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slides

chapter 5

business cycles in emerging countries:

productivity shocks versus financial frictions

A Quick Reminder Of The OE-RBC Model

$$\max E_0 \sum_{t=0}^{\infty} \beta^t U(c_t, h_t),$$

subject to

$$d_t + A_t F(k_t, h_t) = (1 + r_{t-1}) d_{t-1} + c_t + k_{t+1} - (1 - \delta) k_t + \Phi(k_{t+1} - k_t).$$

and a no-Ponzi-game constraint. The driving force is the productivity shocks

$$\ln A_{t+1} = \rho \ln A_t + \tilde{\eta} \epsilon_{t+1},$$

A debt-elastic country interest rate to induce stationarity

$$r_t = r^* + p(\tilde{d}_t).$$

From Developed to Less Developed Countries

• We saw that a calibrated version of the SOE-RBC model captures well key empirical regularities of a developed SOE like Canada (chapter 4).

• **Question:** Can the OE-RBC model also explain business cycles in emerging and poor economies?

• Two important differences between business cycles in developed and emerging and poor economies.

– Emerging and poor economies are twice as volatile as developed economies (fact 8 in chapter 1).

– In developed economies consumption is less volatile than output, whereas in emerging and poor economies consumption is at least as volatile as output (fact 9 in chapter 1).

Let's look at each of these two differences more closely.

Emerging and poor economies are twice as volatile as developed economies (fact 8, chapter 1).

• In principle, the SOE-RBC model can easily handle this difference. Simply jack up (by a factor of around 2) the standard deviation of the productivity shock. After all, in the SOE-RBC model of chapter 4, σ_a was calibrated to match the standard deviation of Canadian GDP.

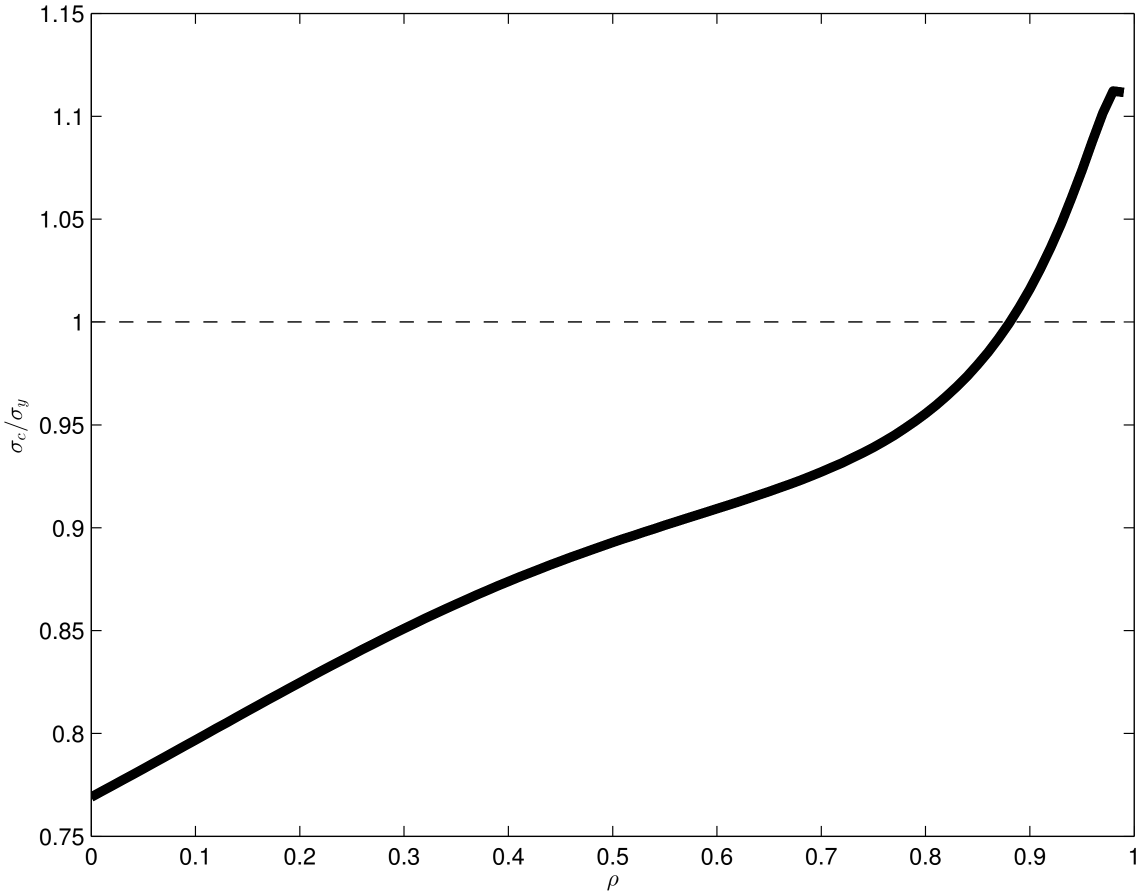
• Since not only output but also all of the components of aggregate demand (consumption, investment, net exports) are more volatile in emerging and poor countries than in rich countries, increasing σ_a would help along more than one dimension.

