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Interest Rates and Real Business Cycles in Emerging Markets*

S. Tolga Tiryaki

Abstract

We study the quantitative effects of interest rates on the business cycles of emerging markets. The real business cycle model featured in Neumeyer and Perri ("Business cycles in emerging economies: The role of interest rates." *Journal of Monetary Economics*, March 2005, 52 (2), 345-380.) is calibrated to match Turkish data. Fluctuations in country spread account for only less than 9 percent of output volatility, less than one-third of the value found in Neumeyer and Perri. We show that their result critically depends on the magnitude of the working capital parameter, the persistence of productivity shocks, and the factor shares. Our simulations highlight the importance of country spreads for the volatility of investment and the cyclicality of net exports. We also discuss the effect of correlated shocks on the countercyclicality of real interest rate and net exports.

KEYWORDS: business cycles, emerging markets, working capital, country spreads

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1 Introduction

Research on emerging market business cycles has become a focal point of interest since 2000s, and mainly investigates the differences in business cycle regularities between emerging market economies and other relatively more developed small open economies. This branch of the literature is essentially an offspring of the literature on dynamic stochastic general equilibrium models for more advanced small open economies, which was established in the early 1990s by Mendoza (1991) and Correia et al. (1995), among others.

Neumeyer and Perri (2005) and Aguiar and Gopinath (2007) highlight four key differences between business cycles of the two group of countries: (*i*) business cycle volatility is higher in emerging market economies relative to developed small open economies; (*ii*) consumption is more volatile than output in emerging market economies, in contrast to the situation in developed small open economies; (*iii*) net exports are strongly countercyclical in emerging market economies, and weakly countercyclical in developed small open economies; and (*iv*) real interest rate is countercyclical in emerging market economies, whereas it is weakly procyclical in developed small open economies.[1] These findings are summarized in Table 1.

This emerging literature tries to identify the causes of these differences in business cycles. The general strategy of analysis is to build on the standard small open economy real business cycle model by adding features representing the distinctive aspects of emerging market economies. These features range from explicitly incorporating the default risk on emerging market sovereign bonds (Arellano, 2008), to including mechanisms that generate sudden stops of capital inflows (Arellano and Mendoza, 2003; Mendoza, 2006), including additional shocks to terms of trade or interest rates (Neumeyer and Perri, 2005; Uribe and Yue, 2006), or adopting special forms of utility function (Neumeyer and Perri, 2005; Raffo, 2008).

Early small open economy models with interest rate disturbances, e.g. Mendoza (1991), Correia et al. (1995), attribute only a moderate role for shocks to world interest rate. For example, Mendoza (1991) shows that the weakness of the effect of interest rate disturbances is due to the low average interest rate and low foreign debt service ratio in Canada. Also, in the model calibrated for Portugal, Correia et al. (1995) find that only the impulse responses of investment and net exports to world interest rate shocks are significantly large, while responses of other variables are small in magni-

[1] Other studies documenting business cycle characteristics of developing small open economies are Agénor et al. (2000), Rand and Tarp (2002), and Carmichæl et al. (2001).

Table 1: Stylized facts of business cycles

		Emerging		Developed	
	Turkey	NP	AG	NP	AG
a. Output volatility					
GDP (y)	3.61	2.79	2.74	1.37	1.34
b. Volatility relative to output volatility					
Consumption (c)	0.71	1.30	1.45	0.92	0.94
Investment (x)	4.60	3.29	3.91	3.44	3.41
Net exports / GDP (nxy)	3.98	2.40	3.22	0.92	1.02
Hours (l)	0.21	0.89	*n.a.*	1.61	*n.a.*
Interest rate (R)	0.95	0.89	*n.a.*	1.24	*n.a.*
c. Correlation with output					
Consumption (c)	0.88	0.80	0.72	0.67	0.66
Investment (x)	0.85	0.88	0.77	0.73	0.67
Net exports / GDP (nxy)	−0.69	−0.61	−0.51	−0.23	−0.17
Hours (l)	0.76	0.65	*n.a.*	0.84	*n.a.*
Interest rate (R)	−0.40	−0.55	*n.a.*	0.20	*n.a.*
d. Correlation with interest rate					
Consumption (c)	−0.30	−0.55	*n.a.*	0.24	*n.a.*
Investment (x)	−0.43	−0.48	*n.a.*	0.21	*n.a.*
Net exports / GDP (nxy)	0.41	0.51	*n.a.*	−0.22	*n.a.*
Hours (l)	−0.25	−0.52	*n.a.*	0.11	*n.a.*

Notes: All variables except R, D, R^*, and nxy are in logs. All variables are Hodrick-Prescott filtered with $\lambda = 1600$. Sources and definitions of the Turkish data are in the data appendix.
NP: Neumeyer and Perri (2005); AG: Aguiar and Gopinath (2007).

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tude. Finally, Blankenau et al. (2001) carry out variance decompositions and show that world interest rate shocks can explain up to 33 percent of output volatility in Canada, but this finding depends significantly on the ordering of variables in their methodology.

Recent emerging economy models by Neumeyer and Perri (2005), Uribe and Yue (2006), and Aguiar and Gopinath (2007) highlight different aspects of emerging market business cycles. Neumeyer and Perri (2005) show that country spreads account for 27 percent of output volatility. Uribe and Yue (2006) find a similar result, but they highlight the role of the interaction between the world interest rate and country spreads. Finally, Aguiar and Gopinath (2007) emphasize the role played by shocks to the trend growth rate of emerging markets.

The objective of this article is to contribute to our understanding of emerging market business cycles in light of the recently thriving literature. More specifically, we seek to find answers for the following intertwined questions: (*i*) whether a simple small open economy real business cycle model can account for the countercyclicality of net exports and real interest rate; (*ii*) how important real interest rate fluctuations are in driving business cycles in emerging market economies; and (*iii*) how sensitive the impact of real interest rate is to various parameters of the model.

In the following sections, we calibrate Neumeyer and Perri's (2005) small open economy real business cycle model featuring a working capital requirement to match Turkey's business cycle statistics. As we can see in Table 1, Turkey's business cycle statistics fit most of the empirical regularities observed in emerging market economies. We also run various simulations to analyse what elements of the model are important in accounting for the properties of business cycles. We show that the model performs quite well in explaining business cycles.

An important finding of this study is that fluctuations in the country spread component of the interest rate account for only less than 9 percent of output volatility, less than one third of the value found in Neumeyer and Perri (2005). We show that their result critically depends on the magnitude of the working capital parameter, the persistence of productivity shocks, and the factor shares. For example, the fraction of output volatility explained by country spread shocks almost doubles if we assume, as in Neumeyer and Perri, that the working capital parameter (the fraction of the wage bill the firm needs to pay in advance) is equal to 1, instead of our calibrated value of 0.41. If we also increase the labour's share parameter to a value comparable to Neumeyer and Perri's calibration for Argentina, then the fraction of output volatility explained by country spread shocks reaches 25 percent.[2] The main transmission mechanism of interest rate fluctuations operates through the working capital requirement and labour market equilibrium condition. Hence, differences in the calibration of parameters governing the firm's demand for labour can yield such a drastic variation in outcomes.

