.08	2.96	0.59	0.76	1.26	1.27	1.51	3.18
	(0.06, 0.09)	(2.29, 3.60)	(0.46, 0.72)	(0.70, 0.82)	(1.09, 1.42)	(1.01, 1.52)	(1.20, 1.82)	(1.91, 5.27)
Korea	0.06	4.30	0.75	0.70	1.11	1.12	1.54	2.42
	(0.04, 0.08)	(3.58, 5.01)	(0.67, 0.83)	(0.63, 0.78)	(0.96, 1.25)	(0.89, 1.34)	(1.25, 1.81)	(1.47, 4.04)
Malaysia	0.05	2.09	0.83	0.75	1.37	1.66	1.64	3.87
	(0.05, 0.05)	(1.47, 2.71)	(0.74, 0.92)	(0.70, 0.80)	(1.11, 1.63)	(1.31, 2.01)	(1.18, 2.07)	(2.62, 5.54)
Mexico	0.05	2.83	0.81	0.54	1.11	1.21	1.92	1.31
	(0.03, 0.07)	(2.30, 3.36)	(0.74, 0.88	(0.48, 0.61)	(0.94, 1.28)	(1.02, 1.40)	(1.58, 2.27)	(0.91, 1.84)
Peru	0.08	3.04	0.78	0.33	1.65	2.98	0.88	1.13
	(0.06, 0.11)	(2.31, 3.75)	(0.71, 0.84)	(0.25, 0.41)	(1.34, 1.97)	(2.45, 3.49)	(0.66, 1.09)	(0.82, 1.50)
Philippines	0.05	1.82	0.80	0.99	1.24	0.44	1.45	107.55
	(0.04, 0.06)	(1.39, 2.25)	(0.73, 0.86)	(0.98, 0.99)	(1.08, 1.40)	(0.36, 0.51)	(1.17, 1.72)	(49.8, 353.7)
Slovak Republic	0.03	1.99	0.73	0.66	0.70	1.27	1.49	3.33
	(0.00, 0.06)	(1.32, 2.72)	(0.59, 0.86)	(0.54, 0.76)	(0.53, 0.86)	(0.96, 1.55)	(0.96, 2.02)	(1.88, 6.37)
Thailand	0.05	1.89	0.87	0.69	1.45	1.20	1.29	1.89
	(0.04, 0.06)	(1.19, 2.55)	(0.81, 0.92)	(0.61, 0.77)	(1.16, 1.73)	(0.89, 1.53)	(0.82, 1.73)	(0.98, 3.43)
Turkey	0.08	3.11	0.71	0.36	1.72	2.50	1.51	0.98
	(0.06, 0.10)	(2.41, 3.80)	(0.60, 0.83)	(0.28, 0.45)	(1.40, 2.03)	(2.08, 2.92)	(1.19, 1.82)	(0.67, 1.37)
Average Emerging	**0.06**	**2.73**	**0.77**	**0.65**	**1.28**	**1.67**	**1.51**	**2.86**
	(0.05,0.08)	(2.02, 3.45)	(0.67, 0.86)	(0.58, 0.72)	(1.05, 1.52)	(1.32, 2.01)	(1.11, 1.90)	(1.92, 4.30)

Developed Small Open Economies

Country	**ψ**	**Φ**	**ρ_z**	**ρ_g**	**σ_z**	**σ_g**	**σ_f**	**RWSR**
Priors	0.06	4.00	0.50	0.10	1.00	1.00	1.00	0.28
	(0.03, 0.09)	(1.53, 6.47)	(0.17,0.82)	(0.03,0.19)	(0.19,2.47)	(0.19,2.47)	(0.19,2.47)	(0.02 ,
Australia	0.06	2.11	0.70	0.42	0.78	0.60	0.84	0.48
	(0.04, 0.08)	(1.68, 2.53)	(0.63, 0.76)	(0.30, 0.55)	(0.66, 0.89)	(0.48, 0.71)	(0.69, 1.00)	(0.27, 0.86)
Austria	0.07	2.40	0.70	0.46	0.46	0.61	0.42	1.18
	(0.04, 0.09)	(1.79, 2.97)	(0.60, 0.82)	(0.35, 0.58)	(0.36, 0.56)	(0.50, 0.73)	(0.33, 0.51)	(0.72, 1.88)
Belgium	0.06	2.41	0.70	0.33	0.54	0.55	0.69	0.56
	(0.04, 0.08)	(1.97, 2.85)	(0.63, 0.77)	(0.24, 0.43)	(0.47, 0.62)	(0.45, 0.64)	(0.57, 0.79)	(0.37, 0.84)
Canada	0.07	2.87	0.77	0.41	0.58	0.59	0.72	0.74
	(0.05, 0.09)	(2.34, 3.40)	(0.71, 0.83)	(0.30, 0.52)	(0.49, 0.66)	(0.49, 0.69)	(0.57, 0.86)	(0.48, 1.16)
Denmark	0.06	1.47	0.33	0.36	0.87	1.11	0.54	0.68
	(0.04, 0.08)	(1.05, 1.83)	(0.17, 0.49)	(0.23, 0.48)	(0.71, 1.02)	(0.89, 1.32)	(0.42, 0.66)	(0.41, 1.14)
Finland	0.03	1.35	0.74	0.74	0.86	0.50	0.45	1.42
	(0.02, 0.04)	(1.03, 1.63)	(0.68, 0.79)	(0.69 0.78)	(0.75, 0.96)	(0.42, 0.58)	(0.34, 0.56)	(0.89, 2.28)
Netherlands	0.03	2.03	0.81	0.86	0.58	0.30	0.45	4.02
	(0.02, 0.04)	(1.57, 2.50)	(0.74, 0.90)	(0.83, 0.90)	(0.50, 0.65)	(0.24, 0.37)	(0.34, 0.56)	(2.31, 7.00)
New Zealand	0.04	1.74	0.64	0.31	0.95	0.89	0.85	0.46
	(0.02, 0.07)	(1.29, 2.19)	(0.53, 0.75)	(0.21, 0.42)	(0.79, 1.12)	(0.73, 1.04)	(0.66, 1.04)	(0.28, 0.73)
Norway	0.07	1.56	0.33	0.43	0.93	1.19	0.92	0.84
	(0.05, 0.08)	(1.23, 1.88)	(0.19, 0.46)	(0.33, 0.53)	(0.79, 1.07)	(0.42, 0.58)	(0.75, 1.08)	(0.15, 1.63)
Spain	0.04	3.24	0.76	0.48	0.58	0.55	0.96	0.85
	(0.02, 0.05)	(2.62, 3.87)	(0.67, 0.84)	(0.39, 0.59)	(0.48, 0.68)	(0.45, 0.66)	(0.79, 1.12)	(0.52, 1.36)
Sweden	0.06	3.50	0.69	0.33	1.06	1.46	1.22	0.84
	(0.04, 0.08)	(2.92, 4.07)	(0.63, 0.76)	(0.24, 0.43)	(0.90, 1.21)	(1.22, 1.71)	(1.00, 1.43)	(0.58, 1.19)
Switzerland	0.02	2.71	0.84	0.50	0.38	0.27	0.44	0.62
	(0.00, 0.04)	(2.21, 3.22)	(0.79, 0.94)	(0.42, 0.59)	(0.29, 0.45)	(0.19, 0.35)	(0.37, 0.52)	(0.30, 1.16)
Average Developed	**0.05**	**2.28**	**0.67**	**0.47**	**0.71**	**0.72**	**0.71**	**1.06**
	(0.03, 0.07)	(1.81, 2.76)	(0.58, 0.75)	(0.38, 0.56)	(0.60, 0.83)	(0.54, 0.90)	(0.57, 0.85)	(0.61, 1.77)

