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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. The dataset used in the study includes quarterly data for Argentina during 1983-2000 and for Brazil, Mexico, Korea, and Philippines, during 1994-2000. In this sample, interest rates are very volatile, strongly countercyclical, and strongly positively correlated with net exports. Output is very volatile and consumption is more volatile than output. These regularities are common to all emerging economies in the sample, but are not observed in a developed economy such as Canada. The paper presents 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 in which (ii) the labor supply is independent of consumption. Using a version of the model calibrated to Argentina's economy, we find that interest rate shocks alone can explain 50% of output fluctuations and can generate business cycle patterns consistent with the regularities described above and with the major booms and recessions in Argentina in the last two decades. We conclude that interest rates are an important factor for explaining business cycles in emerging economies and further research should be devoted to fully understand their determination.

KEYWORDS: Argentina, International business cycles, Country risk

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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 output declines and with increases in their net exports (see figures 1 through 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[2]. 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[3]. An interesting feature of the emerging country data is that in the 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. To see this think of the optimal consumption path of an agent who faces income and interest rates volatility. If transitory income (technology) shocks are dominant her consumption will be smoother than income. If instead interest rate shocks are dominant her consumption will fluctuate more 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 resources. As the

[2] Agenor et al. (2000) also find that business cycles in developed and emerging economies share a number of features.
[3] Australia, Canada, Denmark, Germany, Italy, Japan, Norway, Sweden, United Kingdom, United States.

intertemporal approach to the current account (Obstfeld and Rogoff, 1995) predicts, during periods with high interest rates agents have incentives to save more and invest less, and this is reflected in the net exports data.

The strong relation between interest rates and business cycle in emerging economies contrasts with the significance of interest rate shocks in previous 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 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 consumption and thus quite responsive to wages.

These two assumptions imply that, in the model analyzed in this paper, interest rates are countercyclical. 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 equilibrium employment. The lack of synchronization between the payments and the receipts of firms makes the demand for labor sensitive to the interest rate. Since firms have to borrow to pay for inputs, increases in the interest rate make their effective labor cost higher and reduce their labor demand. The impact of this shift in the labor demand curve on equilibrium employment will depend on the nature of the labor supply. Preference specifications for which the marginal rate of substitution between consumption and leisure is independent of consumption, make the labor supply a function of only the real wage. Hence, inward shifts in the labor demand induce a fall in equilibrium employment that depends on the elasticity of the labor supply with respect to the real wage[4].

The model is calibrated to Argentina's economy for the period 1983-2000. When the model is fed with actual rates faced by Argentina as the only source of disturbance, it can explain about 50% 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. 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 Argentina's economy during the period. Our findings are related to those of Calvo et al.(1993) that stress the importance of external factors for macroeconomic developments in Latin America[5].

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

[4]For other frequently used preference specifications, like the Cobb-Douglas formulation, the labor supply depends negatively on consumption. Later in the paper we will discuss how this feature causes equilibrium employment to respond positively to interest rate shocks.

[5]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 business cycle that is consistent with our findings.

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 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 and not on inflation rates. If we had used inflation as the source of distortion, the model would have predicted large output fluctuations in the 1980s (when Argentine inflation was extremely volatile, see Neumeyer, 1998) but almost no movement in the 1990's (inflation has been virtually zero since 1992)[6].

[6] 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.

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.

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 has been 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. We use data on secondary market prices of emerging market bonds to recover nominal US dollar interest rates because during financial crises most of the borrowing of these countries is through official institutions and thus 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 1983.1-2000.2, and quarterly data for 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 bond prices going back to the 1980's since it issued four 10 year dollar denominated sovereign coupon bonds between 1980 and 1984. We start our sample in 1983 because it is the first year in which we have at least three bond prices. 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[7]. Liquid secondary markets for other emerging country US dollar denominated debt developed only after the first Brady plan in 1990. We look at 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[8]. 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. Figure 5 plots all the three rates from the first quarter of 1994 to the second quarter of 2000. The picture shows that the three rates move together and that the interest rate we

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

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

estimate is very correlated with alternative measures of cost of borrowing of the corporate sector. Over this period the correlation of the interest rate series we estimated for Argentina with the EMBI+ rate and the prime corporate rate is 0.95 and 0.85, respectively.

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 the strong positive correlation between net exports and real interest rates, which is shown in Figure 2. Tables 1,2 and 3 below report business cycle statistics for the main macroeconomic variables in Argentina over the period that goes from the third quarter of 1983 to the second quarter of 2000. 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. Table 1 reports the percentage standard deviations of the series we study

Table 1. Argentine Business Cycles. 1983.1-2000.2. Standard deviations[9]

	% Standard Dev.			$\frac{\text{\%Standard Dev of x}}{\text{\%Standard Dev. of GDP}}$			
	Y	NX	R	Tot. Cons.	Inv.	Emp.	Hrs
Argentina	4.18	1.41	3.35	1.19	3.03	0.45	0.63
	(0.53)	(0.17)	(0.61)	(0.04)	(0.17)	(0.13)	(0.14)
Canada	1.45	0.80	1.57	0.89	2.87	0.96	1.08
	(0.16)	(0.08)	(0.14)	(0.05)	(0.26)	(0.08)	(0.06)

The number in parenthesis are standard error of the GMM estimate of the standard deviations

The table confirms the high volatility of output (Y) that characterize the Argentine cycle (over three times the Canadian level). Real interest rates (R) and net exports (NX) in Argentina are roughly twice as volatile as in Canada. The relative volatility of employment[10] is lower than that observed in Canada while the relative volatility of investment is higher. Total consumption is more volatile than output in Argentina, while in Canada it is less volatile[11].

[9] All variables have been Hodrick Prescott filtered with a smoothing parameter of 1600. All variables except net exports and real interest rates are in logs. Net exports are exports minus imports over GDP, real interest rates are in percentage points. The series for Argentine total consumption includes private and public consumption, changes in inventories and statistical discrepancy, as before 1993 that is the only available quarterly consumption series. The Canadian total consumption series is constructed analogously to the Argentine consumption variable.

[10] The only available employment series for Argentina is semiannual. For comparison purposes alse the Canadian series is semiannual. In both cases, the standard deviation reported is relative to the standard deviation of semiannual GDP.

[11] For the period 1993-2000 a series for private consumption that excludes government consumption, changes in inventories and statistical discrepancy is available. We find that even with this definition, private consumption in Argentina has the same volatility of output while in Canada the volatility of private consumption (in the same period) is about half the one of output (see also table 4).

Table 2. Argentine Business Cycles. 1983.1-2000.2. Correlations[12]

	Correlation of GDP with					
	R	NX	Tot. Cons	Inv.	Emp.	Hrs
Argentina	-0.59	-0.87	0.97	0.93	0.37	0.51
	(0.12)	(0.03)	(0.01)	(0.02)	(0.08)	(0.11)
Canada	0.30	-0.04	0.86	0.73	0.86	0.94
	(0.14)	(0.17)	(0.04)	(0.09)	(0.06)	(0.04)
	Correlation of R with					
	Y	NX	Tot. Cons.	Inv.	Emp.	Hrs
Argentina	-0.59	0.66	-0.62	-0.57	-0.31	-0.55
	(0.12)	(0.07)	(0.11)	(0.12)	(0.13)	(0.13)
Canada	0.30	0.22	0.20	0.05	0.34	0.22
	(0.14)	(0.14)	(0.14)	(0.17)	(0.24)	(0.22)

The number in parentheses are the standard errors of the GMM estimates of the correlations

Table 2 reports the correlation of the same variables with GDP and real interest rate. It confirms the negative and significant 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 (weakly) positively correlated with GDP, consumption,

[12] All variables have been Hodrick Prescott filtered with a smoothing parameter of 1600. All variables except net exports and real interest rates are in logs. Net exports is exports minus imports over GDP, real interest rates are in percentage points.

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. 1983.1-2000.2. Cross-correlations[13]

	Correlation of R(t) with						
	Y(t-3)	Y(t-2)	Y(t-1)	Y(t)	Y(t+1)	Y(t+2)	Y(t+3)
Argentina	-0.06	-0.30	-0.40	-0.59	**-0.72**	-0.65	-0.61
	(0.16)	(0.15)	(0.12)	(0.12)	(0.13)	(0.13)	(0.12)
Canada	0.43	**0.50**	0.47	0.31	0.13	-0.03	-0.20
	(0.15)	(0.15)	(0.14)	(0.14)	(0.14)	(0.15)	(0.16)

The number in parentheses are the standard errors of the GMM estimates of the correlations

The table shows that interest rates in Argentina are strongly countercyclical and lead the business cycle. The highest correlation coefficient between interest rates and GDP occurs for the interest rate in t and the GDP at $t+1$, 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, has a weak positive correlation with output and lags the cycle by two quarters.

[13] All variables have been Hodrick Prescott filtered with a smoothing parameter of 1600.

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

The data on Brazil, Korea, Mexico and Philippines, even though on a shorter sample, confirms the findings for Argentina. Figure 3 shows the relation between interest rates and GDP for these four countries, along with Argentina and Canada and shows that interest rates are countercyclical in all the cases except Canada.

Tables 4 and 5 report business cycle statistics for the same group of countries from the first quarter of 1994 to the second quarter of 2000. Table 4 reports the volatility of output, interest rates and consumption (private and total). In the five emerging economies in the sample output volatility ranges from 1.5 to almost 4 times the volatility of Canadian output. A second feature that emerges from the table is that consumption is at least as volatile as output for all emerging economies, while in Canada, the volatility of consumption is between one half and two thirds the volatility of GDP. Finally, in three out of the five emerging economies real interest rates are much more volatile than in Canada.