Another important finding for business cycle analysis is that country spread shocks are especially important for matching the volatility of investment and the cyclicality of net exports. When the country spread shocks are turned off, the model predicts 83 percent less investment volatility. Also net exports become significantly procyclical when there are no country spread shocks.

We also find that the correlation structure between shocks does have an effect on obtaining the countercyclicality of real interest rate and net exports. There is significant negative correlation between estimated country spread and total factor productivity shocks. When we assume away the existing correlation structure, real interest rate and net exports become less countercyclical or even procyclical, depending on the specification of the country spread equation and the utility function.

2 Model description

The model is due to Neumeyer and Perri (2005) and is a variant of the standard small open economy real business cycle model along the lines of Mendoza (1991) and Correia et al. (1995). The economy is exposed to stochastic productivity and interest rate shocks. Both labour and capital markets are perfectly competitive. Capital is internationally mobile whereas labour is not. Capital and bond holdings are subject to convex adjustment costs.

The representative firm uses labour and capital as inputs to produce the single, internationally-traded final composite good. The production function has a Cobb-Douglas specification and exhibits constant returns to scale

$$y_t = A_t k_{t-1}^{\alpha} \left[(1+\gamma)^t \, l_t \right]^{1-\alpha}, \qquad 0 < \alpha < 1 \tag{1}$$

where y_t represents gross domestic product and α is the capital's share of output. The term $(1+\gamma)^t$ represents the labour-augmenting technical progress, l_t is the hours worked, and k_{t-1} is the capital stock available at the end of period $t-1$ or equivalently at the beginning of period t. The firm rents capital from the household at the beginning of period t at the rental rate of capital r_t. The rent is paid at the end of period t.

[2] We discuss the problem regarding the measurement of factor shares and propose an adjustment in Section 3.1.1.

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The firm is subject to a working capital constraint by which it is required to pay a fraction θ of the wage bill in advance, before production takes place. Therefore, in order to make the advance payment, the firm has to borrow before production the amount $\theta w_t l_t$ at the prevailing gross interest rate R_{t-1}. The firm raises the required borrowing amount by issuing a bond at the beginning of period t that matures at the end of period t. Note that this bond is equivalent to a bond issued at the end of period $t-1$ and maturing at the end of period t, so that the prevailing interest rate at the beginning of period t is R_{t-1}. After production takes place the firm pays back the outstanding gross debt $R_{t-1}\theta w_t l_t$ to the lender, and also pays the remaining wage bill $(1-\theta) w_t l_t$ to the household. In effect, the working capital constraint introduces a wedge between the marginal product of labour and the real wage rate.

The economy consists of an infinitely-lived representative household which maximizes the discounted sum of its lifetime expected utility. The representative household owns the capital and rents it to the firm at the prevailing rate of return. The household is also endowed with time to be allocated between paid labour activities and leisure. It has access to an internationally-traded single-period bond that pays the same rate of interest in all states of the world.

The household derives utility from consumption c_t and leisure h_t. Total time endowment is normalized to 1 so that hours worked l_t is defined as $l_t = 1-h_t$. The maximization problem of the household is

$$\max_{\{c_t,l_t,k_t,b_t\}} E_0 \sum_{t=0}^{\infty} \beta^t U(c_t, l_t), \qquad 0<\beta<1, \tag{2}$$

where β is the household's subjective discount factor and $U(\cdot)$ represents the period utility function, which is strictly increasing in consumption and strictly decreasing in hours worked, l_t. We consider two alternative specifications for the period utility function. The first one, the so-called GHH preferences, is due to Greenwood et al. (1988). GHH preferences are widely used in the small open economy literature because of their ability to generate higher volatility of consumption and countercyclical net exports (see, Neumeyer and Perri, 2005; Correia et al., 1995, among others). The other preference specification is the standard Cobb-Douglas preferences. The two forms are as follows:

$$U^{\text{GHH}}(c_t, l_t) = \frac{\left[c_t - \psi (1+\gamma)^t l_t^{\nu}\right]^{1-\sigma}}{1-\sigma}, \qquad \nu>1, \quad \psi>0 \tag{3}$$

$$U^{\text{CD}}(c_t, l_t) = \frac{\left[c_t^{\mu} (1-l_t)^{1-\mu}\right]^{1-\sigma}}{1-\sigma}, \qquad 0<\mu<1 \tag{4}$$

where σ is the coefficient of relative risk aversion (or equivalently, inverse of the intertemporal elasticity of substitution), ν (in the GHH preferences) and μ (in the Cobb-Douglas preferences) are the intertemporal elasticity of substitution in labour supply, and ψ is a scaling parameter.

The household chooses an infinite sequence of consumption, hours worked, bond holdings b_t, and capital subject to the budget constraint and given the initial values of bond holdings, interest rate, and capital.

Labour supply functions vary with the specification of the period utility functions. Under GHH preferences, labour supply is independent of consumption. However, under Cobb-Douglas preferences, labour supply is a function of both wage rate and consumption. This brings about an additional labour supply response through consumption to both productivity and interest rate shocks.

Markets for factors of production clear instantaneously by equating supply to demand at a given factor price. Hence, log-linearized labour market equilibrium under GHH utility is obtained as

$$\hat{l}_t = \left(\frac{1}{\alpha + \nu - 1}\right)\left[\hat{A}_t + \alpha \hat{k}_{t-1} - \left(\frac{\theta \bar{R}}{1 + \theta\left(\bar{R} - 1\right)}\right)\hat{R}_{t-1}\right], \tag{5}$$

where a hat indicates the log-deviation of a variable from its steady state. Labour supply does not respond significantly to interest rate shocks since labour supply decisions are independent of consumption decisions under GHH preferences. Therefore, only labour demand responds to an interest rate shock; but the resulting equilibrium level of hours depends on the wage elasticity of labour demand, $-1/\alpha$, as well as the wage elasticity of labour supply, $1/\left(\nu - 1\right)$. Under Cobb-Douglas preferences, equation (5) becomes

$$\hat{l}_t = \left(\frac{1}{\alpha + \bar{l}/\left(1 - \bar{l}\right)}\right)\left[\hat{A}_t + \alpha \hat{k}_{t-1} - \hat{c}_t - \left(\frac{\theta \bar{R}}{1 + \theta\left(\bar{R} - 1\right)}\right)\hat{R}_{t-1}\right]. \tag{6}$$

Notice the $-\hat{c}_t$ term under Cobb-Douglas preferences creates an additional channel through which real interest rate affects hours worked in equilibrium, unlike the case with GHH preferences.

