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Business Cycles in Emerging Economies: The Role of Interest Rates

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Abstract

This paper documents the empirical relation between the interest rates that emerging economies face in international capital markets and their business cycles. It shows that the patterns observed in the data can be interpreted as the equilibrium of a dynamic general equilibrium model of a small open economy, in which (i) firms have to pay for a fraction of the input bill before production takes place, and (ii) preferences generate a labor supply that is independent of the interest rate.

In our sample, interest rates are strongly countercyclical, strongly positively correlated with net exports, and they lead the cycle. Output is very volatile and consumption is more volatile than output. The sample includes data for Argentina during 1983-2000 and for four other large emerging economies, Brazil, Mexico, Korea, and Philippines, during 1994-2000.

The model is calibrated to Argentina's economy for the period 1983-1999. When the model is fed with actual US interest rates and the actual default spreads of Argentine sovereign interest rates, interest rates alone can explain forty percent of output fluctuations. When simulated technology shocks are added to the model, it can account for the main empirical regularities of Argentina's economy during the period. A 1% increase in country risk causes a contemporaneous fall in output of 0.5 'subsequent recovery. An increase in US rates causes output to fall by the same on impact and by almost 2% two years after the shock. The asymetry in the effect of shocks to US rates and country risk is due to the fact that US interest rates are more persistent than country risk and that there is a significant spillover effect from US interest rates to country risk.

1. Introduction

In recent years the economies of emerging countries have faced large disturbances in the conditions they face in international financial markets. This paper documents the relation between the interest rates faced by emerging economies in these markets and the empirical regularities of their business cycles. The data shows that increases in interest rates are associated with large output declines and with increases in their net exports (see figures 1 and 4). We also find weak evidence that interest rates lead the cycle. In contrast, interest rates in Canada and the United States are acyclical and lag the cycle.

In an influential paper that studies international evidence on the historical properties of business cycles Backus and Kehoe (1992) found that "although the magnitude of output fluctuations has varied across countries and periods, relations among real quantities have been remarkably uniform." Our investigation of business cycles in five emerging countries confirms this finding. Although output in these economies is much more volatile than in the US and Canada during the same period, the behavior of consumption, investment and net exports during the cycle is pretty much the same as in the Backus and Kehoe dataset[1]. An interesting feature of the emerging country data is that in the emerging economies we study consumption is consistently more volatile than output. We attribute the excess volatility of consumption to the dominant role played by interest rate shocks in these economies. If transitory technology shocks where dominant, the permanent income hypothesis implies that consumption would be smoother than income.

The evidence on the strong correlation between interest rates and net exports shown in figures 2 and 4 also highlights the key role played by interest rates in the allocation of

[1] Australia, Canada, Denmark, Germany, Italy, Japan, Norway, Sweden, United Kingdom, Uniteed States.

resources. During periods with high interest rates agents have incentives to save more and invest less, which are reflected in the net export data. This data set lends strong support to the intertemporal approach to the current account (see Obstfeld and Rogoff, 1995).

The important role played by interest rate shocks in the business cycle of emerging economies contrasts with the significance of these shocks in dynamic general equilibrium models. Quantitative exercises performed in this class of models show that interest rate disturbances do not play a significant role in driving business cycles (see Mendoza 1991, and 1995, Correia et. al 1995). Moreover, in these models interest rates are either acyclical or procyclical, while consumption is less volatile than output. As these properties of existing models are at odds with the data, one of the objectives of this paper is to reconcile theory and data.

We show that the empirical regularities found in the emerging country data can be interpreted as equilibrium relations in a model subject to shocks to international (US) interest rates, country risk, and technology shocks. The key departure from the standard dynamic general equilibrium model that generates this result is that firms have to pay for part of the factors of production before production takes place. Another important assumption of the model (common in the small open economy business cycle literature) is that preferences generate a labor supply that is independent of the interest rate.

The rational for these two assumptions is best understood through the production function. As output is equal to a function of labor and capital and at business cycle frequencies the capital stock is relatively stable, fluctuations in output stem mainly from fluctuations in employment. Under our two assumptions the labor supply is independent of interest rates and interest rates shift the labor demand.

The lack of synchronization between the payments and the receipts of firms makes the the demand for inputs sensitive to the interest rate. Since firms have to borrow to pay for inputs, increases in the interest rate make their effective cost higher and reduce their demand. As a result, in equilibrium, there is a wedge between the consumption-leisure marginal rate of substitution and the marginal product of labor that is proportional to the real interest rate these countries face in international financial markets.

The household's preferences employed in the simulations we report are described by the functional form proposed by Greenwood, Hercovitz, and Huffman (1988), and are often used in open economy dynamic general equilibrium models (Mendoza and Correia et al (op. cit.)). These preferences insulate labor supply decisions from interest rates. Other frequently used functional forms like the Cobb-Douglas formulation cause the labor supply to increase when interest rates go up.

The model is calibrated to Argentina's economy for the period 1983-1999. When the model is fed with actual US interest rates and the actual default probabilities implied by Argentine rates, interest rates alone can explain forty percent of output fluctuations. On impact a 1% shock in country risk causes a fall in output of 0.5% of trend and an increase in net exports of about 1% of GDP. Shocks to US interest rates have the same impact effect, but since they are more persistent and they spillover to country risk, their maximum impact occurs two quarters after the shock. The maximal impact of a shock to US rates on GDP is of almost 2% of trend two years after the shock, and its effect on net exports reaches over 2.5% of GDP two quarters after the shock. When simulated technology shocks are added to the model, it can account for the main empirical regularities (second moments of national account components and interest rates) of the Argentina's economy during the period.

The quantitative exercise carried out in this paper focuses on the case of Argentina because it is the country for which the longest relevant interest rate series is available. The quantitative general equilibrium literature on business cycles in Argentina is largely focused on the business cycle associated to exchange rate based stabilization plans (see Rebelo and Vegh, 1995, and Calvo and Vegh, 1998). Rebelo and Vegh show that current theories cannot account for the magnitude of the fluctuations in economic activity observed during exchange rate based stabilization plans. The quantitative exercise carried out in this paper implies that fluctuations in country risk might provide the amplification mechanism needed to reconcile data and theory. The two exchange rate based stabilization plans that fall within our sample are the Austral Plan that started in June 1985 and the Convertibility Plan that started in April 1991. In both events the business cycle expansion was lead by falls in the real interest rate faced by Argentina in world markets. It is possible that the reforms associated with these stabilization plans and their probability of success, reduced the probability assigned to an Argentine default. The resulting fall in interest rates was an important factor in the economic expansion that followed the plans. Conversely, the increased country risk at the end of the Austral plan increased interest rates and induced a recession.

In a related paper Agenor (1997) argues that a model with a friction similar to ours that is consistent with the qualitative properties of the Argentine business cycle in the aftermath of the Tequila crisis. Avila (1998) provides an econometric analysis of the relation between interest rates and country risk that is consistent with our findings.

In the closed economy literature, Cooley and Hansen (1989) and Christiano and Eichenbaum (1991) study the effect of a distortion very similar to ours on business cycles. In Cooley and Hansen, a cash-in-advance constraint creates a wedge between the consumption-leisure marginal rate of substitution and the marginal product of labor that is equal to the nominal interest rate (the inflation tax). Christiano and Eichenbaum create this wedge, as we do, by assuming that firms must borrow working capital to finance labor costs. In our experiment real interest rates affects the same margin as in the articles cited above, but have different effects due to the different specification of preferences. It is worth emphasizing that our model is non-monetary and the distortion introduced by the firm's need for working capital depends on real interest rates. If we had used nominal interest rates in our model, the simulated volatility of output would have been too large relative the data in the 1980's (Argentine inflation was extremely volatile in the 1980's, see Neumeyer, 1998) and too small in the 1990's (inflation has been virtually zero since 1992)[2].

2. Interest Rates and Business Cycles in Emerging Economies

This section documents empirical regularities about business cycles and interest rates in five open emerging economies: Argentina, Brazil, Korea, Mexico, and Philippines. To enable comparison we also document the same facts for Canada, a developed small open economy that has been widely studied. In all the five emerging economies we study: (i) output is at least twice as volatile as it is in Canada, (ii) consumption is more volatile than output (while in Canada it is less volatile), (iii) interest rates are strongly countercyclical (while in Canada they are weakly procyclical) , and (iv) interest rates lead the cycle or are coincidental with the cycle (while in Canada they lag the cycle). In three out of the five emerging economies interest rates are much more volatile than in Canada.

[2] Uribe (1995) uses the same margin as Cooley and Hansen, with a nominal distortion, to generate the output expansion that follows an exchange rate based stabilization plan.

A. Interest Rates

The interest rate that corresponds to the theoretical model presented below is the expected three month real interest rate at which firms and households can borrow. We chose to look at interest rates on US Dollar denominated financial contracts because as inflation in these countries was very volatile during the sample period, it is very difficult to recover ex-ante real interest rates from domestic currency nominal interest rates. Expected real interest rates were computed by subtracting expected US inflation from these interest rates. For Canada we use Canadian Dollar government bonds and Canadian inflation. Implicit in our analysis is the assumption that the measurement error stemming from deviations from purchasing power parity is smaller than the error in measuring inflation expectations (inflation in Argentina, for example, varies from over 30% per month in some months to 0% the following period)[3]. We use data on secondary market prices of emerging market bonds to recover nominal US dollar interest rates because during financial crises these countries do not borrow and recorded interest rate data on new loans may not reflect the true intertemporal terms of trade they face; the price at which investors are willing to hold emerging market bonds does. The lack of time series data on emerging market bond prices constrains the set of countries and sample periods we can study.

Our data set includes quarterly data for Argentina and Canada for the period 1983.2-2002.2, and quarterly data for Argentina, Brazil, Korea, Mexico and Philippines between 1994.1 and 2000.2. As far as we know, Argentina is the only country for which there is data on

[3] This approach is conservative since taking into account deviations from PPP would increase the negative correlation between output and interest rates. Since the relative price of non-traded is procyclical, real interest rates measured in a composite basket of traded and non-traded goods would be higher in recessions and lower in booms.

bond prices going back to the 1980's since it issued four 10 year dollar denominated sovereign coupon bonds between 1980 and 1984. We use data on Argentine bond prices and US treasury strips to estimate the yield of an hypothetical constant maturity three month zero coupon Argentine sovereign bond using a methodology developed by Alvarez, Buera and Neumeyer (1999) described in the appendix[4]. Liquid secondary markets for other emerging country US dollar denominated debt developed only after the first Brady plan in 1990. We look at Argentina, Brazil, Korea, Mexico and Philippines because they are the non-oil exporting countries with the longest data series in the Emerging Markets Bond Index Plus (EMBI+) dataset constructed by J. P. Morgan[5]. The sovereign spreads are measured by an average of the spread of different US Dollar denominated sovereign bonds issued by each country over US treasury bonds of comparable duration weighted by their market capitalization. The bonds included in the index are liquid bonds with a credit rating lower than BBB+/Baa1. The spread duration of the country sub-indices range from 4 to 7 years during the sample period. We construct the US Dollar denominated nominal interest rates faced by these countries by adding the sovereign spread implicit in the EMBI+ to the 3 month US treasury bill.

As a diagnostic check, we compared the interest rate we estimated for Argentina with the yield to maturity on the EMBI+ Argentina sub-index, and with the 90 day prime corporate rate for Argentina for US Dollar denominated loans. The latter rate is the average interest rate reported by 16 Argentine banks to the central bank for loans to prime corporations in Argentina and is available since January of 1994. The correlation between the

[4] In the data as the Argentine bonds approach their maturity, the spread over similar US treasury bonds converges to zero even though the conuntry risk for longer maturity bonds does not. Hence, the necessity to estimate the yield of a constant maturity bond.

[5] The missing data in the EMBI+ was obtained from the EMBI Global.

interest rate series estimated for the 1982-2000 sample for Argentina and the one constructed from the EMBI+ in the common sample period is over 95%. Figure 4 shows that the EMBI rate and the corporate rate move together, and their correlation is around 85%. The EMBI rate is higher because the average spread duration in the Argentine EMBI since 1994 is over 4 years and the interest rates in the figure are for 90 day loans.

