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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 the productivity shocks, and the factor shares. We also discuss the effect of correlated shocks on the countercyclicality of the interest rate and net exports.

1 Introduction

Even though emerging market business cycles have dampened during the past decade, they are still more volatile than the business cycles in developed economies. Moreover, there are other striking differences in the behaviour of the business cycles between emerging markets and developed economies. More specifically, the real interest rate and net exports are both negatively correlated with output, and consumption is more volatile than output in emerging markets in contrast to that in mature economies. The standard macroeconomic models of the business cycles, on the other hand, have failed, to a large extent, to reproduce these characteristics of the emerging market economies. Therefore, recent real business cycle research

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focuses on the mechanisms or frictions that are deemed to be capable of amplifying (or reducing, in the case of investment) volatility, and introducing new channels through which various shocks are propagated.

Another key difference of emerging market business cycles is that emerging economies are frequently faced with sudden stops in capital inflows which most often are accompanied by financial crises. Sudden stops, or sharp reversals in the current account, are often observed along with sizeable output drops and very high real interest rates. Interest rate increases during sudden stops are caused either by monetary policy responses to defend the exchange rate peg or by the rise in the country risk embedded in the prices of sovereign debt instruments. Therefore, an analysis of the propagation mechanism of the country risk in the interest rate is warranted for emerging markets.

In the standard closed economy real business cycle models, such as King and Rebelo (1999) or King et al. (1988), the interest rate is positively correlated with output. This result, by and large, depends on the persistence of the technology shock, that is, it holds only when the persistence of the technology shock is sufficient enough to generate realistic output persistence. Intuitively, when the economy is hit by a persistent positive productivity shock, output immediately jumps to a higher level and then returns gradually to the steady state; also the real interest rate jumps to a higher level as a response to the increase in the marginal product of capital and then starts to fall gradually. This co-movement of output and interest rate is the reason for the standard model to yield positive correlation between output and interest rate. As Beaudry and Guay (1996) show, modifications to tone down the sensitivity of demand components to technology shocks by introducing capital adjustment cost and habit persistence in consumption improve the standard model's prediction, and produces negative correlation between output and interest rate.[1]

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, empirically it is the productivity shocks that dominantly drives the equilibrium stochastic process of the model. He reasons 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 developed nations, particularly Canada in his model. 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 the magnitude of the response of other variables is small.

[1]Beaudry and Guay (1996) note that their result holds only when the predicted moments are compared to the moments calculated after identifying shocks to the stochastic trend, but not when compared to the moments drawn directly from raw data.

In a more recent study, Blankenau et al. (2001) take a different approach in which they recover the exogenous shocks implied by the model's first-order conditions and data on the model's endogenous variables. After obtaining the implied shocks, they carry out variance decompositions in order to judge the importance of world interest rates in explaining the business cycle of a small open developed economy, Canada. The variance decompositions show that world interest rate shocks can explain up to 33 percent of output volatility depending 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 aim of this article is to study the quantitative effects of interest rates on the business cycles of emerging markets. The small open economy real business cycle model of Neumeyer and Perri (2005) is calibrated to match Turkish data. The model features a working capital requirement which facilitates stronger propagation of interest rate shocks. We find that fluctuations in the 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 the productivity shocks, and the factor shares. We also discuss the effect of correlated shocks on the countercyclicality of the interest rate and net exports.

1.1 Empirical regularities

A number of studies report main features of the business cycles (particularly the second moments of consumption, output, investment, net exports, etc., and cross and serial correlations of these aggregates) in developing countries. It emerges that the most significant differences are in the relative volatility of consumption with respect to output, the cyclical behaviour of the current account and the real interest rate. As a general finding, developing countries have higher consumption volatility relative to output compared to that in developed countries. This finding is interesting because it is despite the fact that output in developing countries has a comparable persistence with the persistence of output in developed countries, implying that, other things being equal, both type of countries should have the same strength of incentive for consumption smoothing.[2] However, limited access to international financial markets by developing countries may also limit consumption smoothing in these countries. Secondly, current accounts are strongly countercyclical in developing countries, unlike the weakly countercyclical current accounts in developed countries. As a third difference in developing country business cycles, we observe that real interest rates are also strongly countercyclical in developing countries compared to the weakly procyclical relationship in developed countries. Lastly, it is widely documented that developing countries are subject to sudden stops in capital inflows (or sharp reversals in the current account). The sudden stops are most of the time accompanied by sharp falls in output, also helping to obtain the strong countercyclical current account.