The distinctive feature of small open economy models is that the interest rate is no longer endogenously determined but taken as given at the world interest rate. However, the borrowing rates of emerging economies have been historically higher than those of the advanced small open economies. This fact can be represented as a spread over the world interest rate. In order to capture this feature of emerging economies, we breakdown the interest rate into two

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components as

$$R_t = R_t^* D_t, \tag{7}$$

where R_t^* the world interest rate, and D_t is the country spread. Following Neumeyer and Perri (2005), we consider two cases for the determination of the country spread component. In the first case, the *independent country risk* case as referred to by Neumeyer and Perri (or the 'X models'), the country spread is independent of the fundamentals of the economy, and the deviations of the country spread from its trend is modelled as an autoregressive process:

$$\hat{R}_t^* = \rho_{R^*} \hat{R}_{t-1}^* + \varepsilon_t^R. \tag{8}$$

In the second case, the *induced country risk* case (or the 'N models'), the country spread is a function of the expected productivity in the next period as:

$$\hat{D}_t = \eta E_t \hat{A}_{t+1} + u_t, \qquad \eta < 0. \tag{9}$$

We first solve for the steady state balanced growth paths of variables and calibrate other parameters of the model. Then we log-linearize the model around its steady state growth path and derive a set of linear equations describing the transition dynamics around the balanced growth path. We use Uhlig's (1999) toolkit for solving and simulating the log-linearized model.[3]

3 Calibration

3.1 Steady-state equilibrium and structural parameters

We set the coefficient of relative risk aversion, σ, for Turkey to 3.65, which is the average of the two close estimates by Salman (2005) under slightly different specifications. Following Neumeyer and Perri (2005), we set the intertemporal elasticity of substitution in labour supply, ν, under GHH preferences to 1.6. This value governs the wage elasticity of labour supply, which is $1/(\nu - 1) = 1.67$.

We calibrate most other parameters by using long-run averages of Turkish time series and the steady state relationships among variables. The sample covers 18 years of quarterly observations from 1987 to 2004. We set the rate of technical progress γ to 0.54 percent quarter-on-quarter, to match the average quarterly growth rate of GDP. The quarterly real interest rate is 3.8

[3] A more detailed analysis of the model is available in Tiryaki (2010).

percent, from which we calculate the discount factor[4] using the steady state representation of the household's first order condition with respect to bonds as

$$\tilde{\beta} = \frac{1+\gamma}{\bar{R}}. \tag{10}$$

The working capital parameter θ, which governs the ratio of the wage bill paid in advance, is calculated from the balance sheet and income statements of Turkish firms. Data come from the Company Accounts database of the Central Bank of Turkey. We observe that the ratio of non-interest-bearing current liquid assets to gross sales is 13.8 percent, which is a proxy for the ratio of working capital held by firms to GDP. From the national income accounts we observe that labour's compensation, that is, the wage bill, is 34.1 percent of GDP. This makes $\theta = (13.8\%) / (34.1\%) = 40.5\%$. We calculate α using the steady state representation of the firm's first order condition with respect to labour

$$(1-\alpha) = \frac{\bar{w}\bar{l}}{\bar{y}} \left[1 + \left(\bar{R}-1\right)\theta\right]. \tag{11}$$

Finally, using the steady state representation of investment equation,

$$\bar{x} = \bar{k} - (1-\delta)\left(\frac{1}{1+\gamma}\right)\bar{k} \tag{12}$$

the firm's first order condition with respect to capital

$$\alpha = \left(\frac{1}{1+\gamma}\right)\frac{\bar{r}\bar{k}}{\bar{y}}, \tag{13}$$

and observing the investment/output ratio $\bar{x}/\bar{y}$ from the data, we can calculate the depreciation rate δ.

Household's first order conditions in the steady state with respect to bonds and capital give a no-arbitrage-type relationship between the return on capital and the interest rate on bonds as

$$\bar{r} = \bar{R} - 1 + \delta. \tag{14}$$

Having obtained α and $\bar{r}$, we can calculate that the annualized steady-state capital/output ratio $\bar{k}/\bar{y}$ is 2.3.

[4] Note that $\tilde{\beta}$ is the transformed discount factor of the stationary representation of the model and its value does not vary between the two utility specifications. But the *untransformed* discount factor is $\beta = \tilde{\beta}(1+\gamma)^{-(1-\sigma)}$ under GHH preferences, and $\beta = \tilde{\beta}(1+\gamma)^{-\mu(1-\sigma)}$ under Cobb-Douglas preferences.

Following Neumeyer and Perri (2005) we set the steady state bond holdings to match the time series average of net foreign assets of Turkey as reported in Lane and Milesi-Ferretti (2006). This is used in calculating the steady-state bonds/output ratio $\overline{b/y}$ from $\bar{f} = \bar{b} - \theta\bar{w}\bar{l}$.

Labour statistics indicate that a worker in the manufacturing industry worked on average 35.8 hours per week in the sample period. Assuming that there are $7 \times 14 = 98$ hours in a week to share between leisure and work, working 35.8 hours per week translates into $\bar{l} = 0.365$. We also set the scaling parameter ψ in the GHH utility function using the steady-state labour supply condition

$$\bar{w} = \psi\nu\bar{l}^{\nu-1}, \tag{15}$$

and μ in the Cobb-Douglas utility using the steady-state labour supply condition

$$\bar{w} = \left(\frac{1-\mu}{\mu}\right)\frac{\bar{c}}{1-\bar{l}}. \tag{16}$$

The value of the bond holding cost parameter κ is set to ensure the bond holdings on the balanced growth path is stationary. The capital adjustment parameter ϕ is set to match the actual volatility of investment relative to output.

Parameter values under GHH and Cobb-Douglas utility functions for Turkey are summarized in Table 2, which also presents a comparison of parameters between Turkey and Argentina (from Neumeyer and Perri, 2005).

3.1.1 A note on the calibration of factor shares

The parameter α is calibrated by observing the labour share in GDP and substituting this value into equation (11). The observed value of the labour share, i.e. labour compensation as a fraction of GDP, is 0.34, which implies a value of 0.65 for α. There are two empirical studies confirming the value obtained from the national accounts statistics. In the first one, Senhadji (2000) estimates a Cobb-Douglas production function with human capital, and finds that $\alpha = 0.62$ for Turkey over the sample period 1960-1994. In the second study, İsmihan and Metin-Özcan (2005) estimate the same production function for Turkey over the sample period 1960-2004, and find two estimates, $\alpha = 0.58$ and $\alpha = 0.65$, using two estimation methods. These studies provide empirical support in favour of using $\alpha = 0.65$, as suggested by the published statistics.

On the other hand, these values for α are dubiously large relative to commonly calibrated values which lie in the range between 0.30 and 0.40. This problem is highlighted by Gollin (2002) for a cross-section of countries, and

Table 2: Parameters

Parameter	Symbol	Turkey GHH	Turkey CD	Argentina† GHH	Argentina† CD
Coef. of relative risk aversion	σ	3.65	3.65	5	5
Labour curvature (GHH)	ν	1.6	–	1.6	–
Ratio of time devoted to work	$\bar{l}$	0.365	0.365	0.2	0.2
Wage elasticity of labour supply	$1/(\nu-1)$	1.67	–	1.67	–
Wage elasticity of labour supply	$(1-\bar{l})/\bar{l}$	–	1.74	–	4
Labour weight in GHH utility	ψ	25.82	–	2.48	–
Consumption share in CD utility	μ	–	0.53	–	0.24
Real interest rate (quarterly)	$\bar{R}$	1.038	1.038	1.037	1.037
Depreciation rate (quarterly)	δ	0.033	0.033	0.044	0.044
Rate of tech. progress (quarterly)	γ	0.0054	0.0054	0.0062	0.0062
Working capital parameter	θ	0.41	0.41	1	1
Discount factor (adjusted)	$\tilde{\beta}$	0.969	0.969	0.97	0.97
Discount factor	β	0.983	0.976	0.93	0.98
Capital's exponent	α	0.65	0.65	0.38	0.38
Bond holding cost	κ	0.0005	0.0001	0.00001	0.00001
Capital adjustment cost	ϕ				
X models		5.35	6.97	25.5	25.5
N models		8.00	9.24	40	25.5

† Parameters for Argentina are from Neumeyer and Perri (2005). The discount factor adjusted for the balanced growth path, $\tilde{\beta}$, is calculated by the author using $\tilde{\beta} = (1+\gamma)/\bar{R}$ given the values of γ and $\bar{R}$ for Argentina.