• **Problem:** Not all volatilities increase in the same proportion as we move from rich to emerging or poor countries. This brings us to the second difference between business cycles in rich and emerging/poor countries . . .

In developed economies consumption is less volatile than output, whereas in emerging and poor economies consumption is at least as volatile as output (fact 9, chapter 1).

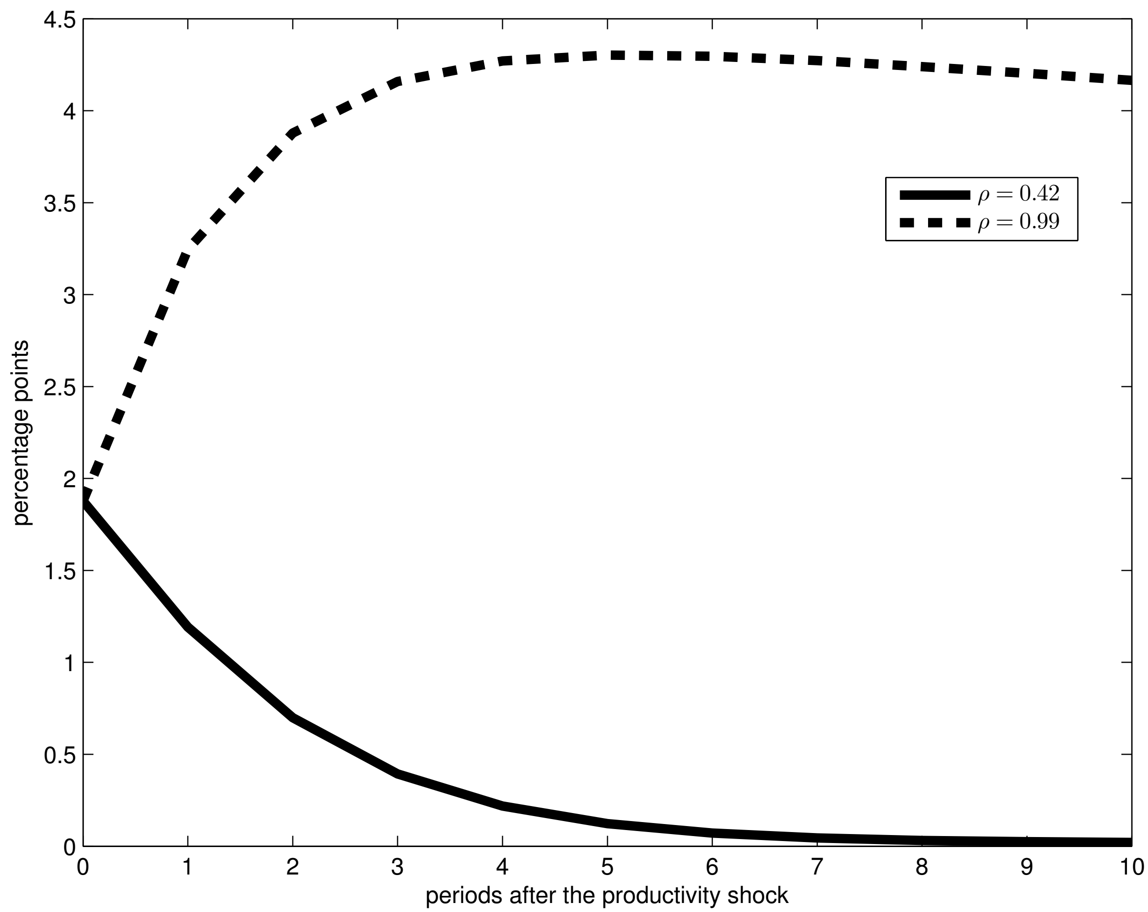
In principle, the OE-RBC model can also handle this fact. Consider varying the persistence of the productivity shock, governed by the parameter ρ.