Note: The table shows the mean and 90% confidence intervals of the estimated parameters and the shocks' standard deviations. The estimation uses Bayesian Likelihood Methods and HP filtered data for output, consumption and investment.
Posterior statistics are based on one-million MCMC chain from which the first 20% were discarded. RWSR average for emerging countries excludes Philippines, otherwise figures get distorted with an average of 11.59.

Table 5, below, reports one of the two main results of the paper associated to the comparison of the Real Business Cycles and Financial Frictions models. The table shows the posterior model probability associated to the comparison of log marginal densities. The Financial Frictions model is favored in all the emerging market economies lending support to the findings in Garcia-Cicco et al. (2010) and Chang and Fernandez (2010) about the importance of considering credit market imperfections when modeling emerging economies. The Financial Frictions model is also favored in five developed small open economies (Belgium, Denmark, Netherlands, Norway and Sweden). Interestingly, for the other seven developed small open economies, the extended Real Business Cycles model matches the data better in three countries (Canada, Finland and Switzerland), while there are no definite results in the remaining four countries (Australia, Austria, New Zealand and Spain).

Table 5: Real Business Cycles and Financial Frictions Model Comparison: Posterior Model Probability

Emerging Market Economies			**Developed Small Open Economies**		
Country	**RBC**	**FF**	**Country**	**RBC**	**FF**
Argentina	0% (•356.86)	100% (•340.73)	Australia	64% (•548.93)	36% (•549.54)
Brazil	0% (•402.58)	100% (•363.99)	Austria	40% (•279.50)	60% (•279.10)
Ecuador	0% (•404.50)	100% (•394.16)	Belgium	0% (•471.83)	100% (•450.92)
Israel	0% (•782.73)	100% (•719.65)	Canada	100% (•413.69)	0% (•447.49)
Korea	0% (•708.89)	100% (•678.42)	Denmark	0% (•412.77)	100% (•391.82)
Malaysia	0% (•451.01)	100% (•426.47)	Finland	100% (•573.61)	0% (•585.55)
Mexico	0% (•730.68)	100% (•719.69)	Netherlands	1% (•517.13)	99% (•512.36)
Peru	0% (•465.24)	100% (•443.81)	New Zealand	46% (•419.98)	54% (•419.81)
Philippines	0% (•749.18)	100% (•727.38)	Norway	0% (•710.29)	100% (•665.76)
Slovak Republic	0% (•336.47)	100% (•329.30)	Spain	75% (•488.61)	25% (•489.72)
Thailand	0% (•358.04)	100% (•344.34)	Sweden	0% (•646.82)	100% (•624.40)
Turkey	0% (•553.59)	100% (•531.42)	Switzerland	99% (•334.78)	1% (•339.83)

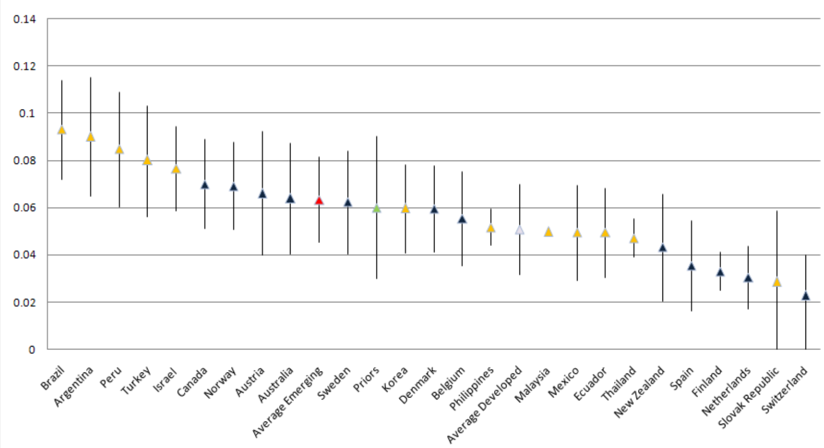
Note: The table shows the posterior model probability between the Real Business Cycle and Financial Frictions models. The log marginal density is reported in parentheses.