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by Mercenier and Yeldan (1999) especially for Turkey. The problem is rooted in the fact that the published national income accounts are not corrected for the labour income earned by self-employed workers. Gollin (2002) shows that, once adjustment is made to correct this exclusion, the resulting labour shares $(1-\alpha)$ for most countries tend to fall in the range of 0.65-0.80.

The employment status as defined by the International Labour Organization can be either employee (regular or casual), employer, own-account worker or contributing family worker. The national income accounts, however, treat all income earned by employers, own-account workers *and* contributing family workers as a component of the *entrepreneurial* income. In Turkey over the period 1988-2004, employees (both regular and casual) account for 44 percent of total employment, while own-account workers and contributing family workers together comprise 51 percent of total employment. This high ratio shows the extent of the possible bias due to excluding the latter group in the calculation of the labour share in GDP.

We adjust the official labour share series by first dividing the labour income by the number of salaried employees and then multiplying it by total employment minus the number of employers. We assume that the average earnings of each group are equal so that it is possible to make the adjustment using only employment numbers. The fraction of labour compensation to GDP after this adjustment becomes 0.59, which implies a value of 0.40 for α.

$$\left(\frac{wl}{y}\right)_{\text{Adjusted}} = \left(\frac{wl}{y}\right)\left(\frac{\#\text{Employee} + \#\text{Own-Account} + \#\text{Family}}{\#\text{Employee}}\right) \quad (17)$$

A similar adjustment for Turkey is made by Saygılı et al. (2001). They calculate the value of α as 0.53. As another example, Bergoeing et al. (2002) set $1-\alpha = 0.70$ instead of the lower values (0.58 and 0.47, respectively) implied by the national income accounts in their growth accounting for Mexico and Chile, two other countries having the same problem of small labour shares in the published statistics.

We provide a comparison of the results from the baseline model under both the official $\alpha = 0.65$ and adjusted $\alpha = 0.40$.

3.1.2 A note on the calibration of the depreciation rate

Calibration of the depreciation rate δ follows from equations (12), (13), and (14). Solving these equations for δ we can express the depreciation rate as a function of $\bar{x}/\bar{y}$, $\bar{R}$, α, and γ. Given the observed values of $\bar{R} = 1.038$ and $\gamma = 0.54\%$, the equation defining the depreciation rate is written as

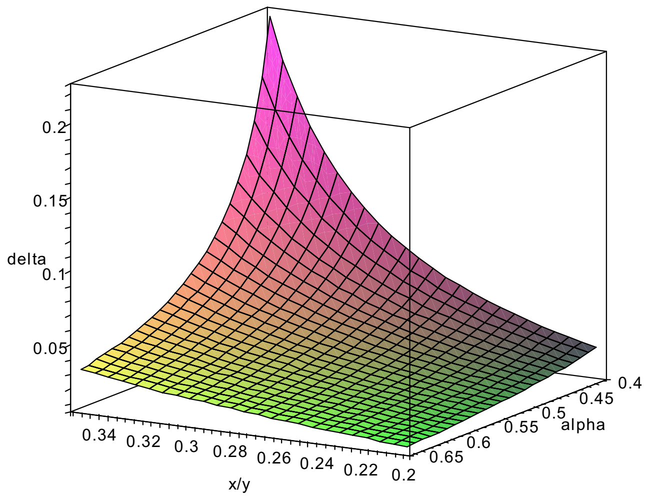

Figure 1: Depreciation rate as a function of investment/output ratio and capital's share

$$\delta = \frac{\left(\frac{\bar{x}}{\bar{y}}\right)\left(\bar{R}-1\right) - \alpha\gamma}{\alpha - \left(\frac{\bar{x}}{\bar{y}}\right)}. \tag{18}$$

Equation 18 is plotted in Figure 1, which shows clearly that the effect of changing the capital share parameter α from 0.65 to 0.40 on the depreciation rate δ is significantly larger when the investment/output ratio $\bar{x}/\bar{y}$ approaches 0.35, the observed value in Turkey. At this level, decreasing α to 0.40 raises δ from 3.3 percent to 21.8 percent. This higher depreciation rate implies that the steady state quarterly rate of return on capital is 20.9 percent, which is implausibly high.

In order to avoid this counterintuitive situation when $\alpha = 0.40$, we assign $\delta = 0.033$ beforehand, and then calculate the implied investment/output ratio. As a consequence, the steady state investment/output and consumption/output ratios will be determined within the model rather than being set to match data. This means that when $\alpha = 0.40$, the investment/output ratio decreases from 0.35 to 0.22 and the consumption/output ratio rises from 0.68 to 0.81.

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3.2 Total factor productivity and interest rate processes

3.2.1 Solow residuals

The total factor productivity term $\hat{A}_t$ in the log-linearized production function can be written as $\hat{A}_t = \hat{y}_t - \alpha\hat{k}_{t-1} - (1-\alpha)\,\hat{l}_t$. From this equation we can obtain the time series for total factor productivity as the Solow residuals by first-differencing the equation

$$\hat{A}_{t+1} - \hat{A}_t = (\hat{y}_{t+1} - \hat{y}_t) - \alpha\left(\hat{k}_t - \hat{k}_{t-1}\right) - (1-\alpha)\left(\hat{l}_{t+1} - \hat{l}_t\right), \tag{19}$$

provided that we have quarterly time series for capital stock and hours worked. Unfortunately, although there are estimates of annual capital stock series for Turkey, these are not available on a quarterly basis. However, following Cooley and Prescott (1995), we assume that quarterly changes in the capital stock are negligible so that $\hat{k}_t - \hat{k}_{t-1} = 0$. This enables us to construct time series of the total factor productivity using the calibrated value of α. After obtaining the series, we estimate the following AR(1) process for the productivity process

$$\hat{A}_t = \rho_A \hat{A}_{t-1} + \varepsilon_t^A \tag{20}$$

for the productivity process.