The Open-Economy RBC Model
The Relative Volatility of Consumption as a Function of the Persistence of the Stationary Technology Shock



The following figure helps build intuition for why a more persistent productivity shock increases the volatility of consumption relative to that of output.

The SOE-RBC Model: Impulse Response of Output to a One-Percent Increase in Productivity for High and Low Persistence Of the Stationary Productivity Shock



Intuition

• With highly persistent productivity shocks, the impulse response of y_t is increasing over time for a number of periods. This makes it possible that at $t = 0$, permanent income is higher than current income. Since consumption depends on permanent income, consumption increases by more than current income.

• With less persistent productivity shocks, permanent income increases by less than current income, so consumption increases by less than current income.

• Why? If productivity increases are expected to last long, it pays to increase the stock of physical capital. But this takes time. The gradual build-up of the capital stock dominates the gradual decline of productivity to its steady state, which translates into an increasing path for output (see the analysis of chapter 3).

Problem:

Recall that in the calibration strategy of chaper 4, ρ was picked to match the observed serial correlation of output with the one predicted by the OE-RBC model.

Thus, there is a tradeoff between using ρ to match the excess volatility of consumption and using it to match the serial correlation of output.

The OE-RBC Model with Nonstationary Technology Shocks

Aguiar and Gopinath (2007) propose solving this problem by adding a second productivity shock.

The second productivity shock is nonstationary as in the closed-economy RBC model of King, Plosser, and Rebelo (1988, II).

The analysis of chapter 2 suggests that even in the context of an endowment economy, nonstationary endowment shocks have the potential to induce excess volatility of consumption.

The SOE-RBC Model With Nonstationary Technology Shocks

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \frac{[C_t^{\gamma}(1-h_t)^{1-\gamma}]^{1-\sigma}-1}{1-\sigma}$$

subject to

$$\frac{D_{t+1}}{1+r_t} + Y_t = D_t + C_t + K_{t+1} - (1-\delta)K_t + \frac{\phi}{2}\left(\frac{K_{t+1}}{K_t} - g\right)^2 K_t,$$

$$Y_t = a_t K_t^{\alpha}(X_t h_t)^{1-\alpha}$$

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

The country interest rate

$$r_t = r^* + \psi\left[e^{\tilde{D}_{t+1}/X_t - \overline{d}} - 1\right],$$

In equilibrium, $\tilde{D}_{t+1} = D_t$.

Laws of Motion of Productivity Shocks

$$\ln a_t = \rho_a \ln a_{t-1} + \sigma_a \epsilon_t^a$$

and

$$\ln(g_t/g) = \rho_g \ln(g_{t-1}/g) + \sigma_g \epsilon_t^g,$$

where

$$g_t \equiv \frac{X_t}{X_{t-1}}$$

SOE-RBC Model With Nonstationary Shocks

Calibrated Parameters

β	γ	ψ	α	σ	δ	$\bar{d}$
0.98	0.36	$\boxed{0.001}$	0.32	2	0.05	0.1

Estimated Parameters (GMM)

σ_g	σ_a	ρ_g	ρ_a	g	ϕ
0.0213	0.0053	0.00	0.95	1.0066	1.37

The time unit is a quarter. Data from Mexico 1980:Q1 to 2003:Q1. Six parameters estimated by matching 10 moments. For moments matched, see next slide.

Model Fit

Statistic	Data	Model
$\sigma(y)$	2.40	2.13
$\sigma(\Delta y)$	1.52	1.42
$\sigma(c)/\sigma(y)$	1.26	1.10
$\sigma(i)/\sigma(y)$	4.15	3.83
$\sigma(nx)/\sigma(y)$	0.80	0.95
$\rho(y)$	0.83	0.82
$\rho(\Delta y)$	0.27	0.18
$\rho(y, nx)$	-0.75	-0.50
$\rho(y, c)$	0.82	0.91
$\rho(y, i)$	0.91	0.80

Note. y denotes HP-filtered log output and Δy denotes growth rate of output. Same for c and i; nx denotes the HP-filtered trade balance.