To gain intuition behind these results and to appreciate the differences between the estimated parameters, we present independent graphs, one for each parameter, where countries are sorted by the estimated posterior mean. Countries´ groups are denoted with different colors reserving yellow for emerging countries and dark blue for developed ones. Arithmetic group averages are represented with red and light blue for emerging and developed countries, respectively, while priors are represented in green.

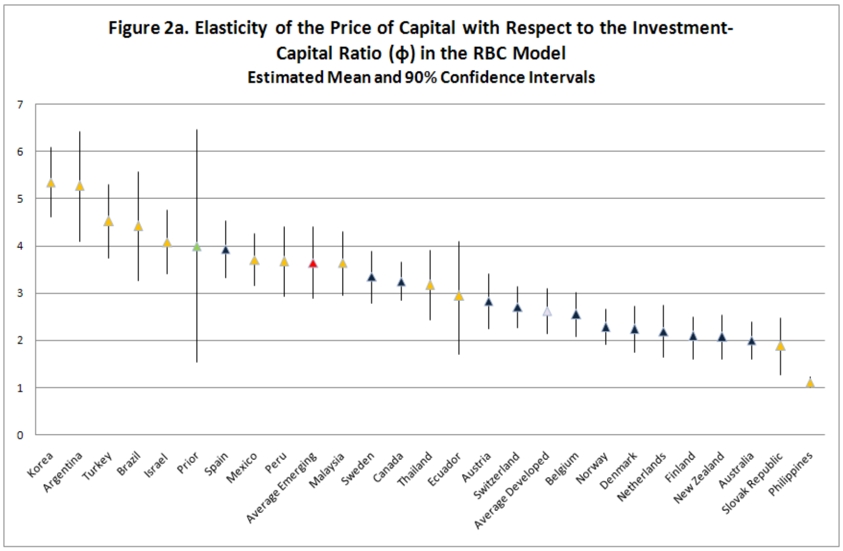
When reading these graphs it is important to keep in mind that the posteriors are distributed normally with the posterior mean denoted with the triangle mark and the 90% confidence intervals shown with the range of the lines. The priors mean and distribution are those specified in subsection 3.3.2.

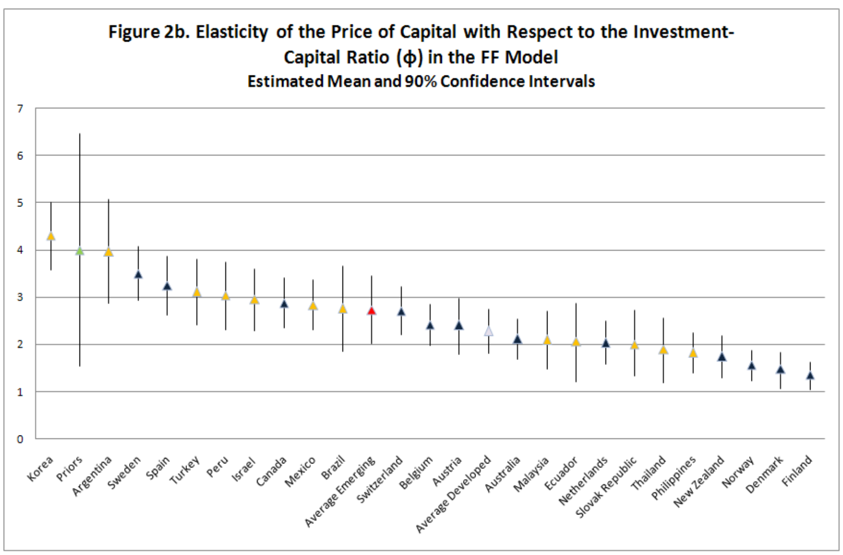
Figure 1, below, reports the estimated elasticity of the country's borrowing interest rate with respect to changes in indebtedness, which was only estimated in the model with financial frictions. Even when there is no perfect separation between groups of countries, the 5 countries with highest estimated elasticity are emerging economies, while 5 of the 6 countries with the smallest elasticity are developed economies. Remember that we are not using financial data and the transmission mechanisms of the financial frictions are limited, as we do not have working capital requirements or other mechanisms to create amplifications. Despite this limitation, it is reassuring to observe that countries like Brazil, Argentina, Peru and Turkey exhibit a cost of borrowing more sensitive to their financial position relative to the one faced by Switzerland, Netherlands, Finland, Spain and New Zealand.

Figure 1: Elasticity of the country's borrowing interest rate with respect to changes in indebtedness (ψ)
Estimated Mean and 90% Confidence Intervals