Mendoza (1991) studies real business cycles in small open economies to account for both the observed positive correlation between domestic savings and investment (the Feldstein-Horioka puzzle), and the countercyclical current account in an open economy with perfect capital mobility. He examines the business cycles in Canada, a typical developed small open economy. He finds that the Canadian business cycles are characterized by lower relative volatility of consumption and trade balance with respect to output, mildly countercyclical trade balance, and a positive correlation between savings and investment even when there is perfect capital mobility. However, these results rely on the persistence of productivity shocks. It is only when the productivity shocks are highly persistent that the impact of a positive productivity shock on investment expenditures out of future income outweighs the impact on savings out of current income, where the resulting difference (the current account deficit) is financed by borrowing (capital inflows).

Correia et al. (1995) examine the Portuguese business cycles and find that private consumption, investment, and employment are procyclical and highly persistent, whereas the trade balance is both countercyclical and highly volatile compared to output. The volatility of investment is also higher than that of output, but consumption is less volatile than output. However, they note that the empirical success of their model critically hinges on both the period utility they adopted and the existence of productivity shocks. They find that the Cobb-Douglas preferences cannot reproduce the main characteristics of observed series, while the preference structure due to Greenwood et al. (1988) is capable of replicating the actual moments. The other important finding is that neither the shocks to government expenditures nor to foreign transfers, but shocks to productivity can generate similar to observed business cycles.

Agénor et al. (2000) present a wide variety of stylized facts about business cycles in developing countries. Their sample consists of 12 developing

[2] This point is noted by Aguiar and Gopinath (2007).

countries including Turkey. Their main findings related to our interests in this paper are that output is more volatile in developing countries than in developed countries, that developed country real interest rates are positively correlated with developing country output fluctuations (although in their sample Turkey is an exception to this result), and that there is no uniform correlation behaviour between trade balance and output in developing countries.

Rand and Tarp (2002) also investigate a sample of developing countries that also includes rather less-developed countries than those in Agénor et al. (2000). They use annual data but they diverge from the literature in that they use a value for the Hodrick-Prescott-filtering parameter λ which is around unity, instead of the widely used $\lambda = 100$. This implies that their results are based on shorter cycles. Nonetheless, they find that output volatility is higher in developing countries (but not so much as found in other studies), consumption is more volatile than output, consumption and investment are procyclical, and trade balance is weakly countercyclical.

Carmichæl et al. (2001) report stylized facts for a sample of 19 developing or recently industrialized countries. They find that private consumption is on average as variable as output, investment and trade balance are more volatile than output, and trade balance is slightly countercyclical.

Neumeyer and Perri (2005) also report key differences between business cycles in emerging versus developed economies. Their findings show that there is a striking difference in the co-movements of output and real interest rate between emerging and developed countries. In emerging economies, real interest rates are strongly countercyclical and lead the cycle, while there is no significant pattern of co-movement in many developed countries. Generally, volatility is higher in emerging economies, and also consumption is more volatile than output in emerging economies while in developed countries consumption volatility is almost equal to output volatility. Finally, net exports are more strongly countercyclical in emerging economies than in developed countries.

1.2 Business cycles in Turkey

In this section we explore the main characteristics of Turkish business cycles by examining the volatility, and serial and cross correlations of main Turkish macroeconomic aggregates. The variables are transformed by removing the seasonal components, dividing by population, and taking natural logarithms. Then they are filtered by the Hodrick-Prescott filter with a filtering parameter of $\lambda = 1600$, a value typically used in the literature for quarterly data. We use net exports as a ratio of GDP so we do not take its log; and neither do we take the log of the real interest rate. Our sample spans the 1987-2004 period and the unit of time is a quarter. Sources and definitions

