Real Business Cycles versus Financial Frictions Models for Small Open Economies

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Abstract

Is a real business cycle model extended with non-stationary technology shocks able to describe small open economies or do credit market imperfections are needed? This study addresses this question by providing evidence of the relative ability of a model with and without financial frictions to replicate the data for 12 emerging and 12 developed small open economies. Our main finding is that including financial frictions improves the fit of the model in all the studied emerging market economies, but only in five developed small open economies. Also, we find that permanent technology shocks are relatively more important in emerging market economies expanding the analysis in Aguiar and Gopinath (2007). 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.

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1 Introduction

The study of economic fluctuations in emerging countries is experiencing a lively debate between those who show that a real business cycle model extended with non-stationary technology shocks is able to replicate some features of the business cycles in these economies (Mark Aguiar and Gita Gopinath (2007)) and those who show that real models are insufficient and credit market imperfections are needed (Javier Garcia-Cicco, Roberto Pancrazi, and Martin Uribe (2010) and Roberto Chang and Andres Fernandez (2010)). This study contributes to this debate by providing evidence of the relative ability of both approaches to replicate the data for 12 emerging and 12 developed small open economies.

To provide quantitative answers we use Bayesian Maximum Likelihood methods to compare the relative fit of models with and without financial frictions.

Our main finding is that the financial frictions model is favored in all the studied emerging market economies, while it is favored only 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 not definite results in the remaining four countries (Australia, Austria, New Zealand and Spain).

There is great heterogeneity in the observed business cycle fluctuations, which translates into heterogeneity of the estimated parameters of a common model 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. Consistent with the much larger volatility of emerging market economies, the standard deviations of the innovations that perturb the model are estimated to be larger in these economies relative to those of developed small open economies. We find that trend shocks to productivity are relatively more important in emerging than in developed economies in line with the findings in Aguiar and Gopinath (2007) that analyzes the cases of Mexico and Canada.

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, without financial frictions, we assume that the country can borrow at this world interest rate. Meanwhile, in a model with financial frictions the country's borrowing rate will be a function of its level of indebtedness. As in Aguiar and Gopinath, this small open economy model is augmented to include transitory and trend shocks to productivity.

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

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

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

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

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

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

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

where $|\rho_z| < 1$, $\left|\rho_g\right| < 1$ 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.

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

$$\sum_{t=0}^{\infty} \beta^t u\left(C_t, 1-N_t\right)$$

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

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

where $\gamma \epsilon (0,1)$ is the elasticity of substitution between consumption and labor in the utility function 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

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

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

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

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

$$NX_t = Y_t - C_t - X_t$$

Up to this point both models share identical elements, the only difference between the real business cycle model and a model with financial frictions will be the assumption about the 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

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

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 $\psi \longrightarrow 0$ [1], 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. This extra innovation allows us to use a third data series and was required for technical reasons in the estimation of the model with financial frictions, otherwise ψ was weakly identified.

3 Estimation Strategy and Empirical Implementation

The model presented above is estimated using Bayesian methods[2]. 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

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

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

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

where $L\left(\theta \mid Y^T\right)$ is the likelihood conditional on observed data $Y^T = \{Y_1, \ldots, Y_T\}$. In our case, as detailed below, $Y_t = \left[obs(y_t), obs(c_t), obs(x_t)\right]'$ for $t = 1, \ldots, T$.

The likelihood function is computed under the assumption of normally distributed disturbances by combining the state-space representation implied by

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

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

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 for θ are obtained from the generated values.

3.2 Data

As Aguiar and Gopinath, we part from the premise that a small open economy responds differently to permanent and transitory technology shocks by fully adjusting to permanent shocks, but smoothing temporary ones. The identification of the nature of the technology shocks is accomplished by using 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 data was originally compiled by Aguiar and Gopinath and for most countries the sample starts in 1980 and spans up to 2003[3].

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. The quarterly discount rate β is set to 0.98, and the world interest rate, r^*, is set to satisfy the condition that $\beta\left(1+r^*\right)=e^{\mu_g[1-\gamma(1-\sigma)]}$, which is required for well-behaved consumption. The elasticity of substitution between consumption and labor 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 at two. The capital depreciation rate δ is set to 0.05. The steady-state normalized debt $b \equiv \frac{B}{Y}$ is set to 0.1. The results in the benchmark model without financial frictions are insensitive to alternative values given that the elasticity of the borrowing interest rate to changes in indebtedness ψ is set to 0.001. In the model with financial frictions this debt figure would play a significant role and this figure could be approximated using the net foreign asset position as reported by Philip R. Lane and Gian Maria Milesi-Ferretti (2007). The labor share in production α is set to 0.68, while the productivity's long-run

[3]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). In this first exercise we decided to directly use the data compiled by Aguiar and Gopinath to limit the factors modified in the analysis.

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
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 parameter is estimated in the model with financial frictions.

3.3.2 Priors

As already 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 case of the financial friction 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 and analyze the implied characteristics related to the sources of economic fluctuations. Then, we discuss the fit of both models. Finally, we present the model comparison to answer which model matches the data better.

4.1 Estimation

Tables 3 and 4, below, summarizes 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 Cycle 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 standard deviations of the estimated parameters. 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

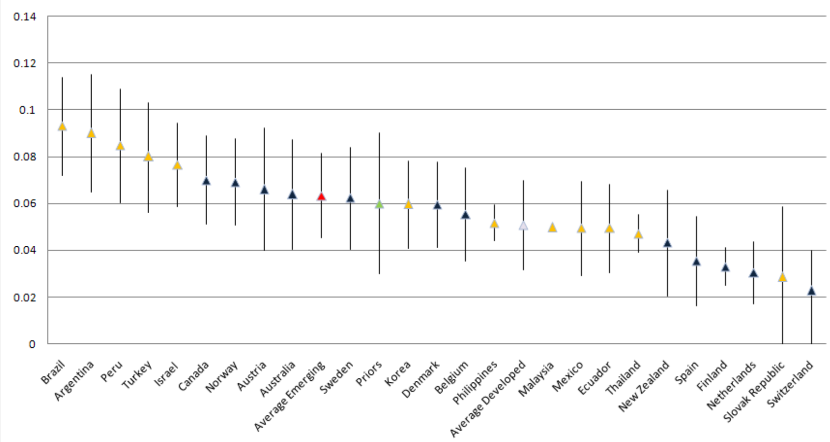
Country	ψ	ϕ	ρ_z	ρ_g	σ_z	σ_g	σ_f	RWSR
Priors	0.06	4.00	0.50	0.10	1.00	1.00	1.00	0.28
	(0.03, 0.09)	(1.53, 6.47)	(0.17,0.82)	(0.03,0.19)	(0.19,2.47)	(0.19,2.47)	(0.19,2.47)	(0.02 , 1.08)
Australia	0.06	2.11	0.70	0.42	0.78	0.60	0.84	0.48
	(0.04, 0.08)	(1.68, 2.53)	(0.63, 0.76)	(0.30, 0.55)	(0.66, 0.89)	(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 standard deviations of the estimated parameters. 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.

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 and groups are denoted with different colors reserving orange 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.

