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ABSTRACT

We investigate the hypothesis that an RBC model driven by permanent and transitory productivity shocks can explain well observed business-cycle fluctuations in emerging countries. A drawback of existing studies is the use of short samples to identify permanent shifts in productivity. We overcome this difficulty by using more than one century of Argentine data to estimate the structural parameters of a small-open-economy RBC model.

We place particular emphasis on the behavior of the trade balance because this variable plays a central role in all existing empirical or theoretical characterizations of the developing-country business-cycle. We find that the RBC model predicts a near random walk behavior for the trade balance-to-output ratio with a flat autocorrelation function close to unity. By contrast, in the data, the autocorrelation function of the trade balance-to-output ratio is significantly below unity and converges quickly to zero, resembling the one implied by a stationary autoregressive process. In addition, we show that the RBC model fails to capture a number of other important aspects of the emerging-market business cycle, including the volatilities of output, consumption, investment, and the trade balance.

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1 Introduction

A central characteristic of business cycles in developed countries is their remarkable dampening after the second world war. This phenomenon is often attributed to improved policy management. Policymakers and policy institutions are generally credited for avoiding large economic depressions like the one that took place in the interwar period. By contrast, business cycles in many emerging countries display no signs of moderation in the past fifty years. Large swings in aggregate activity are as likely to occur now as they were a century ago. For instance, following the debt crisis of the 1980s most countries in Latin America underwent output contractions of enormous dimensions, in many cases comparable to the one that took place during the U.S. Great Depression. Not surprisingly, misplaced government policies and widespread market imperfections have been blamed for the failure to achieve and maintain aggregate stability in the region.

Recently, a number of studies have departed from the mainstream view that in order to understand economic fluctuations in emerging markets, theoretical models must take explicitly into account the role of policy and market failures. This line of research argues that business cycles in emerging countries can be explained well using an undistorted neoclassical model driven solely by shocks to total factor productivity. Kydland and Zarazaga (2002), for instance, adopt a strong view by arguing that the RBC model can replicate satisfactorily the 'lost decade' of the 1980s in Argentina. More recently Aguiar and Gopinath (2007) have suggested that an RBC model driven by permanent and transitory shocks to productivity can explain well business cycles in developing countries. These authors acknowledge the fact that shocks impinging upon emerging countries are numerous and of different natures, but argue that their combined effect can be satisfactorily modeled as an aggregate shock to total factor productivity. In addition, they argue that the neoclassical model is an adequate framework for understanding the transmission of such shocks.

In this paper, we undertake an investigation of the hypothesis that an RBC model driven by a combination of permanent and transitory shocks to total factor productivity can account satisfactorily for observed aggregate dynamics in developing countries. We place particular emphasis on the behavior of the trade balance. For movements in this variable represent a central characteristic of the business-cycle experience in many emerging economies. Theoretically, the trade balance and other components of the external accounts have been the central focus of numerous strands of research aimed at understanding the nature of aggregate fluctuations in developing countries. Examples include the literatures on balance of payments crises, sudden stops, sovereign debt, and exchange-rate-based stabilization.

We conduct a GMM estimation of the parameters of a small open economy RBC model using Argentine data over the period 1900-2005. The use of long time series is motivated by what we believe is an important drawback of the existing studies advocating the ability of the RBC model to explain business cycles in developing countries. Namely, the use of short samples both for characterization of observed business cycles and for estimation of the parameters of the theoretical model, particularly those defining the stochastic process of the underlying driving forces.

Our central finding is that the RBC model does a poor job at explaining the behavior of net exports. Specifically, in the model, the trade balance-to-output ratio is a near random walk, with a flat autocorrelation function close to unity. By contrast, in the data, the highest autocorrelation coefficient of the trade balance-to-output ratio takes place at the first order and is less than 0.6, with higher-order autocorrelations converging quickly to zero. In addition, we find that the RBC model fails to match several other important features of the business cycle in emerging countries. In particular, the model predicts consumption growth to be less volatile than output growth, whereas in Argentina, as in many other developing economies, consumption growth is more volatile than output growth. Also, the model predicts investment to be significantly less volatile and the trade balance to be significantly more volatile than their corresponding empirical counterparts. These results are robust to a number of theoretical and econometric modifications. One of these modifications consists in shortening the time horizon to include only the postwar period.

In section 2, we present a number of stylized facts associated with the Argentine business cycle over the period 1913-2005. In section 3, we lay out the theoretical model. In section 4, we discuss the estimation of the structural parameters of the model. In section 5 we present the main results of the paper. We compare the predictions of the RBC model with actual data. In section 6, we present an extensive robustness analysis. In section 7, we provide concluding remarks.

2 Business Cycles in Argentina: 1900-2005

Before proceeding with our empirical characterization of business cycles in Argentina, we provide information about data sources. Detailed references are contained in Appendix A. Our data set consists of annual series for gross domestic product, private consumption, gross investment, exports, imports, and population. For the period 1900 to 1912 the source is Ferreres (2005). For the period 1913-1980, the source is IEERAL (1986). For the period 1981-2005, the data were taken from various official statistical offices of Argentina. These data sources are standard in academic studies on Argentine growth and business cycles (see, for example, della Paolera and Taylor, 2003).

Our joint analysis of the pre- and post-world-war-two periods represents a departure from the usual practice in studies focused on developed countries. Typically, these studies concentrate either on the pre-world-war-two period—often emphasizing the Great Depression years—or on the post-world-war-two period—as do most of the many papers spurred by the work of Kydland and Prescott (1982) and King, Plosser, and Rebelo (1988). There is a good reason for separating the pre- and post-world-war-two periods when examining developed-country data. For the volatility of business cycles in industrialized countries fell sharply in the second half of the twentieth century. In sharp contrast, in emerging countries business cycles do not appear to moderate after the second world war. This fact is clearly illustrated by figure 1, which shows with a solid line the logarithm of GDP per capita between 1900 and 2005 and with a broken line the associated quadratic trend for the United States (panel a) and Argentina (panel b). In the United States, the first half of the twentieth century is dominated by the Great Depression and appears as highly volatile. By comparison, the half century following the end of World War II appears as fairly calm, with output evolving smoothly around its long-run trend. A similar pattern can be shown to emerge for each of the remaining G7 countries (see Basu and Taylor 1999, table A3). On the other hand, in Argentina output fluctuations appear equally volatile in the prewar period as in the postwar period.[1]