Table 4. Business Cycles in Five Emerging Economies[14]. 1994.1 -2000.2

	Percentage Standard Deviations			
	GDP	Real Int. Rate	$\frac{\text{S.D. Priv. Cons}}{\text{S.D. GDP}}$	$\frac{\text{S.D. Tot. Cons}}{\text{S.D. GDP}}$
Argentina	3.44	2.88	1.04	0.95
	(0.46)	(0.62)	(0.05)	(0.05)
Brazil	1.84	2.75	NA	1.87
	(0.24)	(0.33)		(0.16)
Korea	4.04	1.42	1.38	2.47
	(0.62)	(0.30)	(0.08)	(0.22)
Mexico	3.61	2.87	1.43	1.44
	(0.62)	(0.64)	(0.11)	(0.06)
Philippines	1.78	1.44	1.32	1.02
	(0.27)	(0.18)	(0.13)	(0.12)
Canada	1.17	1.56	0.56	0.87
	(0.12)	(0.18)	(0.09)	(0.12)

The number in parenthesis are standard error of the GMM estimate of the standard deviations

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

[14]GDP and consumption are detrended using a linear trend. We do not use HP filter because of the short sample. Total consumption is defined as in table 1.

Table 5. Business Cycles in Five Emerging Economies. 1994.1 2000.2

	Correlations of R(t) with							
	Y(t-3)	Y(t-2)	Y(t-1)	Y(t)	Y(t+1)	Y(t+2)	Y(t+3)	NX(t)
ARG	0.06	-0.13	-0.31	-0.56	-0.77	**-0.80**	-0.70	0.63
	(0.15)	(0.18)	(0.20)	(0.15)	(0.15)	(0.18)	(0.22)	(0.13)
BRA	-0.36	-0.31	-0.40	**-0.41**	-0.38	-0.22	-0.06	0.29
	(0.20)	(0.22)	(0.31)	(0.30)	(0.20)	(0.21)	(0.20)	(0.21)
KOR	-0.03	-0.34	-0.58	**-0.66**	-0.65	-0.51	-0.34	0.79
	(0.20)	(-0.18)	(0.16)	(0.18)	(0.17)	(0.17)	(0.17)	(0.06)
MEX	0.48	0.20	-0.07	-0.48	**-0.70**	-0.61	-0.46	0.55
	(0.25)	(0.29)	(0.25)	(0.16)	(0.14)	(0.15)	(0.16)	(0.12)
PHI	-0.34	-0.56	**-0.70**	-0.66	-0.63	-0.43	-0.29	0.34
	(0.19)	(0.13)	(0.08)	(0.13)	(0.17)	(0.22)	(0.23)	(0.18)
CAN	0.26	0.36	**0.38**	0.37	0.33	0.31	0.30	0.24
	(0.26)	(0.28)	(0.28)	(0.26)	(0.19)	(0.13)	(0.16)	(0.20)

The number in parenthesis are the standard errors of the GMM estimates of the correlations

The table shows that in all the emerging economies interest rates are significantly counter-cyclical while in Canada they are weakly pro-cyclical. In Argentina, Mexico the interest rate leads the cycle, while in Brazil and Korea the interest rate is coincidental with the cycle. For all economies the real interest rate is positively correlated with net exports (see also figure 4) and this correlation tend to be stronger in emerging economies.

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. In the model time is discrete and a period is a quarter.

In the domestic economy there are households and competitive firms. They can borrow from foreigners at a rate $R(s^t)$ that is given by

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

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. Country risk stems from assuming that there is a probability that each domestic borrower is going to default on a fraction of its liabilities[15].

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

[15] We think of this as a tax imposed by the government on international creditors so domestic agents always pay back their debts but there is a probability that the government confiscates the payments to the international investors. Let the processes for the probability of confiscation, $p\left(s^t\right)$, and the confiscation rate, $\tau\left(s^t\right)$, be stochastic and exogenously to the other variables in the model. Assuming foreigners are risk-neutral and that they lend positive amounts to the domestic agents, interest rates paid by domestic agents 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 $D\left(s^t\right) = 1/\left(1-p\left(s^t\right)\tau\left(s^t\right)\right)$.

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, θ_l, θ_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 $t+1$.

In the financial market trading session firms borrow $\theta_l w\left(s^t\right) l\left(s^t\right) + \theta_k r\left(s^t\right) k\left(s^{t-1}\right)$ units of the final good from foreign lenders, households repay their outstanding bonds $b\left(s^{t-1}\right)$ and spend $R\left(s^t\right)^{-1} b\left(s^t\right)$ units of goods on the purchase of bonds maturing in $t+1$. In the factor market trading session firms hire $l\left(s^t\right)$ and $k\left(s^{t-1}\right)$ units of labor and capital, paying $\theta_l w\left(s^t\right) l\left(s^t\right) + \theta_k r\left(s^t\right) k\left(s^{t-1}\right)$ to households up-front. In the goods market trading session firms sell $y\left(s^t\right)$ units of the good, pay $\left(1-\theta_l\right) w\left(s^t\right) l\left(s^t\right) + \left(1-\theta_k\right) r\left(s^t\right) k\left(s^{t-1}\right)$ to households and keep $y\left(s^t\right) - \left(1-\theta_l\right) w\left(s^t\right) l\left(s^t\right) + \left(1-\theta_k\right) r\left(s^t\right) k\left(s^{t-1}\right)$ 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 $\left[\theta_l w\left(s^t\right) l\left(s^t\right) + \theta_k r\left(s^t\right) k\left(s^{t-1}\right)\right] R\left(s^t\right)$ for the working capital they borrowed. Households use their income from renting their labor and capital in consumption, $c\left(s^t\right)$, investment $x\left(s^t\right)$ and they also pay a cost, $\kappa\left(s^t\right)$, 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

(3) $$nx\left(s^t\right) = y\left(s^t\right) - c\left(s^t\right) - x\left(s^t\right) - \kappa\left(s^t\right)$$

The profits of the firm in period $t+1$ are

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

This profits correspond to the production carried out in period t, but are expressed in terms of period $t+1$ goods. The term $(R(s^t)-1)\left[\theta_l w(s^t) l(s^t) + \theta_k r(s^t) k(s^{t-1})\right]$ represents the interest firms pay on the inputs paid before production takes place. Competition insures that in equilibrium profits are 0.

For convenience, we detrend variables that grow in steady state. Let variables with a hat denote a detrended variable: $\hat{x}\left(s^t\right) = x\left(s^t\right)(1+\gamma)^{-t}$ (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,

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

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)[16].

The capital accumulated by households must satisfy the technological constraint

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

[16] 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 $\bar{b}$. 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.

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

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

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

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

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 [17]

$$(8) \quad u\left(c, l\right) = \frac{1}{1-\sigma}\left[c - \psi(1+\gamma)^t l^v\right]^{1-\sigma}, v > 1, \psi > 0.$$

These preferences (that we label GHH) have been introduced by Greenwood et al. (1988). They have been used in open economy models by Mendoza (1991) and Correia et al. (1995) among others. Many authors have noted that these preference are a crucial element for the ability of the models to reproduce business cycle facts. We also analyze how the results change if we consider the

[17] Note that for these preferences to be consistent with long run growth one needs to assume that technological progress increases the utility of leisure. Benhabib et al.(1991) show that these preferences can be interpreted as reduced form preferences for an economy with home production and technological progress in the home production sector. Preferences in the stationary economy are then given by

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

with $\beta\left(1+\gamma\right)^{1-\sigma} < 1$

Cobb-Douglas utility function[18]

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

In equilibrium, the markets for factor inputs clear; firms choose capital, $k\left(s^{t-1}\right)$, and labor, $l\left(s^{t}\right)$, in order to maximize profits, (4), subject to the technological constraint, (2); and households choose the state contingent sequence of consumption, $c\left(s^{t}\right)$, leisure, $l\left(s^{t}\right)$, bond holdings, $b\left(s^{t}\right)$, and investment, $x\left(s^{t}\right)$, 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

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

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, $\theta_l,\theta_k>0$, interest rate shocks affect production decisions in the same way productivity shocks do; in particular if $\theta_l>0$ an increase in the interest rate reduces the firms's demand for labor.

The equilibrium effect of an interest rate shock on employment (and output) can be seen

[18] In this case preferences in the stationary economy are given by

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

with $\beta(1+\gamma)^{\mu(1-\sigma)}<1$

combining the firm's and the household's optimization conditions for labor to obtain

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

The solution of this equation is represented by the crossing of the two lines in the panels in figure 6, where the left hand side can be interpreted as the labor supply (L^s) and the right hand side as the labor demand (L^d). Starting from an initial equilibrium employment l_0 an interest rate shock shifts the labor demand to the left and its effect on equilibrium employment will depend on the slope of the labor supply curve and on its reaction to an interest rate shock. For the GHH preferences, as the labor supply curve is independent of consumption, it is independent of the interest rate. Hence, the shift in the labor demand induces a movement along the labor supply curve and a reduction in equilibrium employment (and output). This is shown on the left panel of figure 6. For the Cobb Douglas preferences specification, the labor supply depends negatively on consumption and, since a rise in the interest rate causes a drop in consumption, it also induces an outward shift in the labor supply curve. The outward shift in the labor supply curve can offset the inward shift in the labor demand curve and the final effect on equilibrium employment can be positive. This is the case shown in the right panel of figure 6. In the results and in the sensitivity sections we derive analytically (in a linearized version of the model) the effects of interest rate shocks on equilibrium employment and show what are the key parameters that affects the magnitude of these effects.