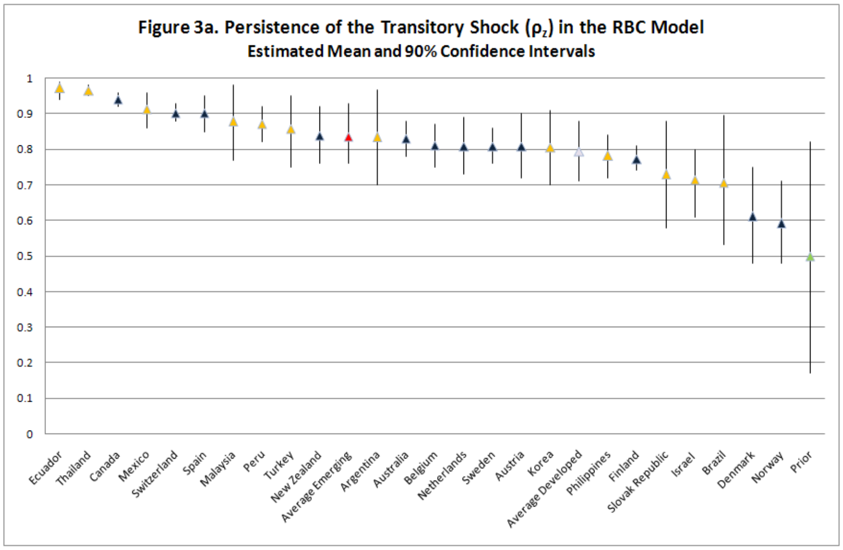


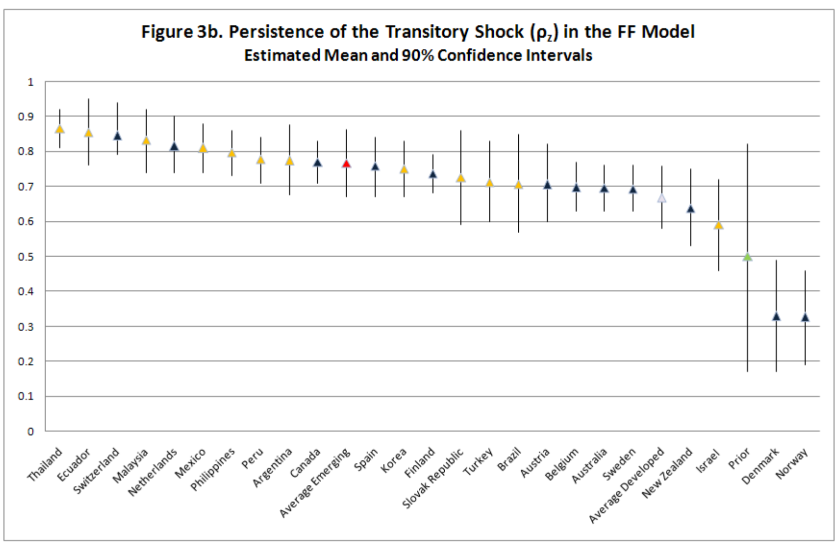
Figures 2a and 2b, below, report the estimated elasticity of the price of capital with respect to the investment-capital ratio for the Real Business Cycles and Financial Frictions models, respectively. In the RBC model emerging countries generally exhibit higher values of this elasticity, which is needed to match the more volatile investment. When we move to the financial frictions model there is another mechanism to capture the volatility of investment and the ordering becomes less clear.





Figures 3a and 3b, below, report the autoregressive parameter of the transitory technology shock ρ_z. There is great variation in the estimated persistence of the transitory technology shock between countries with values ranging from 0.59 to 0.97. There is no clear ordering of country's categories in the RBC model, while in the financial frictions model emerging countries generally exhibit more persistent processes and, on average, persistence of the transitory technology shock diminishes.





Figures 4a and 4b, below, report the autoregressive parameter of the permanent technology shock ρ_g. Similarly to the transitory innovation case, here there is also great variation in the estimated persistence of the permanent technology shock with values that seem fairly large by U.S. standards, but within the range of values estimated by Garcia-Cicco et al. (2010) and Chang and Fernandez (2010). Again there is no clear ordering for the RBC model, while in the Financial Frictions model emerging countries generally exhibit higher permanent technology shock persistence.

Figure 4a. Persistence of the Permanent Shock (ρ_g) in the RBC Model
Estimated Mean and 90% Confidence Intervals

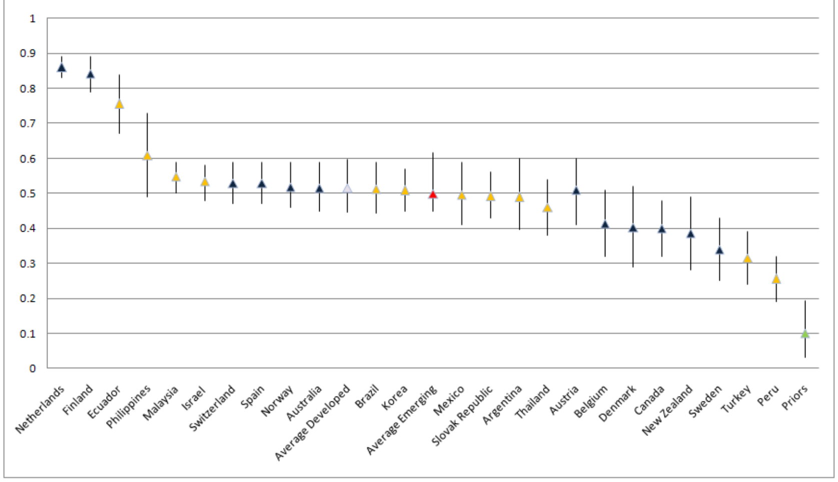
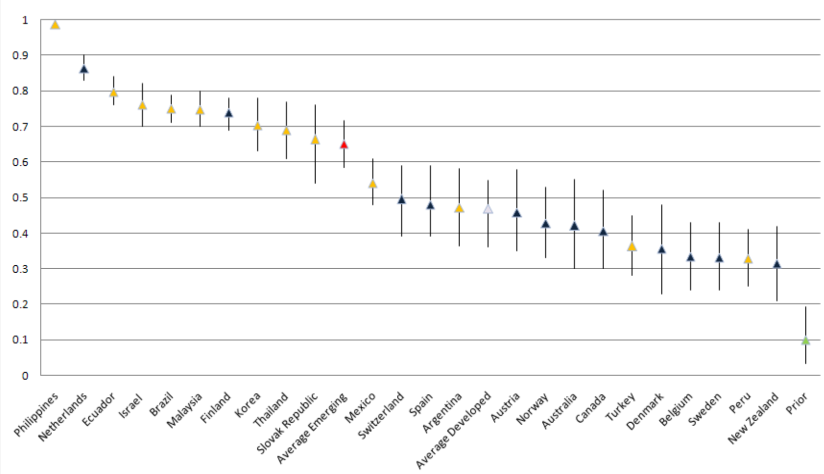


Figure 4b. Persistence of the Permanent Shock (ρ_g) in the FF Model
Estimated Mean and 90% Confidence Intervals



Figures 5a and 5b, below, report the standard deviation of the transitory technology shock σ_z. Here the ordering of the estimated parameters is very clear and consistent across models, with emerging countries exhibiting much larger variability.