The message conveyed by figure 1 is confirmed by table 1. Over the whole sample,

Table 1: Standard Deviation of Per-Capita Output Growth in Argentina and the United States

Period	Argentina	United States
1900-2005	5.4	4.9
1900-1945	5.7	6.4
1946-2005	5.2	3.4

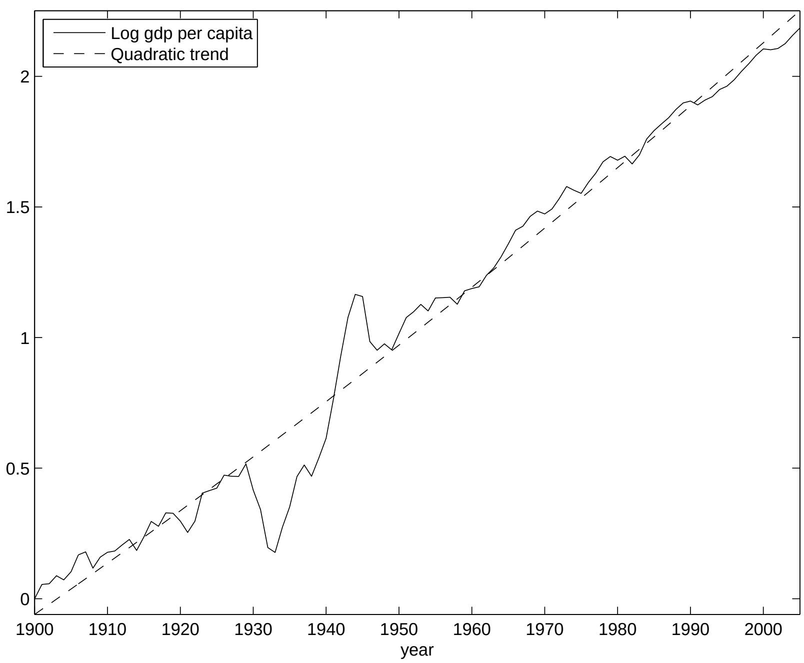
Note: In percentage points.

1900-2005, the United States and Argentina display similar volatilities in per-capita output growth of about 5 percent. However, in the United States the volatility of output growth falls significantly from 6.4 to 3.4 between the pre- and postwar periods. By contrast, in Argentina the volatility of output growth falls insignificantly from 5.7 in the earlier half of

[1]Basu and Taylor (1999) also find no differences in output volatility in Argentina in the prewar and postwar eras (see their table A3). Using data from Argentina for the period 1884 to 1990, Sturzenegger and Moya (2003) find that business cycles in the pre world war II period were more volatile than in the postwar period. This different result is due to the fact that their sample does not include the years 1991-2005, which are among the most volatile of the postwar era and that their sample includes the period 1884-1900, which was particularly volatile (see Basu and Taylor, 1999, table A3).

Figure 1: Output Per Capita in Argentina and the United States: 1900-2005

(a) United States



(b) Argentina

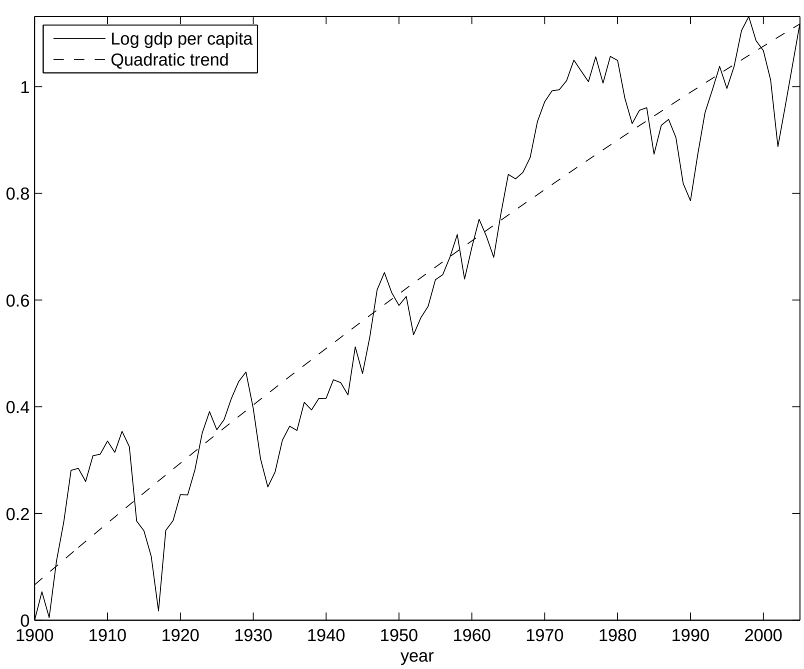
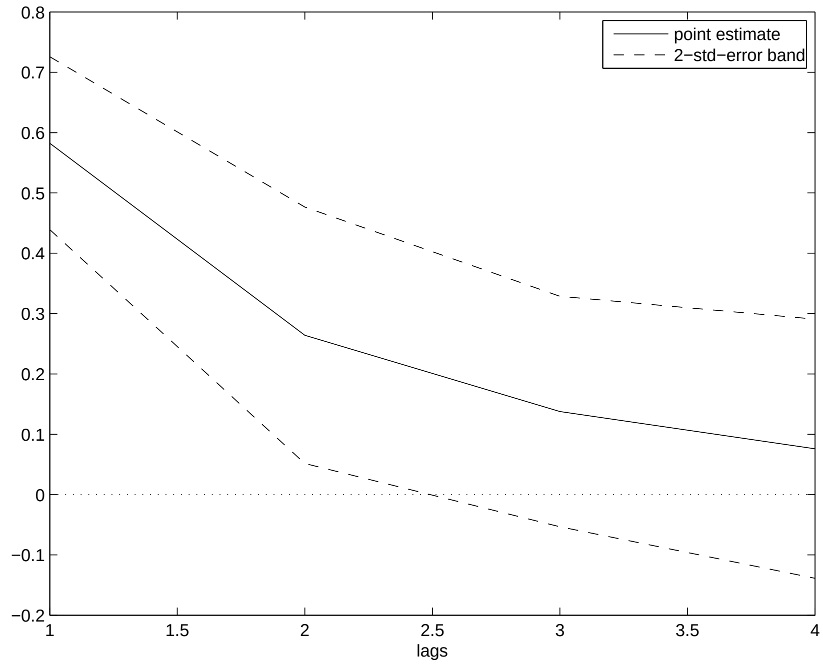


Figure 2: Autocorrelation Function of the Trade Balance-to-Output Ratio



the twentieth century to 5.2 percent in the later half.[2] It is this fact that motivates us to pursue a joint analysis of the Argentine pre- and postwar periods.