4. Parameters and shock processes

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 GHH preference specification, v, that we set to 1.6, that is an intermediate value between the value of 1.5, used by Mendoza (1991) and the value of 1.7 used by Correia et. al. (1995). This parameter determines the labor supply elasticity that is given by $\frac{1}{\nu-1}$ and it is important for the quantitative results[19]. We assume that only wages are paid in advance and set $\theta_k = 0$ and $\theta_l = 1$. The sensitivity of the results to this choice of parameters and to the choice for the parameter v is analyzed in section (6).

The parameters, $\gamma, \beta, \alpha, \delta, \psi$ are set so that the steady state values of the model are consistent with the long run averages found in the data. In particular we match an average growth rate of Argentine real output of 2.6% per year, an average real interest rate on Argentine foreign debt of 14% per year, an average time spent working of 20% of total time, a labor's share of income[20] of 0.6, the investment output ratio of 0.21, an external debt to output ratio of 0.45.

The capital stock 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 Argentine data while the bond holding cost parameter κ is set to the minimum value that guarantees that the equilibrium solution is stationary. The parameter values are summarized

[19] We could not find an independent estimate of the elasticity of the labor supply with respect to wages in Argentina, but the value of v we use is consistent with microstudies for the US and Canada.

[20] Since here part of the income is used to pay interest the parameter α is not exactly equal to 1 minus the labor share. To calibrate α we use data on the labor share plus the following steady state relation

$$\text{Labor Share} = \frac{1-\alpha}{1+(\bar{R}-1)\theta_l}$$

where $\bar{R}$ is the steady state interest rate.

in table 6.

Table 6. Baseline parameter values

Name	Symbol	Value
Annual growth rate of technological progress	γ	2.6%
Quarterly discount factor	β	0.94
Risk aversion	σ	5
Labor weight (GHH pref.)	ψ	7.5
Labor exponent (GHH pref.)	v	1.66
Consumption share (Cobb Douglas pref.)	μ	0.29
% of labor income paid in advance	θ_l	1
% of capital income paid in advance	θ_k	0
Capital exponent (production)	α	0.38
Quarterly depreciation rate	δ	0.043
Capital stock adjustment cost	ϕ	24.5
Bond holding cost	κ	0.001

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 first derive a time series for $D(s^t)$ by dividing 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 ($R^{US}(s^t)$) on three months treasury bills. We then 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

$$\begin{pmatrix} \hat{R}^{US}\left(s^t\right) \\ \hat{D}\left(s^t\right) \end{pmatrix} = \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix} \begin{pmatrix} \hat{R}^{US}\left(s^{t-1}\right) \\ \hat{D}\left(s^{t-1}\right) \end{pmatrix} + \begin{pmatrix} \varepsilon_R\left(s^t\right) \\ \varepsilon_D\left(s^t\right) \end{pmatrix}$$

where $\varepsilon_R\left(s^t\right)$ and $\varepsilon_D\left(s^t\right)$ are jointly normally distributed with mean 0, variances $\sigma^2_{\varepsilon_R}, \sigma^2_{\varepsilon_D}$ and correlation $\rho_{\varepsilon_R,\varepsilon_D}$

The estimates of the parameters for the process are reported in table 7 below,

Table 7. Parameters of the process for interest rate[21]

a_{11}	a_{12}	a_{21}	a_{22}
0.73	0.04	0.70	0.58
(0.08)	(0.03)	(0.35)	(0.10)
σ_{ε_R}	σ_{ε_d}	$\rho_{\varepsilon_R,\varepsilon_d}$	
0.42%	1.96%	0.30	

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 period t causes an increase of 70 basis points in country risk and 143 basis points in Argentine Rates in period $t+1$ 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. We assume that innovation to productivity $\varepsilon_A\left(s^t\right)$ are normally distributed and serially uncorrelated and we set their volatility so that the simulated volatility of output in the model with interest rate shocks and productivity shocks matches the Argentine data[22]. We also assume that the innovations to productivity are uncorrelated with both the innovations to the US interest rates and with the innovations to country risk.

5. 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 7 and 8. 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 equation (10) around the steady state (with $\theta_l = 1$ and $\theta_k = 0$) yields

[22] The actual number for the standard deviation of innovation of productivity shocks is 1.98%

$$(12)\quad \hat{l}_t = -\frac{1}{1/\varepsilon_s - 1/\varepsilon_d}\hat{R}_t,$$

showing that the fall in employment that results from an increase in the interest rate depends on the wage elasticity of the labor demand, $\varepsilon_d = -1/\alpha$, and on the wage elasticity of the labor supply, $\varepsilon_s = 1/(\nu - 1)$.

For our parameter values a 1% increase in interest rates induces a fall in employment of about 1% and a fall in output of just over 0.5% of trend. The fall in consumption is over 1% of trend due to the intertemporal substitution effect. The interest rate shock induces a positive growth rate of consumption, but since the long run wealth and consumption are reduced (because now resources are needed to pay higher interests on debt) this can be achieved only with a drop in current consumption. The impact on the growth rate of consumption is exacerbated by the path of equilibrium employment[23]. Notice that this is the key mechanism through which the model can generate consumption that is more volatile than output and that the higher the intertemporal elasticity of substitution $(1/\sigma)$ the bigger will be the response of current consumption to interest rate shocks. 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 interest rates differs from the effect of an innovation to country risk due to the persistence and spillover effect of this shocks mentioned in section 4. 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 US interest rates, induces a more persistence decline in investment that reduces the

[23] 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.

capital stock. The trough of the cycle induced by an innovation in international interest rates occurs 2 years after the shock and is around 1.6% of trend[24].

In figures 9 and 10 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 so 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 figure 11 we report the cross correlation function between interest rate and GDP in the data and in the model. Even though the model overpredicts the negative contemporaneous correlation between output and interest rate it reproduces quite well the entire dynamic cross-correlation structure.

Table 8 below report standard business cycle statistics for the macroeconomic series simulated by the model, together with the statistical properties 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 fed to the model are the actual shocks from the data while productivity shocks are randomly generated by (11). The statistics for the artificial economy with interest rate and productivity shocks are the averages of 50 simulations, with each simulation having sample length equal to our data sample (1983.1-2000.2).

The model with only interest shocks is able to generate about 50% 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

[24] Table 8 shows that this large and persistent effect is related to the large volatility of investment in a model with only interest rate shocks.

of the interest rate with the other macroeconomic variables are stronger than in the data. This is not surprising as in this model economy interest rate shocks are the only source of fluctuations.

In fact, in the model with productivity shocks, as well as interest rate shocks, both of the discrepancies discussed above are significantly reduced. Notice that this version of the model is also able to reproduce the right volatility of consumption relative to GDP. One major discrepancy that remains between the model and the data is that the volatility of net exports in the model is still too high relative to the data. This suggests that the model is missing some friction on the transfer of goods between the domestic economy and the rest of the world.

Table 8. Simulated and Actual Argentine Business Cycles

	% Standard Dev.			$\frac{\%\text{Standard Dev. of } x}{\%\text{Standard Dev. of GDP}}$		
	GDP	NX	R	Tot. Cons.	Inv.	Hrs
Argentine Data	4.18	1.41	3.35	1.19	3.03	0.63
Model (R shocks)	2.12	4.03	3.35	2.03	6.00	1.46
Model (R & A shocks)	4.18	4.70	3.35	1.18	3.03	0.87

	Correlation with GDP of.				
	R	NX	Tot. Cons.	Inv.	Hrs
Argentine Data	-0.59	-0.87	0.97	0.93	0.51
Model (R Shocks)	-0.84	-0.94	0.92	0.97	0.95
Model (R & A Shocks)	-0.24	-0.88	0.83	0.50	0.86

	Correlation with R of				
	GDP	NX	Tot. Cons.	Inv.	Hrs
Argentine Data	-0.59	0.66	-0.62	-0.57	-0.55
Model (R Shocks)	-0.84	0.95	-0.97	-0.95	-0.96
Model (R & A Shocks)	-0.24	0.65	-0.72	-0.92	-0.68

6. Sensitivity analysis

The elements of the model that are crucial for the results presented in the previous section are the type of utility function, the elasticity of labor supply in the GHH preferences and the presence of working capital. In table 9 below we analyze how the key results quantitatively depend on these elements. In the table we report two key statistics from the model, the volatility of output (relative to the volatility of output in the data) and the correlation of output with interest rates for a variety of parameter configurations. We consider a high and a low value of the labor supply elasticity[25] in the GHH preferences and the case of Cobb Douglas preferences. We also consider a case in which only 50% of the labor cost has to be paid in advance ($\theta_l = 0.5$) and a case in which it is not necessary to pay labor in advance ($\theta_l = 0$). In all the experiments we keep constant all other parameters (including the capital adjustment cost) and for simplicity we focus on the model with only interest rate shocks.

First focus on the baseline GHH preferences. When θ_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 θ_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 θ_l we reduce the negative impact that interest rates have on labor demand. Notice though that even with $\theta = 0.5$ interest rate shocks induce significant output fluctuations (about 1/3 of the one observed in the data) that are negatively correlated with interest rates.