Figure 1, below, reports the estimated elasticity of the the country's borrowing interest rate with respect to changes in indebtedness ψ, which was only estimated in the model with financial frictions. Even when there is not a 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, it is reasurring to observe that countries like Brazil, Argentina, Peru and Turkey exhibit a cost of borrowing very 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 ϕ 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.

Figure 2a. Elasticity of the Price of Capital with Respect to the Investment-Capital Ratio (ϕ) in the RBC Model
Estimated Mean and 90% Confidence Intervals

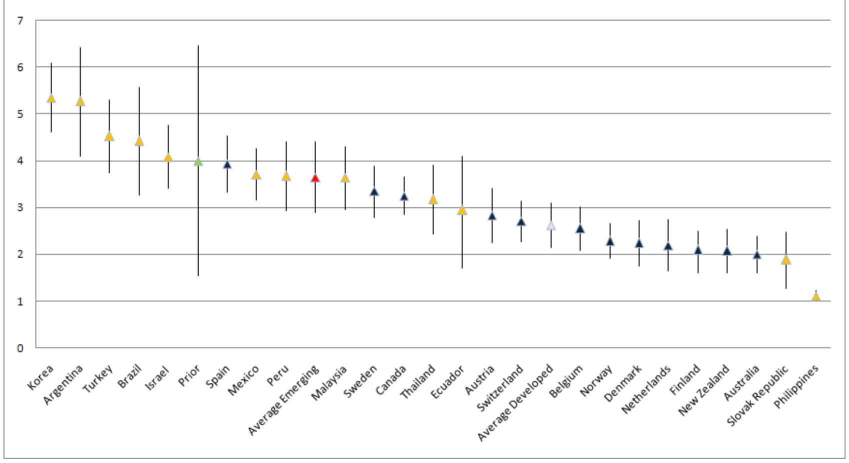
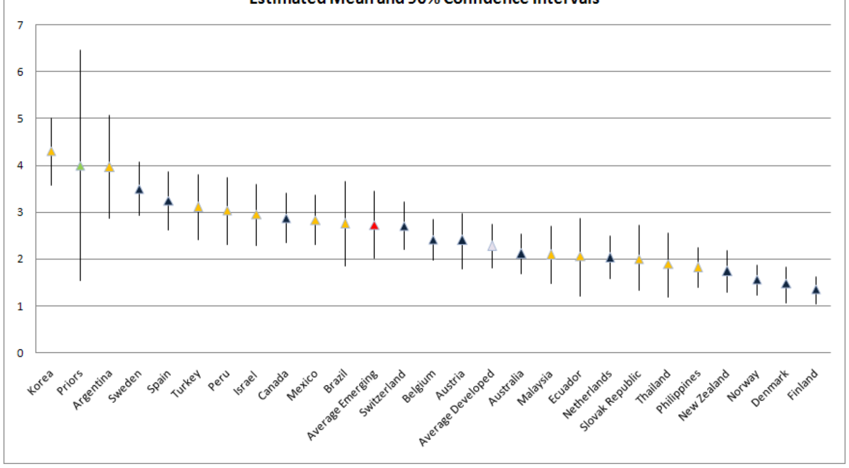
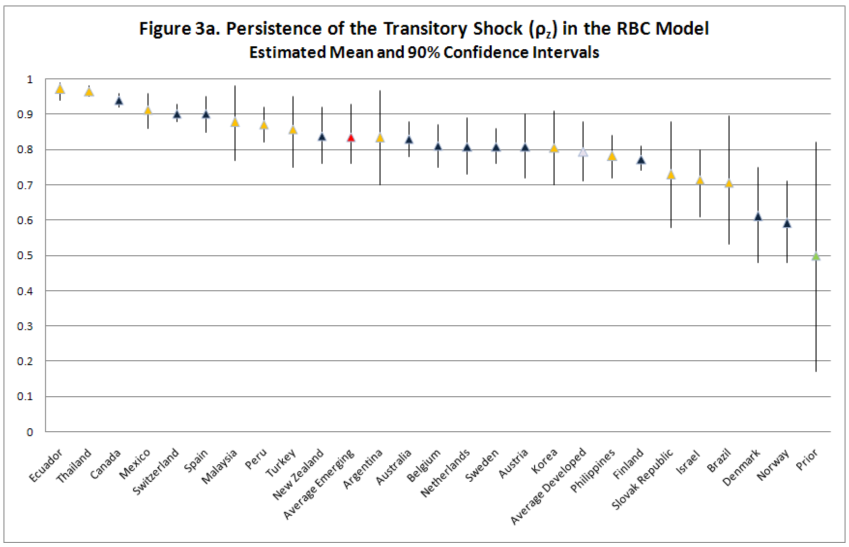
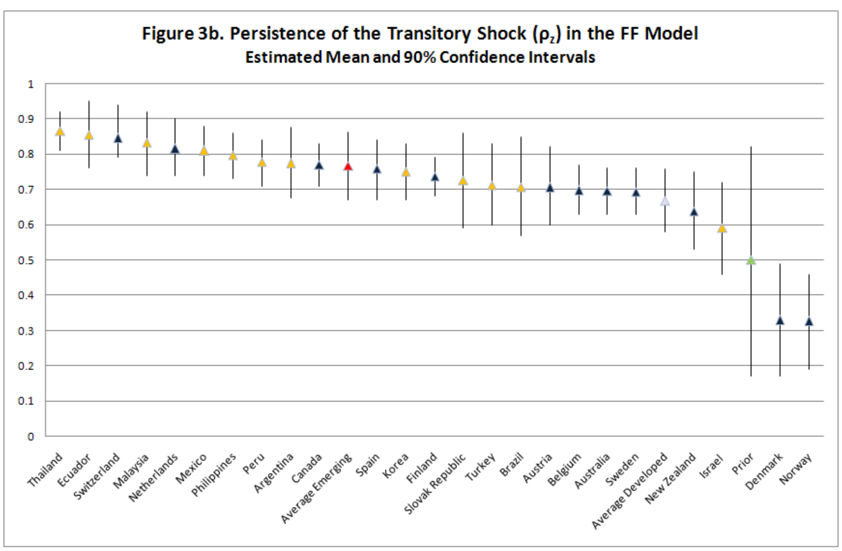


Figure 2b. Elasticity of the Price of Capital with Respect to the Investment-Capital Ratio (ϕ) in the FF Model
Estimated Mean and 90% Confidence Intervals



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 0.97 to 0.59. 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.





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 US 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 a higher permanent technology shock persistence.