Figure 2 displays with a solid line the autocorrelation function of the trade balance-to-output ratio and with broken lines the associated two-standard-deviation confidence band. This autocorrelation function, which is at the heart of our analysis, is similar to that of an AR(1) process with a positive autoregressive coefficient slightly below 0.6. The first- and second-order autocorrelations are significantly above zero. Our goal is to establish whether an estimated real-business-cycle model driven by permanent and transitory shocks to productivity can account for the autocorrelation function of the trade-balance share in output. This question has not been addressed in the literature on business cycles in emerging countries, which is surprising, given the prominence that the external accounts are believed to have in shaping macroeconomic swings in these countries.

In addition to the autocorrelation function of the trade balance, our analysis evaluates the ability of the RBC model to match a number of other statistics typically used to characterize business cycles. Table 2 displays the set of additional statistics we consider. Notably, unlike

[2]Modeling the conditional volatility of the cyclical component of output per capita as a GARCH(1,1) process and applying Chow and QLR tests, we found no structural breaks in volatility over the sample. The same result obtains under alternative ways of detrending the data, such as HP filtering or taking growth rates. By contrast, the volatility of U.S. per-capita output growth presents a significant decline after the second war.

Table 2: Argentina 1900-2005: Summary Statistics

Statistic	g^Y	g^C	g^I	tby
Standard Deviation	5.3	7.5	20.0	5.2
	(0.4)	(0.6)	(1.8)	(0.5)
Correlation with g^Y	—	0.72	0.67	-0.03
	—	(0.07)	(0.09)	(0.09)
Correlation with tby	—	-0.27	-0.19	—
	—	(0.07)	(0.08)	—
Serial Correlation	0.11	0.00	0.32	0.58
	(0.09)	(0.08)	(0.10)	(0.07)

Note: g^Y, g^C, and g^I denote the growth rates of output per capita, consumption per capita, and investment per capita, respectively, and tby denotes the trade balance-to-output ratio. Standard deviations are reported in percentage points. Standard errors are shown in parenthesis. The discrepancy between the standard deviation of output growth shown on this table and on table 1 is due to the fact that the second moments shown in this table were estimated jointly with the autocorrelation function of order four shown in figure 2, which entails a loss of 4 degrees of freedom.

in developed countries, per-capita consumption growth in Argentina is significantly more volatile than per-capita output growth. Others have documented this fact for Argentina and other emerging countries using postwar data (Neumeyer and Perri, 2006, Aguiar and Gopinath, 2007, and Uribe, 2006). Our contribution here is to show that the high volatility of consumption relative to output remains present after augmenting the sample to include the first half of the twentieth century. Gross investment growth is enormously volatile. Its standard deviation is about four times as large as that of output growth. At the same time, the trade balance-to-output ratio is about as volatile as output growth. The observed correlation between the trade balance-to-output ratio and output growth is negative but insignificantly different from zero. By contrast the domestic components of aggregate demand, private consumption growth and investment growth, are significantly negatively correlated with the trade balance.

Finally, the bottom row of table 2 shows that the first-order autocorrelation of output growth is positive but small and not significantly different from zero. This fact represents a significant impediment for the ability of the estimated RBC model to account for the observed excess volatility of consumption. The reason is that, a productivity shock produces a deterioration in the trade balance and large increases in consumption (as is required for consumption growth to be more volatile than output growth) if current increases in the level of output are accompanied by further expected increases in output. That is, if output growth is sufficiently positively serially correlated. For if in response to a productivity shock future output is expected to be even larger than current output, then households will wish to borrow against future expected income thereby increasing today's consumption beyond the current increase in income.

3 The Model

The theoretical framework is the small open economy model presented in Schmitt-Grohé and Uribe (2003) augmented with permanent and transitory productivity shocks as in Aguiar and Gopinath (2007). The production technology takes the form

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

where Y_t denotes output in period t, K_t denotes capital in period t, h_t denotes hours worked in period t, and a_t and X_t represent productivity shocks. We use upper case letters to denote variables that contain a trend in equilibrium, and lower case letters to denote variables that do not contain a trend in equilibrium.

The productivity shock a_t is assumed to follow a first-order autoregressive process in logs. That is,

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

The productivity shock X_t is nonstationary. Let

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

denote the gross growth rate of X_t. We assume that the logarithm of g_t follows a first-order autoregressive process of the form

$$\ln(g_{t+1}/g) = \rho_g \ln(g_t/g) + \epsilon^g_{t+1}.$$

The innovations ϵ^a_t and ϵ^g_t are assumed to be uncorrelated i.i.d. processes with mean zero and variances σ_a^2 and σ_g^2, respectively. The parameter g measures the deterministic gross growth rate of the productivity factor X_t. The parameters $\rho_a, \rho_g \in [0, 1)$ govern the persistence of a_t and g_t, respectively.

Household face the following period-by-period budget constraint:

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

where D_{t+1} denotes the stock of debt acquired in period t, r_t denotes the domestic interest rate on bonds held between periods t and $t+1$, C_t denotes consumption, I_t denotes gross investment, and the parameter ϕ introduces quadratic capital adjustment costs. The capital stock evolves according to the following law of motion:

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

where $\delta \in [0, 1)$ denotes the depreciation rate of capital.

In order to induce independence of the deterministic steady state from initial conditions, we assume that the country faces a debt-elastic interest-rate premium as in Schmitt-Grohé and Uribe (2003). Specifically, the domestic interest rate is assumed to be the sum of the world interest rate $r^* > 0$, assumed to be constant, and a country premium that is increasing in a detrended measure of aggregate debt as follows:

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

The variable $\tilde{D}_t$ denotes the aggregate level of external debt per capita, which the household takes as exogenous. In equilibrium, we have that $\tilde{D}_t = D_t$.