The Implied Importance ofNonstationary Productivity Shocks

Let $TFP_t \equiv a_t X_t^{1-\alpha}$ be total factor productivity, and $X_t^{1-\alpha}$ its non-stationary component, which is orthogonal toa_t.

$$
\begin{aligned}
\frac{\text{var}\left(\Delta \ln X_t^{1-\alpha}\right)}{\text{var}\left(\Delta \ln TFP_t\right)} &= \frac{\text{var}((1-\alpha)g_t)}{\text{var}(\Delta \ln TFP_t)} \\
&= \frac{(1-\alpha)^2\sigma_g^2/(1-\rho_g^2)}{2\sigma_a^2/(1+\rho_a)+(1-\alpha)^2\sigma_g^2/(1-\rho_g^2)} \\
&= \frac{(1-0.32)^2 \times 0.021^2/(1-0.00^2)}{2\times 0.005^2/(1+0.95)+(1-0.32)^2\times 0.021^2} \\
&= 0.8793.
\end{aligned}
$$

$\Rightarrow$ The estimated model predicts that TFP growth is driven primarily by nonstationary productivity shocks.

How Should We Interpret This Result?

Three observations:

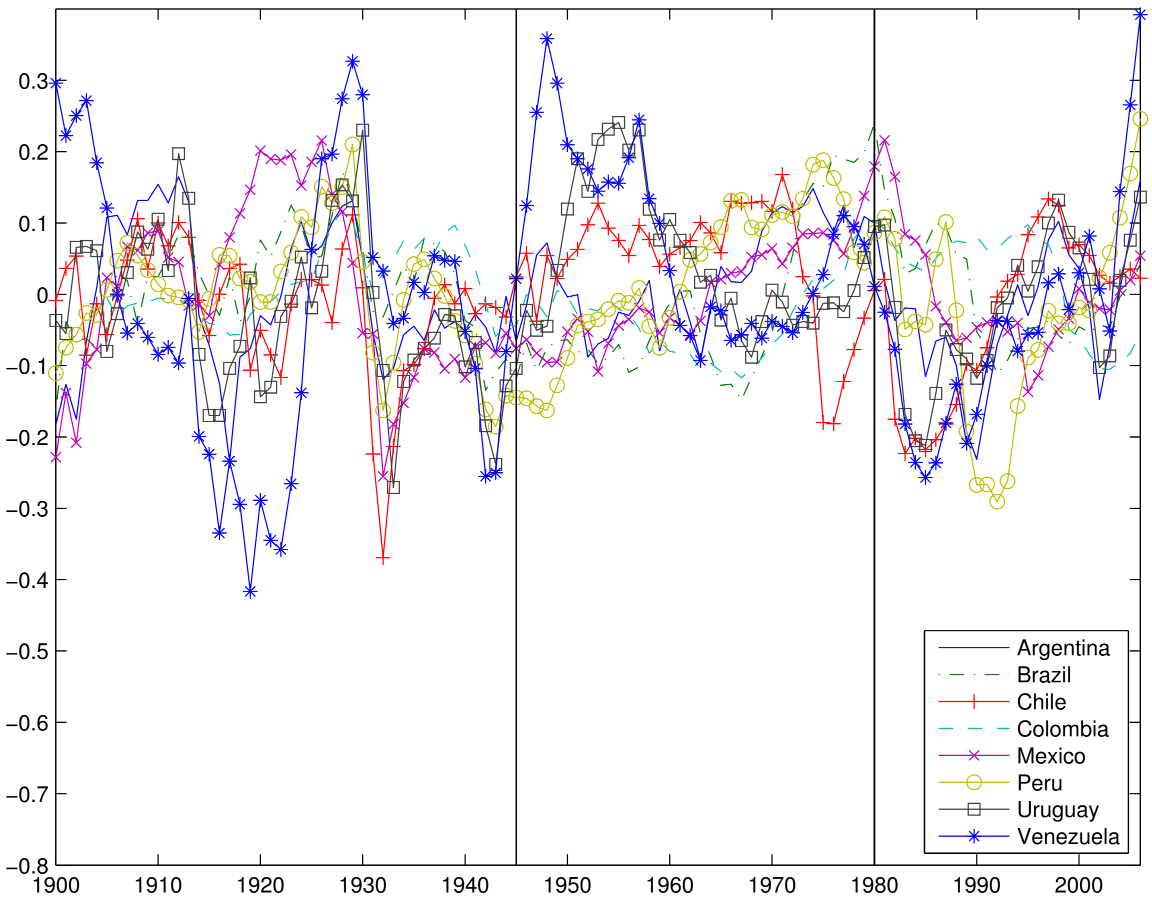
• Short sample (1980-2003): problematic if the main goal is to distinguish persistent but transitory productivity shocks from non-stationary productivity shocks.