B. Interest Rates and Business Cycles in Argentina: 1983-2000

As Argentina is the country with the longest data series for interest rates we start by looking at the empirical regularities of interest rates and business cycles in Argentina. The Argentine data displays the facts mentioned above: (i) output is very volatile (relative to Canada), (iii) consumption is more volatile than output, (iii) interest rates and output are negatively correlated, (iv) interest rates lead the cycle, and (v) interest rates are very volatile (relative to Canada). Abstracting from these facts, business cycles in Argentina are similar to other countries (as was also documented by Kydland and Zarazaga, 1997). Figure 1, which shows the relation between interest rates and output in Argentina illustrates many of these properties. Another striking feature of the Argentine data is its strong support for the intertemporal approach to the current account, which is shown in Figure 2.

Table 1: Argentine Business Cycles: 1983:2- 2000:2

	% Standard Dev.			$\frac{\text{\%Standard Dev of x}}{\text{\%Standard Dev. of GDP}}$			
	GDP	NX	R	Con	Inv	Emp	Hrs
Argentina	4.24	1.41	3.39	1.17	3.00	0.43	0.58
Canada	1.30	0.74	1.48	0.88	2.83	0.98	1.06

Table 1 reports the percentage standard deviations from trend[6] of the quarterly time series for the main macroeconomic variables in Argentina for the period 1983.2-2000.2. To enable comparison we report also the same statistics for the same period for Canada, a non emerging open economy that has been widely studied.

The table confirms the high volatility of output that characterize the Argentine cycle (over three times the Canadian level). Real interest rates and net exports in Argentina are roughly twice as volatile as in Canada. The relative volatility of employment[7] is lower than that observed in Canada while the relative volatility of investment is higher. Consumption is more volatile than output in Argentina, while in Canada it is less volatile[8].

Table 2: Argentine Business Cycles: 1983:2- 2000:2

	Correlation of x with GDP					
	R	NX	Con	Inv	Emp	Hrs
Argentina	-0.59	-0.90	0.96	0.93	0.37	0.41
Canada	0.28	0.02	0.87	0.65	0.84	0.96

	Correlation of x with R					
	GDP	NX	Con	Inv	Emp	Hrs
Argentina	-0.59	0.66	-0.64	-0.58	-0.35	-0.52
Canada	0.28	0.22	0.28	0.01	0.25	0.25

[6] All variables are log deviations from Hodrick-Prescott trend except for Net Exports, which is the deviation of Net Exports over GDP from the Hodrick-Prescott trend.

[7] The employment series for Argentina is the number of employed people working at least 35 hours per week and it is reported at a semiannual frequency. Hours is the number of employed people times the average number of hours worked in greater Buenos Aires.

The employment series for the US is taken from the Bureau of Labor Statistics establishment survey. It is for non-farm employment and the aggregate inder of hours. It is converted to a semiannual frequency to make it comparable to Argentina's statistics.

In both cases, the standard deviation reported is relative to the standard deviation of semiannual GDP.

[8] Prior to 1993, Argentine data for consumption includes private and public consumption, changes in inventories and statistical discrepancy. The Canadian variable is the analogue of the Argentine consumption variable. The fact that consumption is more volatile than output in Argentina persists in the sample without measurement error after 1993 as it is shown below.

Table 2 reports the correlation of the same variables with GDP and real interest rate. It confirms the negative contemporaneous correlation between interest rates and GDP observed in Figure 1 and the strong correlation between net exports and interest rates shown in Figure 2. The table also shows that Argentine business cycles are similar to those of other countries since consumption, investment, and employment are procyclical and the current account is countercyclical. These facts and the countercyclical interest rates are also reflected in the negative correlation between interest rates and consumption, investment, and employment. In contrast, in the Canadian data, interest rates are positively correlated with GDP, consumption, investment and employment.

Table 3 reports cross correlations of GDP with leads and lags of the real interest rate for Argentina and Canada, with standard errors between parenthesis.

Table 3: Argentine Business Cycles: 1983:2- 2000:2

(Cross-correlations of GDP(t) with)

	R(t-3)	R(t-2)	R(t-1)	R(t)	R(t+1)	R(t+2)	R(t+3)
Argentina	-0.62	-0.66	−0.73	-0.59	-0.42	-0.31	-0.07
	(0.09)	(0.10)	(0.11)	(0.11)	(0.11)	(0.15)	(0.16)
Canada	-0.22	-0.07	0.09	0.28	0.41	0.41	0.39
	(0.16)	(0.15)	(0.15)	(0.14)	(0.13)	(0.14)	(0.14)

Standard errors estimated with GMM are reported in parenthesis.

The table shows that interest rates in Argentina lead the business cycle. The highest correlation coefficient between interest rates and GDP occurs for the interest rate in $t-1$

and the GDP at t, indicating a one quarter phase shift in the interest rate cycle. The cross cross-correlations between interest rates and GDP is always negative and standard errors are relatively small. The interest rate in Canada, on the other hand, lags the cycle by at least a quarter.

C. Interest Rates and Business Cycles: Argentina, Brazil, Korea, Mexico and Philippines: 1994-2000

The data on Brazil, Korea, Mexico and Philippines for the period 1994.1 2000.2 confirms the findings for Argentina. Figure 3 shows the relation between interest rates and GDP for these three countries, Argentina and Canada and shows that interest rates are countercyclical in all the cases except Canada.

Table 4 shows that the volatility of output, interest rates and consumption. In the five emerging economies in the sample output volatility ranges from 2 to 5 times the volatility of Canadian output. A second feature of these table is that consumption is at least as volatile as output in the four emerging economies for which we have data, while in Canada, the volatility of consumption is only two thirds the volatility of GDP. The volatility of consumption of non-durable goods and of services relative to output in Korea and Mexico is still much larger than in Canada. Finally, in three out of the five emerging economies interest rates are much more volatile than in Canada.

The cyclical properties of interest rates for this dataset are shown in table 5, which reports the correlation of GDP with leads and lags of the interest rate.

Table 5 shows that, in the sample period that ranges from the first quarter of 1994 to the

Table 4: Business Cycles in Five Emerging Economies: 1994-2000
(Percentage Standard Deviations)

1994.1-2000.2	SD GDP	SD Int. Rate	$\frac{\text{SD Cons}}{\text{SD GDP}}$	$\frac{\text{SD CNDS}}{\text{SD GDP}}$
Canada	0.63	1.57	0.67	0.31
Argentina	3.23	2.83	1.05	NA
Brazil	1.55	2.76	N.A.	NA
Korea	3.86	1.39	1.29	0.79
Mexico	3.11	2.82	1.25	0.93
Philippines	1.44	1.43	1.02	NA

Table 5: Business Cycles in Five Emerging Economies: 1994-2000
(Cross-correlations of GDP(t) with)

	R(t-3)	R(t-2)	R(t-1)	R(t)	R(t+1)	R(t+2)	R(t+3)
Argentina	-0.74	**−0.83**	-0.79	-0.55	-0.25	-0.05	0.15
	(0.14)	(0.12)	(0.09)	(0.15)	(0.22)	(0.20)	(0.17)
Brazil	-0.03	-0.20	-0.33	**−0.38**	-0.22	-0.16	-0.24
	(0.21)	(0.22)	(0.19)	(0.30)	(0.30)	(0.23)	(0.20)
Korea	-0.34	-0.52	-0.65	**−0.68**	-0.59	-0.37	-0.06
	(0.17)	(0.17)	(0.19)	(0.17)	(0.14)	(0.16)	(0.20)
Mexico	-0.46	-0.66	**−0.78**	-0.52	-0.12	0.16	0.45
	(0.16)	(0.15)	(0.12)	(0.15)	(0.28)	(0.32)	(0.27)
Philippines	-0.31	-0.45	**−0.67**	-0.58	-0.58	-0.50	-0.23
	(0.23)	(0.23)	(0.14)	(0.14)	(0.13)	(0.14)	(0.19)
Canada	-0.07	-0.09	0.01	0.21	0.28	**0.32**	0.28
	(0.13)	(0.17)	(0.23)	(0.27)	(0.27)	(0.23)	(0.19)

Standard errors estimated with GMM are reported in parenthesis.

second quarter of 2000, in all the emerging economies interest rates are countercyclical while in Canada they are acyclical. In Argentina, Mexico and Philippines the interest rate leads the cycle, while in Brazil and Korea the interest rate is coincidental with the cycle. In spite of the small sample the standard errors of the estimators of the cross-correlations are relatively small.

3. Model

This section describes an economic environment in which the empirical regularities established in the preceding section can be interpreted as the equilibrium of a small open economy subject to shocks to total factor productivity, international interest rates (US rates) and country risk.

The interest rate faced by domestic borrowers, R, is given by

(1) $$R(s^t) = R^{US}\left(s^t\right) D(s^t)$$

where the state of the economy in period t is represented by s^t, and D measures the spread paid by domestic residents over the international risk free real interest rate, R^{US}. This measure of country risk, D, will be greater than one when risk neutral investors give a a positive probability to the event that their loans will not be paid back in full.

Agents in the domestic economy are households, firms and financial intermediaries. Domestic firms and households are restricted to trade financial assets only with domestic financial intermediaries, who borrow from foreigners at a rate $R(s^t)$. Perfect competition between intermediaries implies that the lending and borrowing rates faced by domestic households and firms are equal to $R(s^t)$. Country risk stems from assuming that there is a probability that each financial intermediary is going to default on a fraction of its liabilities[9]. Loans made by financial intermediaries to firms have no cost, while there is a cost of intermediation between foreign investors and households.[10]

Firms transform labor and capital into a final good using the technology

$$(2) \quad y\left(s^t\right) = A\left(s^t\right)\left[k\left(s^{t-1}\right)\right]^{\alpha}\left[(1+\gamma)^t l\left(s^t\right)\right]^{1-\alpha}$$

where $y\left(s^t\right)$ denotes output in state s^t, A is a random technology shock, k is the stock of capital, l is labor and γ is the rate of labor augmenting technical change.

The transactions technology requires firms to pay for a fraction of factor inputs before production takes place: firms need working (or circulating) capital to conduct their business. In each period there are three sub-periods: a financial market trading session, a factor market trading session and a final good market trading session.

Let $w\left(s^t\right)$ and $r\left(s^t\right)$ be the wage rate and the rental rate for capital in state s^t, μ_l, μ_k be the fraction of the wage bill and of the capital bill that firms have to pay up-front in the factor market, and $b\left(s^t\right)$ the quantity of bonds purchased in state s^t that pay a unit of the final good in every state at $t+1$.

[9] We think of this as a tax imposed by the government on bank creditors. Let the processes for the probability of default, $p\left(s^t\right)$, and the default rate, $\tau\left(s^t\right)$, be stochastic and exogenously given. Assuming foreigners are risk-neutral and that they lend positive amounts to the intermediaries, interest rates paid by the intermediaries must satisfy the condition

$$R^{US}\left(s^t\right) = \left(1 - p\left(s^t\right)\right) R\left(s^t\right) + p\left(s^t\right)\left(1 - \tau\left(s^t\right)\right) R\left(s^t\right),$$

which implies that $D\left(s^t\right) = 1/\left(1 - p\left(s^t\right)\tau\left(s^t\right)\right)$.

[10] A small cost of intermediation between households and foreigners is needed because otherwise the model has multiple steady states (the bond holdings are not determined) and bond holdings are not a stationary variable.

In the financial market trading session firms borrow $\mu_l w(s^t) l(s^t) + \mu_k r(s^t) k(s^{t-1})$ units of the final good from banks, households receive $b(s^{t-1})$ units of the good from the bonds purchased in s^{t-1} and spend $R(s^t)^{-1} b(s^t)$ units of goods on the purchase of bonds maturing in $t+1$. Domestic financial intermediaries borrow $\mu_l w(s^t) l(s^t) + \mu_k r(s^t) k(s^{t-1}) + R^{-1}(s^t) b(s^t) - b(s^{t-1})$ from foreign investors, which they lend domestically at a zero profit. In the factor market trading session firms hire $l(s^t)$ and $k(s^{t-1})$ units of labor and capital, paying $\mu_l w(s^t) l(s^t) + \mu_k r(s^t) k(s^{t-1})$ to households up-front. In the goods market trading session firms sell $y(s^t)$ units of the good, pay $(1-\mu_l) w(s^t) l(s^t) + (1-\mu_k) r(s^t) k(s^{t-1})$ to households and keep $y(s^t) - (1-\mu_l) w(s^t) l(s^t) + (1-\mu_k) r(s^t) k(s^{t-1})$ to settle the debt they incurred in the financial market trading session. In the financial trading session in the following period firms use their leftover output to pay $[\mu_l w(s^t) l(s^t) + \mu_k r(s^t) k(s^{t-1})] R(s^t)$ for the working capital they borrowed. Households use their income from renting their labor and capital in consumption, $c(s^t)$, investment $x(s^t)$ and they also pay a cost, $\kappa(s^t)$, on their bond holdings (more on this later).