3.2.2 Estimation of the driving stochastic processes

We consider two alternative sets of equations to represent the driving stochastic processes of the model. First one, the exogenously determined country spread case (the 'X models'), consists of the following three independent equations

$$\begin{aligned} \hat{A}_t &= \rho_A \hat{A}_{t-1} + \varepsilon_t^A & (21)\\ \hat{R}_t^* &= \rho_{R^*} \hat{R}_{t-1}^* + \varepsilon_t^{R^*} & (22)\\ \hat{D}_t &= \rho_D \hat{D}_{t-1} + \varepsilon_t^D. & (23) \end{aligned}$$

In the second one, the endogenously determined country spread case (the 'N models'), the country spread depends on expected productivity. In this specification, expected positive productivity shocks pull the country spread down as the economy is expected to grow more, improving the debt repayment capability of the country. The set of equations of the N models are

$$\begin{aligned} \hat{A}_t &= \rho_A \hat{A}_{t-1} + \varepsilon_t^A & (24)\\ \hat{R}_t^* &= \rho_{R^*} \hat{R}_{t-1}^* + \varepsilon_t^{R^*} & (25)\\ \hat{D}_t &= \eta E_t \hat{A}_{t+1} + u_t, \qquad u_t = \rho_u u_{t-1} + \varepsilon_t^u. & (26) \end{aligned}$$

Table 3: Estimation of the productivity and interest rate processes

		Turkey		Argentina
		$\alpha = 0.65$	$\alpha = 0.40$	$\alpha = 0.38$
X models				
$\hat{A}_t = \rho_A \hat{A}_{t-1} + \varepsilon_t^A$	ρ_A	0.70 (0.09)	0.70 (0.09)	0.95
$\hat{R}_t^* = \rho_{R^*} \hat{R}_{t-1}^* + \varepsilon_t^{R^*}$	ρ_{R^*}	0.87 (0.06)	0.87 (0.06)	0.81
$\hat{D}_t = \rho_D \hat{D}_{t-1} + \varepsilon_t^D$	ρ_D	0.27 (0.12)	0.27 (0.12)	0.78
	σ_A	2.44	2.35	1.75
	σ_{R^*}	0.10	0.10	0.63
	σ_D	3.30	3.30	2.59
N models				
$\hat{A}_t = \rho_A \hat{A}_{t-1} + \varepsilon_t^A$	ρ_A	0.70 (0.09)	0.70 (0.09)	0.95
$\hat{R}_t^* = \rho_{R^*} \hat{R}_{t-1}^* + \varepsilon_t^{R^*}$	ρ_{R^*}	0.87 (0.06)	0.87 (0.06)	0.81
$\hat{D}_t = \eta E_t \hat{A}_{t+1} + u_t$	η	−0.60 (0.25)	−0.64 (0.21)	−1.04
$u_t = \rho_u u_{t-1} + \varepsilon_t^u$	ρ_u	0.25 (0.17)	0.25 (0.12)	*n.a.*
	σ_A	2.44	2.35	1.47
	σ_{R^*}	0.10	0.10	0.63
	σ_u	3.07	3.09	1.7

Note: Equations are estimated by ordinary least squares. Standard errors are given in round brackets. Parameters for Argentina are from Neumeyer and Perri (2005).

The residuals u_t in the country spread equation exhibit serial correlation, so we add a first order autoregressive component in the equation as well. The AR component of the country spread may be thought of representing the market sentiment factor, reflecting speculative financial market behaviour.

The choice of the factor share parameter α slightly alters the estimates of the coefficients in both of the specifications. Table 3 presents estimation results with $\alpha = 0.65$ and $\alpha = 0.40$. Table 4 presents residual correlations of estimated exogenous series.

Note especially that the estimated autoregressive coefficient ρ_A for Turkey is less than the value of 0.95 assumed by Neumeyer and Perri (2005) for Argentina. In their experiments they set the standard deviation of ε_A to different values ranging from 1.47 percent to 1.98 percent in order to match the actual volatility of output under alternative specifications. We estimate the standard deviation of the ε^A term in Turkey to be 2.44 percent meaning that shocks to total factor productivity in Turkey are more volatile than in Argentina.

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Table 4: Residual correlations in estimated equations

X models	$\hat{A}$	$\hat{R}^*$	$\hat{D}$	N models	$\hat{A}$	$\hat{R}^*$	$\hat{D}$
$\hat{A}$	1.00			$\hat{A}$	1.00		
$\hat{R}^*$	0.14	1.00		$\hat{R}^*$	0.14	1.00	
$\hat{D}$	−0.49	−0.16	1.00	$\hat{D}$	−0.20	−0.12	1.00

However, since Argentine shocks are assumed to be more persistent than the estimated shocks for Turkey, the Solow residuals in Neumeyer and Perri's experiments are 1.9 to 3.4 times more volatile than in Turkey.[5] We show later in the analysis of our simulations that Neumeyer and Perri's results critically depend on their assumption of $\rho_A = 0.95$.

Again, comparing the estimates of the country spread with those of Argentina we can see that Turkish spreads are far less persistent than Argentine spreads. Neumeyer and Perri's estimate shows that their persistence coefficient is 0.78. On the other hand, shocks to spreads have less variability in Argentina (2.59 percent) as compared to Turkey (3.33 percent). The sensitivity parameter for Turkey is found to be $\eta = -0.60$, smaller than the Neumeyer and Perri's $\eta = -1.04$ for Argentina.

4 Simulations

4.1 Moments

We simulate the model using two alternative preference specifications and two alternative country spread processes to obtain the moments implied by the model. We feed the residuals from estimated equations in Table 3 to the model's log-linear law-of-motion equations to compute the simulated series. The standard deviations and correlations of the simulated series are reported in Table 5.[6,7]

[5] Note that the variance of $\hat{A}$ is $\text{Var}\hat{A} = \sigma_A^2 / \left(1 - \rho_A^2\right)$, and depends on both the variance of shocks and the persistence of the process.

[6] The abbreviations GHH-X and CD-X refer to the exogenously determined country spread models under GHH and Cobb-Douglas preferences, respectively. Likewise, the abbreviations GHH-N and CD-N refer to the endogenously determined country spread models under GHH and Cobb-Douglas preferences, respectively.

[7] In addition, we also carried out simulations by drawing random shocks from the joint distribution of the estimated shock processes. For these simulations, 500 random shocks were drawn for each exogenous variable, and then second-order moments of the computed