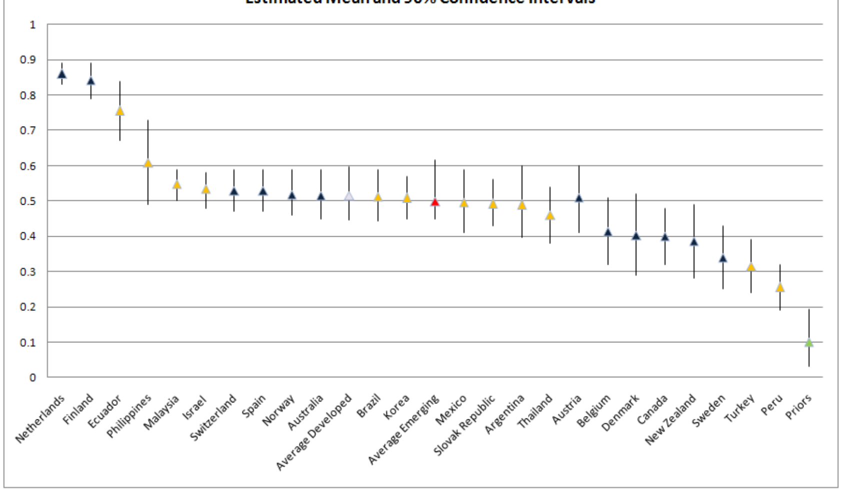


Figure 4a. Persistence of the Permanent Shock (ρ_g) in the RBC Model
Estimated Mean and 90% Confidence Intervals

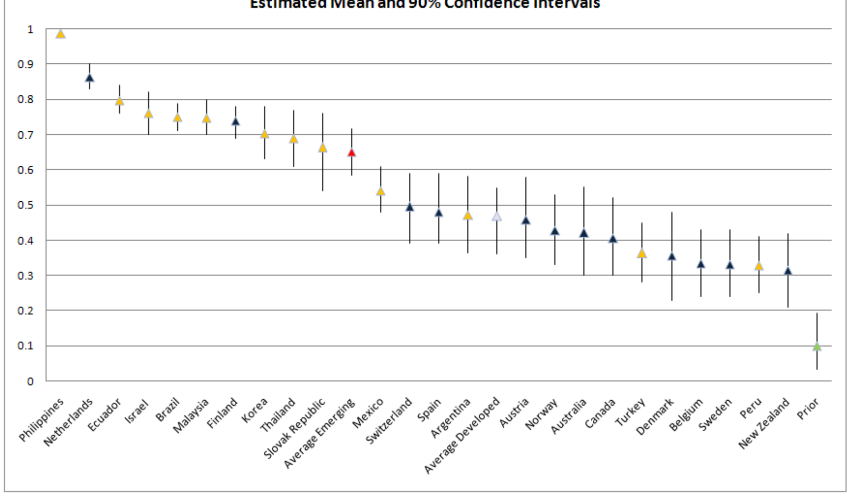


Figure 4b. Persistence of the Permanent Shock (ρ_g) in the FF Model
Estimated Mean and 90% Confidence Intervals

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

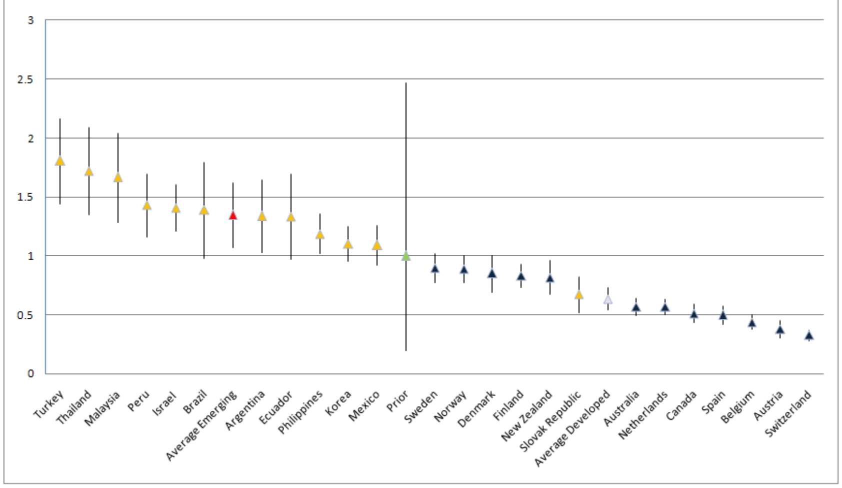
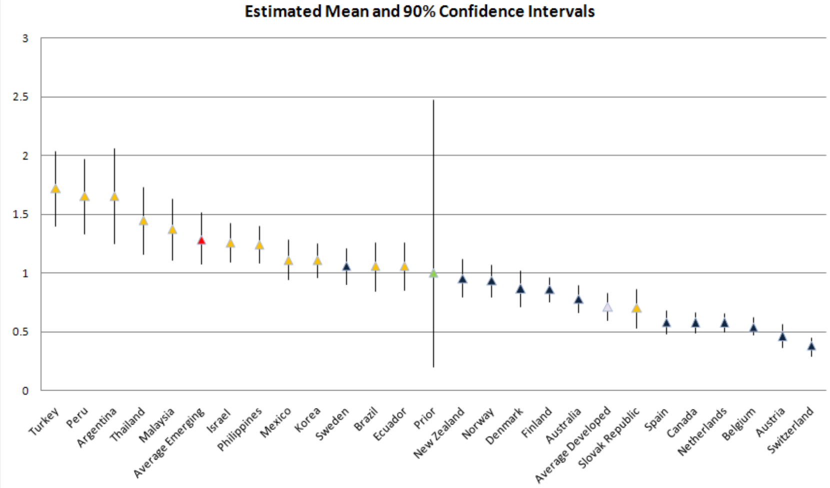


Figure 5b. Standard Deviation of the Transitory Shock (σ_z) in the FF Model
Estimated Mean and 90% Confidence Intervals



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

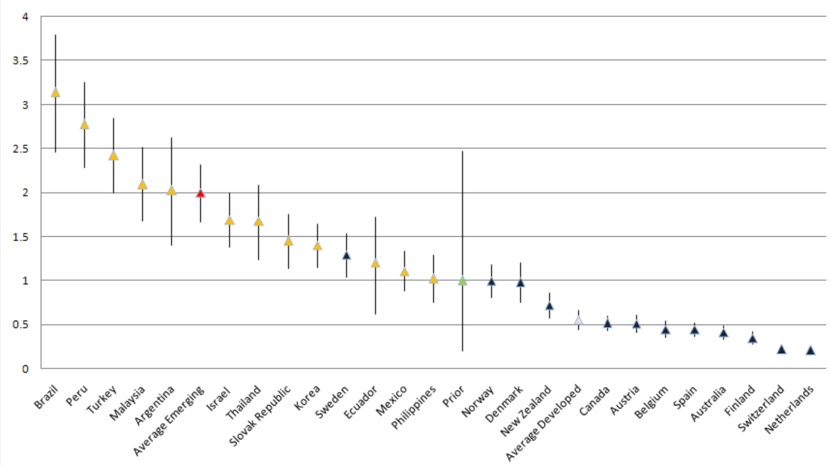
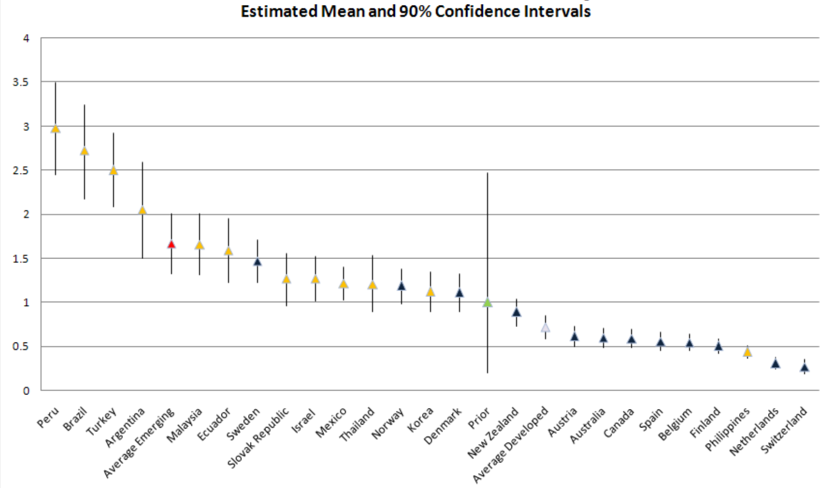


Figure 6b. Standard Deviation of the Permanent Shock (σ_g) in the FF Model
Estimated Mean and 90% Confidence Intervals



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.