Now consider changes in the labor supply elasticity in the GHH preferences. For a fixed θ_l (that determines how labor demand respond to interest rate shocks) increasing the labor supply elasticity (in terms of figure 6 making the L^s curve flatter) generates larger output fluctuations and

[25] A value of $v = 1.2$ implies an elasticity of 5, while $v = 4$ implies an elasticity of 1/3.

reducing it induces smaller output fluctuations; for all values of v though the correlation between output and interest rates is highly negative.

Notice instead that with Cobb Douglas preferences output is still quite volatile but now the interest rates shocks are highly positively correlated with output. To understand this is useful again to consider a linearized version of equation (10) with Cobb Douglas preferences:

$$(13)\quad \hat{l}_t = -\frac{1}{\frac{\bar{l}}{1-\bar{l}} - 1/\varepsilon_d}(\hat{R}_t + \hat{c}),$$

where $\varepsilon_d = -1/\alpha$ is the wage elasticity of the labor demand and $\bar{l}$ is the steady state value of labor supply. Notice that in (13) (differently from 12) the response of labor to interest rate fluctuations depends also on consumption. In particular the drop in consumption caused by an interest rate increase acts as a shift to the right in labor supply (see the right panel of figure 6); under our parameterization this shift is larger than the shift to the left in labor demand, so that the final effect is that interest rate increase causes an increase in equilibrium employment and output. Note that with Cobb Douglas preferences the impact of interest shocks on equilibrium employment depends on the intertemporal elasticity of substitution that in this model is equal to $1/\sigma$; if the elasticity is close to infinity consumption drops strongly in response to an interest rate shocks and (from 13) employment increases strongly. When the elasticity is close to 0 instead consumption does not move much and increases in the interest rate can lead to a reduction in employment. In order to obtain this though one needs to set $\sigma > 30$. Although Cobb Douglas utility does not in general generate negative correlation between interest rate and output, GHH utility is not the only specification that does. In general any preference specification that generate a labor supply that is not very sensitive to consumption can work[26].

[26] An example of this could be a utility function that is a linear combination between Cobb Douglas and GHH with a large weight on GHH.

Notice finally that in the Cobb Douglas case as we reduce θ_l the correlation between output and interest rates increases (as in the GHH case) but the volatility of output increases as θ_l gets reduced. Again to understand this think of labor supply and labor demand shifts. In response to interest rate shocks the consumption effect shifts labor supply to the right while the working capital effect shifts the labor demand to the left. If $\theta_l = 1$ the two effects tend to offset each other, dampening the fluctuations in equilibrium employment.. As we reduce θ_l the consumption effect dominates and it causes equilibrium employment and output to fluctuate more.

Table 9. Sensitivity analysis

	Preferences							
	GHH ($\nu = 1.2$)		GHH (*Baseline*)		GHH ($v = 4$)		Cobb-Douglas	
	$\frac{\sigma(y)}{\sigma(y_{DATA})}$	Corr(y, R)	$\frac{\sigma(y)}{\sigma(y_{DATA})}$	Corr(y, R)	$\frac{\sigma(y)}{\sigma(y_{DATA})}$	Corr(y, R)	$\frac{\sigma(y)}{\sigma(y_{DATA})}$	Corr(y, R)
$\theta_l = 1$	82%	-0.89	51%	-0.84	22%	-0.55	78%	0.84
$\theta_l = 1/2$	49%	-0.69	33%	-0.60	20%	-0.27	94%	0.88
$\theta_l = 0$	34%	0.11	27%	0.09	19%	0.07	110%	0.91

A final remark is that some features of the model like the positive correlation between net exports and interest rates and the high volatility of consumption relative to output are robust to most parameter changes. As mentioned in the introduction the large volatility of consumption relative to output depends volatility of interest rates relative to income volatility; if for example we consider our baseline model with only productivity shocks (and constant interest rates) the volatility of consumption is only 78% of output volatility (as opposed to to 119% in the model with both shocks and 203% in the model with only interest rate shocks).

7. 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. 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 which allow interest rates to have an effect on the business cycle. 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 in which labor supply is not significantly affected by consumption.

The assumption about the exogeneity of the country risk in our model is controversial. 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 and GDP are related because they are driven by the same 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 cycle.

Here we did not want to take a stand in this debate since our primary goal was to find an equilibrium relation between interest rates and economic activity consistent with the data. We believe that this exercise is helpful regardless of the nature of interest shocks. If shocks to country risk are purely exogenous 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 a non modelled 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.

Data 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.

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, also semiannual, is only available from 1986.2. The standard deviation reported is relative to the standard deviation of semiannual GDP.

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, $r_{t,j}^{\text{arg}}$ can be written as the sum of the US rate for a similar bond, $r_{t,j}^{US}$, plus a country spread, $\delta_{t,j}$. 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)

$$(14) \quad \delta_{t,j} = \hat{\delta}(t,j) + \varepsilon_{t,j} = \Delta_t + \alpha_1(t) \cdot j + \alpha_2(t) \cdot j^2 + \alpha_3(t) \cdot j^3 + \varepsilon_{t,j}$$

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, $P^{\text{arg}}_{k,t}$, is given by,

$$P^{\text{arg}}_{k,t} = \sum_{j=1}^{J} C_{k,j} \cdot \exp(-(r^{us}_{t,j} + \delta_{t,j}) \cdot j),$$

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 (14) are those that minimize the loss function L, i.e.

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

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

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

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.

Canada

Quarterly series for GDP, Total Consumption, Private Consumption, Investment and Net Exports are all in constant prices from OECD Quarterly National Accounts. Total consumption is defined in the same way as in Argentina and it includes government consumption, changes in inventories and statistical discrepancy. 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. 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).

Other Countries

For Korea and Mexico quarterly series for GDP, total consumption, private consumption and net exports are all in constant prices from OECD Quarterly National Accounts. For Brazil quarterly series for GDP, total consumption and Net Exports are from Instituto de Pesquisa Econômica Aplicada (IPEA). GDP and total consumption are deflated using the GDP deflator. For Philippines GDP, total consumption and Net Exports are from the IMF International Financial Statistics. GDP and total consumption are deflated using the GDP deflator. In all countries total consumption is defined in the same way as in Argentina and it includes government consumption, changes in inventories and statistical discrepancy. 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.

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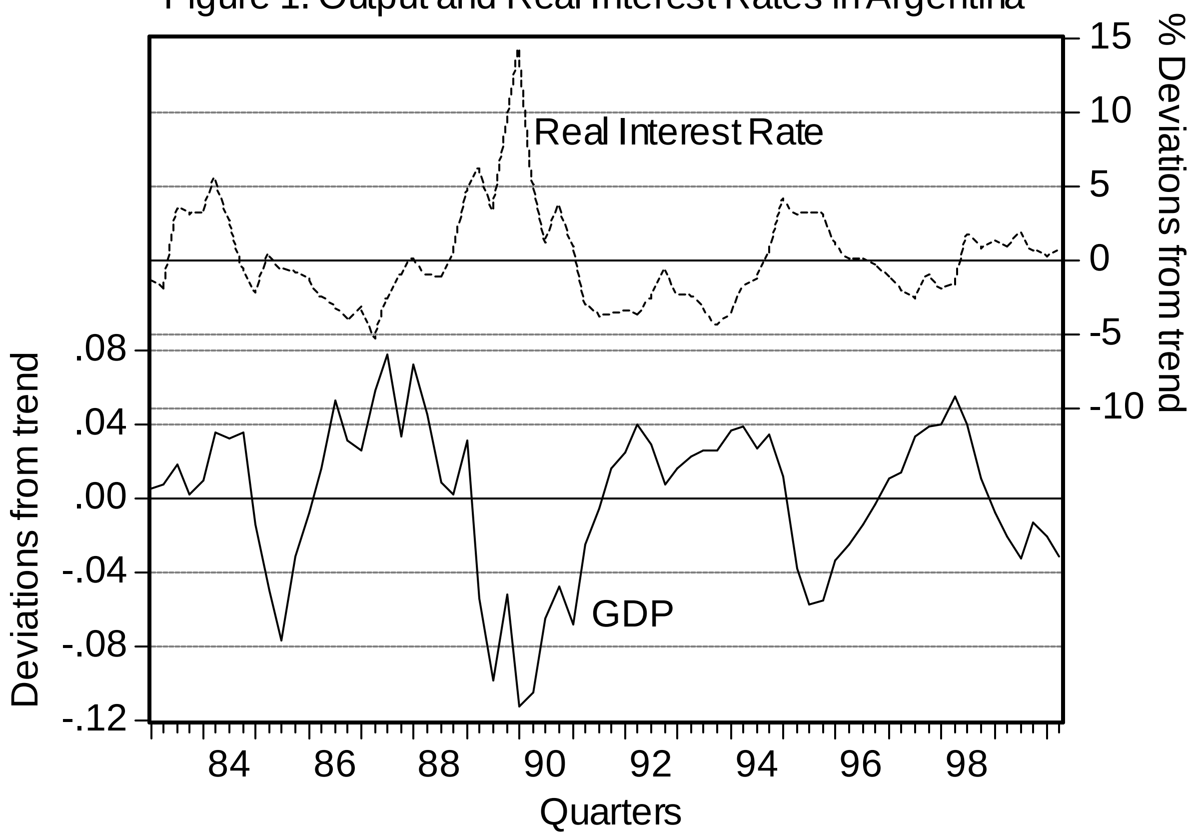
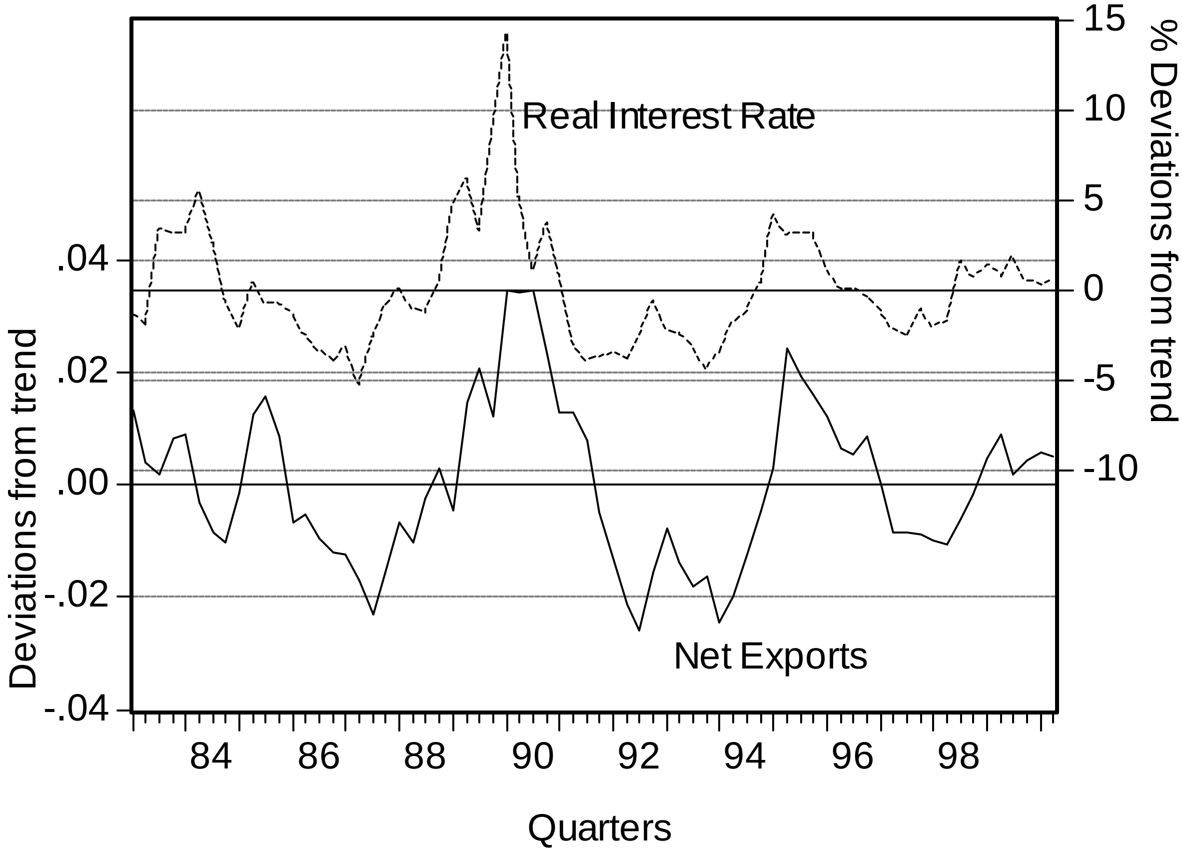
Figure 1. Output and Real Interest Rates in Argentina