The goods produced by domestic firms and not purchased by domestic residents are the country's net exports, given by

$$nx(s^t) = y(s^t) - c(s^t) - x(s^t) - \kappa(s^t) \tag{3}$$

The profits of the firm in terms of state s^{t+1} goods are

$$\begin{aligned} \text{profits} &= y(s^t) - \left[w(s^t) l(s^t) + r(s^t) k(s^{t-1})\right] \\ &\quad - \left[\mu_l w(s^t) l(s^t) + \mu_k r(s^t) k(s^{t-1})\right]\left[R(s^t) - 1\right]. \end{aligned} \tag{4}$$

This profits correspond to the production carried out in period t, but are expressed in terms of period $t+1$ goods. The term $(R(s^t)-1)\left[\mu_l w(s^t)l(s^t)+\mu_k r(s^t)k(s^{t-1})\right]$ represents the interest firms pay on the inputs paid before production takes place.

For convenience, we detrend variables that grow in steady state. Let variables with a hat be $\hat{x}\left(s^t\right)=x\left(s^t\right)(1+\gamma)^{-t}$ (for k and b, $\hat{x}\left(s^{t-1}\right)=x\left(s^{t-1}\right)(1+\gamma)^{-t}$).

Representative households spend the goods they obtained in the financial markets trading session and income from renting the factors of production to firms on consumption, investment, and bond holding costs. Their budget constraint is,

$$(5)\quad \hat{c}(s^t)+\hat{x}(s^t)+\frac{1+\gamma}{R\left(s^t\right)}\hat{b}(s^t)+\hat{\kappa}\left(s^t\right)\leq\hat{w}(s^t)l(s^t)+r(s^t)\hat{k}(s^{t-1})+\hat{b}(s^{t-1})$$

for all s^t, where $\hat{\kappa}\left(s^t\right)=\frac{\kappa}{2}\left(\hat{b}(s^{t-1})-\bar{b}\right)^2/\hat{y}\left(s^t\right)$. The term $\hat{\kappa}\left(s^t\right)$ represents a quadratic cost of holding a quantity of bonds different from $\bar{b}$ (that will be the steady state debt). This cost of intermediation is paid to domestic financial intermediaries, who use these resources to cover their cost of intermediating between foreign investors and households[11].

The capital accumulated by households must satisfy the technological constraint

$$(6)\quad (1+\gamma)\,\hat{k}(s^t)=(1-\delta)\hat{k}(s^{t-1})+\hat{x}(s^t)+\hat{\Phi}(k(s^t),k(s^{t-1}))$$

for all s^t, where the function Φ represents the cost of adjusting the capital stock. We assume

[11] This is needed because otherwise the model has multiple steady states (the bond holdings are not determined) and bond holdings are not a stationary_variable. By adding this term the steady state value of bond holding is uniquely determined and equal to b. We also divide the cost by steady state GDP so that in presence of long term growth this cost grows at the same rate as other variables in the economy.

the adjustment cost function is

$$\hat{\Phi}\left(\hat{k}\left(s^{t}\right), \hat{k}\left(s^{t-1}\right)\right)=\frac{\phi}{2}(1+\gamma)^{2} \frac{(\hat{k}(s^{t})-\hat{k}(s^{t-1}))^{2}}{\hat{k}(s^{t-1})}$$

Adjustment costs such as these are commonly used in the business cycle literature of small open economies in order to match the volatility of investment found in the data.

Consumer's preferences are described by the expected utility

$$\sum_{t=0}^{\infty} \sum_{s^{t}} \beta^{t} \pi\left(s^{t}\right) u\left(\hat{c}\left(s^{t}\right), l\left(s^{t}\right)\right), \tag{7}$$

where $\pi\left(s^{t}\right)$ is the probability of event s^{t} occurring conditional on the information set at time $t=0$. We assume that the period utility function takes the form[12]

$$u(\hat{c}, l)=\frac{1}{1-\sigma}\left[\hat{c}-\psi l^{v}\right]^{1-\sigma}, v>1, \psi>0 \tag{8}$$

We also analyze how the results change if we consider the Cobb-Douglas utility function

$$u(\hat{c}, l)=\frac{1}{1-\sigma}\left[\hat{c}^{\mu}(1-l)^{(1-\mu)}\right]^{1-\sigma}, 0<\mu<1. \tag{9}$$

In equilibrium, the markets for factor inputs clear, firms choose capital, $k\left(s^{t-1}\right)$, and

[12] Preferences in the non stationary economy are

$$\sum_{t=0}^{\infty} \sum_{s^{t}}\left(\frac{\beta}{(1+\gamma)^{1-\sigma}}\right)^{t} \pi\left(s^{t}\right) \frac{1}{1-\sigma}\left[c\left(s^{t}\right)-(1+\gamma)^{t} \psi l^{v}\right]^{1-\sigma}$$

with $0<\beta>(1+\gamma)^{1-\sigma}$.

labor, $l(s^t)$, in order to maximize profits, (4), subject to the technological constraint, (2), and households choose the state contingent sequence of consumption, $c(s^t)$, leisure, $l(s^t)$, bond holdings, $b(s^t)$, and investment, $x(s^t)$, that maximize the expected utility (7) subject to the sequence of budget constraints (5), the capital accumulation constraints (6), a no Ponzi game condition, and initial levels of capital and debt, $k(0)$ and $b(0)$.

The firm's first order conditions for factor demands are

$$
\begin{aligned}
r\left(s^t\right) &= \frac{1}{1+(R(s^t)-1)\mu_k)} A\left(s^t\right) F_k\left(\hat{k}\left(s^{t-1}\right), l\left(s^t\right)\right) \\
\hat{w}\left(s^t\right) &= \frac{1}{1+(R(s^t)-1)\mu_l)} A\left(s^t\right) F_l\left(\hat{k}\left(s^{t-1}\right), l\left(s^t\right)\right).
\end{aligned}
$$

If firms do not have to pay for factor services in advance these first order conditions are standard. When firms pay for factor services in advance, $\mu_l, \mu_k > 0$, interest rate shocks affect production decisions in the same way productivity shocks do.

The households first order conditions are

$$
\begin{aligned}
\hat{w}\left(s^t\right) &= -\frac{\hat{u}_l\left(\hat{c}\left(s^t\right), l\left(s^t\right)\right)}{\hat{u}_c\left(\hat{c}\left(s^t\right), l\left(s^t\right)\right)} \\
1 &= \frac{\hat{\beta}}{1+\gamma} \sum \frac{\pi\left(s^{t+1}|s^t\right) \hat{u}_c\left(\hat{c}\left(s^{t+1}\right), l\left(s^{t+1}\right)\right)}{\hat{u}_c\left(\hat{c}\left(s^t\right), l\left(s^t\right)\right)} \frac{\left(1-\delta+r\left(s^{t+1}\right)+\Phi_2\right)}{1-\Phi_1} \\
\frac{1}{R\left(s^t\right)} &= \frac{\hat{\beta}}{1+\gamma} \sum \frac{\pi\left(s^{t+1}|s^t\right) \hat{u}_c\left(\hat{c}\left(s^{t+1}\right), l\left(s^{t+1}\right)\right)}{\hat{u}_c\left(\hat{c}\left(s^t\right), l\left(s^t\right)\right)} \left(1-\kappa \frac{\hat{b}(s^{t-1})-\bar{b}}{y\left(s^t\right)}\right).
\end{aligned}
$$

These conditions are standard. The first one states that the consumption-leisure marginal rate of substitution equals the real wage, and the last two are the Euler equations for capital and bonds.

The fraction of the input bill that firms must pay before production takes place creates a wedge between the consumption-leisure marginal rate of substitution and the marginal rate of transformation that is proportional to the interest rate. Combining the firm's and the household's optimization conditions for labor we obtain

$$(10)\quad -\frac{\hat{u}_l\left(\hat{c}\left(s^t\right), l\left(s^t\right)\right)}{\hat{u}_c\left(\hat{c}\left(s^t\right), l\left(s^t\right)\right)} = \hat{w} = \frac{1}{1+\mu_l\left(R(s^t)-1\right)} A\left(s^t\right) F_l\left(\hat{k}\left(s^{t-1}\right), l\left(s^t\right)\right),$$

where the left hand side can be interpreted as the labor supply and the right hand side as the labor demand in state s^t. Under the preferences specified in (8) the labor supply is independent of consumption or the real interest rate; while labor demand is a decreasing function of interest rates. An increase in the interest rate acts like a negative productivity shock on the labor demand, leaving the labor supply unaffected, inducing a fall in equilibrium employment. Under alternative preference specifications such as (9) the wealth effect or the intertemporal substitution effect of an increase in interest rates induces a shift in the labor supply that mitigates the effect of an interest rate shock on employment described above.

A. Steady state and calibration

In this section we solve for the steady state equilibrium of the model and use long-run averages from Argentina data to calibrate the model's parameters.

The parameters we set beforehand are the risk aversion σ that we set to 5 following Reinhart and Vegh (1995) and the exponent of labor in the preference specification (8), v, that we set to 1.7 as in Correia et. al. (1995)[13]. We assume that only wages are paid in advance and set $\mu_k = 0$ and $\mu_l = 1$. The sensitivity of the results to this choice of parameter

[13] We could not find an independent estimate of the elasticity of the labor supply with respect to wages in in Argentina.

values is analyzed in section 4.A.

The rest of the parameters, $\beta, \alpha, \delta, \mu, \psi, \phi$ and the steady state values for k, y, r, w and c are set so that they are consistent with the long run values found in the data for the average growth rate of Argentine output, $\gamma = 2.6\%$ per year, the average interest rate on foreign debt, $\bar{R} = 14\%$ per year, the average time spent working, $\bar{l} = 0.2$, labor's share of income, 0.47, the investment output ratio, $\bar{x}/\bar{y} = 0.21$, the debt-output ratio, 0.45, and the relative volatility of investment of 3.

The steady state equilibrium of all variables is denoted by $\bar{x}$ (for growing variables, $\bar{x}$ denotes the steady state of the detrended variables $\hat{x}$).

The average interest rate on foreign bonds ($\bar{R} = 1.14$) and the average growth rate ($\gamma = 0.026$) determine β through the first order condition on bonds yields

$$\beta = \frac{1}{\bar{R}}(1 + \gamma)$$

Once we know β we can obtain $\bar{r}$ from the first order condition on capital (note that in steady states the adjustment costs are 0), given a parameter for depreciation

$$\bar{r} = \frac{1 + \gamma}{\hat{\beta}} - 1 + \delta$$

The average share of GDP going to labor ($\frac{\bar{y}}{wl} = \frac{1}{.47}$) and the firm's first order condition for labor imply

$$\alpha = 1 - \frac{\bar{w}\bar{l}}{\bar{y}} \left[1 + \left(\bar{R} - 1\right)\mu_l\right)\right]$$

The average time spent working ($\bar{l} = .2$) and the firm's first order condition for capital imply

$$\bar{k} = \left[\frac{\bar{r} \left[1 + \left(\bar{R} - 1 \right) \mu_k \right) \right]}{\alpha \bar{A} \bar{l}^{(1-\alpha)}} \right]^{\frac{1}{\alpha - 1}} \quad \text{and} \quad \bar{y} = \bar{A} \bar{k}^{\alpha} \bar{l}^{(1-\alpha)}.$$

The investment output ratio ($\bar{x}/\bar{y} = 21\%$) and the capital accumulation equation (6) imply a steady state investment-output ratio given by

$$\frac{\bar{x}}{\bar{y}} = \delta \frac{\bar{k}}{\bar{y}}.$$

As by the previous expressions both $\bar{k}$ and $\bar{y}$ are functions of δ we can pick a δ to match the investment output ratio observed in Argentina.