Table 5: Second-order moments of the simulated series

	(I)	(II)	(III)	(IV)	(V)
Variables (z)	σ_z	σ_z/σ_y	$\rho(z_t, z_{t-1})$	$\rho(z_t, y_t)$	$\rho(z_t, R_t)$
GDP (y)					
Actual data	3.61	1.00	0.69	1.00	−0.40
Model GHH-X	4.14	1.00	0.61	1.00	−0.34
Model CD-X	3.69	1.00	0.60	1.00	−0.24
Model GHH-N	4.14	1.00	0.63	1.00	−0.33
Model CD-N	3.44	1.00	0.62	1.00	−0.22
Consumption (c)					
Actual data	2.56	0.71	0.66	0.88	−0.30
Model GHH-X	2.64	0.64	0.60	0.92	−0.64
Model CD-X	2.34	0.63	0.47	0.66	−0.86
Model GHH-N	3.12	0.75	0.60	0.94	−0.61
Model CD-N	2.98	0.87	0.52	0.77	−0.78
Investment (x)					
Actual data	16.61	4.60	0.70	0.85	−0.43
Model GHH-X	19.06	4.60	0.27	0.42	−0.99
Model CD-X	16.97	4.60	0.26	0.31	−0.99
Model GHH-N	19.02	4.60	0.38	0.66	−0.91
Model CD-N	15.84	4.60	0.37	0.56	−0.92
Net exports / GDP (nxy)					
Actual data	3.98	1.10	0.71	−0.69	0.41
Model GHH-X	6.71	1.62	0.18	−0.03	0.94
Model CD-X	6.89	1.87	0.17	0.13	0.92
Model GHH-N	6.08	1.47	0.25	−0.35	0.98
Model CD-N	6.01	1.75	0.22	−0.19	0.98
Hours (l)					
Actual data	0.74	0.21	0.80	0.76	−0.25
Model GHH-X	3.20	0.77	0.57	0.98	−0.34
Model CD-X	2.23	0.60	0.26	0.85	0.23
Model GHH-N	3.18	0.77	0.58	0.98	−0.34
Model CD-N	1.79	0.52	0.08	0.69	0.43

Notes: Column (I): standard deviation in percentages; Column (II): relative standard deviation with respect to GDP; Column (III): first order autocorrelation; Column (IV): correlation with GDP; Column (V): correlation with interest rate. All variables except R and nxy are in logs. All variables are Hodrick-Prescott filtered.

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Table 6: The effect of correlated shocks on the countercyclicality of real interest rate and net exports

	Baseline parameterization		No correlation between shocks	
	$\rho(R_t, y_t)$	$\rho(nxy_t, y_t)$	$\rho(R_t, y_t)$	$\rho(nxy_t, y_t)$
Model GHH-X	−0.33	−0.03	0.05	0.31
Model CD-X	−0.23	0.13	0.17	0.46
Model GHH-N	−0.41	−0.42	−0.31	−0.34
Model CD-N	−0.30	−0.26	−0.19	−0.17

Models with Cobb-Douglas preferences produce less output volatility relative to models with GHH preferences which exceed the actual volatility of output by about 15 percent. The persistence of output implied by models are very close to each other and fall slightly short of the actual persistence.

All models seem to be able to generate countercyclical interest rate, but correlations in GHH models are closer to the actual correlation relative to those in Cobb-Douglas preferences. The implied correlation of -0.33 in the model GHH-N is close to the actual correlation of -0.40. It seems from Table 5 that the X models are able to replicate the negative correlation between output and interest rate to a lesser extent than the N models. However, when we use randomly drawn shocks from the estimated distributions and assume away the covariation between shocks, the countercyclicality of the interest rate disappears in the the X models (not reported here). When the shocks are independently distributed, the internal dynamics of the X models yield acyclical or weakly procyclical interest rate. As seen in Table 4, the country spread shocks are negatively correlated with productivity shocks in both X and N models. Therefore, when actual shocks are used there is little need for an internal mechanism in order to obtain countercyclical interest rate result. However, Table 6 shows that when the cross-correlations between shocks are assumed away, the X models are no longer able to generate countercyclical interest rate or net exports. This finding is contrary to the finding of Neumeyer and Perri (2005). They find that the X models can generate countercyclical interest rate and net exports even without a negative correlation between productivity and interest rate shocks.[8]

time series for all variables were calculated. This process was repeated 2000 times in order to obtain consistent estimates. Results of these simulations, available in Tiryaki (2010), are similar to those in Tables 5.

[8]In Neumeyer and Perri (2005) the correlation between the world interest rate and the country spread is 0.05. Since they do not have quarterly time series for hours or labour, they assume an independently distributed AR(1) process for total factor productivity.

Only N models can generate countercyclical net exports, with GHH-N better than CD-N. The magnitude of implied countercyclicality of net exports by N models is still less than the actual correlation.

Relative volatilities reported in column (II) of Table 5 are captured better by N models. All the models exceed the actual volatility of net exports to GDP ratio relative to the simulated output volatility, with the model GHH-N having the closest value. The relative volatility of hours is more problematic in the sense that all the models yield very volatile hours unlike the actual smooth volatility. Also, note that the Cobb-Douglas preferences produce less volatile hours.

For all of the variables, the model GHH-N is the best model in replicating the autocorrelation coefficients as shown in Column (III). It provides reasonably accurate persistence of GDP and consumption. But the model's prediction of the persistence of investment, net exports, and hours fall (significantly in the latter two) short of the actual values.

The column (V) of Table 5 reports each variable's correlation with the interest rate. All of the models over-predict the correlation between the interest rate and consumption, investments, and net exports. Still, the model GHH-N is overall the best model in achieving the closest correlations.

The correlation between the interest rate and hours shows significant variation with respect to the chosen form of preferences. Under GHH preferences the correlation is negative and close to the actual value, while under Cobb-Douglas preferences the correlation is positive. This difference is due to the independence of the optimal labour supply decision from consumption under GHH preferences, which implies the lack of another channel through which interest rate shocks affect the labour supply.

All alternative specifications overshoot the volatility of net exports to GDP ratio, but, again, N models perform better. However, actual hours worked is far less volatile than the volatility implied by either specification. We set the capital adjustment parameter ϕ to match the actual relative volatility of investment with respect to output, which actually is 4.6.

4.2 Counterfactual experiments

All in all, as also concluded by Neumeyer and Perri (2005), the model GHH-N performs better than the alternatives, hence we choose it as the baseline model. Following Neumeyer and Perri's similar experiment, we carry out a kind of variance decomposition of which results are summarized in Table 7. In the first line under each variable are the results from the baseline GHH-N model. The second line gives the outcome when there are 'no A shocks'.

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We do this by replacing the actual series of productivity shocks with zeroes. The direct link from productivity shocks to output through the production function makes it no surprise that productivity shocks account for a major part of output volatility. The standard deviation of output comes down to 0.79 dropping by 81 percent. The elimination of productivity shocks also causes the countercyclicality of the real interest rate and net exports to break down.

When productivity shocks are turned off, consumption becomes more volatile than output because households are now responding only to the interest rate shocks which are more volatile than the productivity shocks. The presence of productivity shocks balances out the negative effect of the interest rate disturbances, resulting in smaller volatility.

The 'no D shocks' line is obtained by setting $\eta = 0$ and eliminating the residual country-spread shocks, ε^u. In this case, output volatility falls by 8.7 percent to 3.78. Half of this fall is due to setting $\eta = 0$, that is, eliminating the response of the country-spread to the expected productivity, which is shown in the 'D shocks only via A' line. The reduction of Argentine output volatility calculated by Neumeyer and Perri (2005) is more than 27 percent, which is more than triple the reduction in the Turkish case.

4.3 Effect of key parameters on volatility

What combinations of parameter values are needed to obtain stronger amplification of interest rate disturbances? Why does the model predict smaller country-spread-induced volatility in the case of Turkey relative to the case of Argentina? In this section, we offer several (not mutually exclusive) explanations from the Turkish case. These explanations may be discussed over the labour market equilibrium condition in the GHH model, equation (5), which involves most of the propagation mechanisms in the model. Obviously, the amplification of shocks via equation (5) depends on the parameters α, ν, θ, and $\bar{R}$.