Figure 5a. Standard Deviation of the Transitory Shock (σ_z) in the RBC Model
Estimated Mean and 90% Confidence Intervals

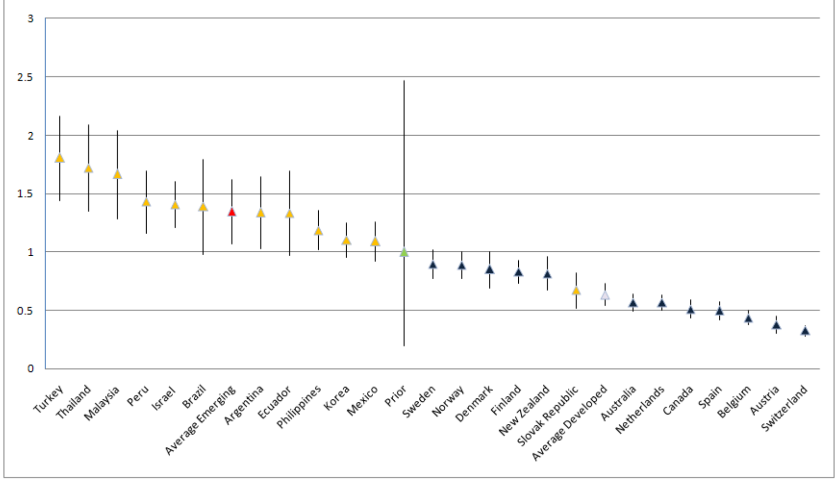
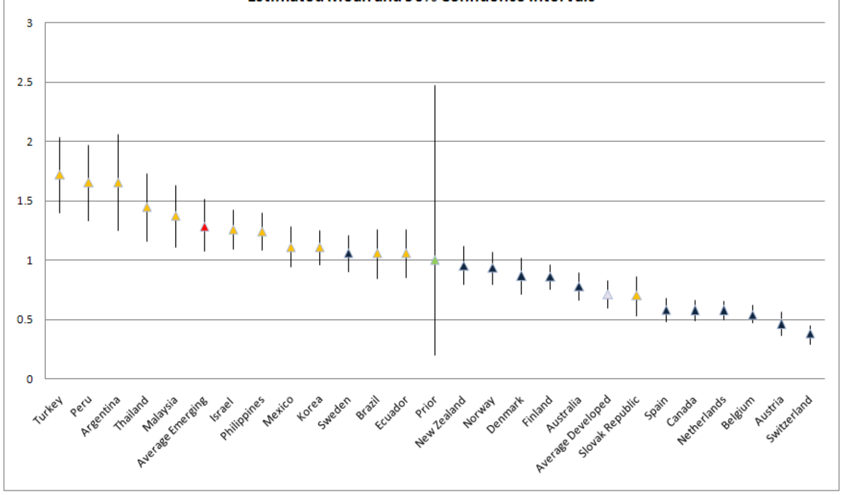


Figure 5b. Standard Deviation of the Transitory Shock (σ_z) in the FF Model
Estimated Mean and 90% Confidence Intervals



Figures 6a and 6b, below, report the standard deviation of the permanent technology shock σ_g. Again there is a clear ordering in both models with emerging countries having larger estimated variability of permanent technology shocks.

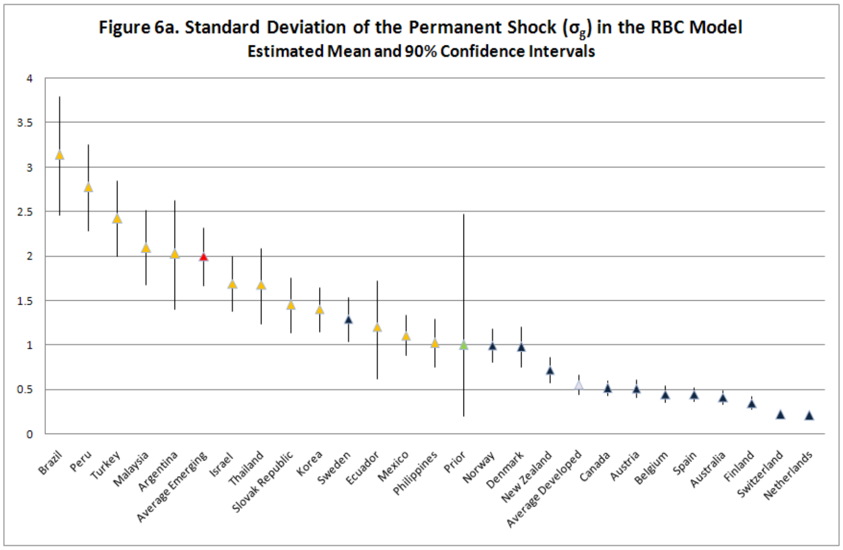


Figure 6a. Standard Deviation of the Permanent Shock (σ_g) in the RBC Model
Estimated Mean and 90% Confidence Intervals