At this point it is also useful to recover steady state wages

$$\bar{w} = (1 - \alpha) \frac{\bar{y}}{\bar{l} \left[1 + \left(\bar{R} - 1 \right) \mu_l \right) \right]}$$

The household's budget constraint and the first order conditions imply the economy's steady state resource constraint

$$(R - 1) \left(\mu_l \bar{w} \bar{l} + \mu_k \bar{r} \bar{k} \right) + \bar{c} + \bar{x} + \frac{1 + \gamma}{\bar{R}} \bar{b} + \bar{\kappa} = \bar{y} + \bar{b}$$

As financial intermediaries finance working capital loans with foreign debt, the consumer's bond-output ratio is

$$\frac{\bar{b}}{\bar{y}} = -d + \frac{\mu_l \bar{w} \bar{l} + \mu_k \bar{r} \bar{k}}{\bar{y}},$$

where d is Argentina's debt-output ratio in the data ($d = 0.45$). Once b/y is set we can recover c/y from the resource constraint. Assuming the bond holding cost is negligible we obtain

$$\frac{\bar{c}}{\bar{y}} = \frac{\bar{w}\bar{l} + \bar{r}\bar{k}}{\bar{y}} + \frac{\bar{b}}{\bar{y}}\left(1 - \frac{1+\gamma}{\bar{R}}\right) - \frac{\bar{x}}{\bar{y}}$$

The expression $\left(\bar{w}\bar{l} + \bar{r}\bar{k}\right)/\bar{y}$ equals one minus the fraction of GDP that is paid to working capital.

The parameters ψ in the GHH preference specification (8) and μ in the Cobb-Douglas preference specification (9) can now be recovered. In the first case, the labor supply derived from the household's first order conditions, $\bar{w} = \psi v \bar{l}^{v-1}$, implies

$$\psi = \frac{\bar{w}}{v\bar{l}^{v-1}}$$

In the second, consumption can be used to calibrate the parameter μ. The household's first order condition for labor and consumption imply

$$\frac{\mu}{1-\mu} = \frac{\bar{c}/\bar{y}}{\bar{w}/\bar{y}\,(1-\bar{l})}$$

The adjustment cost parameter, ϕ, is calibrated so that in the model with productivity and interest rate shocks the simulated volatility of investment relative to output is the same as in the data, 3.

B. Exogenous processes

Argentine rates are determined by country risk, $D\left(s^t\right)$, and US Rates, $R^{US}\left(s^t\right)$, by equation (1). We assume that the percentage deviations from the trend for $R^{US}(s^t)$ and $D(s^t)$, $\hat{R}^{US}(s^t)$ and $\hat{D}(s^t)$, follow a joint first order auto regressive process of the form

$$\begin{pmatrix} \hat{R}^{US}\left(s^t\right) \\ \hat{D}\left(s^t\right) \end{pmatrix} = A \begin{pmatrix} \hat{R}^{US}\left(s^{t-1}\right) \\ \hat{D}\left(s^{t-1}\right) \end{pmatrix} + \begin{pmatrix} \varepsilon_R\left(s^t\right) \\ \varepsilon_D\left(s^t\right) \end{pmatrix}, \text{ where}$$

$$\begin{pmatrix} \varepsilon_R\left(s^t\right) \\ \varepsilon_D\left(s^t\right) \end{pmatrix} \sim N\left(0, \Sigma\right) \text{ with}$$

$$\Sigma = \begin{bmatrix} \sigma_{\varepsilon_D} & \sigma_{\varepsilon_P}\sigma_{\varepsilon_R}\rho_{\varepsilon_R,\varepsilon_D} \\ \sigma_{\varepsilon_D}\sigma_{\varepsilon_R}\rho_{\varepsilon_R,\varepsilon_D} & \sigma_{\varepsilon_D} \end{bmatrix}$$

We estimate this process with a series for $D(s^t)$ that is obtained by dividing a series for the three month Argentine rate on dollar denominated sovereign bonds (see the data appendix for more details) by the time series for the US interest rate on three months treasury bills. The resulting estimates of A and Σ are reported in the table below,

Parameters of the process for interest rate

a_{11}	a_{12}	a_{21}	a_{22}
0.77	0.03	0.58	0.56
(0.08)	(0.03)	(0.30)	(0.10)
σ_{ε_R}	σ_{ε_d}	$\rho_{\varepsilon_R,\varepsilon_d}$	
0.40%	1.54%	0.27	

The estimation of the interest process has several interesting properties: (i) innovations to country risk are more volatile than innovations to the US rate, (ii) innovations to country risk are less persistent than innovations to the US rate, (iii) innovations to country risk and US rates are positively correlated, (iv) there is a significant spillover from the US rate to country risk (an innovation of 100 basis points in the US rate in s^t causes an increase of 58 basis points in country risk in s^{t+1} (133 basis points in Argentine Rates), and of 77 basis points in s^{t+2} (136 basis points in Argentine Rates), and (v) the spillover from the Argentine country risk to the US rate is negligible, and statistically insignificant (in the model's simulation we set it equal to 0).

We assume that the deviations from steady state of the process for total factor productivity, $\hat{A}(s^t)$, follows the AR(1) process

$$(11) \quad \hat{A}\left(s^t\right) = 0.95\hat{A}\left(s^{t-1}\right) + \varepsilon_A\left(s^t\right),$$

which has the same persistence as the process estimated for the US, 0.95, and we set its volatility so that the simulated volatility of output in the model matches the Argentine data.

4. Results

In this section we present the main results of the paper. We show how the main macroeconomic variables in model economy respond to shocks to US interest rates and to country risk, and the statistical properties of the model economy when it is subject to interest rate and productivity shocks.

The first experiment we perform is to examine the response of the main macroeconomic variables to shocks to US interest rate and to country risk. The results of this experiments are illustrated in figures ? and ?.

A 1% increase in country risk, induces a contemporaneous fall in employment, output, and consumption. The increase in interest rates caused by the increase in country risk shifts the labor demand to the left inducing a fall in employment. The linearization of (10) around the steady state,

$$\hat{l}_t = -\frac{1}{\varepsilon_s - \varepsilon_d}\hat{R}_t,$$

shows that the fall in employment that results from an increase in the interest rate depends on the elasticity of the labor demand, $\varepsilon_d = -1/\alpha$, and on the elasticity of the labor supply, $\varepsilon_d = 1/(\nu - 1)$. For our parameter values a 1% increase in interest rates induces a fall in employment of 0.85%. Given our choice of α, the fall in output is just over 0.5% of trend. The fall in consumption is over 1% of trend due to the intertemporal substitution effect. In response to the interest rate shock, it is optimal for households to increase the marginal rate of substitution between current and future consumption. The impact of this on the growth rate of consumption is exacerbated by path of equilibrium employment[14]. Net exports rise by 1% as a result of the increase in savings and a fall in investment.

The effect of a 1% rise innovation to international interets rates differs from the effect

[14]The equilibrium growth rate of consumption must satisfy the (linearized) first order condition for the bond;

$$\hat{c}_{t+1} - \hat{c}_t = \frac{1}{\sigma}\frac{\bar{c} - \psi\frac{\bar{l}^\nu}{\nu}}{\bar{c}}\hat{R}_t + \frac{\psi\bar{l}^\nu}{\bar{c}}\left(\hat{l}_{t+1} - \hat{l}_t\right),$$

where $\hat{l}_{t+1} - \hat{l}_t$ is determined by the interest rate path.

of an innovation to country risk due to the persistence and spillover effect of this shocks mentioned in section A. B. The reaction of employment, consumption and net exports to interest rates follows the pattern described in the previous paragraph. Output exhibits a longer downturn because the persistence of interest rates, induces a more persistence decline in investment that reduces the capital stock. The trough of the cycle induced by an innovation in international interest rates ocurs 2 years after the shock and is of almost 2% of trend[15].

In figures ?? and ?? we present the path for output and for net exports predicted by the model when the only shocks to the economy are shocks to the US interest rate and to country risk. We set the innovation to the shocks in the model such that the series for the percentage deviations from the trend of interest rate in the model $\hat{R}(s^t)$, is identical to the series in the data. Notice that the series for output and net exports predicted by the model display cyclical fluctuations very similar to the data even though output in the model is less volatile than in the data and net exports in the model are more volatile than in the data.

In picture ?? we report the cross correlation function between interest rate and GDP in the data and in the model. The model reproduces quite well the entire dynamic correlation structure.

The following tables report standard business cycle statistics for the macroeconomic series simulated by the model, together with the statistical proerties of the Argentine data. We consider two baseline models: one that is only subject to shocks to international interest rates and country risk and one with shocks to total factor productivity as well. Interest rate shocks are the actual shocks in the data and productivity shocks are randomly generated by

[15] Table ?? shows that this large and persistent effect is related to the large volatility of investment in a model with only interest rate shocks.

(11). The statistics for the artificial economy with interest rate and productivity shocks are the averages of ? simulations. The results are reported in table 6.

The model with only interest shocks is able to generate about 40% of the observed fluctuations in output. One difference between the model and the data is that investment, consumption, employment and net exports are too volatile relative to output (even though they have about the right volatility in absolute terms). Another problem of the model seems to be that the correlation of the interest rate with the other macroeconomic variables are stronger than in the data.

In the model with productivity shocks, as well as interest rate shocks, both of the discrepancies discussed above are reduced. The correlation between output and interest rate, however, is now too low relative to the data.

Table 6: Simulated and Actual Argentine Business Cycles: 1983:2- 2000:2

	% Standard Dev.			$\frac{\%\text{Standard Dev.of } x}{\%\text{Standard Dev.of GDP}}$		
	GDP	NX	R	Con	Inv	Hrs
Argentine Data	4.24	1.41	3.39	1.17	3.00	0.58
Model (R shocks)	1.70	3.41	3.39	1.98	7.50	1.36
Model (R & A shocks)	4.24	4.70	3.39	1.08	3.00	0.75

	Correlation of x with GDP				
	R	NX	Con	Inv	Hrs
Argentine Data	-0.59	-0.90	0.96	0.93	0.41
Model (R Shocks)	-0.74	-0.89	0.86	0.77	0.91
Model (R & A Shocks)	-0.26	-0.90	0.85	0.50	0.89

	Correlation of x with R				
	GDP	NX	Con	Inv	Hrs
Argentine Data	-0.59	0.66	-0.64	-0.58	-0.52
Model (R Shocks)	-0.74	0.92	-0.94	-0.93	-0.93
Model (R & A Shocks)	-0.26	0.64	-0.72	-0.91	-0.65

A. Sensitivity Analysis

The results presented presented above are not very sensitive to small changes in the parameter space. One crucial element, though, is the utility function. In table 7 below we analyze how the key results depend on the utility function and on the presence of working capital. In all the experiments we keep constant all other parameters (including the investment adjustment cost and the standard deviation of productivity shocks). First focus on the GHH preferences (8) with only interest shocks. When μ_l= 1 (100% of labor costs have to be paid in advance) the model generates quite volatile output and negative correlation between output and interest rates. Note that as we reduce the working μ_l from 1 to 0 both the volatility of output and the absolute value of the (negative) correlation between output and interest rates are reduced. This is because by reducing μ_l we reduce the negative impact that interest rates have on output. Now notice that with Cobb Douglas preferences (with only interest rates shocks) output is still quite volatile but now the correlation between interest rates and output is counterfactually highly positive (0.78 v/s -0.59). The reason for that is that with Cobb Douglas preferences labor supply depends on interest rates and wealth, and so in response to increases in interest rates (that reduce consumption due to wealth and intertemporal substitution effects) households respond by increasing their labor supply. With Cobb Douglas this is the dominating effect, and even though the working capital effect works in the usual direction (increase in the interest rates reduce output), the final effect is that interest rate is positively correlated with output. Notice that in the Cobb Douglas case as we reduce μ_l the correlation between output and interest rates increases (as in the GHH case) but the volatility of output increases as μ_l gets reduced. Again to understand this think of wealth and working capital effect. In response to interest rate shocks the wealth effect makes output go up while the working capital makes output go down. If $\mu_l > 0$ the two effects tend to offset each other and output does not move much. As we reduce μ_l the wealth effect is more important and it causes output to fluctuate more.