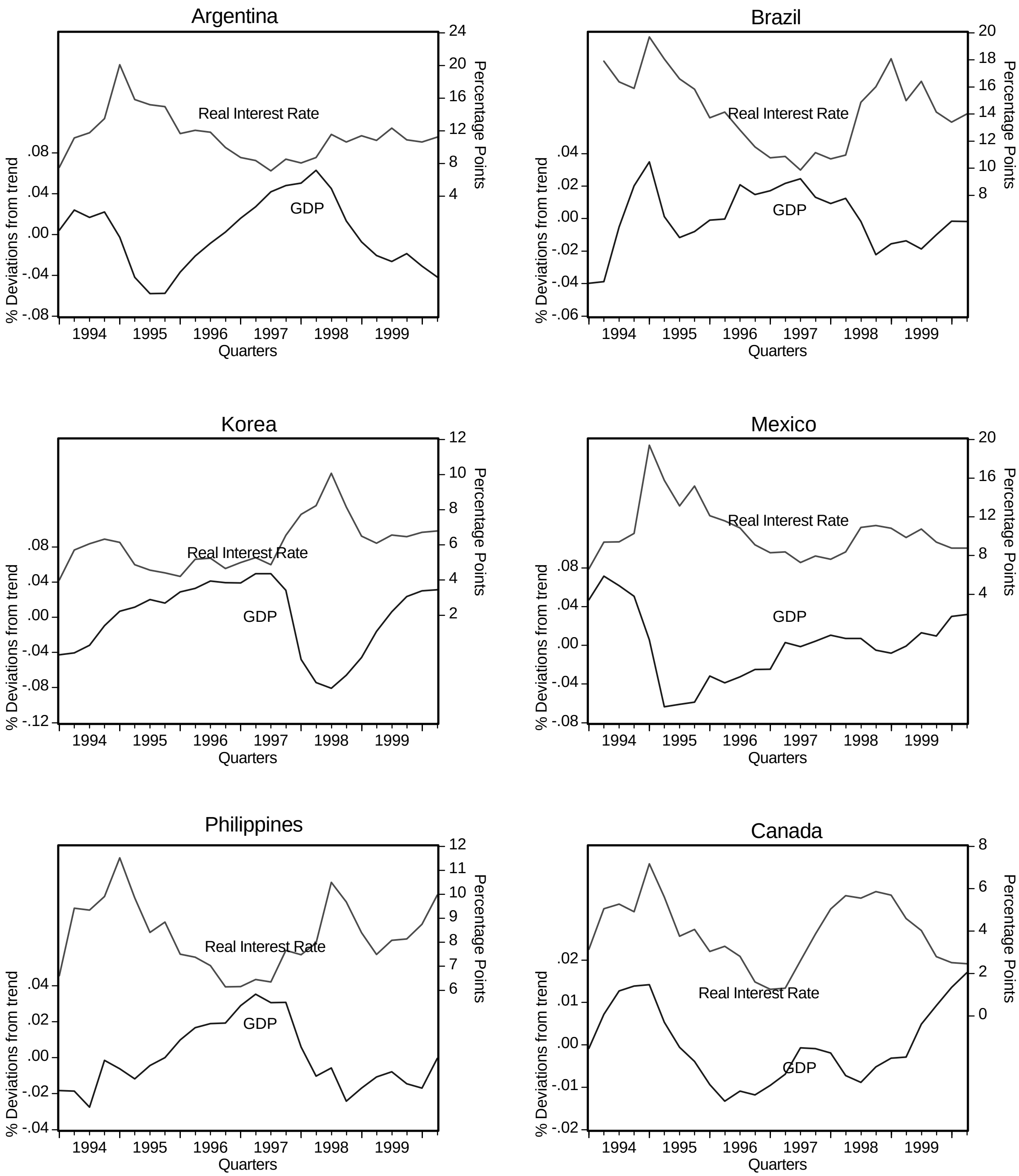
Source: see the data appendix. Interest rate is in percentage points. GDP is in logs.
Both series have been HP filtered with a smoothing parameter of 1600.

Figure 2. Net Exports and Real Interest Rates in Argentina



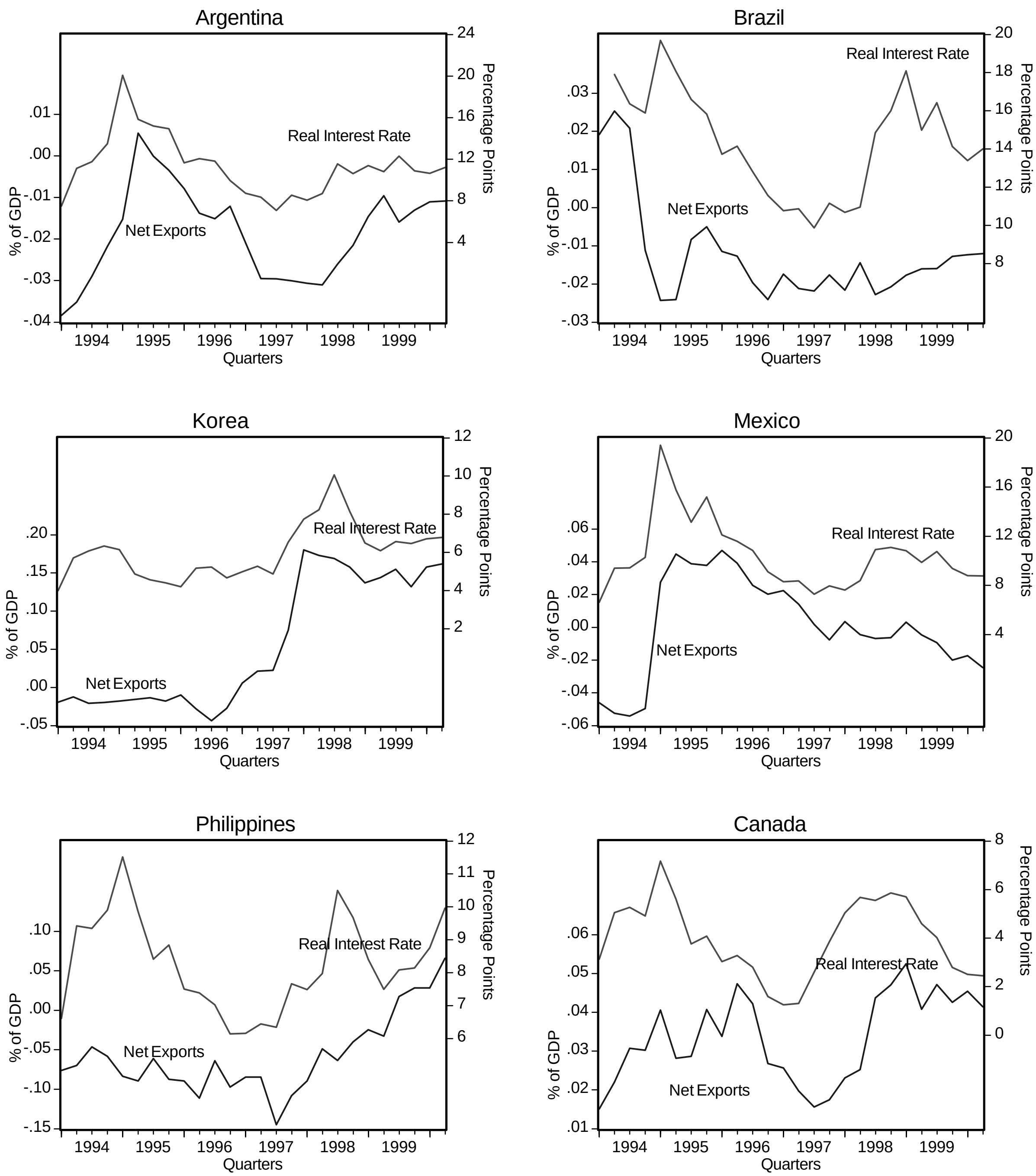
Source: see the data appendix. Interest rate is in percentage points. Net exports is exports minus imports divided by GDP. Both series have been HP filtered with a smoothing parameter of 1600.