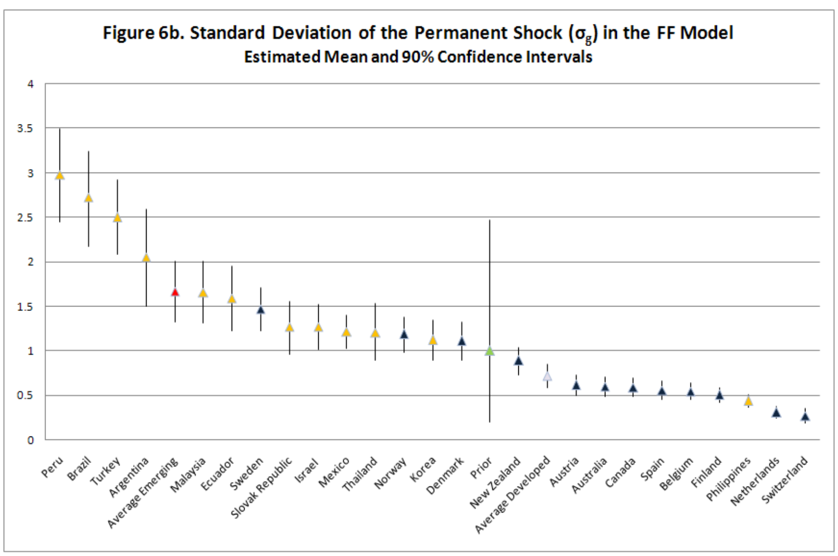
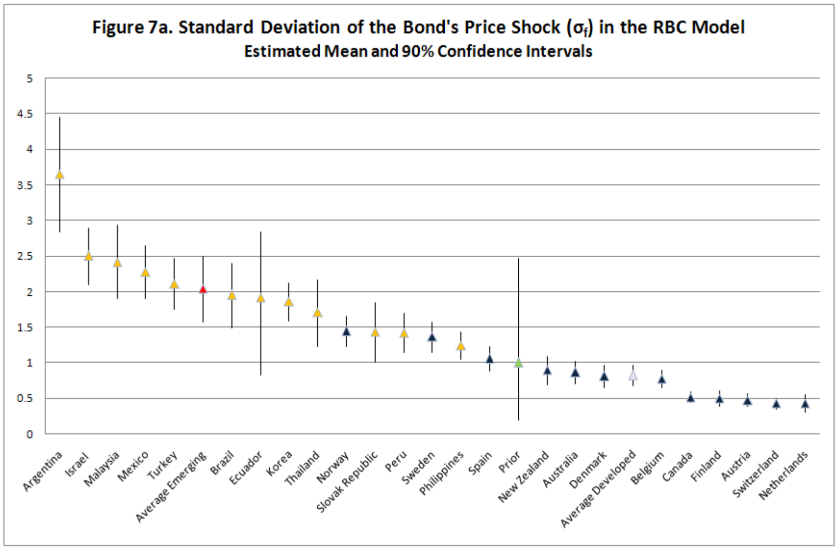
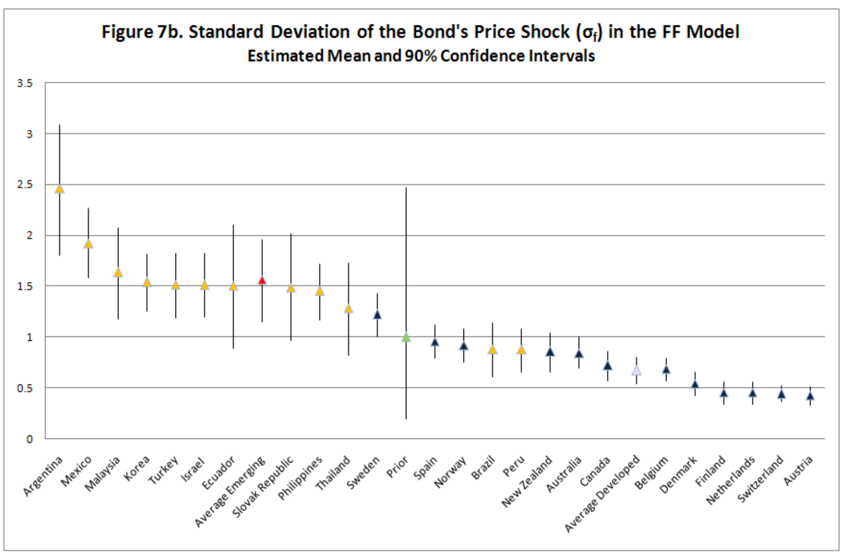


Figure 6b. Standard Deviation of the Permanent Shock (σ_g) in the FF Model
Estimated Mean and 90% Confidence Intervals

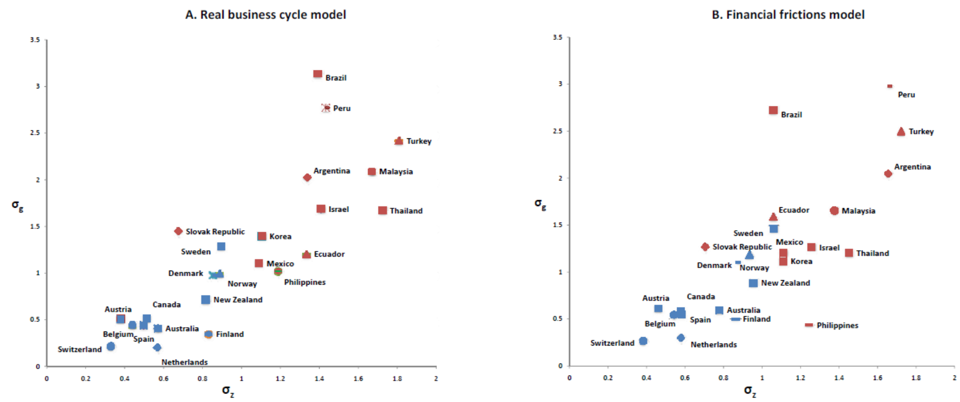
Figures 7a and 7b, below, report the standard deviation of the bond price shock σ_f. Similarly to the technology shocks cases, emerging countries exhibit much larger bond price variability in both models.