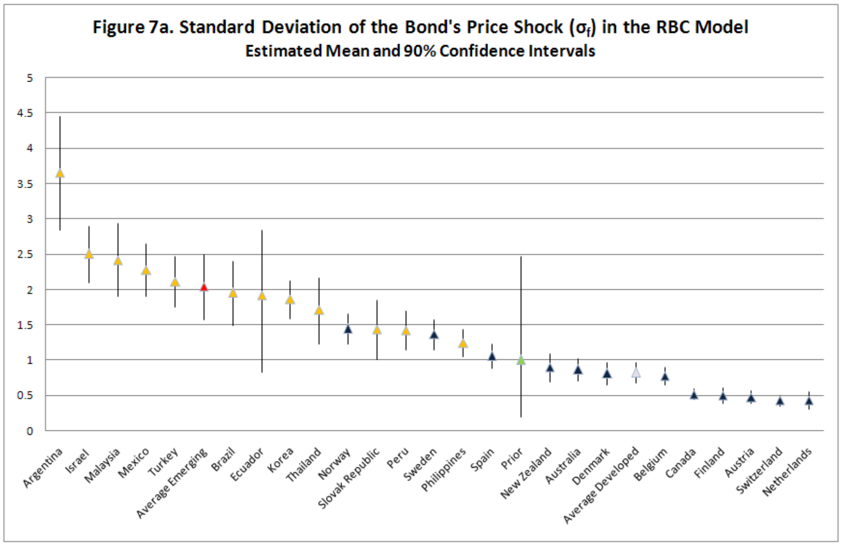


Figure 7a. Standard Deviation of the Bond's Price Shock (σ_f) in the RBC Model
Estimated Mean and 90% Confidence Intervals

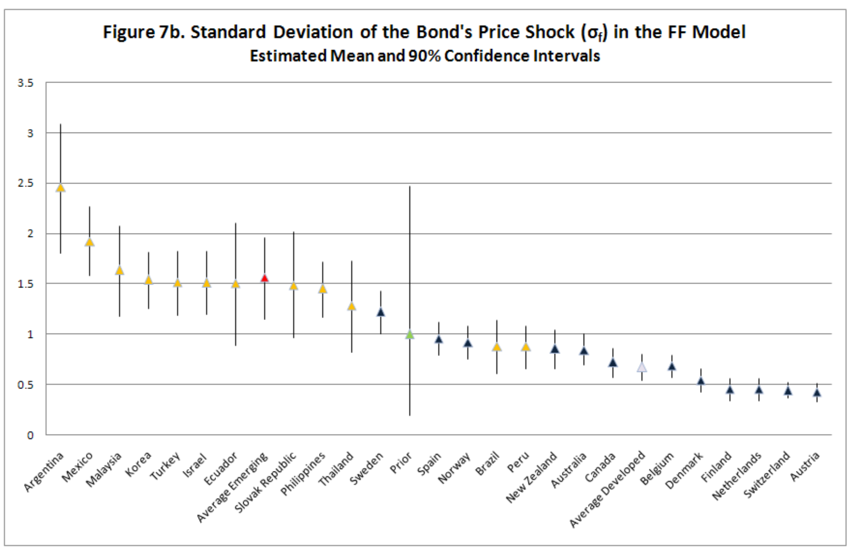
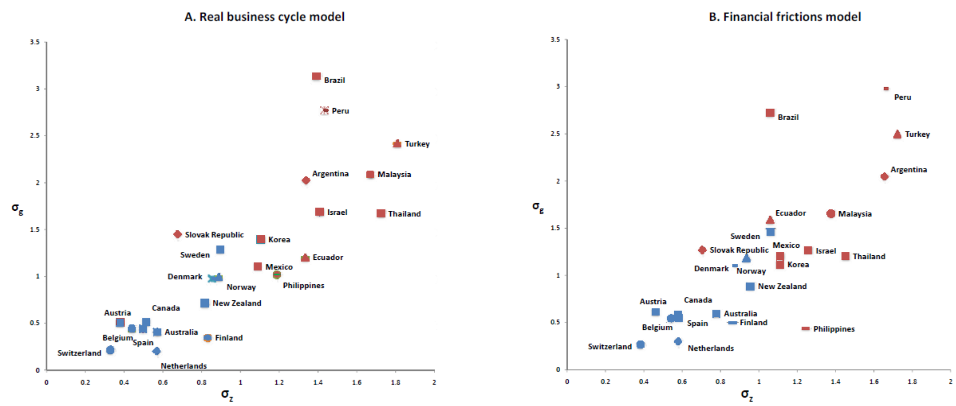


Figure 7b. Standard Deviation of the Bond's Price Shock (σ_f) in the FF Model
Estimated Mean and 90% Confidence Intervals

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.

As described by Aguiar and Gopinath the relative importance of permanent versus transitory technology shocks can be summarized with the random walk component of the Solow residuals ($RWSR$) given by

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

Given 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.

Figure 9a. Random Walk Solow Residuals in the RBC Model
Computed Mean and 90% Confidence Intervals

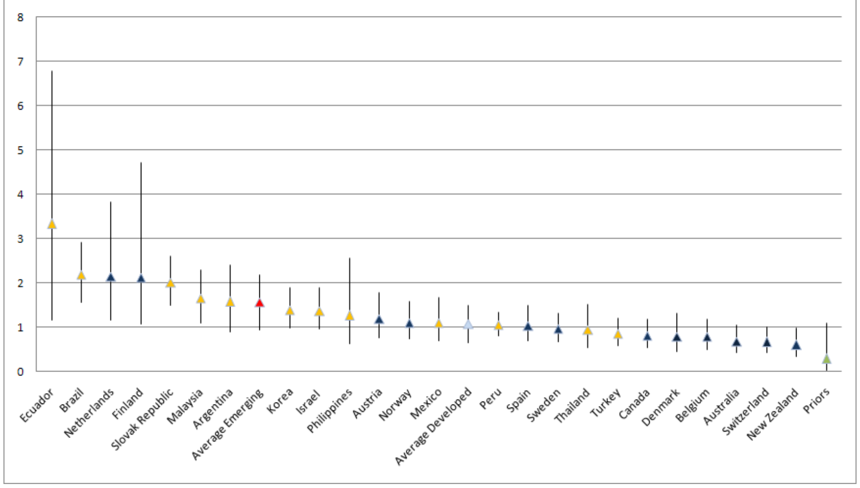


Figure 9b. Random Walk Solow Residuals in the FF Model
Computed Mean and 90% Confidence Intervals