Consumers are subject to a no-Ponzi-scheme constraint of the form $\lim_{j\to\infty} E_t \frac{D_{t+j}}{\prod_{s=0}^{j}(1+r_s)} \leq 0$. The household seeks to maximize the utility function

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{\left[C_t - \theta\omega^{-1}X_{t-1}h_t^{\omega}\right]^{1-\gamma} - 1}{1-\gamma}, \tag{3}$$

subject to (1), (2), and the no-Ponzi-game constraint, taking as given the processes a_t, X_t, and r_t and the initial conditions K_0 and D_{-1}. Appendix B presents the first-order conditions associated with the household's optimization problem, and appendix C presents the equilibrium conditions of this economy expressed in terms of stationary variables.

4 Calibration and Estimation

The time unit in the model is meant to be a year. We assign values to the structural parameters using a combination of calibration and econometric estimation techniques.

Table 3: Calibration

Parameter	Value
γ	2
δ	0.1255
α	0.32
ψ	0.001
ω	1.6
θ	2.24
β	0.9224
$\bar{d}$	0.007

We calibrate the parameters α, δ, ψ, $\bar{d}$, θ, ω, and γ using long-run data relations from Argentina as well as parameter values that are common in related business-cycle studies. Table 3 presents the calibrated parameter values. We set the parameter $\bar{d}$ to induce a small steady-state trade balance-to-output ratio of about 0.25 percent, as observed on average in Argentina over the period 1900-2005. We follow Schmitt-Grohé and Uribe (2003) and assign a small value to the parameter ψ, measuring the sensitivity of the country interest-rate premium to deviations of external debt from trend, with the sole purpose of ensuring independence of the deterministic steady state from initial conditions, without affecting the short-run dynamics of the model. The value assigned to the depreciation rate δ implies an average investment ratio of about 19 percent, which is in line with the average value observed in Argentina between 1900 and 2005. The value assumed for the discount factor β implies a relatively high average real interest rate of about 8.5 percent per annum, which is empirically plausible for an emerging market like Argentina. There is no reliable data on factor income shares for Argentina. We therefore set the parameter α, which determines the average capital income share, at 0.32, a value commonly used in the related literature. We set $\theta = 2.24$, to ensure that in the steady state households allocate about 20 percent of their time to market work. The parameter γ, defining the curvature of the period utility function, takes the value 2, which is standard in related business-cycle studies. Finally, ω is calibrated at 1.6, which implies a labor-supply elasticity of $1/(\omega - 1) = 1.7$. This value is frequently used in calibrated versions of small open economy models (see Mendoza, 1991; Schmitt-Grohé and Uribe, 2003; and Aguiar and Gopinath, 2007).

We estimate econometrically the five parameters defining the stochastic process of the productivity shocks, g, σ_g, ρ_g, σ_a, and ρ_a and the parameter governing the degree of capital adjustment costs, ϕ. To estimate these six parameters, we apply the generalized method of moments (GMM) using annual data from Argentina. The sample period is 1900 to 2005.

Table 4: Estimated Structural Parameters

Parameter	Point Estimate	Standard Error
g	1.001	0.005
σ_g	0.030	0.004
ρ_g	0.399	0.048
σ_a	0.020	0.002
ρ_a	0.006	0.076
ϕ	0.580	0.161
Overidentifying Restrictions Test	p value	0.069

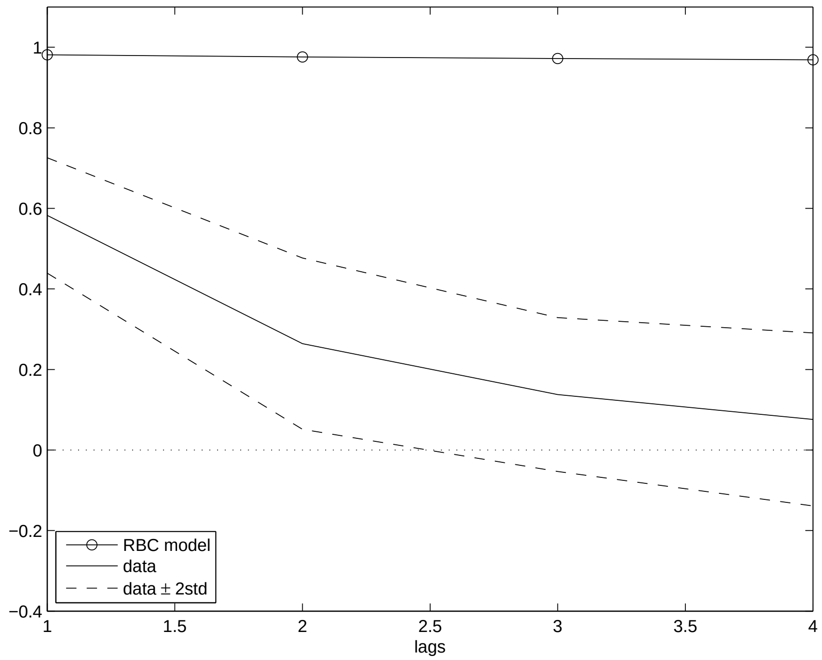
Note: GMM estimates.

(See appendix A for data sources.) We include 16 moment conditions: the variances and first- and second-order autocorrelations of output growth (g^Y), consumption growth (g^C), investment growth (g^I), and the trade balance-to-output ratio, (tby), the correlation of g^Y with g^C, g^I, and tby, and the unconditional mean of g^Y. (See appendix D for more details on the estimation procedure.) The estimated parameters are presented in table 4. The permanent shock, g_t, is estimated to be more volatile and persistent than the transitory shock a_t. The standard deviation and autoregressive coefficient of g_t are estimated with precision. The same is true for the standard deviation of a_t and for the adjustment cost parameter ϕ. However, the autoregressive coefficient of a_t is not significantly different from zero. The p value of the test of overidentifying restrictions, shown at the bottom of table 4, indicates that the null hypothesis that the 16 moment conditions included in the GMM estimation are nil is rejected at a confidence level of 6.9 percent.