Figure 3. Real Interest Rates and GDP



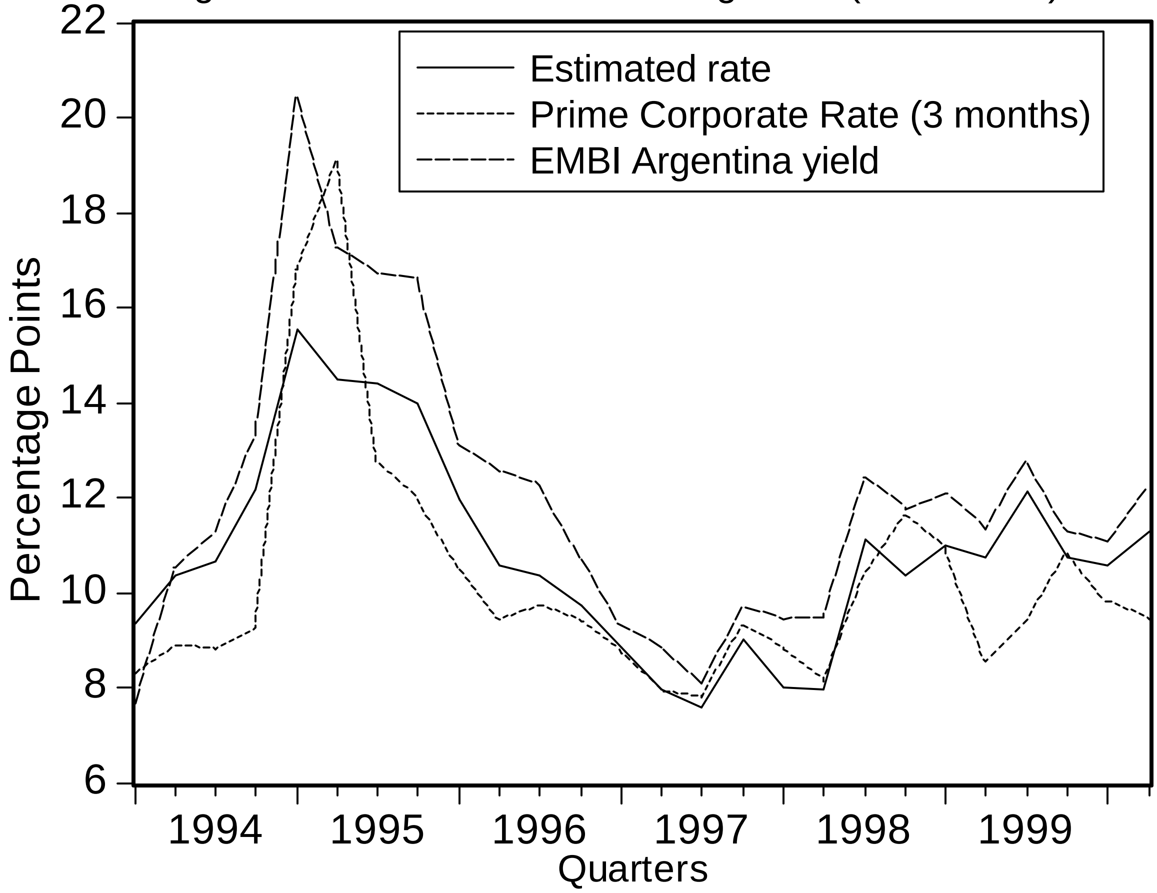
Source: see the data appendix

Figure 4. Real Interest Rates and Net Exports



Source: see the data appendix.

Figure 5. US$ interest rates in Argentina (1994-2000)



Source: see the data appendix.

Figure 6. Equilibrium Employment and Interest Rate Shocks ($R_1 > R_0$)