Table 1: Descriptive statistics of Turkish business cycles

	(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)	3.61	1.00	0.69	1.00	-0.40
Consumption (c)	2.56	0.71	0.66	0.88	-0.30
plus durables	4.18	1.16	0.78	0.86	-0.39
Investment (x)	16.61	4.60	0.70	0.85	-0.43
less durables	19.15	5.31	0.66	0.81	-0.39
Net exports / GDP (nxy)	3.98	1.10	0.71	-0.69	0.41
Hours (l)	0.74	0.21	0.80	0.76	-0.25
Interest rate (R)	3.43	0.95	0.26	-0.40	1.00
Country spread (D)	3.44	0.95	0.27	-0.40	1.00
World interest rate (R^*)	0.19	0.05	0.84	0.13	-0.11

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, D, R^*, and nxy are in logs. All variables are Hodrick-Prescott filtered with $\lambda = 1600$.

of the data are in the data appendix. Table 1 summarizes our findings in this section for Turkey's business cycles.

We consider two alternatives for private consumption and investment. In the first one, we include consumption of durable goods in the consumption aggregate, while the second definition excludes consumer durables. In the latter case, consumer durables are included in investments. The problem with the latter definition is that the ratio of consumption to output exhibits a strong downward trend through time. This implies that the share of durables consumption is increasing at the expense of non-durables consumption, which contains the more basic needs of the household. We try to match the moments of the second definition of consumption throughout the paper.

All variables except net exports and real interest rate are found to be procyclical. Consumption and investment both have more than 0.80 correlation with output. Similar to other findings in the literature, consumption including durables is 16 percent more volatile than output. Investment is more than 5 times volatile than output. When we include consumer durables under investment the correlation of investment with output slightly rises, and the relative volatility of consumption falls below unity. Net exports are strongly countercyclical and slightly more volatile than output.

There is also a strong contemporaneous correlation between output and labour input. We measure labour input by the total number of hours worked per quarter. Hence we combine the two effects of total employment and total hours worked per worker. We find that changes in total hours worked in production can be attributed more to changes in per worker hours than to changes in employment. Although the labour input is far less volatile than output with any measure of labour, the relative volatility of hours per worker is more than twice as much of employment.

Real interest rate is also countercyclical and has virtually the same volatility as output. Both the correlation with output and the volatility stem mostly from the country spread.

This summary shows that the Turkish business cycle fits most of the empirical regularities observed in developing countries discussed in the previous section. In the following sections we present a dynamic stochastic general equilibrium model to quantitatively capture these characteristics of Turkish business cycles. We describe the structure of the model in the following section.

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 representative firm is subject to a working capital constraint by which it is required to pay part of the labour cost in advance before the production takes place. 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.

The model explains the real business cycles around a deterministic common growth rate. Therefore, output, consumption, investment, bonds, and real wage rate grow at a common rate along the balanced growth path of the economy, and we are mainly interested in the fluctuations around the balanced growth path.

The interest rate is composed of a world interest rate and a country spread. Since this is a small economy, the world interest rate is exogenous to our economy. 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, the country spread is independent of the fundamentals of the economy and modelled as an autoregressive process. In the second case, the *induced country risk* case, the country spread is a function of the expected productivity in the next period.

Shocks are observed by the firm and the household at the beginning of each period. Having observed the factor prices and the shocks to total factor productivity and interest rate components, the firm establishes its profit-maximizing demand for labour and capital, while the household decides on its utility-maximizing supply of labour and capital, as well as on the optimal allocation between consumption and savings.

2.1 The representative firm

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 the 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 in kind at the end of period t. We remind that k_{t-1} denotes the capital stock available at the end of period $t-1$ or equivalently at the beginning of period t.

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 the actual production. Therefore, in order to make the advance payment it 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 the 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 profit maximization problem of the firm is

$$\max_{\{k_{t-1}, l_t\}} \Pi_t = y_t - w_t l_t - r_t k_{t-1} - (R_{t-1} - 1)\,\theta w_t l_t, \qquad 0 \leq \theta \leq 1. \tag{2}$$

The last term in the profit equation represents the interest cost of the firm's borrowing. In equilibrium, the firm's profit is equal to zero because of the constant returns to scale production technology.