Consistent with the larger volatility in emerging market economies, these graphs show that the shocks' standard deviations are generally larger in emerging countries relative to those in developed small open economies. To visualize the differences among groups, Figure 8 shows the coordinates of the estimated posterior means for the standard deviation of transitory and permanent technology shocks from the Real Business Cycle model in panel A and the Financial Frictions model in panel B. This figure makes clear that emerging market economies are more volatile with larger transitory and permanent technology shocks with developed small open economies heavily concentrated closer to the origin.

Figure 8: Standard deviation of estimated transitory (σ_z) and permanent (σ_g) technology shocks

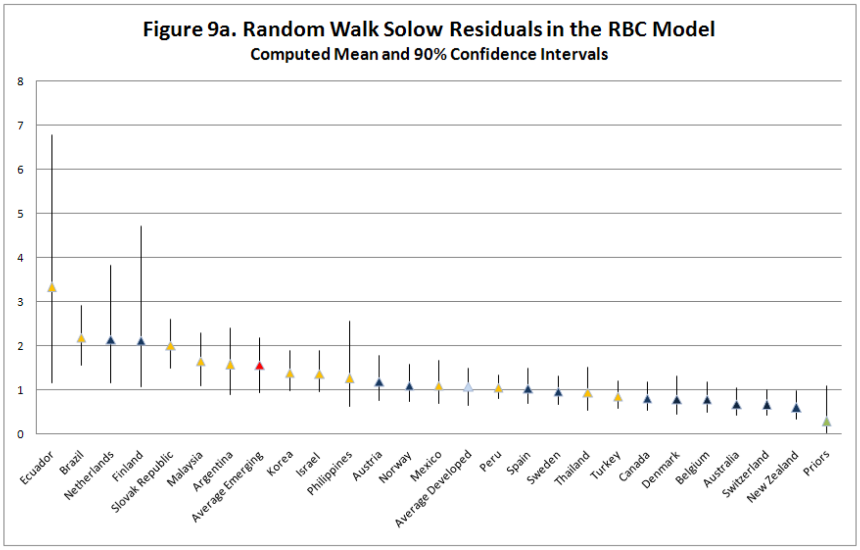


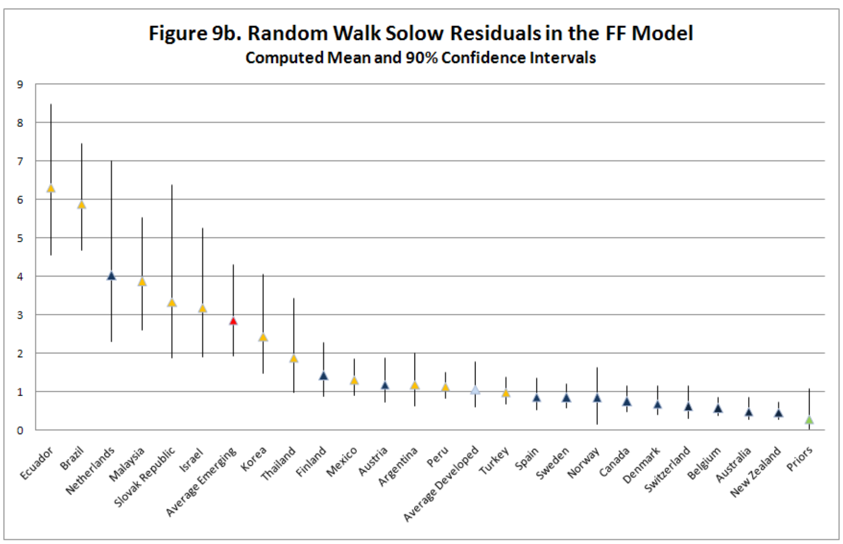
Note: The figure shows the posterior means of the standard deviations of the estimated transitory σz and permanent σg technology shocks for the Real Business Cycle (panel A) and Financial Frictions models (panel B). Emerging market economies are represented with red bullets, while developed small open economies are depicted in blue. The estimation uses Bayesian Maximum Likelihood Methods and HP filtered data for output and consumption. All prior distributions are Inverse Gammawith mean 1 and standard deviation 4. Posterior statistics are based on one-million MCMC chain from which the first 20% were discarded.

To answer which shock plays a larger role in economic fluctuations, we follow Aguiar and Gopinath (2007) who show that the relative importance of permanent versus transitory technology shocks can be summarized with the random walk component of the Solow residuals (RWSR) given by:

$$RWSR = \frac{\frac{\alpha^2\sigma^2}{(1-\rho_g)^2}}{\frac{2}{1+\rho_z}\sigma_z^2 + \frac{\alpha^2\sigma^2}{(1-\rho_g)^2}}$$

Based on our calibrated and estimated parameters, countries are sorted according to the RWSR. As can be seen from Figures 9a and 9b, below, on average permanent technology shocks play a larger role in generating economic fluctuations in emerging economies relative to developed small open economies lending support to the findings in Aguiar and Gopinath (2007). This finding is even more evident in the financial frictions model.





A final note about model's fit is warranted. Recently, García-Cicco, Pancrazi, and Uribe (2010) questioned the ability of the trend-augmented Real Business Cycle model to explain economic fluctuations in emerging countries. They point that the RBC model fails to capture the observed excess volatility of consumption relative to output and that the model predicts an excessively volatile trade balance. They also observe that the RBC model poorly matches the correlation of the trade balance with the domestic components of aggregate absorption. Also, they emphasize that the RBC model predicts that the net exports-to-output ratio is a near random walk, with first-order autocorrelation close to unity, while the empirical data exhibits first-order autocorrelation below unity and converging quickly to zero. In our estimation we do not face these problems given that we are using data for output, Y, consumption, C, and investment, X. Therefore, the model generated moments for these variables will perfectly match the data. Also note that net exports are defined as $NX = Y - C - X$, so the moments for net exports in both models will coincide.