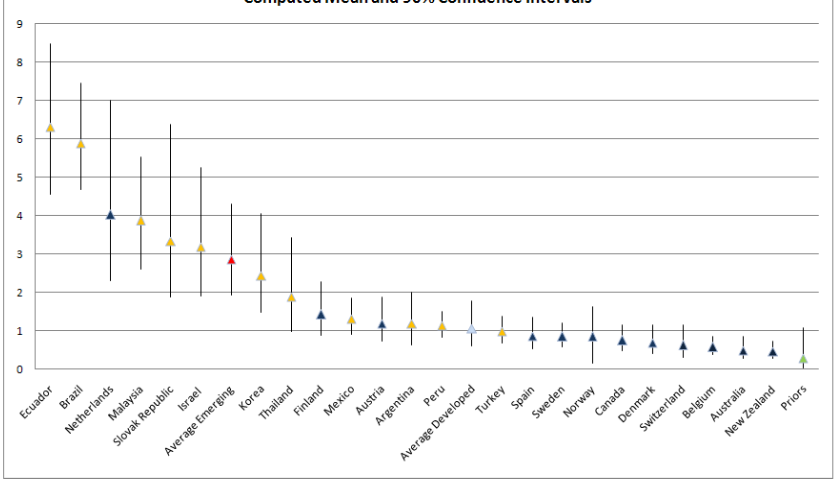


Table 5, below, provides complementary evidence by reporting the variance decomposition of output, consumption and investment now sorted by the percentage of output explained by permanent technology shocks. With some exceptions we again observe that most of the emerging market countries are at the top especially in the financial frictions model.

Table 6, below, complements the variance decomposition analysis by presenting the contribution of the bond price shock in each variance. Again countries were sorted by the percentage of output explained by this shock. Here we do not have a clear ordering among groups perhaps because the model does not include the mechanism that could make interest rates shocks relevant as in Pablo Neumeyer and Fabrizio Perri (2005).[4]

Table 5: Relative importance of permanent shocks (g) in the variance decomposition of output, consumption, and investment

A. Real business cycle model

Type	Country	Output	Consumption	Investment
E	Brazil	0.83	0.97	0.90
D	Netherlands	0.71	0.91	0.58
E	Slovak Republic	0.60	0.90	0.45
E	Israel	0.48	0.81	0.43
E	Philippines	0.41	0.84	0.36
D	Norway	0.40	0.80	0.27
E	Argentina	0.40	0.69	0.34
E	Average Emerging	0.36	0.64	0.45
D	Sweden	0.36	0.76	0.44
D	Finland	0.35	0.73	0.55
E	Korea	0.34	0.74	0.47
D	Austria	0.33	0.77	0.56
E	Peru	0.32	0.68	0.61
E	Malaysia	0.29	0.62	0.48
D	Denmark	0.28	0.79	0.38
D	Average Developed	0.26	0.59	0.33
E	Ecuador	0.24	0.32	0.45
D	Belgium	0.22	0.61	0.22
E	Turkey	0.19	0.52	0.44
E	Mexico	0.18	0.46	0.29
D	Spain	0.17	0.44	0.21
D	Australia	0.15	0.52	0.18
D	New Zealand	0.08	0.36	0.19
D	Switzerland	0.06	0.24	0.16
D	Canada	0.05	0.15	0.23
E	Thailand	0.04	0.09	0.20

B. Financial frictions model

Type	Country	Output	Consumption	Investment
E	Philippines	0.95	0.99	0.65
E	Brazil	0.92	0.99	0.69
E	Slovak Republic	0.63	0.96	0.49
E	Ecuador	0.62	0.94	0.26
E	Israel	0.54	0.93	0.13
E	Korea	0.50	0.89	0.26
E	Average Emerging	0.50	0.84	0.33
E	Malaysia	0.44	0.90	0.32
E	Peru	0.43	0.82	0.49
D	Sweden	0.36	0.81	0.29
E	Turkey	0.36	0.80	0.33
D	Netherlands	0.34	0.87	0.15
E	Argentina	0.29	0.71	0.15
D	Denmark	0.29	0.91	0.37
D	Norway	0.28	0.90	0.20
D	Austria	0.26	0.80	0.31
D	Average Developed	0.20	0.71	0.19
E	Mexico	0.19	0.69	0.13
D	Belgium	0.16	0.63	0.11
D	Canada	0.16	0.59	0.12
D	Spain	0.14	0.63	0.14
D	New Zealand	0.13	0.67	0.14
D	Australia	0.11	0.57	0.08
D	Switzerland	0.08	0.44	0.18
E	Thailand	0.07	0.50	0.10
D	Finland	0.05	0.66	0.17

Note: Countries were sorted by relative importance of permanent technology shocks in the variance decomposition of output. E denotes emerging and D denotes developed small open economy.

[4] Pablo Neumeyer and Fabrizio Perri (2005) extend a stationary real business cycle model with working capital requirements, a cost of borrowing dependent on expected productivity and Greenwood, Hercovitz and Hoffman (1988) type preferences to capture the importance of interest rates shocks in emerging economies' fluctuations.

Table 6: Relative importance of bond price shock (f) in the variance decomposition of output, consumption, and investment

A. Real business cycle model

Type	Country	Output	Consumption	Investment
D	Norway	0.19	0.15	0.72
E	Argentina	0.14	0.15	0.61
D	Belgium	0.13	0.16	0.74
E	Slovak Republic	0.12	0.06	0.53
D	Spain	0.11	0.15	0.69
D	Australia	0.10	0.14	0.75
E	Israel	0.10	0.11	0.55
E	Philippines	0.09	0.05	0.60
D	Denmark	0.08	0.09	0.60
D	Average Developed	0.07	0.09	0.55
D	Sweden	0.07	0.08	0.51
E	Mexico	0.07	0.09	0.57
E	Korea	0.06	0.08	0.46
E	Average Emerging	0.06	0.06	0.41
E	Malaysia	0.05	0.05	0.39
D	Switzerland	0.04	0.08	0.62
D	New Zealand	0.04	0.08	0.63
D	Austria	0.04	0.04	0.37
D	Netherlands	0.02	0.02	0.37
E	Turkey	0.02	0.04	0.32
E	Ecuador	0.02	0.02	0.30
E	Peru	0.02	0.02	0.24
E	Brazil	0.02	0.01	0.10
D	Finland	0.02	0.02	0.30
D	Canada	0.01	0.02	0.28
E	Thailand	0.01	0.01	0.21

B. Financial frictions model

Type	Country	Output	Consumption	Investment
E	Mexico	0.11	0.06	0.74
D	Spain	0.11	0.09	0.73
D	Belgium	0.09	0.08	0.76
D	Australia	0.08	0.07	0.77
E	Slovak Republic	0.08	0.01	0.47
D	New Zealand	0.07	0.05	0.74
D	Norway	0.07	0.03	0.74
E	Argentina	0.06	0.05	0.60
D	Canada	0.06	0.05	0.64
D	Average Developed	0.06	0.04	0.62
E	Korea	0.05	0.02	0.55
D	Sweden	0.05	0.03	0.53
D	Switzerland	0.05	0.05	0.56
E	Israel	0.05	0.02	0.73
E	Average Emerging	0.04	0.02	0.47
E	Ecuador	0.03	0.01	0.60
D	Denmark	0.03	0.01	0.55
D	Austria	0.03	0.01	0.44
E	Malaysia	0.03	0.01	0.47
E	Turkey	0.03	0.02	0.39
E	Thailand	0.02	0.01	0.50
D	Netherlands	0.02	0.01	0.54
D	Finland	0.02	0.01	0.45
E	Peru	0.01	0.00	0.16
E	Philippines	0.00	0.00	0.26
E	Brazil	0.00	0.00	0.17

Note: Countries were sorted by relative importance of bond price shocks in the variance decomposition of output. E denotes emerging and D denotes developed small open economy.