• Only productivity shocks are allowed in the horse race. How about other important shocks for emerging countries, such as country-interest-rate shocks?

• The environment is constrained to be the frictionless neoclassical model. What if distortions were allowed (financial frictions, nominal rigidities, etc.)?

We turn to these issues next . . .

Business Cycles in Latin America: 1900-2005



$\Rightarrow$ The sample 1980-2003 contains at most one and a half cycles.

Addressing The Three Observations

• Short sample (1980-2003): Use annual data on output, consumption, investment, and the trade balance from 1900 to 2005.

• Only productivity shocks are allowed in the horse race: Add more shocks; country-interest-rate shocks, preference shocks, and government spending shocks.

• The environment is constrained to be the frictionless neoclassical model: add financial frictions, namely, by allowing the data to pick the debt elasticity of the country interest rate and by including a working capital constraint.

A Model With Multiple Shocks and Financial Frictions (GPU, AER 2010)

Households: $$\max E_0 \sum_{t=0}^{\infty} \nu_t \beta^t \frac{\left[C_t - \omega^{-1} X_{t-1} h_t^{\omega}\right]^{1-\gamma} - 1}{1-\gamma},$$

subject to

$$\frac{D_{t+1}}{1+r_t} = D_t - W_t h_t - u_t K_t + C_t + S_t + I_t + \frac{\phi}{2}\left(\frac{K_{t+1}}{K_t} - g\right)^2 K_t,$$

$$K_{t+1} = (1-\delta)K_t + I_t,$$

Firms: $$\max_{\{h_t, K_t\}} \left\{ a_t K_t^{\alpha} (X_t h_t)^{1-\alpha} - u_t K_t - W_t h_t \left[1 + \frac{\eta r_t}{1+r_t}\right] \right\},$$

Country Interest Rate: $$r_t = r^* + \psi\left(e^{\frac{\widetilde{D}_{t+1}/X_t - \overline{d}}{\overline{y}}} - 1\right) + e^{\mu_t - 1} - 1,$$

Five Shocks

$$\ln a_{t+1} = \rho_a \ln a_t + \epsilon^a_{t+1}.$$

$$\ln(g_{t+1}/g) = \rho_g \ln(g_t/g) + \epsilon^g_{t+1}, \qquad g_t \equiv \frac{X_t}{X_{t-1}}$$

$$\ln \nu_{t+1} = \rho_\nu \ln \nu_t + \epsilon^\nu_{t+1},$$

$$\ln \mu_{t+1} = \rho_\mu \ln \mu_t + \epsilon^\mu_{t+1}.$$

$$\ln(s_{t+1}/\overline{s}) = \rho_s \ln(s_t/\overline{s}) + \epsilon^s_{t+1}, \qquad s_t \equiv \frac{S_t}{X_{t-1}},$$

Calibrated Parameters

Parameter	Value
g	1.0107
$\overline{d}/\overline{y}$	0.037
δ	0.1255
r^*	0.10
α	0.32
γ	2
ω	1.6
$\overline{s}/\overline{y}$	0.10

Bayesian Estimation

Estimate the model on 4 time series: output growth, consumption growth, investment growth, and the trade balance-to-output ratio.

Estimate 13 structural parameters and 4 nonstructural parameters associated with measurement errors.

The structural parameters include 10 defining the processes of the 5 structural shocks, σ_g, ρ_g, σ_a, ρ_a, σ_ν, ρ_ν, σ_s, σ_μ, ρ_μ , and the parameters governing capital adjustment costs, ϕ, the debt elasticity of the country intrest rate, ψ, and the magnitude of the working-capial constraint, η.

The nonstructural parameters are the standard deviations of measurement errors on output growth, $\sigma^{me}_{g^Y}$, consumption growth, $\sigma^{me}_{g^C}$, investment growth, $\sigma^{me}_{g^I}$, and the trade-balance-to-output ratio, $\sigma^{me}_{TB/Y}$.