Table 7: Sensitivity Analysis

		Preferences					
		GHH			Cobb-Douglas		
		$\sigma(y)$	$\frac{\sigma(c)}{\sigma(y)}$	Corr(y,R)	$\sigma(y)$	$\frac{\sigma(c)}{\sigma(y)}$	Corr(y,R)
$\mu_l = 1$	R Shocks	1.70	1.98	-0.74	2.80	1.68	0.78
	Both Shocks	4.24	1.08	-0.26	4.42	1.12	0.58
$\mu_l = 1/2$	R Shocks	1.23	1.91	-0.45	3.30	1.27	0.83
	Both Shocks	4.06	0.93	-0.04	4.76	0.95	0.66
$\mu_l = 0$	R Shocks	1.11	1.27	0.11	3.83	0.96	0.87
	Both Shocks	4.01	0.81	0.12	5.14	0.79	0.72

5. Conclusions and Future Research

Fluctuations in interest rates determined by changes in international interest rates and changes in country risk play an important role in the business cycles of emerging economies. Interest rates lead the business cycle and increases in interest rates are associated with downturns in economic activity and increases in the trade surplus of these countries.

The aim of this paper was to explore how much of the output fluctuations in these economies can be explained by fluctuations in interest rates and to build a model with equilibrium prices and allocations that are consistent with the data. To that end we studied a model in which domestic interest rates are determined by international interest rates and a variable that we called country risk.

In the numerical exercise we perform we use the actual values of US interest rates and country risk found in the data (taking into account the spillover effect of US rates on country risk) as an exogenous variable that drives the business cycle. As a result of this exercise we learned that we can interpret the business cycle properties of interest rates in Argentina as the equilibrium of a model in which the payments and receipts of firms are not synchronized and their is no intertemporal substitution of leisure.

The assumption about the exogeneity of the country risk in our model is controversial since there is a debate on the determinants of country risk. There are two possible (non-mutually exclusive) ways in which business cycles and country risk are related. One view is that fundamental shocks to a country's economy are the source of shocks to GDP and to country risk. Under this view interest rates lead the cycle because they anticipate future shocks. The second view is that some exogenous factor (like foreign rates, contagion, or political factors exogenous to GDP) drives country risk, which in turn affects the business cycles.

We do not want to take a stand in this debate since our primary goal was to find an equilibrium relation between interest rate series and economic activity consistent with the data (in our numerical exercise we used the actual values of country risk). We believe that this exercise is helpful regardless of the nature of interest shocks. If shocks to country risk are purely exogenous to our model then this exercise provides us with a measure of how much they can affect business cycles. If on the other hand country risk is determined by an unmodelled fundamental shock that also affects total factor productivity, the study of the equilibrium relation we performed is important for understanding the transmission and amplification of shocks that initially affect both interest rates and output. Our results stress the importance of a deeper study of the determinants of country risk for improving our understanding of business cycles in emerging economies.

Appendix

Argentina quarterly series for GDP, Consumption, Investment and Net Exports (Exports minus imports divided by GDP) are all in constant prices from Ministerio de Economía (MECON). We use the 1993 base year prices series for 1993.1-2000.2 and for the period 1983.3-1992.4 we use the 1986 base year prices. For the period 1993-2000 consumption is defined, consistently with the previous period, as the sum of private and public consumption, change in inventories and statistical discrepancy. For Canada quarterly series for GDP, Consumption, Investment and Net Exports are all in constant prices from OECD Quarterly National Accounts. Consumption is defined in the same way as the series for consumption in Argentina.

The series for employment in Argentina is the number of employed people working at least 35 hours per week and the series for total hours is the series for employment multiplied by the average weekly hours worked in Buenos Aires (both series are from Encuesta Permanente de Hogares). The series for employment is semi-annual from 1983.2 to 2000.1 while the series for hours is only available form 1986.2. For Canada the employment series is total number of employed people from the OECD, Quarterly Labor Force Statistics and the series for total hours is the series for employment multiplied by the average weekly hours worked in manufacturing (from OECD, main Economic Indicators). Both series are converted to a semiannual frequency and have the same sample to make it comparable to Argentina's statistics. The standard deviation reported for both countries is relative to the standard deviation of semiannual GDP.

Real interest rate for Canada is the rate on 3 months Canadian treasury bills deflated by expected Canadian GDP deflator inflation (computed as the average inflation in the previous 4 quarters).

Series for real interest rates in Brazil, Korea, Mexico and Philippines are the stripped spreads from JP Morgan's Emerging Market Bond Index (EMBI) plus the interest rate on US three month treasury bill deflated by the US GDP deflator expected inflation (computed as above). Series for Real GDP for Brazil, Korea, Mexico and Philippines are from the IMF International Financial Statistics. Series for real GDP and consumption for Korea are from the Bank of Korea's web site, and for Mexico from Instituto Nacional de Estadística, Geografía e Informática (INEGI). The series for GDP and consumption for Philippines are from IFS. Real consumption is obtained dividing nominal consumption by the GDP deflator.

The three month real interest rate for Argentina is estimated with a procedure developed by Alvarez, Buera and Neumeyer (1999). We use data on prices of Argentine Government Dollar denominated bonds (BONEX 80, BONEX 81, BONEX 82, BONEX 84, BONEX 89, GRA, Brady Discount, Global 01, Global 03, Global 06, Global 17, Global 27) and US treasury strips.

The Argentine rate on a j period zero coupon bond in period t, $r_{t,j}^{\arg}$ can be written as the sum of the US rate for a similar bond, $r_{t,j}^{US}$, plus a country spread, $\delta_{t,j}$

$$r_{t,j}^{\arg} = r_{t,j}^{us} + \delta_{t,j}.$$

In order to estimate the term spreads, $\delta_{t,j}$, we assume they are given by the following functional form (a polynomial on j and t)

$$\text{(A1)}\ \ \delta_{t,j} = \hat{\delta}(t,j) + \varepsilon_{t,j} = \Delta_t + \alpha_1(t) \cdot j + \alpha_2(t) \cdot j^2 + \alpha_3(t) \cdot j^3 + \varepsilon_{t,j}$$

where,

$$\alpha_i(t) = a_{i,0} + a_{i,1} \cdot t + a_{i,2} \cdot t^2 + a_{i,3} \cdot t^3, \qquad i = 1,2,3,$$

$\varepsilon_{t,j}$ is the approximation error and Δ_t is a fixed effect for each period (that can be interpreted as the spread of a zero maturity bond).

The price, at period t, of a coupon bond, k, issued by the argentine government, $P_{k,t}^{\mathrm{arg}}$, is given by,

$$P_{k,t}^{\mathrm{arg}} = \sum_{j=1}^{J} C_{k,j} \cdot \exp(-(r_{t,j}^{us} + \delta_{t,j}) \cdot j),$$

where $C_{k,j}$ is the coupon paying at t of bond k.

The estimated parameters, $a_{i,\cdot}$and Δ_t, of the spread function (A1) are those that minimize the loss function L, i.e.

$$\min_{a_{i,\cdot}\Delta_t} L = \sum_{t=1}^{T} \sum_{k=1}^{K} \left[\frac{1}{\mathrm{dur}_{t,k}} \ln \left(\frac{\sum_{j=1}^{J} c_j \cdot \exp\left(-\left(r_{t,j}^{us} + \hat{\delta}\left(t,j\right)\right) \cdot j\right)}{P_{k,t}^{\mathrm{arg}}} \right) \right]^2,$$

where $\mathrm{dur}_{t,k}$ is the duration of bond k at time t,which is given by the formula

$$\mathrm{dur}_{t,k} = \frac{\sum_{j=1}^{J} c_{kj} \cdot \exp\left(-r_{t,j}^{us} \cdot j\right) j}{\sum_{j=1}^{J} c_{kj} \cdot \exp\left(-r_{t,j}^{us} \cdot j\right)}.$$

Thus, 3 month argentine interest rates are the sum of the US 3 month treasury bill interest rate and the estimated spread with $j = 3$. Expected real rates are obtained by subtracting US expected inflation from these rates. US expected inflation is the average of the previous four quarters expected inflation.

The 90 prime corporate rate in Argentina is from Boletín Estadístico, Banco Central de la República Argentina.