5 Model Performance

Figure 3 presents the main result of this paper. It displays with circles the theoretical autocorrelation functions of the trade balance-to-output ratio. To facilitate comparison with the data, the figure reproduces with a solid line the corresponding estimated autocorrelation function, and with broken lines a two-standard-deviation confidence interval around the point estimate. All four autocorrelations predicted by the RBC model take values close to unity, indicating that in the model the trade balance-to-output ratio behaves as a near random walk. By contrast, the empirical autocorrelation function takes a value slightly below 0.6 at order one and then declines quickly toward zero, resembling a variable with a stationary autoregressive behavior. Further, the theoretical autocorrelation function lies

Figure 3: The Predicted Autocorrelation Function of the Trade Balance-to-Output Ratio



entirely outside the error band around the empirical point estimate. To understand why the trade balance displays quasi-random-walk dynamics in equilibrium, it is useful to think of an endowment economy in which the endowment follows a random walk process. Consider the response to an unanticipated innovation in the endowment. In response to this shock, consumption experiences a once-and-for-all increase about equal in size to the increase in the endowment, as households, realizing that the increase in endowment is permanent, feel no need to increase savings. It follows that the trade balance is more or less unaffected by the shock and, as a result, that the ratio of the trade balance to output inherits the random walk nature of the endowment process.

The flat nature of the autocorrelation function of the trade balance-to-output ratio is a more general property of the RBC model than figure 3 might suggest. In particular, it is not a consequence of the presence of a nonstationary productivity shock. We find that the autocorrelation function of tb/y continues to be horizontal even if the nonstationary productivity shock is shut down by setting $\sigma_g = 0$. The reason for this result is that with stationary productivity shocks, although output and investment become stationary variables, consumption follows a near random walk typical of small open economies.

Table 5 reports second moments implied by the theoretical model. To facilitate comparison, the table reproduces the empirical counterparts and their associated standard errors from table 2. In the RBC model, consumption growth is less volatile than output growth.

Table 5: Comparing Model and Data: Summary Statistics

Statistic	g^Y	g^C	g^I	*tby*
Standard Deviation				
– Model	6.1	4.5	13.5	17.6
– Data	5.3	7.5	20.4	5.2
	(0.4)	(0.6)	(1.8)	(0.6)
	**	***	***	***
Correlation with g^Y				
– Model		0.96	0.54	0.003
– Data		0.72	0.67	-0.04
		(0.07)	(0.09)	(0.09)
			**	
Correlation with *tby*				
– Model		-0.03	-0.08	
– Data		-0.27	-0.19	
		(0.07)	(0.08)	
		**		
Serial Correlation				
– Model	-0.31	-0.17	-0.17	0.98
– Data	0.11	-0.005	0.32	0.58
	(0.09)	(0.08)	(0.10)	(0.07)
	***		***	***

Note: g^Y, g^C, and g^I denote the growth rates of output per capita, consumption per capita, and investment per capita, respectively, and *tby* denotes the trade balance-to-output ratio. Standard deviations are reported in percentage points. Standard errors of sample-moment estimates are shown in parenthesis. One, two, or three asterisks indicate that the hypothesis that an individual theoretical moment equals its empirical counterpart is rejected at the 10, 5, or 1 percent confidence level, respectively, using the test proposed by Tauchen (1985).

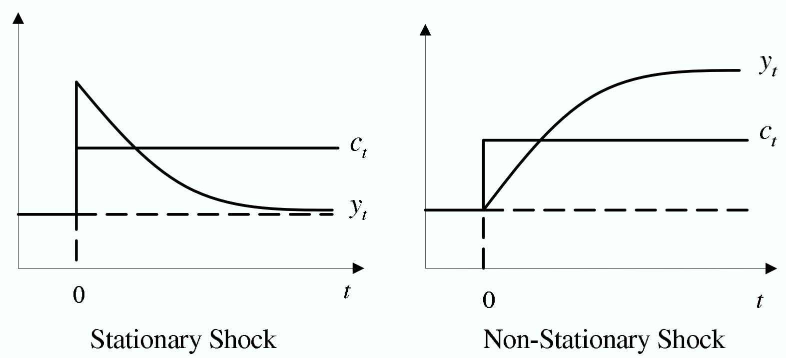


Figure 4: Stationary Versus Nonstationary Productivity Shocks

This prediction represents a significant difficulty of the estimated RBC model, as excess consumption volatility is a key characteristic of emerging economies. To understand why the model fails to replicate the observed high volatility of consumption, it is important to note that the consumption-output volatility ratio depends positively upon the importance of nonstationary shocks relative to stationary shocks in driving business cycles. Figure 4 builds some intuition behind this statement by displaying qualitatively the responses of output and consumption to transitory and permanent output shocks in a small open economy. A transitory productivity shock produces an increase in the level of current output followed by a gradual decline toward its pre-shock level. Because output is expected to fall in the future, it is optimal for consumption-smoothing households to save, causing consumption to increase by less than income. By contrast, in response to a positive and persistent shock to productivity growth, current output increases on impact and is expected to continue to grow in the future. This increasing profile for future expected income levels induces households to consume beyond the increase in current output. When both, trend stationary and permanent shocks to productivity are present, whether consumption growth turns out to be more or less volatile than output becomes a quantitative issue. In our estimated RBC model the tradeoff is resolved, counterfactually, in favor of consumption smoothing. As far as the volatility of consumption is concerned, therefore, the estimated model appears to assign too much importance to transitory shocks. The reason why the estimation procedure does not allocate a larger role to nonstationary shocks, is, or course, that the GMM technique sets parameter values to match a relatively large set of statistics (16 in our case), of which the volatilities of output and consumption growth are just two elements.

For instance, there is a dimension along which permanent productivity shocks appear to be too volatile in the estimated model. Namely, the volatility of the trade balance. In the data, the trade-balance share in output is about as volatile as output growth, where as in the model the trade-balance share is more than three times as volatile as output growth. Much of this discrepancy between data and model is due to the permanent component of productivity shocks. Shutting off the permanent productivity shock by setting σ_g equal to zero while holding constant all other parameter values results in a significant reduction in the volatility of the trade-balance share relative to the volatility of output growth.

Furthermore, there is a sense in which both the permanent and the transitory components of total factor productivity are estimated to be insufficiently volatile. For the model predicts too little volatility in investment growth. Higher volatility in either source of uncertainty would contribute to ameliorating this significant mismatch between data and model.

The RBC model correctly predicts a near-zero correlation between output growth and the trade balance-to-output ratio. However, it significantly underpredicts the negative correlations of the trade-balance share with private consumption growth as well as with investment growth. The fact that the trade-balance share is more correlated with the components of aggregate demand than with output growth may be an indication that shocks other than movements in total factor productivity could be playing a role in driving business cycles in Argentina. Finally, the RBC model incorrectly predicts negative autocorrelations of output and investment.