Bayesian Estimation Results

	Uniform Prior Distributions			Posterior Distributions			
Parameter	Min	Max	Mean	Mean	Median	5%	95%
$\boxed{\sigma_g}$	0	0.2	0.1	0.0082	$\boxed{0.0067}$	$\boxed{0.00058}$	$\boxed{0.021}$
$\boxed{\rho_g}$	-0.99	0.99	0	0.15	$\boxed{0.21}$	$\boxed{-0.69}$	$\boxed{0.81}$
σ_a	0	0.2	0.1	0.032	0.032	0.027	0.036
ρ_a	-0.99	0.99	0	0.84	0.84	0.75	0.91
σ_ν	0	1	0.5	0.53	0.51	0.39	0.77
ρ_ν	-0.99	0.99	0	0.85	0.85	0.76	0.93
σ_s	0	0.2	0.1	0.062	0.064	0.0059	0.12
ρ_s	-0.99	0.99	0	0.46	0.56	-0.42	0.92
σ_μ	0	0.2	0.1	0.12	0.11	0.067	0.18
ρ_μ	-0.99	0.99	0	0.91	0.92	0.83	0.98
ϕ	0	8	4	5.6	5.6	3.9	7.5
ψ	0	10	5	1.4	$\boxed{1.3}$	0.55	2.4
η	0	5	2.5	0.42	0.4	0.18	0.7

Note. Based on an MCMC chain of length 1 million produced using the Metropolis-Hastings algorithm. Estimates of the standard deviations of measurement errors are presented in chapter 5.

Observations On Estimation Results

The parameters defining the process of the nonstationary technology shock are estimated with substantial uncertainty.

By contrast, the parameters defining the process of the stationary technology shock are more tightly estimated.

The data assigns a value significantly higher than 0 to the debt-elasticity of the country interest rate, ψ.

Empirical and Theoretical Second Moments

Statistic	g^Y	g^C	g^I	TB/Y
Standard Deviation				
Model	$\boxed{6.2}$	$\boxed{8.9}$	18.6	$\boxed{4.9}$
Data	$\boxed{5.3}$	$\boxed{7.5}$	20.4	$\boxed{5.2}$
	(0.43)	(0.6)	(1.8)	(0.57)
Correlation with g^Y				
Model		0.80	0.53	$\boxed{-0.18}$
Data		0.72	0.67	$\boxed{-0.04}$
		(0.07)	(0.09)	(0.09)
Correlation with TB/Y				
Model		-0.37	-0.31	
Data		-0.27	-0.19	
		(0.07)	(0.08)	
Serial Correlation				
Model	0.04	-0.06	-0.098	0.51
Data	0.11	-0.0047	0.32	0.58
	(0.09)	(0.08)	(0.10)	(0.07)

Observations On Model Fit

• The model does a good job at capturing a number of second moments of interest. In particular,

• The high volatility of output growth.

• The excess volatility of consumption growth relative to output growth.

• A volatility of the trade-balance-to-output ratio comparable to that of output growth and a mild negative correlation between this variable and output growth.

• The model does not capture the positive serial correlation of investment growth.

Variance Decomposition

Shock	g^Y	g^C	g^I	TB/Y
Nonstationary Tech.	$\boxed{2.6}$	1.1	0.2	0.1
Stationary Tech.	81.8	42.4	12.7	0.5
Preference	6.8	27.7	29.1	6.2
Country Premium	6.1	25.8	52.0	92.1
Spending	0.0	0.3	0.3	0.1
Measurement Error	0.4	0.7	5.2	0.4

Note. Median of an MCMC chain of length 1 million.

Observations On Variance Decomposition

• The nonstationary productivity shock explains a small fraction of the variance of output growth and other variables.

• Much of the variance of output growth is explained by stationary technology shocks.

• In explaining the excess volatility of consumption, the data appears to prefer a combination of stationary productivity shocks, interest-rate shocks, and preference shocks, rather than nonstationary productivity shocks, as was the case in the RBC model driven solely by two productivity shocks.

• Interest-rate shocks are assigned a primary role in explaining movements in investment and the trade-balance-to-output ratio.

The Implied Importance of Nonstationary Productivity Shocks Revisited

Variance Decomposition of TFP Growth

$$\begin{aligned}\frac{\text{var}(\Delta \ln(X_t^{1-\alpha}))}{\text{var}(\Delta \ln TFP_t)} &= \frac{(1-\alpha)^2\sigma_g^2/(1-\rho_g^2)}{2\sigma_a^2/(1+\rho_a)+(1-\alpha)^2\sigma_g^2/(1-\rho_g^2)} \\ &= 0.024.\end{aligned}$$

$\Rightarrow$ The estimated model predicts a negligible contribution of non-stationary productivity shocks to movements in TFP growth.