4.2 Models' Fit

Recently, García-Cicco, Pancrazi, and Uribe (2010) questioned the ability of the 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 matches poorly 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 a close autocorrelation close to unity, while the data exhibits a 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. Table 7, below, reports the empirical moments and those generated by our estimated models.

Panel A of table 7, below, shows the volatility and autocorrelation of filtered income in the data, which given the fact that this variable is part of the observables is perfectly replicated by the model. Panel B of table 7 shows the relative volatility of consumption, investment and net exports. Given that, as just mentioned, we are also using consumption and investment data, the estimated model perfectly matches the relative volatilities of consumption and investment to output. In most cases the estimated models generate excess volatility of net exports, but nothing comparable to the twenty-fold excess volatility of net exports that García-Cicco et. al. report for Argentina. Panel C of table 7 shows the contemporaneous correlation with output replicating the correlation with consumption and investment, and on average generating a negative correlation with net exports, too large for developed countries. Panel D of table 7 shows the contemporaneous correlation with net exports where data and model generated moments are aligned but exhibit some divergence. Finally, panel E reports the serial correlation of output, investment, and net exports.

Table 7

A. Volatility and Autocorrelation of Filtered Output: Data and Estimated RBC and FF Models

	σ (Y)	$\rho(Y_t, Y_{t-1})$		σ (Y)	$\rho(Y_t, Y_{t-1})$
Emerging markets			**Developed markets**		
Argentina	3.68	0.85	Australia	1.39	0.84
Brazil	1.98	0.65	Austria	0.89	0.85
Ecuador	2.44	0.82	Belgium	1.02	0.79
Israel	1.95	0.50	Canada	1.64	0.91
Korea	2.51	0.78	Denmark	1.02	0.49
Malaysia	3.10	0.85	Finland	2.18	0.85
Mexico	2.48	0.82	Netherlands	1.20	0.77
Peru	3.68	0.64	New Zealand	1.56	0.77
Philippines	3.00	0.87	Norway	1.40	0.48
Slovak Republic	1.24	0.66	Spain	1.11	0.82
Thailand	4.35	0.89	Sweden	1.52	0.53
Turkey	3.57	0.67	Switzerland	1.11	0.92
Mean Emerging	2.83	0.75	**Mean Developed**	1.34	0.75

Note: For each country the table reports the empirical moments which coincide with those generated by the Real Business Cycles (RBC) and the Financial Frictions (FF) models using HP Filtered output, consumption and investment . Mean corresponds to the simple arithmetic average of each group of countries.

B. Relative Volatility of Consumption, Investment, and Net Exports-to-Output Ratio: Data versus Estimated Models

	σ(C)/σ(Y)	σ(I)/σ(Y)	σ(NX/Y)		σ(C)/σ(Y)	σ(I)/σ(Y)	σ(NX/Y)
Emerging markets				**Developed markets**			
Argentina	1.38	2.53	2.56	Australia	0.69	3.69	1.08
Argentina Model	1.38	2.53	2.47	Australia Model	0.69	3.69	1.69
Brazil	2.01	3.08	2.61	Austria	0.87	2.75	0.65
Brazil Model	2.01	3.08	4.08	Austria Model	0.87	2.75	1.02
Ecuador	2.39	5.56	5.68	Belgium	0.81	3.72	0.91
Ecuador Model	2.39	5.56	7.28	Belgium Model	0.81	3.72	1.25
Israel	1.60	3.42	2.12	Canada	0.77	2.63	0.91
Israel Model	1.60	3.42	3.24	Canada Model	0.77	2.63	1.82
Korea	1.23	2.50	2.32	Denmark	1.19	3.90	0.88
Korea Model	1.23	2.50	3.53	Denmark Model	1.19	3.90	1.31
Malaysia	1.70	4.82	5.30	Finland	0.94	3.26	1.11
Malaysia Model	1.70	4.82	7.16	Finland Model	0.94	3.26	3.07
Mexico	1.24	4.05	2.19	Netherlands	1.07	2.92	0.71
Mexico Model	1.24	4.05	4.45	Netherlands Model	1.07	2.92	1.59
Peru	0.92	2.37	1.25	New Zealand	0.90	4.38	1.37
Peru Model	0.92	2.37	3.84	New Zealand Model	0.90	4.38	2.49
Philippines	0.62	4.66	3.21	Norway	1.32	4.33	1.73
Philippines Model	0.62	4.66	3.91	Norway Model	1.32	4.33	1.95
Slovak Republic	2.04	7.77	4.29	Spain	1.11	3.70	0.86
Slovak Republic Model	2.04	7.77	3.67	Spain Model	1.11	3.70	1.80
Thailand	1.09	3.49	4.58	Sweden	0.97	3.66	0.94
Thailand Model	1.09	3.49	6.92	Sweden Model	0.97	3.66	1.74
Turkey	1.09	2.71	3.23	Switzerland	0.51	2.56	0.96
Turkey Model	1.09	2.71	4.95	Switzerland Model	0.51	2.56	0.99
Mean Emerging	1.44	3.91	3.28	**Mean Developed**	0.93	3.46	1.01
Mean Emerging Model	1.44	3.91	4.63	**Mean Developed Model**	0.93	3.46	1.73

Note: For each country the table compares the empirical moments with those generated by the Real Business Cycles (RBC) and Financial Frictions (FF) models using HP Filtered output, consumption and investment . Mean corresponds to the simple arithmetic average of each group of countries.