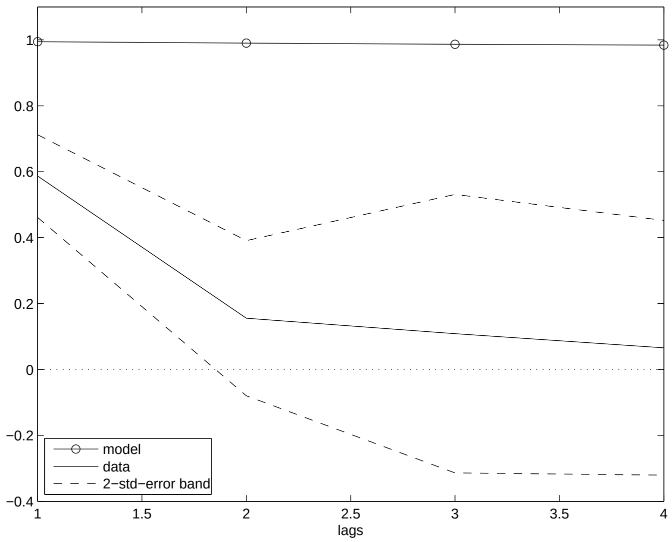
6 Robustness

To establish the robustness of our results, we examine the sensitivity of the predictions of the model to a number of perturbations to the theoretical structure, to the estimation procedure, and to the data sample.

6.1 The Postwar period

Figure 5 displays with a solid line the autocorrelation function of the trade balance-to-output ratio estimated over the subsample 1946-2005. Over the postwar period the autocorrelation function of the trade balance-to-output ratio takes a value of about 0.6 at order one and then decreases quickly toward zero, resembling the autocorrelation function of an AR(1) process. This is essentially the same pattern obtained under the longer bench mark sample. The figure also displays, with circles, the autocorrelation function of the trade balance-to-output ratio predicted by the model reestimated over the postwar period. In contrast to the data, the predicted autocorrelation function is flat and close to unity, as in a random walk process. It follows that the problem of excess persistence in the predicted behavior of the trade balance-to-output ratio continues to arise under a shorter sample that eliminates the

Figure 5: The Postwar Autocorrelation Function of TB/Y



early period 1900-1945.

A similar conclusion can be derived from examining other statistics of interest. Table 6 shows that most of the empirical regularities identified using the sample 1900-1946 also emerge when one restricts attention to the postwar period. In particular, consumption is more volatile than output, investment is significantly more volatile than output, and the correlation of the trade-balance share with output growth is negative but fairly modest. When estimated over the period 1946-2005, the RBC model fails to mimic the data along the same dimensions as when it is estimated using the baseline sample 1900-2005. In particular, the model counterfactually predicts consumption growth to be less volatile than output growth, investment growth to be significantly less volatile than its empirical counterpart, and the trade-balance ratio to be much more volatile than it is in the data.

6.2 Small Number of Overidentifying Restrictions

To gauge the sensitivity of our results to reducing the number of overidentifying restrictions, we eliminate all autocorrelations of order two from the moment conditions used in the GMM estimation. This modification reduces the total number of moment conditions from 16 to 12. The results appear in the column labeled ‘No AC Order 2’ in table 6. The implied dynamics of the model are virtually unaffected by the adoption of this alternative specification.

Table 6: Robustness Analysis

	Data	Bench-mark	No AC Order 2	Shares for Estimation	Cobb Douglas	$\gamma = 5$	1946-2005 Data	1946-2005 Model
				A. Standard Deviation				
g^Y	5.3	6.1	6.1	6.0	5.5	4.8	5.1	4.2
g^C	7.5	4.5	4.5	4.4	3.6	3.7	6.4	3.8
g^I	20.4	13.5	13.6	13.3	12.6	12.6	16.7	10.2
tby	5.2	17.5	17.5	17.5	19.4	23.3	3.0	16.1
				B. Correlation with g^Y				
g^C	0.72	0.96	0.96	0.96	0.49	0.96	0.90	0.98
g^I	0.67	0.54	0.54	0.54	0.00	0.57	0.s86	0.86
tby	-0.04	0.00	0.00	0.00	-0.01	-0.01	-0.23	-0.05
				C. Correlation with *tby*				
g^C	-0.27	-0.03	-0.03	-0.03	-0.20	-0.04	-0.24	-0.06
g^I	-0.19	-0.08	-0.08	-0.08	-0.22	-0.06	-0.32	-0.06
				D. Autocorrelation Function of *tby*				
1st Order	0.58	0.98	0.98	0.98	0.95	0.99	0.59	0.99
2nd Order	0.26	0.98	0.98	0.98	0.92	0.99	0.16	0.99
3rd Order	0.14	0.97	0.97	0.97	0.91	0.99	0.11	0.99
4th Order	0.08	0.97	0.97	0.97	0.90	0.99	0.07	0.99
				D. Autocorrelation Function of g^Y				
1st Order	0.11	-0.31	-0.30	-0.31	-0.19	-0.27	0.12	-0.10
2nd Order	-0.08	0.03	0.02	0.03	0.11	0.04	-0.17	0.02
3rd Order	-0.04	0.03	0.03	0.03	0.07	0.03	-0.02	0.05
4th Order	-0.05	0.02	0.02	0.02	0.04	0.03	0.04	0.05

Note: g^Y, g^C, and g^I denote the growth rates of output per capita, consumption per capita, and investment per capita, respectively, and *tby* denotes the trade balance-to-output ratio. Standard deviations are reported in percentage points.

6.3 Using Shares for Estimation

Our third sensitivity experiment consists in replacing the growth rates of consumption and investment by the shares of these variables in GDP in the GMM estimation. This modification is motivated by the fact that in the model consumption and investment are cointegrated with output. The results are shown in the column labeled 'Shares' in table 6. Both the fit and business-cycle implications of the model are similar whether it is estimated in growth rates or shares.

6.4 Cobb-Douglas Preferences

The column labeled 'Cobb Douglas Preferences' in table 6 displays the equilibrium dynamics implied by a version of the model featuring a Cobb Douglas specification for the aggregator of consumption and leisure in preferences. Formally, we assume that the utility function is given by

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

Unlike the preference specification assumed in the baseline model, the Cobb Douglas preference implies a nonzero wealth elasticity of labor supply. We set the parameter ω at 3.4 to ensure that in the deterministic steady state households supply 20 percent of their time to the labor market. We reestimate the structural parameters of the model following the same procedure as in the benchmark case.