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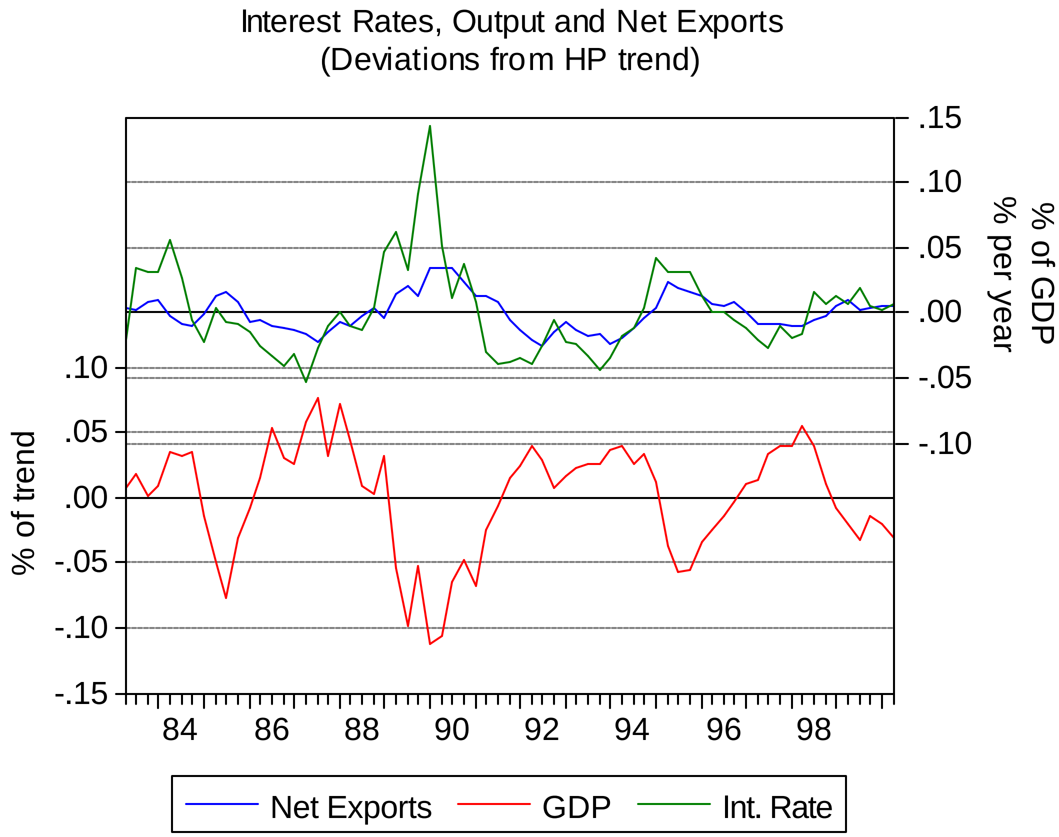
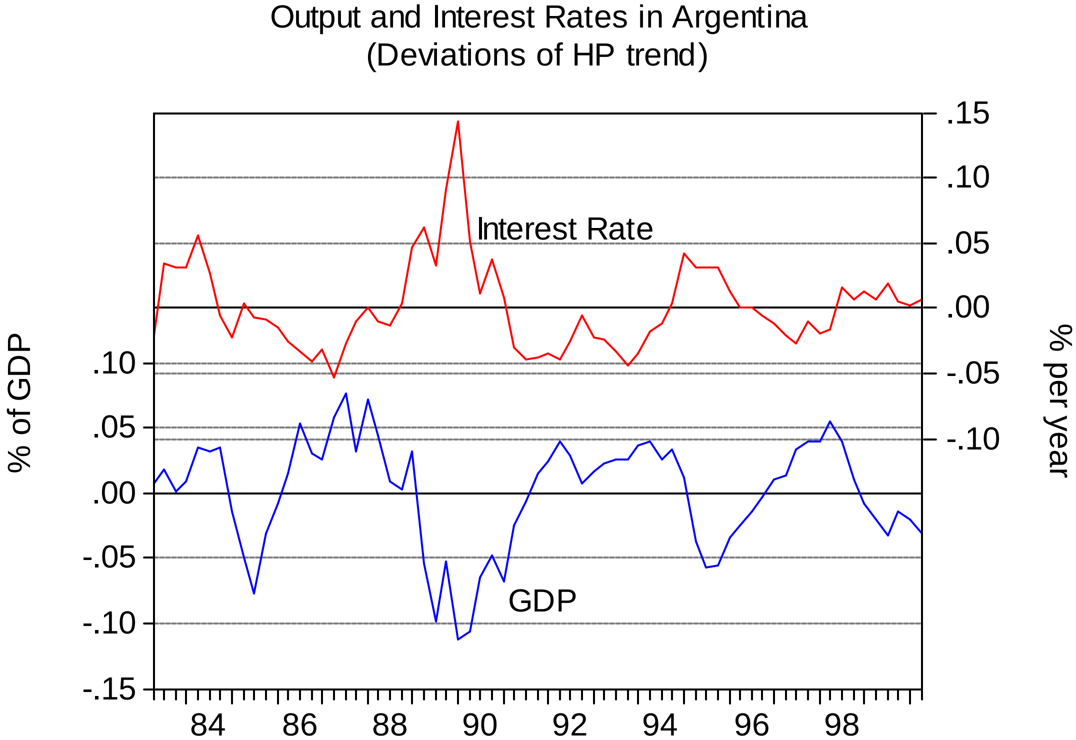
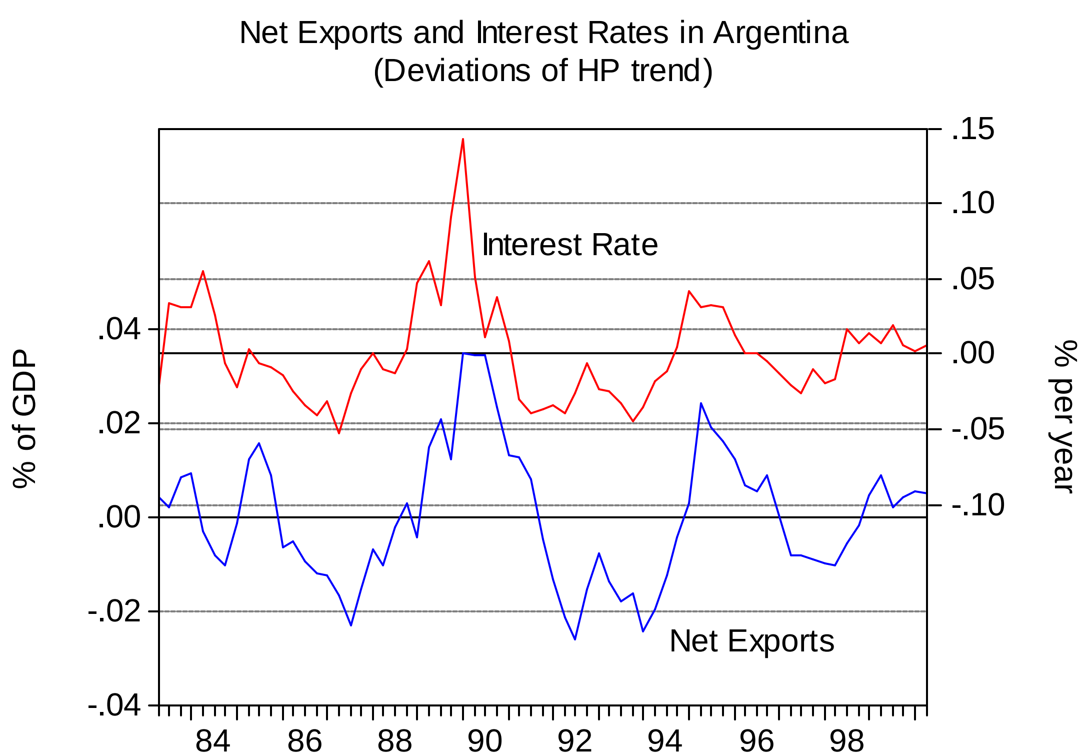

Interest Rates, Output and Net Exports
(Deviations from HP trend)
.15
.10
.05
.00
-.05
-.10
% of GDP
% per year
.10
.05
.00
-.05
-.10
-.15
% of trend
84
86
88
90
92
94
96
98
Net Exports
GDP
Int. Rate

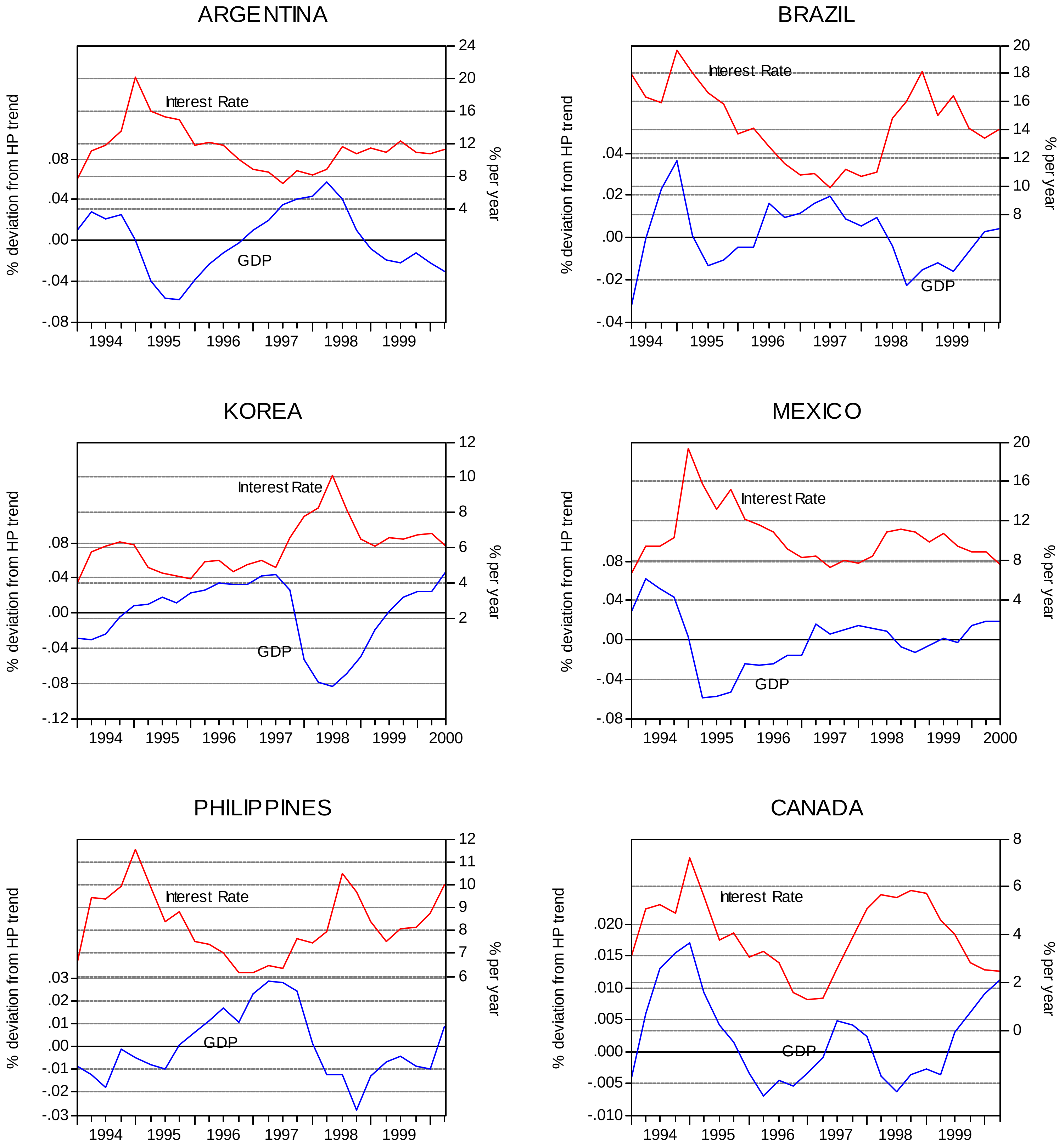


Output and Interest Rates in Argentina
(Deviations of HP trend)
Interest Rate
GDP
% of GDP
% per year
.15
.10
.05
.00
-.05
-.10
-.15
84
86
88
90
92
94
96
98