C. Contemporaneous Correlation with Output: Data versus Estimated Models

	ρ(C, Y)	ρ(I, Y)	ρ (NX/Y, Y)		ρ(C, Y)	ρ(I, Y)	ρ (NX/Y, Y)
Emerging markets				**Developed markets**			
Argentina	0.90	0.96	-0.70	Australia	0.48	0.80	-0.43
Argentina Model	0.90	0.96	-0.95	Australia Model	0.48	0.80	-0.77
Brazil	0.41	0.62	0.01	Austria	0.74	0.75	0.10
Brazil Model	0.41	0.62	-0.49	Austria Model	0.74	0.75	-0.81
Ecuador	0.73	0.89	-0.79	Belgium	0.67	0.62	-0.04
Ecuador Model	0.73	0.89	-0.83	Belgium Model	0.67	0.62	-0.73
Israel	0.45	0.49	0.12	Canada	0.88	0.77	-0.20
Israel Model	0.45	0.49	-0.56	Canada Model	0.88	0.77	-0.83
Korea	0.85	0.78	-0.61	Denmark	0.36	0.51	-0.08
Korea Model	0.85	0.78	-0.84	Denmark Model	0.36	0.51	-0.59
Malaysia	0.76	0.86	-0.74	Finland	0.84	0.88	-0.45
Malaysia Model	0.76	0.86	-0.84	Finland Model	0.84	0.88	-0.90
Mexico	0.92	0.91	-0.74	Netherlands	0.72	0.70	-0.19
Mexico Model	0.92	0.91	-0.77	Netherlands Model	0.72	0.70	-0.77
Peru	0.78	0.85	-0.24	New Zealand	0.76	0.82	-0.26
Peru Model	0.78	0.85	-0.75	New Zealand Model	0.76	0.82	-0.84
Philippines	0.59	0.76	-0.41	Norway	0.63	0.00	0.11
Philippines Model	0.59	0.76	-0.82	Norway Model	0.63	0.00	-0.45
Slovak Republic	0.42	0.46	-0.44	Spain	0.83	0.83	-0.60
Slovak Republic Model	0.42	0.46	-0.51	Spain Model	0.83	0.83	-0.87
Thailand	0.92	0.91	-0.83	Sweden	0.35	0.68	0.01
Thailand Model	0.92	0.91	-0.91	Sweden Model	0.35	0.68	-0.63
Turkey	0.89	0.83	-0.69	Switzerland	0.58	0.69	-0.03
Turkey Model	0.89	0.83	-0.91	Switzerland Model	0.58	0.69	-0.71
Mean Emerging	0.72	0.78	-0.51	**Mean Developed**	0.65	0.67	-0.17
Mean Emerging Model	0.72	0.78	-0.77	**Mean Developed Model**	0.65	0.67	-0.74

Note: For each country the table compares the empirical moments with those generated by the Real Business Cycles (RBC) and Financial Frictions (FF) models using HP Filtered output, consumption and investment . Mean corresponds to the simple arithmetic average of each group of countries.

D. Contemporaneous Correlation with Net Exports: Data versus Estimated Models

	ρ(Y, NX)	ρ(C, NX)	ρ (I, NX)		ρ(Y, NX)	ρ(C, NX)	ρ (I, NX)
Emerging markets				**Developed markets**			
Argentina	-0.72	-0.93	-0.62	Australia	-0.38	-0.57	-0.70
Argentina Model	-0.76	-0.95	-0.74	Australia Model	0.08	-0.64	-0.42
Brazil	0.01	-0.68	-0.42	Austria	0.07	0.04	-0.12
Brazil Model	-0.03	-0.89	-0.61	Austria Model	0.03	-0.5	-0.45
Ecuador	-0.78	-0.88	-0.92	Belgium	0.01	-0.16	-0.20
Ecuador Model	-0.66	-0.97	-0.86	Belgium Model	0.07	-0.39	-0.59
Israel	0.07	-0.31	-0.38	Canada	-0.07	-0.35	-0.46
Israel Model	0.05	-0.75	-0.51	Canada Model	0.05	-0.33	-0.56
Korea	-0.61	-0.83	-0.68	Denmark	-0.01	-0.41	-0.46
Korea Model	-0.30	-0.70	-0.69	Denmark Model	0.21	-0.54	-0.39
Malaysia	-0.74	-0.87	-0.84	Finland	-0.44	-0.59	-0.61
Malaysia Model	-0.60	-0.94	-0.85	Finland Model	-0.40	-0.75	-0.71
Mexico	-0.77	-0.82	-0.87	Netherlands	-0.13	-0.35	-0.40
Mexico Model	-0.77	-0.90	-0.91	Netherlands Model	-0.05	-0.60	-0.59
Peru	-0.30	-0.54	-0.39	New Zealand	-0.22	-0.45	-0.58
Peru Model	-0.10	-0.60	-0.32	New Zealand Model	-0.37	-0.74	-0.77
Philippines	-0.35	-0.35	-0.48	Norway	0.24	-0.22	-0.41
Philippines Model	-0.11	-0.36	-0.64	Norway Model	0.28	-0.28	-0.74
Slovak Republic	-0.46	-0.64	-0.74	Spain	-0.58	-0.75	-0.72
Slovak Republic Model	-0.20	-0.82	-0.88	Spain Model	-0.47	-0.80	-0.79
Thailand	-0.82	-0.88	-0.87	Sweden	0.05	-0.25	-0.21
Thailand Model	-0.69	-0.87	-0.88	Sweden Model	0.10	-0.63	-0.32
Turkey	-0.69	-0.74	-0.75	Switzerland	-0.07	-0.40	-0.53
Turkey Model	-0.42	-0.71	-0.74	Switzerland Model	0.51	-0.25	-0.20
Mean Emerging	-0.52	-0.70	-0.66	**Mean Developed**	-0.13	-0.37	-0.45
Mean Emerging Model	-0.38	-0.79	-0.72	**Mean Developed Model**	0.00	-0.54	-0.54

Note: For each country the table compares the empirical moments with those generated by the Real Business Cycles (RBC) and Financial Frictions (FF) models using HP Filtered output, consumption and investment . Mean corresponds to the simple arithmetic average of each group of countries.

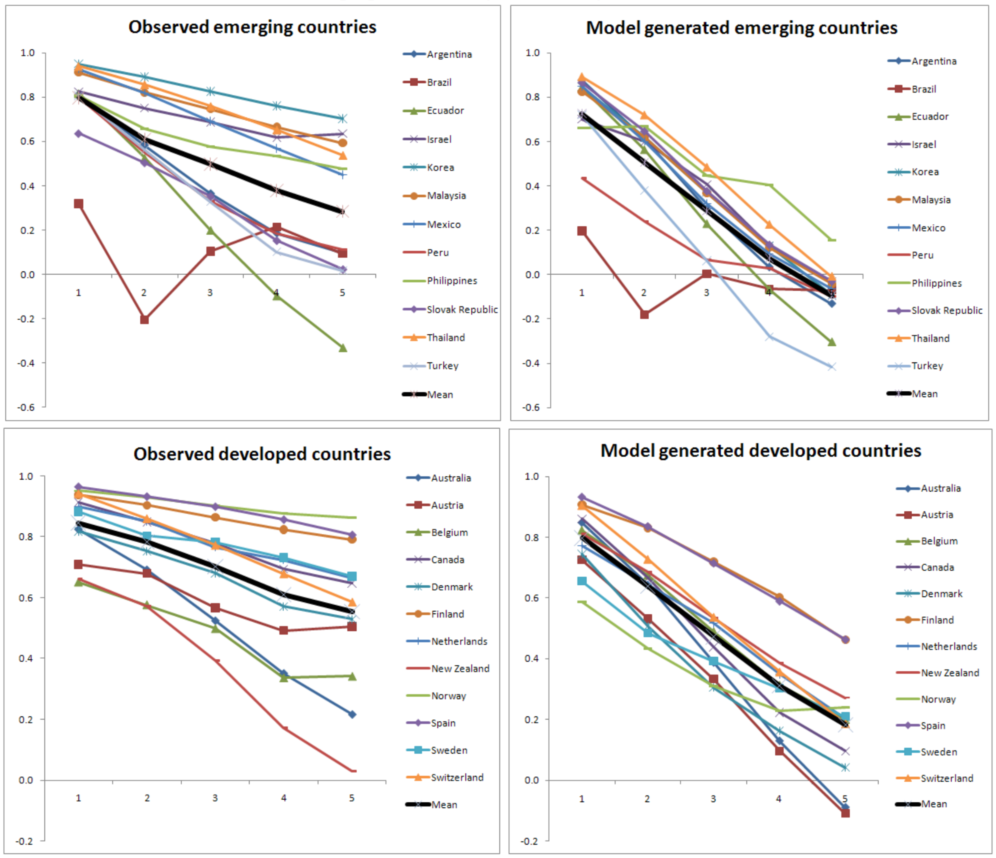
E. Serial Correlation of Consumption, Net Exports and Investment : Data versus Estimated Models