2.2 The representative household

The economy consists of an infinitely-lived representative household which maximize 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. Hence, we implicitly assume that bond markets are incomplete and households cannot insure themselves against all possible states.

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

$$\max_{\{c_t, l_t, k_t, b_t\}} E_0 \sum_{t=0}^{\infty} \beta^t U(c_t, l_t), \qquad 0 < \beta < 1, \tag{3}$$

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:

$$U^{\text{GHH}}(c_t, l_t) = \frac{\left[c_t - \psi (1+\gamma)^t l_t^{\nu}\right]^{1-\sigma}}{1-\sigma}, \qquad \nu > 1, \quad \psi > 0 \tag{4}$$

$$U^{\text{CD}}(c_t, l_t) = \frac{\left[c_t^{\mu} (1-l_t)^{1-\mu}\right]^{1-\sigma}}{1-\sigma}, \qquad 0 < \mu < 1 \tag{5}$$

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. The budget constraint is

$$c_t + x_t + b_t + \kappa(b_t) \leq w_t l_t + r_t k_{t-1} + R_{t-1} b_{t-1}, \qquad t = 0, \ldots, \infty. \tag{6}$$

This constraint implies that the sum of current consumption, physical investment x_t, investment in bonds (or borrowing by bonds) b_t, and the cost incurred for holding bonds cannot exceed household's total income, which is earned by supplying labour services and renting capital to the firms, and the gross return on previous period's bond holdings. Note that when the household is a net debtor b_{t-1} is negative, and hence $R_{t-1}b_{t-1}$ represents the gross debt service of the household. The transversality condition for bonds also applies as the household is not allowed to engage in Ponzi-type schemes.

The function $\kappa(b_t)$ denotes the cost associated with holding bonds and its form guarantees that the steady state equilibrium is not altered by this friction.

$$\kappa(b_t) = \frac{\kappa}{2} y_t \left(\frac{b_t}{y_t} - \overline{b/y} \right)^2 \tag{7}$$

Under this specification, $\kappa > 0$ is a constant parameter, y_t denotes output, and $\overline{b/y}$ denotes the steady state ratio of bonds to output. This type of stationarity-related modifications are typically used in the small open economy dynamic general equilibrium models in order to eliminate the unit root in bond holdings along the equilibrium path (see, Neumeyer and Perri, 2005; Uribe and Yue, 2006, among others).[3] An intuitive explanation for the existence of bond holding costs is provided by Uribe and Yue (2006). They assume that domestic banks act as financial intermediaries between domestic and foreign agents, and show that the operational costs of these intermediaries constitute a mark-up over the country rate that includes the country spread. In effect, domestic households and firms face a higher interest rate than what domestic banks can access in the international markets. In our model, we confine ourselves to contain a bond holding cost in the model while refraining from explicitly incorporating a financial sector.

Investment is defined as

$$x_t = k_t - (1 - \delta) k_{t-1} + \Phi(k_t, k_{t-1}) \tag{8}$$

$$\Phi(k_t, k_{t-1}) = \frac{\phi}{2} k_{t-1} \left(\frac{k_t}{k_{t-1}} - (1 + \gamma) \right)^2 \tag{9}$$

where the function $\Phi(k_t, k_{t-1})$ represents the capital adjustment cost, and $\phi > 0$ is a constant parameter. Capital adjustment costs are pragmatically used in many real business cycle models in order to reduce the excessive volatility of investment generated by these models (see, Baxter and Crucini, 1993; Blankenau et al., 2001; Correia et al., 1995; Köse, 2002; Uribe and Yue, 2006).

[3] Alternative ways of inducing stationarity are discussed in Schmitt-Grohé and Uribe (2003).

The national income identity implies that output produced in a period can be spent on consumption, investment, paying for bond holding costs or exported to the rest of the world. In case the domestic production falls short of outlays, imports of foreign goods are used to fill the gap. We can write this formally as

$$y_t = c_t + x_t + \kappa(b_t) + nx_t \tag{10}$$

where nx_t represents net exports. The country's net foreign asset position is defined as the difference between the household's bond holdings b_{t-1} and the firm's borrowings $\theta w_t l_t$, that is, $f_t = b_{t-1} - \theta w_t l_t$.