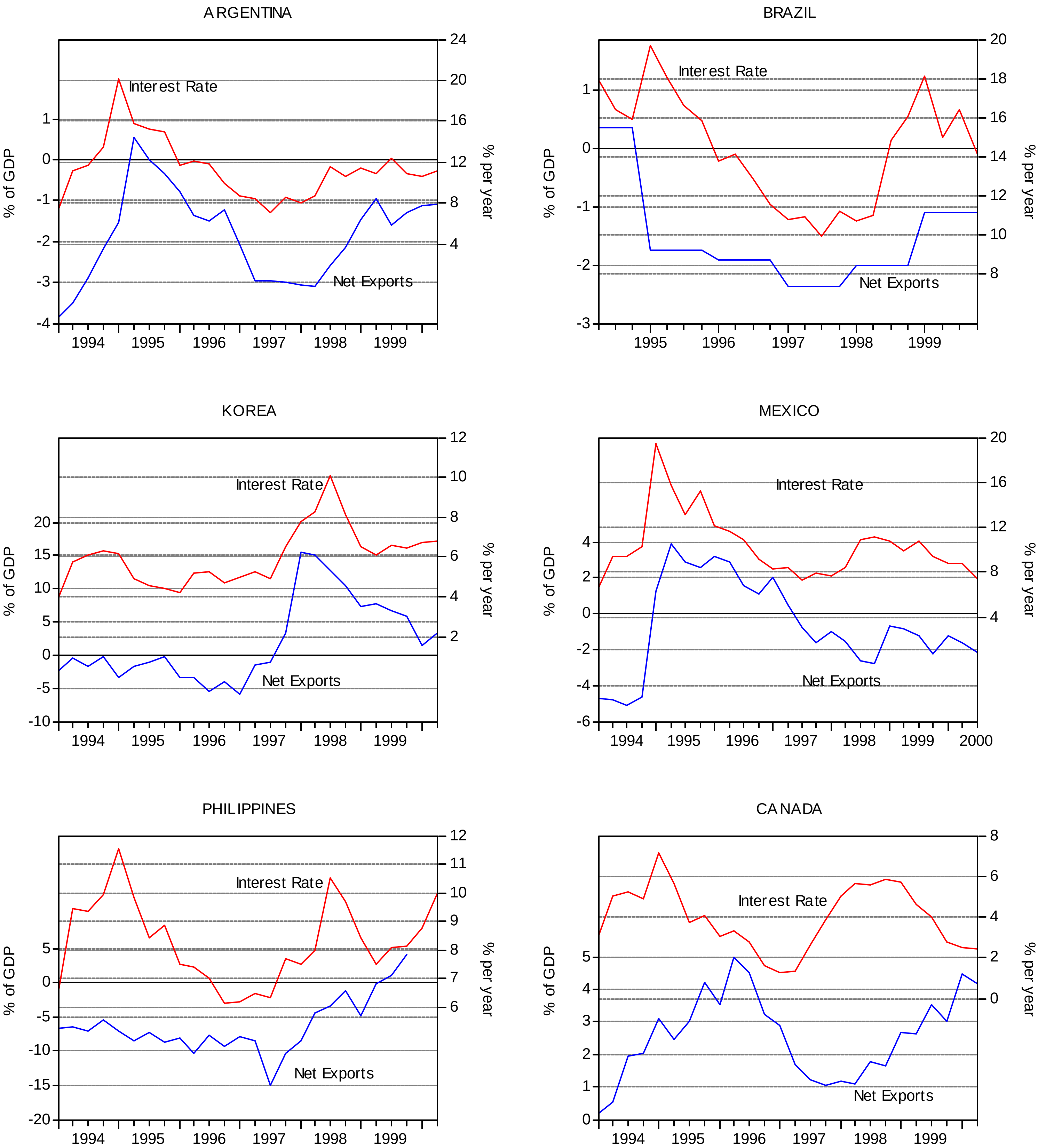


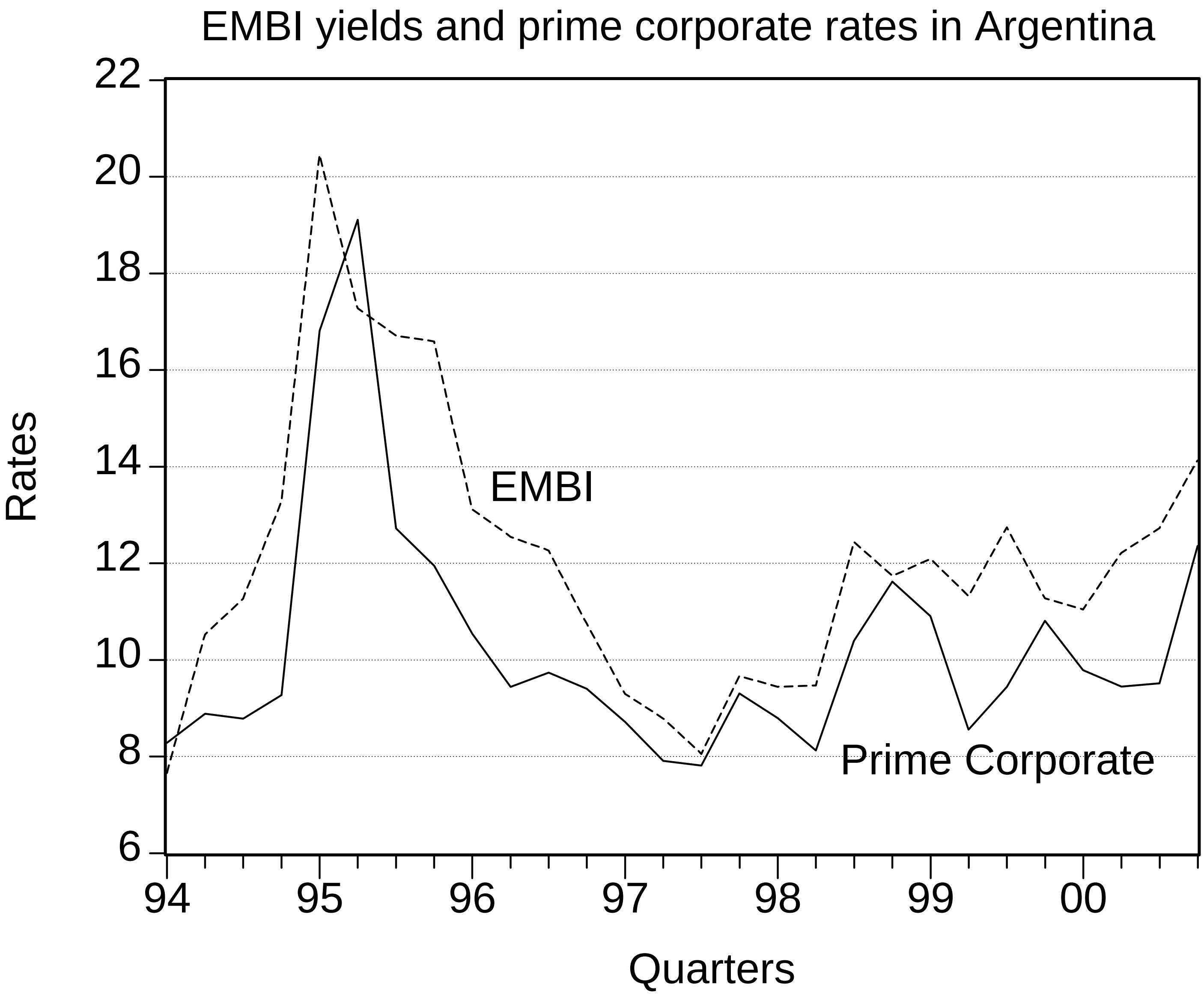
Net Exports and Interest Rates in Argentina
(Deviations of HP trend)
Interest Rate
Net Exports
% of GDP
% per year
.04
.02
.00
-.02
-.04
.15
.10
.05
.00
-.05
-.10
84
86
88
90
92
94
96
98