Under Cobb-Douglas preferences, a positive (permanent) productivity shock produces a wealth effect that induces agents to reduce their labor supply.In fact, in response to a positive innovation in the permanent technology shock g_t hours fall under the Cobb Douglas specification, but increases under the baseline specification. The negative effect on labor supply mitigates the response of output. At the same time, a positive permanent productivity shock increases the future expected marginal productivity of capital inducing firms to invest more. But at the same time the negative wealth effect on labor supply and the fact that the marginal product of capital is increasing in labor imply that the incentives to invest in response to a positive permanent productivity shock are weaker under Cobb Douglas preferences than under the baseline preference specification.

The main effect of introducing Cobb-Douglas preferences is a dramatic decline in the procyclicality of investment growth. Indeed, under Cobb-Douglas preferences investment growth becomes virtually acyclical.

6.5 Lower Intertemporal Elasticity of Substitution

Finally, table 6 displays the case of a low elasticity of intertemporal substitution. This parameterization is motivated by the existence of empirical studies arguing that emerging-country aggregate data are consistent with relatively interest-inelastic consumption growth rates. Reinhart and Végh (1995), for example, using data from Argentina estimate γ to be 5. We compute the dynamics of the model using this parameter value. We find that the results obtained under the baseline parameterization are robust to increasing the curvature of the period utility function.

7 Conclusion

The present study scrutinizes the hypothesis that business cycles in developing economies are driven by permanent and/or transitory exogenous shifts in total factor productivity and transmitted through the familiar mechanism of the frictionless RBC model.

The starting point of our investigation is the notion that if permanent shocks are to play an important role in the macroeconomy, then long time series are called for both for characterizing business cycles, as well as for identifying the parameters defining the stochastic process of the underlying shocks. Accordingly, we build a data set covering more than a century of aggregate data from Argentina. We use these data to estimate a battery of statistics that provide a fairly complete picture of the Argentine business cycle. We then formulate a standard RBC model of the small open economy driven by permanent and transitory productivity shocks. We estimate the parameters of these productivity shock processes and other structural parameters of the model using our data from Argentina.

Comparing the predictions of the model with the data, we arrive at the conclusion that the RBC model does a poor job at explaining business cycles in Argentina. We place emphasis on the behavior of the trade balance-to-output ratio because this variable is at center stage in every empirical and theoretical account of aggregate fluctuations in emerging countries. In the model, the trade balance-to-output ratio follows a near random walk, with a flat autocorrelation function close to one. In the data, the autocorrelation of the trade-balance share is far below unity and converges quickly to zero. The presence of permanent shocks certainly contributes to this discrepancy. But not much. Shutting off the permanent shock results in only a small downward shift in the autocorrelation function of the trade-balance share.

Our test of the RBC model is not limited to the autocorrelation function of the trade balance. One challenge for the RBC model is the empirical fact that in Argentina, as in many other emerging countries, private consumption growth is more volatile than output growth. In order for the RBC model to explain this fact, permanent shocks to productivity must be sufficiently predominant. The econometric estimation does not assign permanent shocks this predominance. On the other hand, there is a sense in which permanent shocks are too important in the model. In effect, in the model the trade balance-to-output ratio is about four times as volatile as output growth, whereas in the data these two variables are equally volatile. This mismatch between model and data is due to the permanent component of productivity shocks. For shutting off this shock in the theoretical model causes the volatility of the trade balance-share to fall by about 75 percent.

Taken together, our findings suggest that the RBC model driven by productivity shocks does not provide an adequate explanation of business cycles in emerging countries like Argentina. We note, however, that all of the results reported in the present study are based on a joint hypothesis that the productivity shocks and the transmission mechanism built in the RBC model fit the data. Consequently, discerning whether the failure of the RBC model is to be blamed on productivity shocks or on the model's propagation mechanism remains a subject for future research.

Appendix

A. Data Sources

Argentina

GDP, Investment, Exports, and Imports

1900-1912: Ferreres (2005).

1913 - 1980: IEERAL (1986), table 2.

1981 - 1992: Dirección Nacional de Cuentas Nacionales (1996). Available at
`http://www.mecon.gov.ar/secpro/dir_cn/ant/contenido.htm`.

1993 - 2005: Secretearia de Politica Economica (2006). Available at
`http://www.mecon.gov.ar/peconomica/informe/indice.htm`.

Private Consumption:

1900-1912: Ferreres (2005).

1913 - 1980: IEERAL (1986), table 2.

1980 - 1992: República Argentina, Ministerio de Economía y Obras y Servicios Públicos (1994).

1993 - 2005: Secretearia de Politica Economica (2006). Available at
`http://www.mecon.gov.ar/peconomica/informe/indice.htm`.

Population:

1900-1912: Ferreres (2005).

1913 - 1949: IEERAL (1986), table 4.

1950 - 2005: CEPAL and INDEC (2004). Available at
`http://www.indec.gov.ar/principal.asp?id_tema=165`.

United States:

GDP

1900 - 1928: Romer, C.D. (1989).

1929 - 2005: Bureau of Economic Analysis. Available at
`www.bea.gov`.

Population

1900 - 2005: U.S. Census, Statistical Abstract of the United States. Available at
`http://www.census.gov/compendia/statab/population/`.

B. Optimality Conditions of the Household's Problem

Letting $\lambda_t X_{t-1}^{-\gamma}$ denote the Lagrange multiplier associated with the sequential budget constraint, the optimality conditions associated with this problem are (1), (2), the no-Ponzi-game constraint holding with equality, and

$$\left[C_t/X_{t-1} - \theta\omega^{-1}h_t^{\omega}\right]^{-\gamma} = \lambda_t$$

$$\left[C_t/X_{t-1} - \theta\omega^{-1}h_t^{\omega}\right]^{-\gamma}\theta h_t^{\omega-1} = (1-\alpha)a_t\left(\frac{K_t}{X_{t-1}h_t}\right)^{\alpha}\left(\frac{X_t}{X_{t-1}}\right)^{1-\alpha}\lambda_t$$

$$\lambda_t = \beta\frac{1+r_t}{g_t^{\gamma}}E_t\lambda_{t+1}$$

$$\begin{aligned}\left[1+\phi\left(\frac{K_{t+1}}{K_t}-g\right)\right]\lambda_t \quad &= \quad \frac{\beta}{g_t^{\gamma}}E_t\lambda_{t+1}\left[1-\delta+\alpha a_{t+1}\left(\frac{X_{t+1}h_{t+1}}{K_{t+1}}\right)^{1-\alpha}\right.\\ &\qquad \left. +\phi\left(\frac{K_{t+2}}{K_{t+1}}\right)\left(\frac{K_{t+2}}{K_{t+1}}-g\right)-\frac{\phi}{2}\left(\frac{K_{t+2}}{K_{t+1}}-g\right)^2\right]\end{aligned}$$