The distinctive feature of small open economy models is that the interest rate is no longer endogenously determined but is taken as given at the world interest rate. However, the borrowing rates of emerging economies has been historically higher than those of the advanced small open economies, which 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 components as

$$R_t = R_t^* D_t \tag{11}$$

where R_t^* the world interest rate, and D_t is the country spread.

2.3 Equilibrium

An equilibrium is an allocation $\{c_t, l_t, b_t, k_t\}$ such that, given initial conditions b_{-1}, k_{-1}, and R_{-1} and a sequence of A_t and R_t, this allocation solves the optimality conditions at prevailing factor prices w_t and r_t, and both markets for factors of production clear.

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. For a generic variable $\tilde{z}_t$, we denote the steady state value of z by $\bar{z}$, and the log deviation from steady state by $\hat{z}_t$, that is, $\hat{z}_t = \log \tilde{z}_t - \log \bar{z}$. We use Uhlig's (1999) toolkit for the solution and simulation of the log-linearized model.

2.4 Stationary representation and optimality conditions

The labour-augmenting technical progress term $(1+\gamma)^t$ in the production function adds a deterministic trend to the model so that the equilibrium levels of all variables except hours worked, interest rate, and rental rate of capital exhibit constant growth along the balanced-growth path. In order to obtain a stationary representation of the model we transform the model using $c_t \equiv \tilde{c}_t (1+\gamma)^t$, etc., where $\tilde{c}_t$ denotes detrended consumption.

Rewriting household's maximization problem as such alters the effective discount rate β. In the GHH preferences case, the infinite summation of expected utility becomes

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{\left[c_t - \psi (1+\gamma)^t l_t^v\right]^{1-\sigma}}{1-\sigma} = E_0 \sum_{t=0}^{\infty} \tilde{\beta}^t \frac{(\tilde{c}_t - \psi l_t^v)^{1-\sigma}}{1-\sigma} \tag{12}$$

where $\tilde{\beta} \equiv \beta (1+\gamma)^{1-\sigma}$ is the transformed discount rate.

In the case of Cobb-Douglas preferences the same kind of manipulation yields

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{\left[c_t^{\mu} (1-l_t)^{1-\mu}\right]^{1-\sigma}}{1-\sigma} = E_0 \sum_{t=0}^{\infty} \tilde{\beta}^t \frac{\left[\tilde{c}_t^{\mu} (1-l_t)^{1-\mu}\right]^{1-\sigma}}{1-\sigma} \tag{13}$$

where $\tilde{\beta} \equiv \beta (1+\gamma)^{\mu(1-\sigma)}$.

First order conditions of the firm's profit maximization problem with respect to labour and capital are

$$(1-\alpha)\, \tilde{y}_t = \tilde{w}_t l_t \left[1 + \theta (R_{t-1} - 1)\right] \tag{14}$$

and

$$\alpha \tilde{y}_t = \left(\frac{1}{1+\gamma}\right) r_t \tilde{k}_{t-1}. \tag{15}$$

respectively. The firm hires labour up to the point where labour's marginal product equals the marginal cost of labour. In the standard growth models with endogenous labour, e.g. Hansen (1985), the marginal cost of labour is equal to the wage rate. However, because of the working capital constraint in the model, the marginal cost of labour turns out to be higher than the wage rate by the interest paid on the advance payment of the wage bill, $\theta (R_{t-1} - 1)\, w_t$. On the other hand, the firm rents capital up to the point where the marginal product of capital equals the rental rate of capital, r_t.

The firm's demand for labour is increasing in output and decreasing in the wage rate and the interest rate. This relationship between the labour demand and the interest rate is critical to the dynamics of our model economy and will be explored in later sections. Demand for capital, on the other hand, is positively related to output and negatively related to the rental rate of capital.