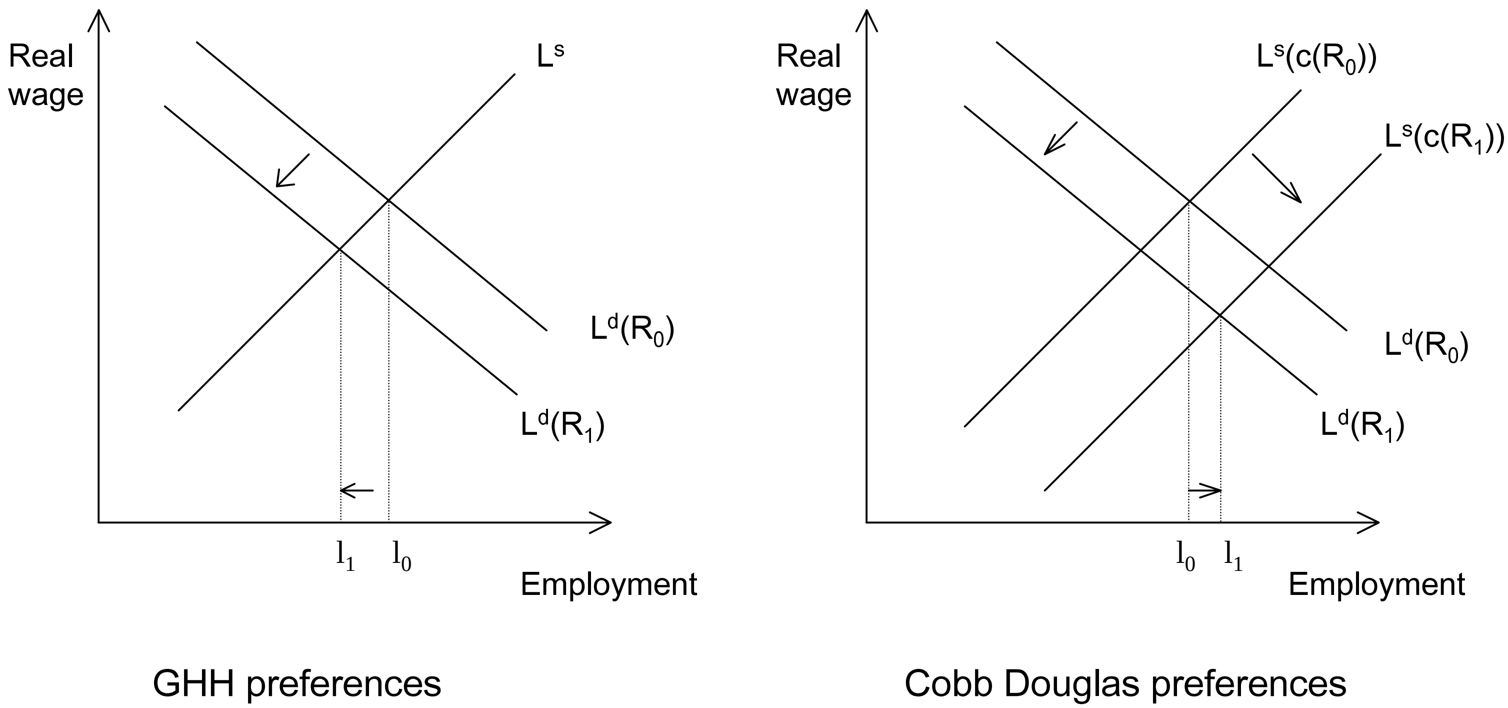


Figure 7. Impulse responses to a 1% shock in country risk

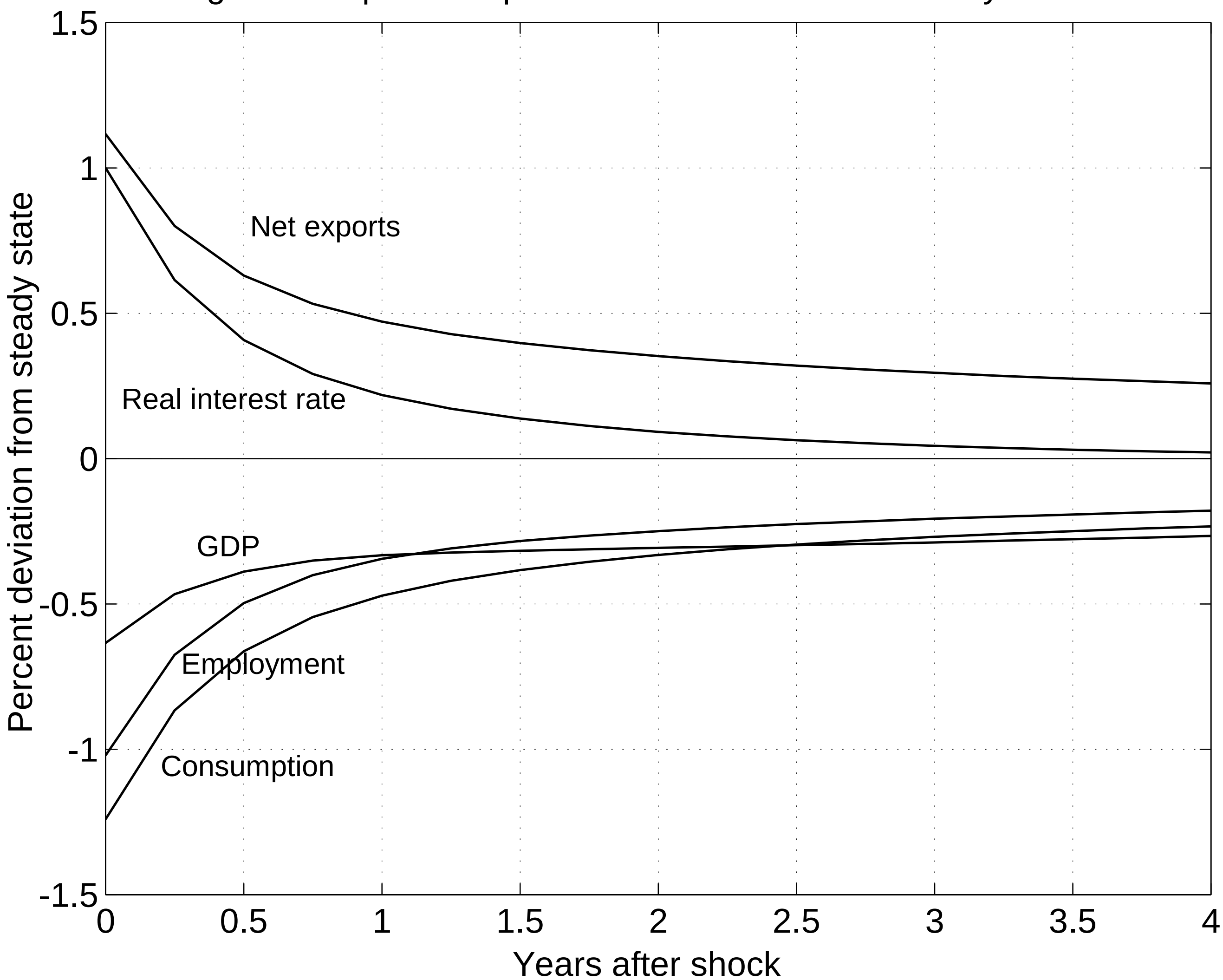


Figure 8. Impulse responses to a 1% shock in US rates

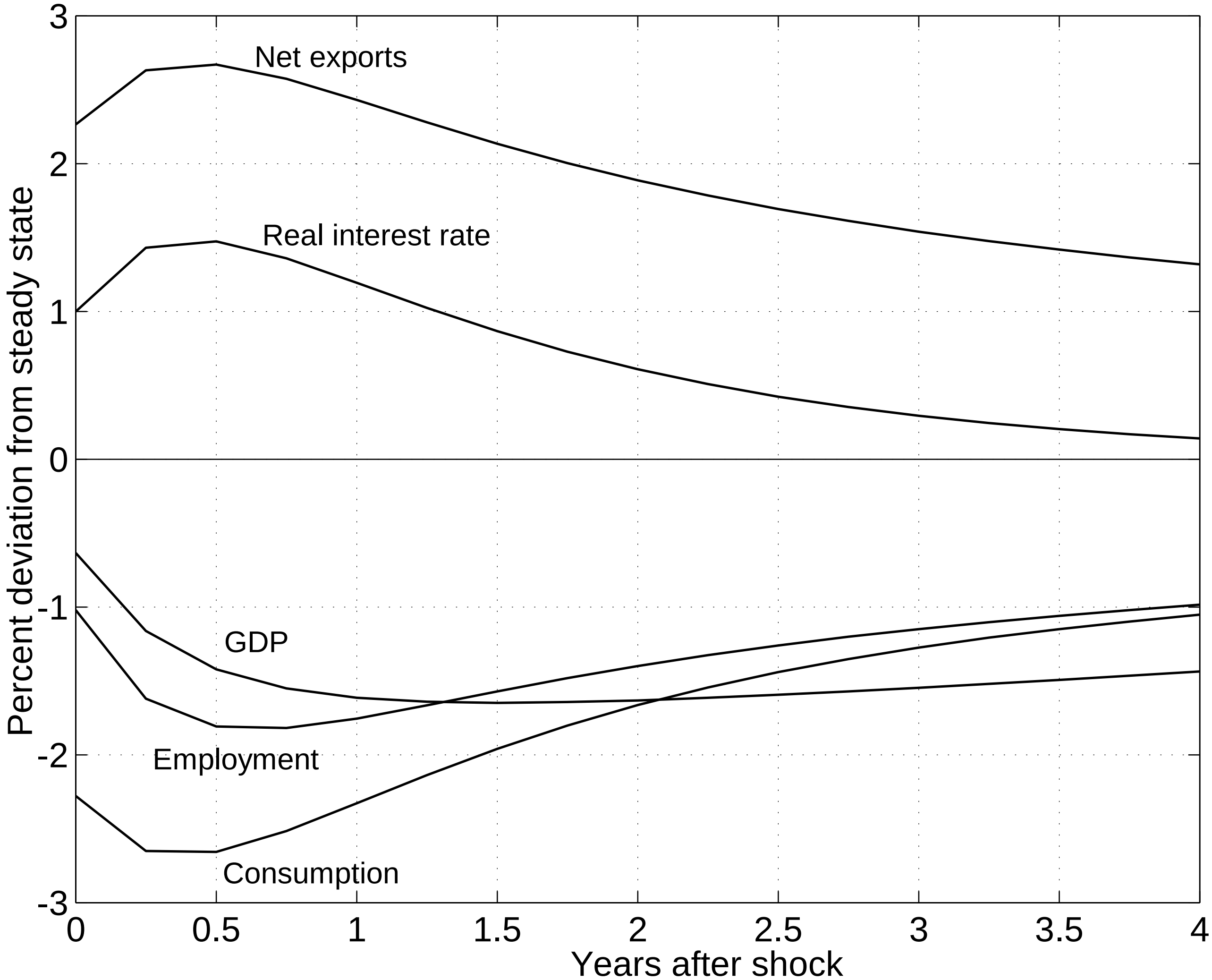


Figure 9. Output Cycles in Argentina