First, the working capital parameter θ is one of the key parameters in determining the strength of the effect of interest rate disturbances on output volatility. When there is no working capital constraint, $\theta = 0$, the demand for labour by the firm does not depend on the interest rate. Therefore, one of the channels through which interest rate shocks are transmitted is eliminated; so we may expect to see less propagation of these shocks. Indeed, output, consumption, and hours are all more volatile when $\theta = 1$ compared to the case when $\theta = 0$, in the order of 14 to 16 percent for output, and 85 to 103 percent for hours in all of the four models. The change in consumption volatility varies

Table 7: Counterfactual experiments using the baseline model

Variables (z)	(I) σ_z	(II) σ_z/σ_y	(III) $\rho(z_t, z_{t-1})$	(IV) $\rho(z_t, y_t)$	(V) $\rho(z_t, R_t)$
GDP (y)					
Model GHH-N	4.14	1.00	0.63	1.00	−0.33
No A shocks	0.79	1.00	0.50	1.00	0.12
No D shocks	3.78	1.00	0.61	1.00	0.08
D shocks only via A	3.96	1.00	0.67	1.00	−0.95
No R^* shocks	4.13	1.00	0.63	1.00	−0.33
Consumption (c)					
Model GHH-N	3.12	0.75	0.60	0.94	−0.61
No A shocks	1.23	1.55	0.54	0.49	−0.78
No D shocks	1.62	0.43	0.64	0.97	−0.05
D shocks only via A	2.75	0.69	0.69	0.99	−0.95
No R^* shocks	3.15	0.76	0.61	0.94	−0.61
Investment (x)					
Model GHH-N	19.02	4.60	0.38	0.66	−0.91
No A shocks	12.88	16.29	0.19	−0.14	−0.99
No D shocks	3.23	0.85	0.76	0.50	−0.82
D shocks only via A	13.60	3.44	0.62	0.94	−1.00
No R^* shocks	19.24	4.66	0.40	0.67	−0.92
Net exports / GDP (nxy)					
Model GHH-N	6.08	1.47	0.25	−0.35	0.98
No A shocks	5.31	6.72	0.18	0.20	0.98
No D shocks	2.53	0.67	0.65	0.89	0.52
D shocks only via A	2.85	0.72	0.63	−0.80	0.94
No R^* shocks	6.15	1.49	0.28	−0.37	1.00
Hours (l)					
Model GHH-N	3.18	0.77	0.58	0.98	−0.34
No A shocks	1.21	1.53	0.26	0.90	−0.08
No D shocks	2.36	0.62	0.61	1.00	0.07
D shocks only via A	2.71	0.68	0.72	1.00	−0.94
No R^* shocks	3.18	0.77	0.58	0.97	−0.34

Notes: Column (I): standard deviation in percentages; Column (II): relative standard deviation with respect to GDP; Column (III): first order autocorrelation; Column (IV): correlation with GDP; Column (V): correlation with interest rate. All variables except R and nxy are in logs. All variables are Hodrick-Prescott filtered.

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with the utility function: between 32 and 40 percent with GHH preferences, and between 13 and 16 percent with Cobb-Douglas preferences.

The working capital parameter θ is also instrumental in accounting for the differences in interest-rate-induced volatility between Argentina and Turkey. In order to see a more realistic picture of an economy in which $\theta < 1$, unlike the one in Neumeyer and Perri (2005) with $\theta = 1$, we set $\theta = 0.405$ to match the ratio of non-interest-bearing current assets to gross sales, which is calculated from the accounts of a cross-section of firms from all sectors representing the whole of the Turkish economy. Setting $\theta < 1$ weakens the response of equilibrium hours worked in response to an interest rate shock relative to the response to a productivity shock. The value of the term $\theta\bar{R}/\left(1+\theta\left(\bar{R}-1\right)\right)$ in front of $\hat{R}_{t-1}$ in equation (5) is equal to 0.414 in our parameterization for Turkey; however, it is equal to 1 when $\theta = 1$. This implies that the equilibrium response of hours under our parameterization is 59 percent less sensitive to interest rate disturbances than to productivity disturbances, whereas under Neumeyer and Perri's assumption the response is the same to both shocks, except for the sign. If we take $\theta = 1$, then the fraction of output volatility accounted for by country spreads would rise to 16.1 percent in the Turkish case.

Second explanation follows from the fact that the labour share $(1-\alpha)$ used in the calibration of the baseline GHH-N model is smaller than that used in Neumeyer and Perri's calibration. Under the baseline parameterization, the term $1/\left(\alpha+\nu-1\right)$ in equation (5) is equal to 0.8 in our calibration, whereas it is 1.02 in Neumeyer and Perri's calibration. Coupled with the difference in θ, the smaller labour share in the Turkish case implies that response of hours to interest rate disturbances is only 0.32, which is considerably smaller than the value of 1.02 in the Argentine case.

In order to visualize how economy's responses would change under different combinations of $(1-\alpha)$ and θ, impulse responses of hours and output to a shock in the world interest rate in the GHH-N model are plotted in Figure 2. The left column shows the case when labour's exponent $(1-\alpha) = 0.35$, and the right column shows the case when $(1-\alpha) = 0.60$. In both cases, the initial responses of hours worked and output are increasing as θ approaches 1. However, the increase in the sensitivity of hours is transmitted more strongly to output when labour's exponent $(1-\alpha)$ is larger in the production function.

In order to see by how much the fraction of output volatility induced by country spread shocks would change after we make the previously described adjustment on the calculation of the labour share, we carried out the same counterfactual exercise using the possibly more plausible value of $\alpha = 0.40$

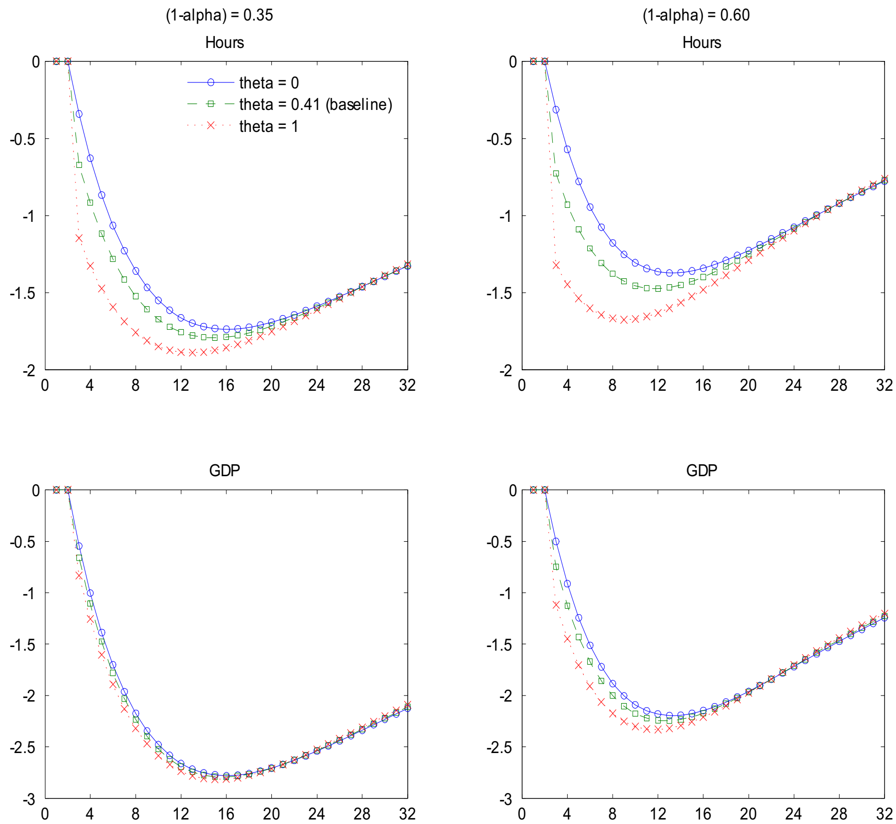

Figure 2: Impulse responses to a shock in world interest rate: sensitivity with respect to α and θ (GHH-N model)