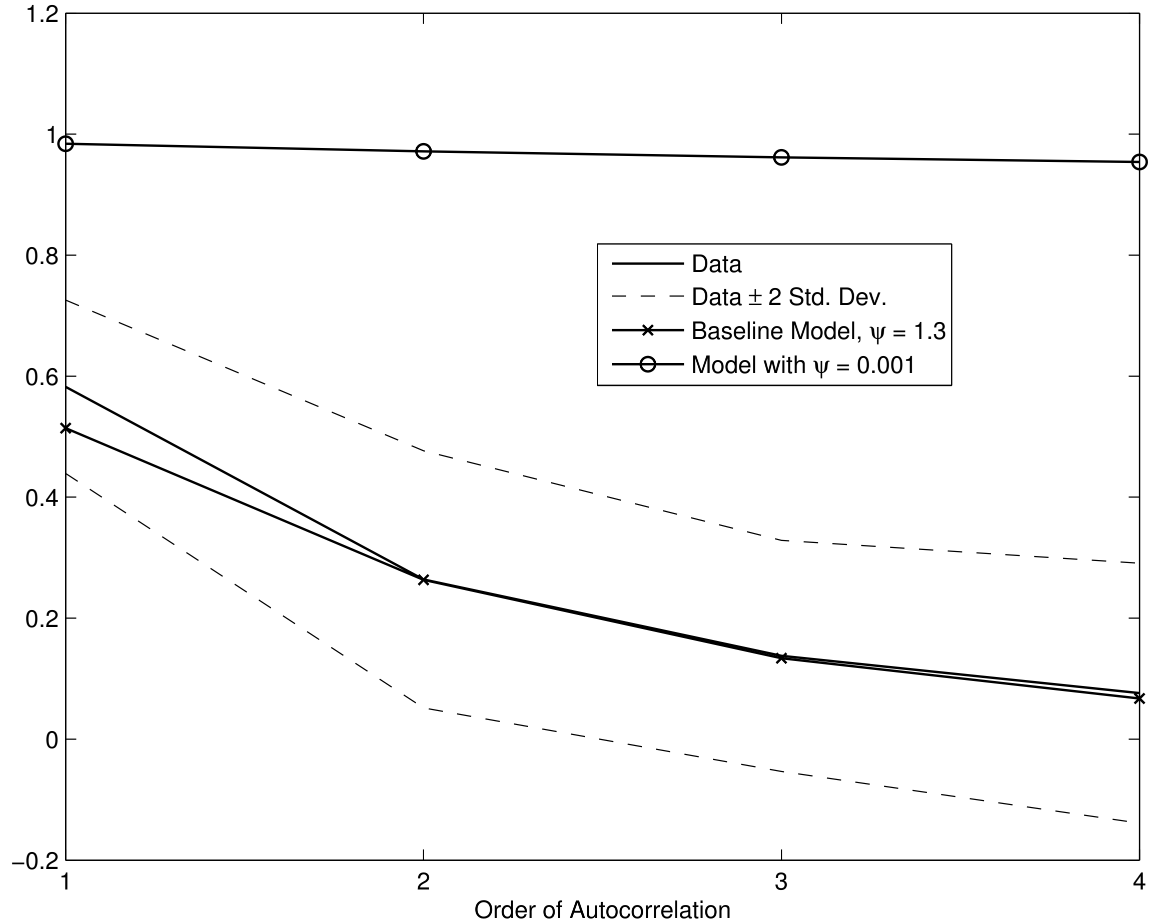
The Importance of Financial Frictions

• Put to choose, the data favors a value of ψ, governing the debt-elasticity of the interest rate, much higher than the small vlaue required to induce stationarity. This is an indication of the importance of that financial frictions.

• To quantify this importance, the next slide displays observed autocorrelation function of the trade-balance-to-output ratio along with the ones predicted by the model for two values of ψ, its posterior median of 1.3 and a small value of 0.001.

• Why look at the trade balance to output ratio? Because ψ affects the country's ability to borrow internationally, and, as a result, the cyclicality of the current account, of which the trade balance is a main component.

The Autocorrelation Function of the Trade-Balance-To-Output Ratio



Note. The point estimate and error band of the empirical autocorrelation function was estimated by GMM. After setting ψ to 0.001, the theoretical model was reestimated.