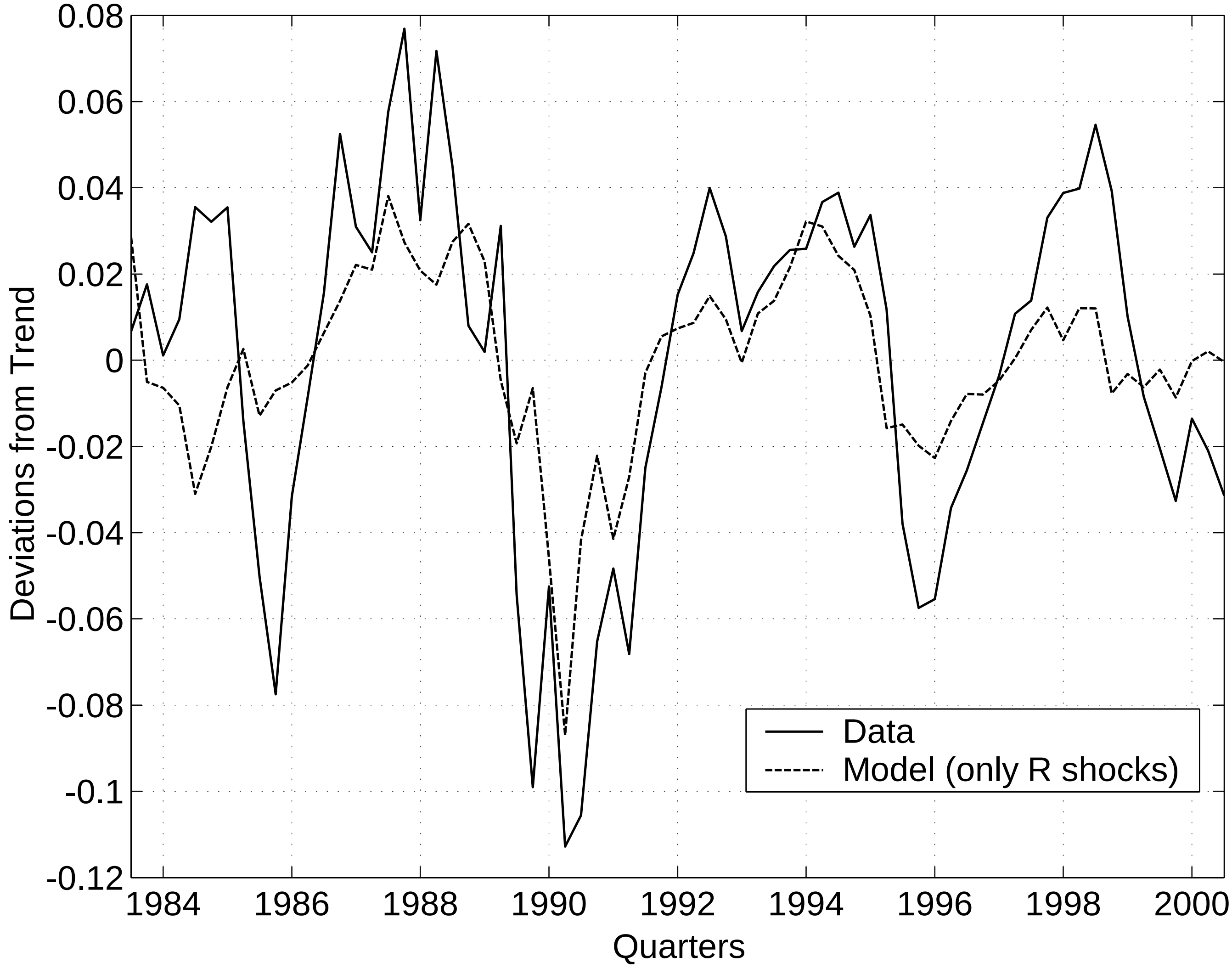


Figure 10. Net exports in Argentina

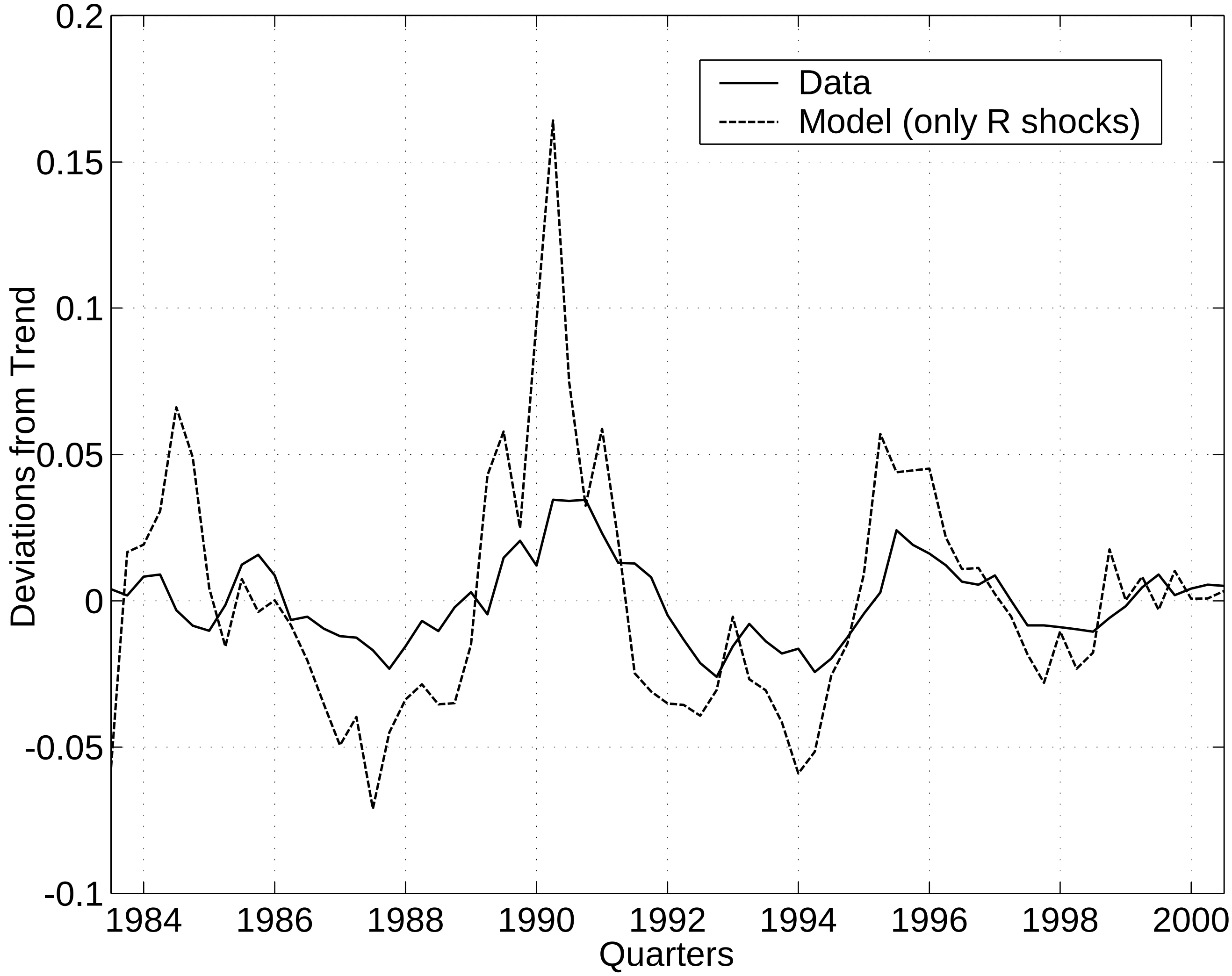
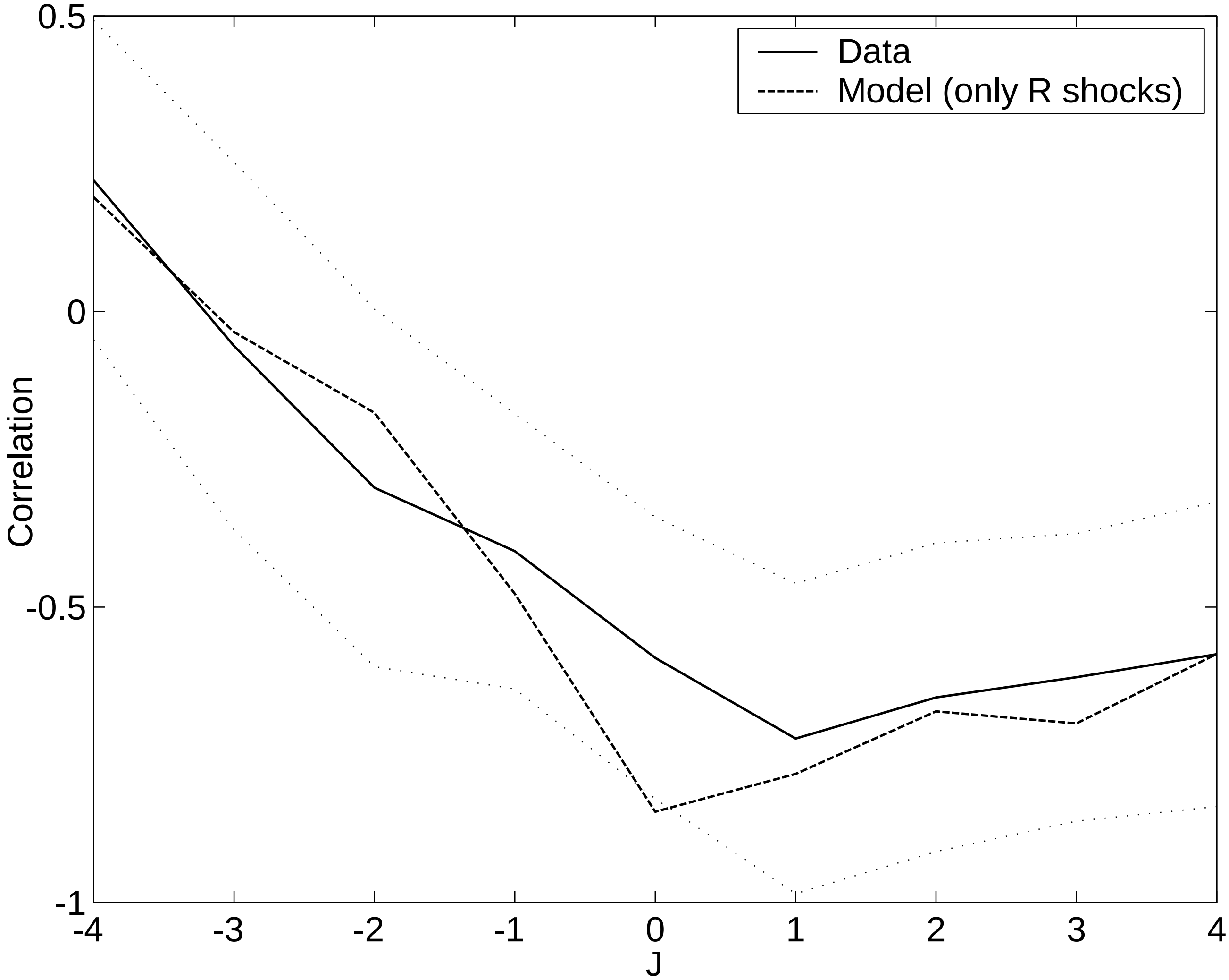


Figure 11. Correlation between R(t) and GDP(t+J)



The dotted lines are 2 standard errors bands around the cross correlation estimated in the data