	$\rho(C_t, C_{t-1})$	$\rho(I_t, I_{t-1})$	$\rho(NX_t, NX_{t-1})$		$\rho(C_t, C_{t-1})$	$\rho(I_t, I_{t-1})$	$\rho(NX_t, NX_{t-1})$
Emerging markets				**Developed markets**			
Argentina	0.90	0.85	0.89	Australia	0.81	0.83	0.82
Argentina Model	0.90	0.85	0.83	Australia Model	0.80	-0.42	-0.02
Brazil	0.17	0.39	0.18	Austria	0.60	0.70	0.04
Brazil Model	0.17	0.39	0.04	Austria Model	0.57	0.70	0.34
Ecuador	0.81	0.90	0.84	Belgium	0.83	0.82	0.14
Ecuador Model	0.81	0.87	0.81	Belgium Model	0.83	0.78	0.59
Israel	0.72	0.70	0.41	Canada	0.85	0.88	0.69
Israel Model	0.72	0.70	0.54	Canada Model	0.80	0.63	0.54
Korea	0.81	0.83	0.81	Denmark	0.62	0.51	0.54
Korea Model	0.81	0.83	0.72	Denmark Model	0.62	0.52	0.34
Malaysia	0.81	0.75	0.79	Finland	0.90	0.83	0.46
Malaysia Model	0.81	0.75	0.69	Finland Model	0.90	0.83	0.72
Mexico	0.82	0.86	0.82	Netherlands	0.81	0.53	0.43
Mexico Model	0.80	0.85	0.81	Netherlands Model	0.81	0.51	0.61
Peru	0.39	0.74	0.61	New Zealand	0.75	0.76	0.50
Peru Model	0.32	0.64	0.13	New Zealand Model	0.75	0.76	0.66
Philippines	0.51	0.49	0.57	Norway	0.80	0.34	0.46
Philippines Model	0.50	0.48	0.11	Norway Model	0.79	0.35	0.23
Slovak Republic	0.50	0.73	0.55	Spain	0.88	0.93	0.72
Slovak Republic Model	0.54	0.73	0.62	Spain Model	0.88	0.93	0.77
Thailand	0.89	0.88	0.87	Sweden	0.57	0.84	0.34
Thailand Model	0.88	0.87	0.73	Sweden Model	0.59	0.84	0.50
Turkey	0.68	0.71	0.67	Switzerland	0.90	0.91	0.85
Turkey Model	0.68	0.71	0.53	Switzerland Model	0.89	0.90	0.86
Mean Emerging	0.67	0.73	0.67	**Mean Developed**	0.78	0.74	0.50
Mean Emerging Model	0.66	0.72	0.55	**Mean Developed Model**	0.77	0.61	0.51

Note: For each country the table compares the empirical moments with those generated by the Real Business Cycles (RBC) and Financial Frictions (FF) models using HP Filtered output, consumption and investment . Mean corresponds to the simple arithmetic average of each group of countries.

Figure 10, below, shows the autocorrelation function of net exports-to-output ratio in the data and in the models. Given that we are using data on output, consumption and investment to estimate the models, we are directly defining the trade balance, therefore, even in the Real Business Cycle version we do not have the problem of an autocrrelation function of net exports-to-output close to unity, which Garcia-Cicco et al. (2010) point out as a problem with the model without financial frictions. The differences between the observed an model generated autocorrelation functios are due to the fact that the models do not include government, which was not removed from the observed series. Otherwise, both graphs should coincide.

Figure 10: Observed and model generated autocorrelation function of the trade balance-to-output ratio for Emerging and Developed Small Open Economies



Note: The graphs show the data or model generate (Real Business Cycles and Financial Frictions models coincide) autocorrelation function of the trade balance-to-output ratio in the group of countries indicated.

4.3 Models' comparison

Table 8, below, reports the main result 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. Also, the financial frictions model is favored in five developed small open economies (Belgium, Denmark, Netherlands, Norway and Sweden). Interestengly, 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 not definite results in the remaining four countries (Australia, Austria, New Zealand and Spain). It would be worth exploring the factors that contribute to these seven cases where adding financial frictions is not necessarily contributing to match the data better.

Table 8: 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	100	Australia	64	36
	(-356.86)	(-340.73)		(-548.93)	(-549.54)
Brazil	0	100	Austria	40	60
	(-402.58)	(-363.99)		(-279.50)	(-279.10)
Ecuador	0	100	Belgium	0	100
	(-404.50)	(-394.16)		(-471.83)	(-450.92)
Israel	0	100	Canada	100	0
	(-782.73)	(-719.65)		(-413.69)	(-447.49)
Korea	0	100	Denmark	0	100
	(-708.89)	(-678.42)		(-412.77)	(-391.82)
Malaysia	0	100	Finland	100	0
	(-451.01)	(-426.47)		(-573.61)	(-585.55)
Mexico	0	100	Netherlands	1	99
	(-730.68)	(-719.69)		(-517.13)	(-512.36)
Peru	0	100	New Zealand	46	54
	(-465.24)	(-443.81)		(-419.98)	(-419.81)
Philippines	0	100	Norway	0	100
	(-749.18)	(-727.38)		(-710.29)	(-665.76)
Slovak Republic	0	100	Spain	75	25
	(-336.47)	(-329.30)		(-488.61)	(-489.72)
Thailand	0	100	Sweden	0	100
	(-358.04)	(-344.34)		(-646.82)	(-624.40)
Turkey	0	100	Switzerland	99	1
	(-553.59)	(-531.42)		(-334.78)	(-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.

5 Conclusions

This paper is a contribution to the quest in the identification of features that could help a 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 the data of such large 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 $|\rho_z| < 1$, $\left|\rho_g\right| < 1$ 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 and $\sigma > 0, \neq 1$ is the inverse of the elasticity of intertemporal substitution.

Optimal capital accumulation is given by

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

where $\zeta_3 = \zeta_1 - \phi\mu_g$, $\zeta_4 = \phi\mu_g$, $\zeta_5 = \beta\mu_g^{\zeta_1+2}\phi$, $\zeta_6 = \beta\mu_g^{\zeta_1}(1-\alpha)\frac{Y}{K}$, $\zeta_7 = \beta\mu_g^{\zeta_1+2}\phi$ and $\zeta_8 = \beta\mu_g^{\zeta_1}\left[(1-\alpha)\frac{Y}{K} + \phi\mu_g^2\right] + \phi\mu_g$. The parameter $\phi \geq 0$ 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

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

where $\psi \geq 0$ captures the elasticity of the borrowing interest rate to changes in indebtedness. In the model without financial frictions $\psi \longrightarrow 0$ [5], 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.

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