despite empirical evidence in favour of $0.58 \leq \alpha \leq 0.65$. In this case, the drop in output volatility becomes 12.3 percent, about 3.6 percentage points higher than the baseline parameterization. When $\alpha = 0.40$ and $\theta = 1$, we obtain a comparable reduction by 25 percent in output volatility as in Argentina. These results are summarized in Table 8.

The third explanation is based on the differences arising from the interaction between expected productivity and the country spread. Neumeyer and Perri (2005) assume that the persistence of the productivity process in Argentina is $\rho_A = 0.95$. This implies that 95 percent of a productivity shock in the current period will affect next period's expected productivity. However, in the Turkish case, we estimate that the persistence parameter is $\rho_A = 0.70$.

Table 8: Fraction of output volatility accounted for by country spread shocks

	$\alpha = 0.65$	$\alpha = 0.40$
$\theta = 0.41$	8.7%	12.3%
$\theta = 1.00$	16.1%	25.0%

Besides, the sensitivity of the country spread to expected productivity is estimated as $\eta = -0.60$ in Turkey, while it is set to $\eta = -1.04$ by Neumeyer and Perri in order to match the persistence of the real interest rate series. All in all, one-unit shock to productivity in the current period decreases the country spread in the next period by 0.42 in Turkey and by 0.99 in Argentina.

Finally, the parameter ν, which governs the wage elasticity of labour supply $1/(\nu - 1)$ in models with GHH preferences, is another key parameter that determines model's ability to amplify shocks. Following Neumeyer and Perri (2005), it is set to $\nu = 1.6$, which implies an elasticity of 1.67. A more elastic labour supply implies that hours would fluctuate more as a response to shocks. This higher volatility in hours is transmitted to output and consumption. For example, when we set a higher wage elasticity of labour supply at 5 (that is, $\nu = 1.2$), volatility of hours increases by 47 percent, output by 12 percent, and consumption by 19 percent relative to the baseline parameterization of the GHH-N model; or when we set a lower wage elasticity of labour supply at 1/3 (that is, $\nu = 4$), volatility of hours decreases by 66 percent, output by 17 percent, and consumption by 22 percent relative to the baseline parameterization.

5 Conclusion

In this paper, we examined the quantitative role of the interest rate in driving macroeconomic volatility in emerging market economies. Using Neumeyer and Perri's (2005) small open economy real business cycle model augmented with a working capital constraint on the wage bill, and various specifications of the interaction between the country spread and domestic macroeconomic conditions, we found that fluctuations in country spread account for only less than 9 percent of output volatility, less than one third of the value found in Neumeyer and Perri.

We showed that the quantitative importance of the country spread in macroeconomic volatility varies significantly with the working capital parameter, the persistence of the productivity shocks, and the factor shares. An analysis of simulation results reveal that country spread shocks are especially important for matching the volatility of investment and the cyclicality of net exports. When the country spread shocks are turned off, the model predicts very little investment volatility. The countercyclicality of net exports also breaks down when there are no country spread shocks. We also found that the negative correlation present in the data between country spread shocks and productivity shocks further strengthens the countercyclicality of real interest rate and net exports.

6 Data Appendix

Data are from the database of the Central Bank of Turkey except noted otherwise. We use quarterly series between 1987 and 2004. Before applying any other transformation, we removed any significant seasonal component from each series using TRAMO-SEATS.

Population We use quarterly total population estimates rather than economically active population because the series "non-institutional civilian population (15+ years)" is only available on a semiannual basis since the second half of 1988, and on a quarterly basis since 2000.

Consumption Consists of private final consumption (excluding consumption expenditure on durables) and statistical discrepancy in constant 1987 prices divided by total population.

Investment Consists of gross fixed capital formation (including consumption expenditure on durables) and changes in inventories in constant 1987 prices divided by total population.

Net exports Exports minus imports of goods and services in constant 1987 prices divided by total population. We use net exports as a percentage of gross domestic product.

Gross domestic product Sum of private final consumption, investment, and net exports in constant 1987 prices divided by total population.

Total hours and employment Total number of hours worked and total number of persons employed in manufacturing industry. We calculate the number of hours per worker by dividing "total hours" by "employment". The source of data is OECD's Main Economic Indicators.

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Real interest rate For the nominal interest rate we use compound interest rates on Turkish Treasury bills weighted by net sales. For inflation expectations, we use the GDP deflator for calculating inflation expectations until 1999. We assume that expectations are formed by averaging backward-looking and forward-looking expectations. For backward-looking expectations at time t we use the observed inflation at time t; for forward-looking expectations we use the observed inflation at $t + 1$ assuming that agents' forecasts of future inflation are on average correct. Celasun (2006) provides evidence in support of this type of expectation formation. Between 1999 and the second quarter of 2001, we use the wholesale price inflation expectations from the Business Tendency Survey of the Central Bank of Turkey. From the third quarter of 2001 onwards we use the consumer price inflation expectations from the Central Bank of Turkey's Expectations Survey.

For the world interest rate we use the secondary market rates of 3-month US Treasury bills, deflated by the US GDP deflator. US Treasury bill data are from the Board of Governors of the Federal Reserve Bank. GDP deflator data come from the US Bureau of Economic Analysis.

Spread is calculated as the ratio of Turkish gross real interest rate to US gross real interest rate.

Wages We use index of real earnings per production worker in private manufacturing industry (1997=100). Available quarterly from 1988 onwards.

Working capital We calculate the current assets (excluding marketable securities) to gross sales ratio of companies between 1996 and 2003 from annual data. The source of the data is the Company Accounts from the database of the Central Bank of Turkey. The Company Accounts database contains yearly balance sheets and income statements of a sample of companies representative of the whole economy, not just the manufacturing industry.

Gross domestic product by sources of income classification Data contain quarterly estimates of taxes on production and imports, depreciation of fixed capital, compensation of employees, and operating surplus, all in current prices. The State Institute of Statistics calculates the operating surplus as a residual from GDP by production, so this series may also contain noise caused by other components of GDP. Therefore we do not use operating surplus. The data are available from 1987 to 2002.

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