C. Equilibrium Conditions

Define $y_t = Y_t/X_{t-1}$, $c_t = C_t/X_{t-1}$, $d_t = D_t/X_{t-1}$, and $k_t = K_t/X_{t-1}$. Then, a stationary competitive equilibrium is give by a set of processes stationary solution to the following equations:

$$[c_t - \theta\omega^{-1}h_t^{\omega}]^{-\gamma} = \lambda_t$$

$$\theta h_t^{\omega-1} = (1-\alpha)a_t g_t^{1-\alpha}\left(\frac{k_t}{h_t}\right)^{\alpha}$$

$$\lambda_t = \frac{\beta}{g_t^{\gamma}}\left[1+r^*+\psi\left(e^{d_t-\bar{d}}-1\right)\right]E_t\lambda_{t+1}$$

$$\begin{aligned}\left[1+\phi\left(\frac{k_{t+1}}{k_t}g_t-g\right)\right]\lambda_t \quad &= \quad \frac{\beta}{g_t^{\gamma}}E_t\lambda_{t+1}\left[1-\delta+\alpha a_{t+1}\left(\frac{g_{t+1}h_{t+1}}{k_{t+1}}\right)^{1-\alpha}\right.\\ &\qquad \left. +\phi\frac{k_{t+2}}{k_{t+1}}g_{t+1}\left(\frac{k_{t+2}}{k_{t+1}}g_{t+1}-g\right)-\frac{\phi}{2}\left(\frac{k_{t+2}}{k_{t+1}}g_{t+1}-g\right)^2\right]\end{aligned}$$

$$\frac{d_{t+1}}{1+r_t}g_t = d_t - y_t + c_t + i_t + \frac{\phi}{2}\left(\frac{k_{t+1}}{k_t}g_t - g\right)^2 k_t,$$

$$r_t = r^* + \psi\left(e^{d_t-\bar{d}}-1\right),$$

$$k_{t+1}g_t = (1-\delta)k_t + i_t$$

$$y_t = a_t k_t^{\alpha}(g_t h_t)^{1-\alpha}$$

D. GMM Estimation Procedure

Let $b \equiv [g\,\sigma_g\,\rho_g\,\sigma_a\,\rho_a\,\phi]'$ be the 6×1 vector of structural parameters to be estimated. We write the moment conditions as:

$$u_t(b) = \begin{bmatrix} E_{gy}(b) - g_t^Y \\ \sigma_{gy}^2(b) - (g_t^Y - \bar{g}^Y)^2 \\ \sigma_{gc}^2(b) - (g_t^C - \bar{g}^C)^2 \\ \sigma_{gi}^2(b) - (g_t^I - \bar{g}^I)^2 \\ \sigma_{tby}^2(b) - (tby_t - \overline{tby})^2 \\ \rho_{gy,gc} - \frac{(g_t^Y - \bar{g}^Y)(g_t^C - \bar{g}^C)}{\sigma_{gy}(b)\sigma_{gc}(b)} \\ \rho_{gy,gi} - \frac{(g_t^Y - \bar{g}^Y)(g_t^I - \bar{g}^I)}{\sigma_{gy}(b)\sigma_{gi}(b)} \\ \rho_{gy,tby} - \frac{(g_t^Y - \bar{g}^Y)(tby_t - \overline{tby})}{\sigma_{gy}(b)\sigma_{tby}(b)} \\ \rho_{gy1}(b) - \frac{(g_t^Y - \bar{g}^Y)(g_{t-1}^Y - \bar{g}^Y)}{\sigma_{gy}^2(b)} \\ \rho_{gy2}(b) - \frac{(g_t^Y - \bar{g}^Y)(g_{t-2}^Y - \bar{g}^Y)}{\sigma_{gy}^2(b)} \\ \rho_{gc1}(b) - \frac{(g_t^C - \bar{g}^C)(g_{t-1}^C - \bar{g}^C)}{\sigma_{gc}^2(b)} \\ \rho_{gc2}(b) - \frac{(g_t^C - \bar{g}^C)(g_{t-2}^C - \bar{g}^C)}{\sigma_{gc}^2(b)} \\ \rho_{gi1}(b) - \frac{(g_t^I - \bar{g}^I)(g_{t-1}^I - \bar{g}^I)}{\sigma_{gi}^2(b)} \\ \rho_{gi2}(b) - \frac{(g_t^I - \bar{g}^I)(g_{t-2}^I - \bar{g}^I)}{\sigma_{gi}^2(b)} \\ \rho_{tby1}(b) - \frac{(tby_t - \overline{tby})(tby_{t-1} - \overline{tby})}{\sigma_{tby}^2(b)} \\ \rho_{tby2}(b) - \frac{(tby_t - \overline{tby})(tby_{t-2} - \overline{tby})}{\sigma_{tby}^2(b)} \end{bmatrix},$$

where $Ex(b)$ denotes the expected value of the variable x_t implied by the theoretical model, $\sigma_x(b)$ denotes the standard deviation of x_t implied by the theoretical model, $\rho_{xy}(b)$ denotes the correlation between x_t and y_t implied by the theoretical model, and ρ_{xj} denotes the autocorrelation of order j of x_t implied by the theoretical model. All of these statistics are functions of the vector b of structural parameters. We denote by $\bar{x} \equiv T^{-1}\sum_{t=1}^{T} x_t$ the sample mean of x_t, where T is the sample size. We compute moments implied by the theoretical model by solving a linearized version of the system of equilibrium conditions with respect to the logarithm of all variables except the trade-balance share in GDP, which we keep in levels.

Define $J(b, W) = \bar{u}'W\bar{u}$, where $\bar{u}(b)$ denotes the sample mean of $u_t(b)$ and W is a symmetric positive definite matrix compatible with $\bar{u}(b)$. The GMM estimate of b, denoted $\hat{b}$, is given by

$$\hat{b} = \operatorname*{argmin}_{b} J(b, W).$$

The matrix W is estimated in two steps. For more details see Burnside (1999).

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