5 Conclusions

This paper is a contribution to the quest of identifying features that could help a DSGE model better describe the cycles in small open economies. Our findings show that the addition of financial frictions helps a basic neoclassical growth model to match the data better in twelve (out of twelve) emerging and five (out of twelve) developed small open economies.

When this basic neoclassical growth model is confronted with data of such a large heterogeneous set of economies, the need to capture their different behavior translates into different estimated parameters and shock processes. There is some clustering of parameter estimates with differences between emerging and developed small open economies. For example, trend stationary technology shocks are relatively more important in emerging market economies, which extends upon the evidence reported by Aguiar and Gopinath (2007) that shows that these shocks are relatively more important in Mexico than in Canada. We also provide estimates of the elasticity of the borrowing interest rate to changes in indebtedness, which captures the degree of financial frictions in international capital markets. Even without the direct use of financial data, the parameter estimates suggest, that during the studied period, Brazil, Argentina, Peru and Turkey had a much more sensitive cost of financing than Switzerland, Netherlands, Finland, Spain and New Zealand. Finally, without relevant transmission mechanisms, bond's price shocks do not play a significant role explaining economic fluctuations.

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Appendix

Here we present the detrended model in log-linear form with all lower case letters representing deviations from the steady-state and with all capital letters denoting steady-state values of the non-detrended levels of the corresponding lower cases.

The technology yields output, y_t, from capital, k_t, and labor, n_t, according to

$$y_t = z_t + (1-\alpha)k_t + \alpha(g_t + n_t)$$

where $\alpha \epsilon (0,1)$ is the labor share in output, and as mentioned, output is affected by transitory, z_t, and permanent, g_t, innovations that follow the AR(1) processes:

$$z_t = \rho_z z_{t-1} + \varepsilon_t^z$$

and

$$g_t = \left(1-\rho_g\right)\mu_g + \rho_g g_{t-1} + \varepsilon_t^g$$

where $|\rho_t| < 1, \left|\rho_g\right| < 1$ and ε_t^z and ε_t^g represents independently and identical distributed draws from two separate normal distributions with zero mean and standard deviations σ_z and σ_g, respectively, while μ_g represents productivity's long-run mean growth rate.

The per period resource constraint requires that output and newly acquired debt, b_{t+1}, with price, q_t, must be enough to finance consumption, c_t, investment, x_t, and previously contracted debt obligations according to

$$y_t + \frac{\mu_g QB}{Y}(q_t + b_{t+1} + g_t) = \frac{C}{Y}c_t + \frac{X}{Y}x_t + \frac{B}{Y}b_t$$

The per period time constraint requires that total time, normalized to 1, is devoted to labor and leisure, l_t, which implies that in log-linear deviations from steady state we have

$$Ll_t + Nn_t = 0$$

Labor market equilibrium is given by

$$n_t = y_t - c_t + l_t$$

Given the presence of capital depreciation, $\delta \epsilon (0,1)$ and quadratic capital adjustment cost, capital accumulates according to

$$\mu_g k_{t+1} = \frac{X}{K}x_t + (1-\delta)k_t - \mu_g g_t$$

Optimal bond accumulation is given by the Euler equation

$$\zeta_1 c_t + \zeta_2 l_t - \zeta_1 g_t = -q_t + \zeta_1 E_t\{c_{t+1}\} + \zeta_2 E_t\{l_{t+1}\}$$

where $\zeta_1 = \gamma(1-\sigma) - 1$ and $\zeta_2 = (1-\gamma)(1-\sigma)$. The parameter $\gamma \epsilon (0,1)$ is the elasticity of substitution between consumption and labor in the utility function $\sigma > 0 \neq 1$ is the inverse of the elasticity of intertemporal substitution.

Optimal capital accumulation is given

$$\zeta_1 c_t + \zeta_2 l_t - \zeta_3 g_t - \zeta_4 k_t = \\ \zeta_1 c_t E_t\{c_{t+1}\} + \zeta_2 c_t E_t\{l_{t+1}\} + \zeta_5 c_t E_t\{g_{t+1}\} + \zeta_6 c_t E_t\{y_{t+1}\} + \zeta_7 E_t\{k_{t+2}\} - \zeta_8 E_t\{k_{t+1}\}$$

where $\zeta_3 = \zeta_1 - \emptyset\mu_g$, $\zeta_4 = \emptyset\mu_g$, $\zeta_5 = \beta{\mu_g}^{\zeta_1+2}\emptyset$, $\zeta_6 = \beta{\mu_g}^{\zeta_1}(1-\alpha)\frac{Y}{K}$, $\zeta_7 = \beta{\mu_g}^{\zeta_1+2}$ and $\zeta_8 = \beta{\mu_g}^{\zeta_1}\left[(1-\alpha)\frac{Y}{K} + \emptyset\mu_g^2\right] + \emptyset\mu_g$. The parameter $\emptyset \geq 0$ is the elasticity of the price of capital with respect to the investment-capital ratio due to the capital adjustment costs.

Net exports-to-output ratio, nx_t, is given by

$$nx_t = (1 - NX)y_t - \frac{C}{Y}c_t - \frac{X}{Y}x_t$$

where $NX = \frac{Y-C-X}{Y}$.

Up to this point both models share identical elements, the only difference will be the assumption about the bond price determination. The price of bonds is inversely related to the interest rate and it is a function of the level of indebtedness according to

$$q_t = -\psi QB b_{t+1} + \varepsilon_t^f$$

where $\psi \geq 0$ captures the elasticity of the borrowing interest rate to changes in indebtedness. In the model without financial frictions $\psi \to 0$, while if financial frictions are present $\psi \gg 0$. In both versions we introduce an innovation ε_t^f to the price of bonds and assume that it represents independently and identical distributed draws from a normal distribution with zero mean and standard deviation σ_f.