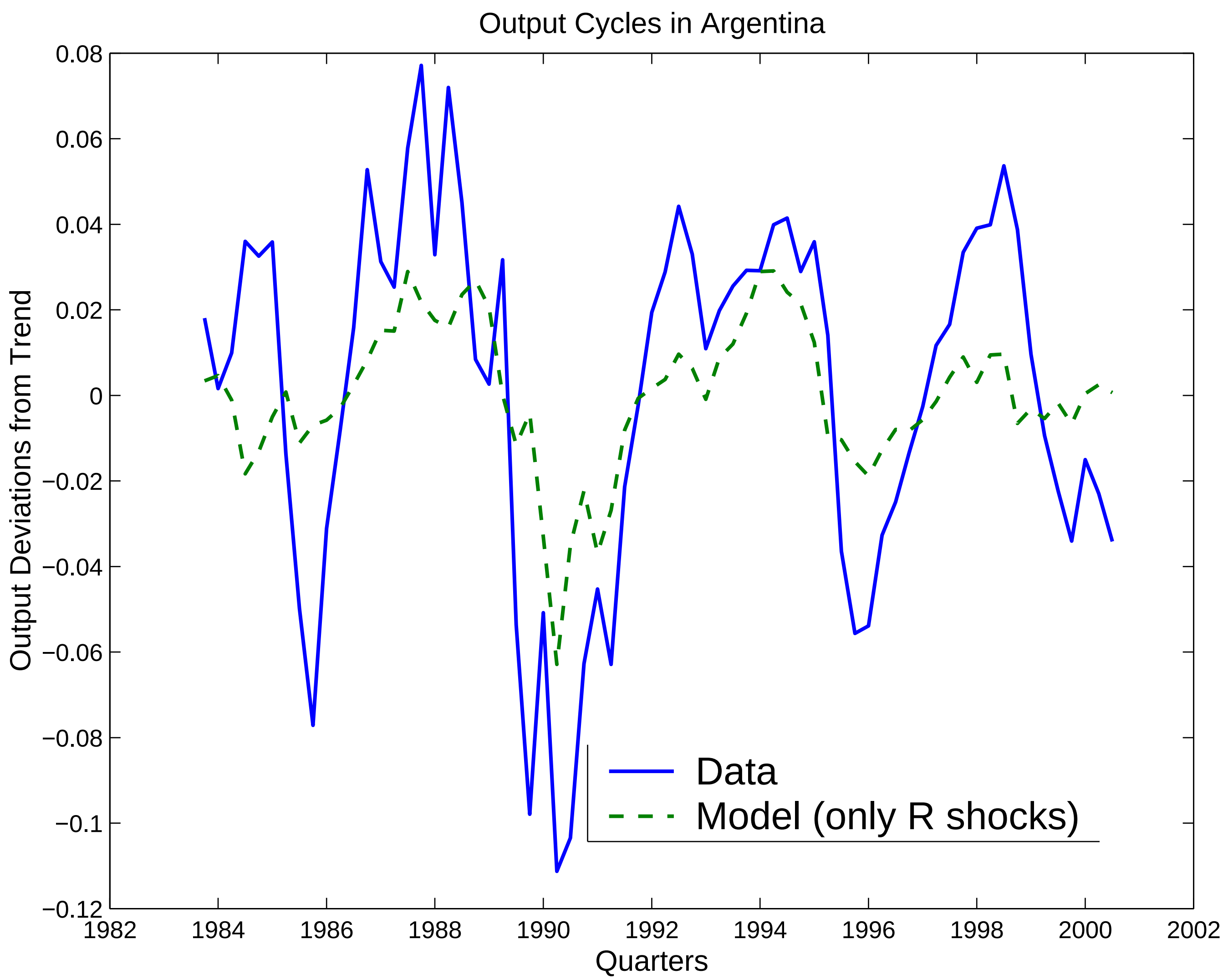
OUTPUT AND INTEREST RATES

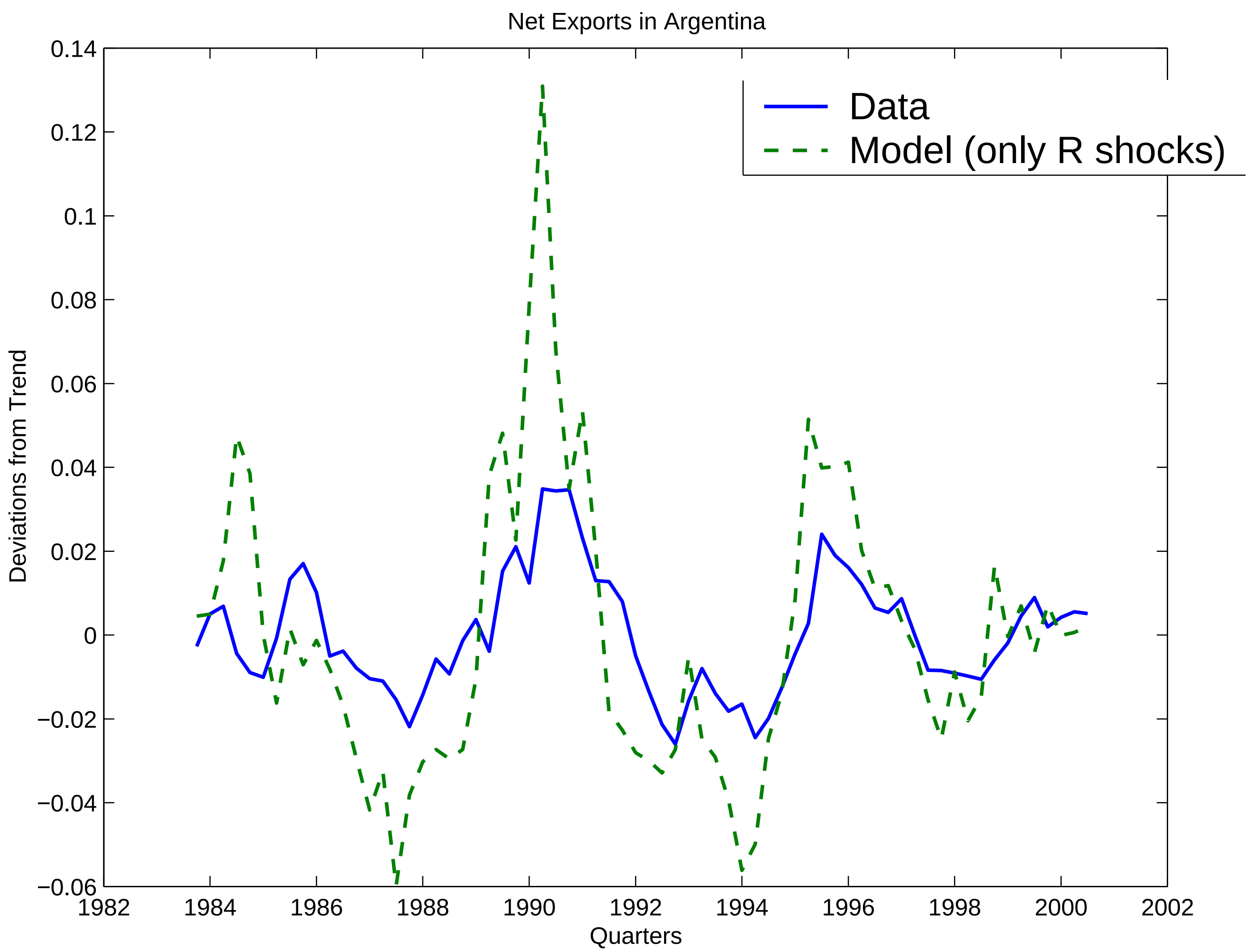


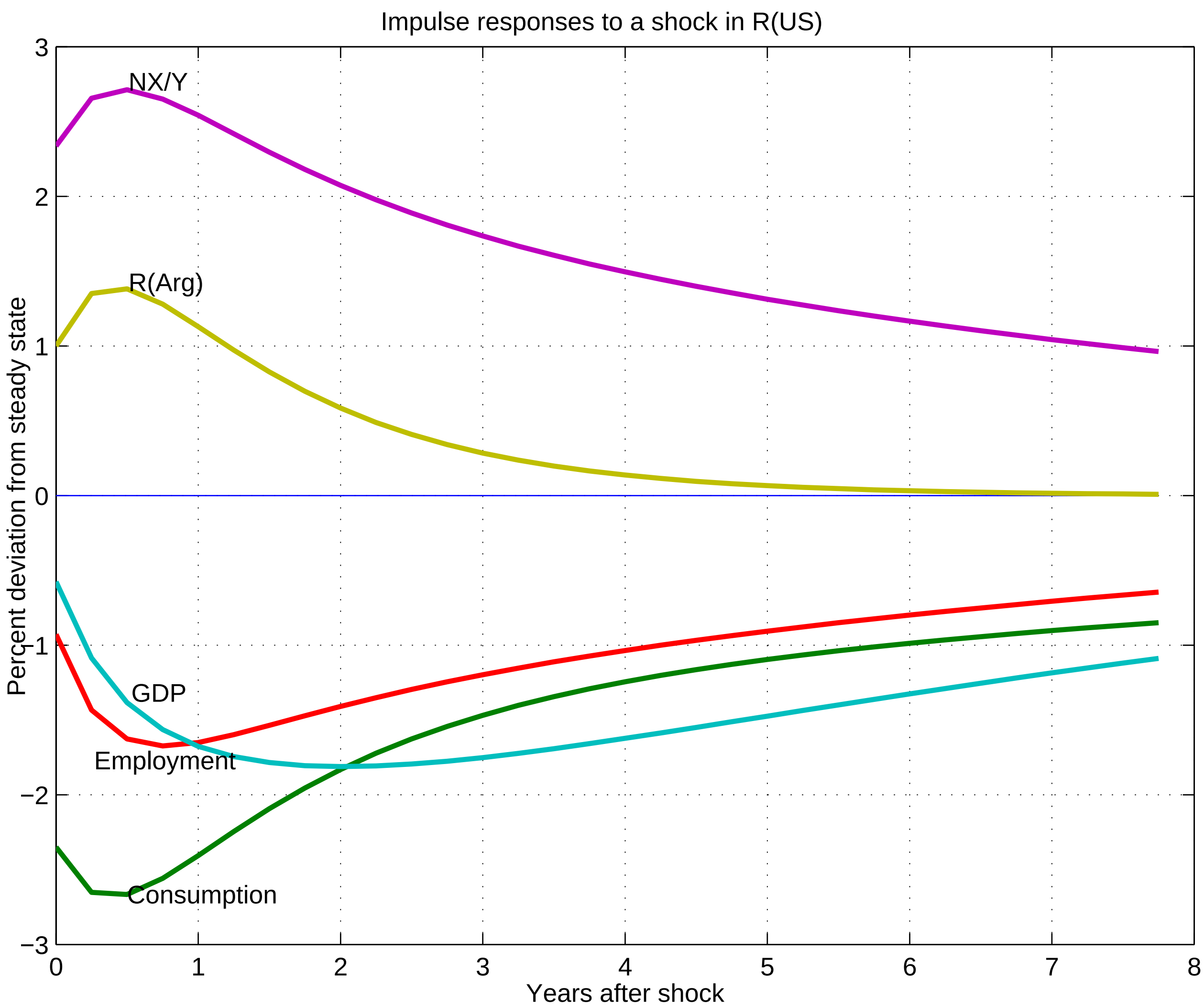
NET EXPORTS AND INTEREST RATES



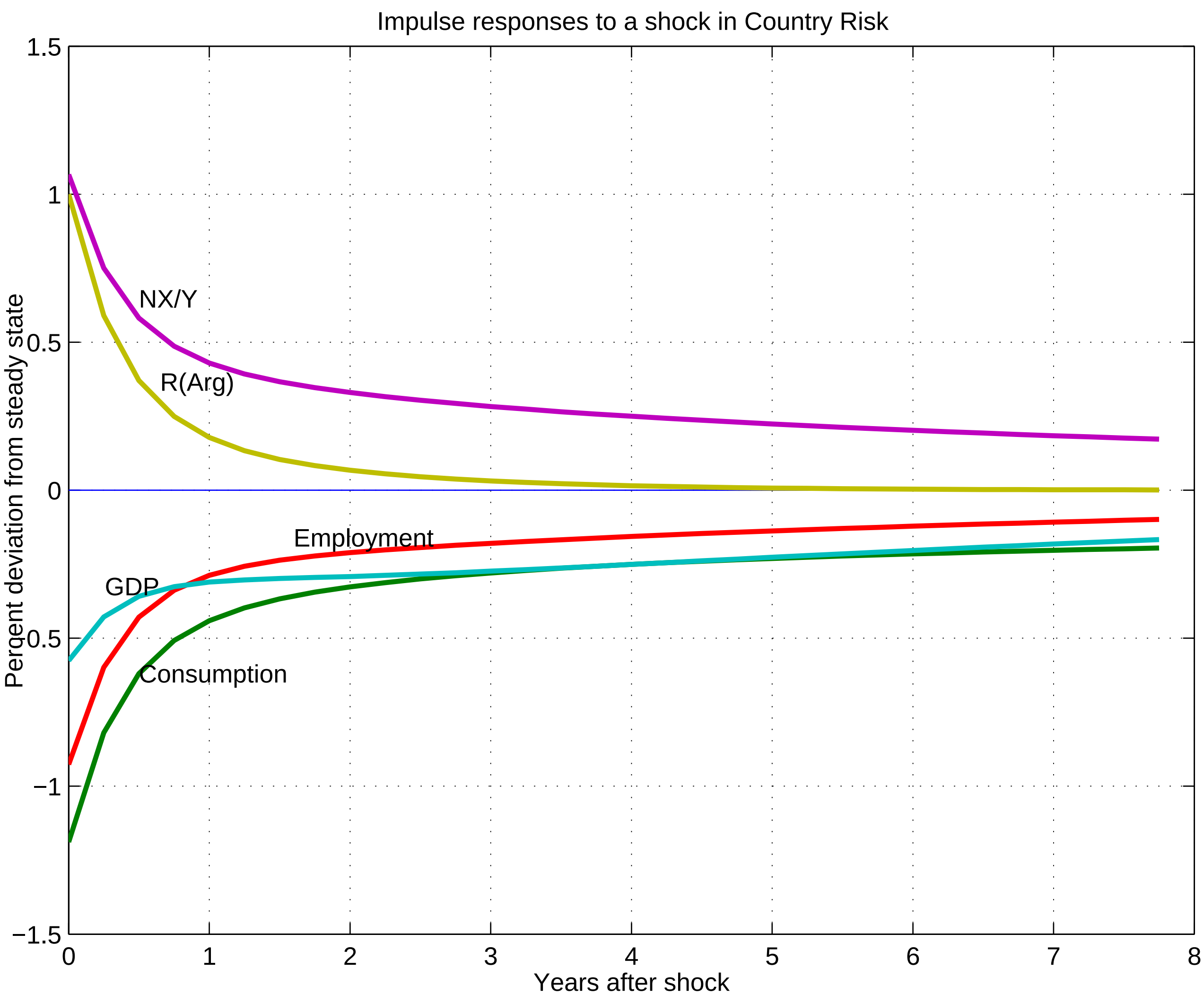

EMBI yields and prime corporate rates in Argentina
22
20
18
16
14
12
10
8
6
Rates
EMBI
Prime Corporate
94
95
96
97
98
99
00
Quarters


Output Cycles in Argentina
Output Deviations from Trend
Quarters
0.08
0.06
0.04
0.02
0
−0.02
−0.04
−0.06
−0.08
−0.1
−0.12
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
Data
Model (only R shocks)

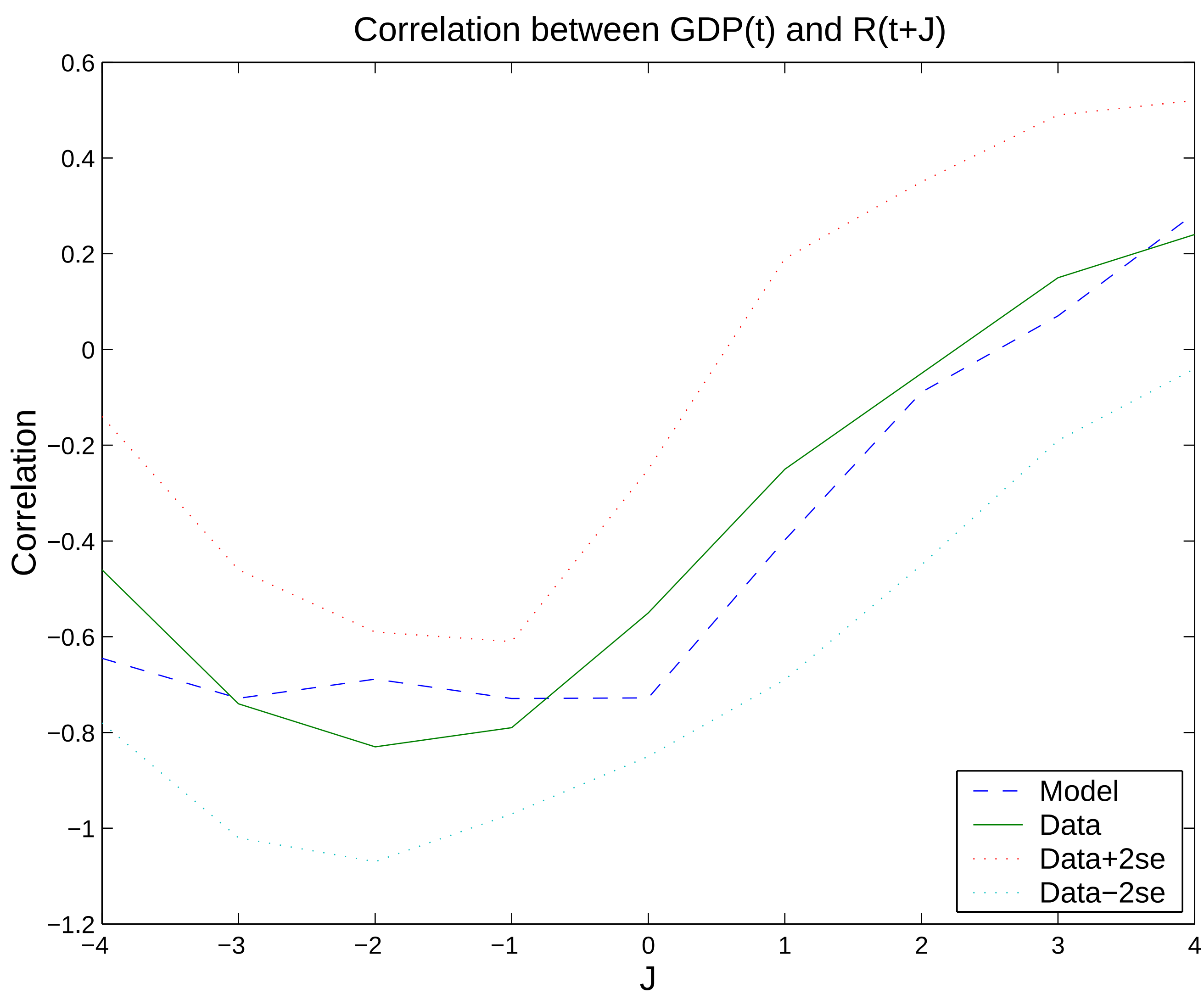

Net Exports in Argentina
Data
Model (only R shocks)
Deviations from Trend
Quarters
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
−0.02
−0.04
−0.06
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002



Impulse responses to a shock in R(US)
NX/Y
R(Arg)
GDP
Employment
Consumption
Percent deviation from steady state
Years after shock
3
2
1
0
−1
−2
−3
0
1
2
3
4
5
6
7
8



Impulse responses to a shock in Country Risk
1.5
1
0.5
0
−0.5
−1
−1.5
0
1
2
3
4
5
6
7
8
Years after shock
Percent deviation from steady state
NX/Y
R(Arg)
Employment
GDP
Consumption


Correlation between GDP(t) and R(t+J)
Correlation
J
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8
−1
−1.2
−4
−3
−2
−1
0
1
2
3
4
Model
Data
Data+2se
Data−2se