Household's first order conditions with respect to consumption, labour, bond holdings, and capital under GHH preferences are

$$\lambda_t = (\tilde{c}_t - \psi l_t^{\nu})^{-\sigma}, \tag{16}$$

$$\lambda_t \tilde{w}_t = \left(\tilde{c}_t - \psi l_t^v\right)^{-\sigma} \psi \nu l_t^{\nu-1}, \tag{17}$$

$$1 + \kappa \left(\frac{\tilde{b}_t}{\tilde{y}_t} - \overline{b/y} \right) = E_t \left[\frac{\tilde{\beta}}{1+\gamma} \left(\frac{\lambda_{t+1}}{\lambda_t} \right) R_t \right], \tag{18}$$

and

$$\begin{aligned} & 1 + \phi (1+\gamma) \left(\frac{\tilde{k}_t}{\tilde{k}_{t-1}} - 1 \right) \qquad (19) \\ = \; & E_t \left[\tilde{\beta} \left(\frac{\lambda_{t+1}}{\lambda_t} \right) \left\{ \frac{1-\delta}{1+\gamma} + \left(\frac{1}{1+\gamma} \right) r_{t+1} + \frac{\phi}{2} (1+\gamma)^2 \left[\left(\frac{\tilde{k}_{t+1}}{\tilde{k}_t} \right)^2 - 1 \right] \right\} \right] \end{aligned}$$

respectively, where λ_t is the Lagrange multiplier associated with the budget constraint. Eliminating the Lagrange multiplier λ_t in the first two conditions yields the household's labour supply curve

$$\tilde{w}_t = \psi \nu l_t^{\nu-1}. \tag{20}$$

According to this equation the household's labour supply is independent of the consumption decision, increasing in the wage rate as $\nu > 1$ and $\psi > 0$, and the wage elasticity of labour supply becomes $1/(\nu-1)$.

Household's first order conditions with respect to bonds and capital do not change under Cobb-Douglas preferences, whereas the optimality conditions for consumption and labour are different. These are, respectively,

$$\lambda_t = \tilde{c}_t^{\mu-1} (1-l_t)^{1-\mu} \left[\tilde{c}_t^{\mu} (1-l_t)^{1-\mu} \right]^{-\sigma} \mu, \tag{21}$$

$$\lambda_t \tilde{w}_t = \tilde{c}_t^{\mu} (1-l_t)^{-\mu} \left[\tilde{c}_t^{\mu} (1-l_t)^{1-\mu} \right]^{-\sigma} (1-\mu). \tag{22}$$

Using these two equations we can write the labour supply under Cobb-Douglas preferences as

$$\tilde{w}_t = \left(\frac{1-\mu}{\mu} \right) \frac{\tilde{c}_t}{1-l_t}. \tag{23}$$

It is worth noting that in the case of Cobb-Douglas preferences labour supply is decreasing in the wage rate and decreasing in consumption, whereas under GHH preferences labour supply is independent of consumption.

Note also that equations (18) and (19) do not change under Cobb-Douglas preferences, but the term λ_{t+1}/λ_t becomes

$$\text{GHH:} \qquad \frac{\lambda_{t+1}}{\lambda_t} = \left(\frac{\tilde{c}_{t+1} - \psi l_{t+1}^v}{\tilde{c}_t - \psi l_t^v} \right)^{-\sigma} \tag{24}$$

$$\text{CD:} \qquad \frac{\lambda_{t+1}}{\lambda_t} = \left(\frac{\tilde{c}_{t+1}}{\tilde{c}_t} \right)^{\mu(1-\sigma)-1} \left(\frac{1-l_{t+1}}{1-l_t} \right)^{(1-\mu)(1-\sigma)}. \tag{25}$$

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 between 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 percent, from which we calculate the discount factor using the steady state representation of equation (18) as

$$\tilde{\beta}=\frac{1+\gamma}{\bar{R}}. \tag{26}$$

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 non-transformed discount factor under GHH preferences is $\beta=\tilde{\beta}(1+\gamma)^{-(1-\sigma)}$, and under Cobb-Douglas preferences $\beta=\tilde{\beta}(1+\gamma)^{-\mu(1-\sigma)}$.

The working capital parameter, θ, which governs the ratio of 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

$$(1-\alpha)=\frac{\bar{w}\bar{l}}{\bar{y}}\left[1+\left(\bar{R}-1\right)\theta\right]. \tag{27}$$

Finally, using the steady state representation of investment equation,

$$\bar{x}=\bar{k}-(1-\delta)\left(\frac{1}{1+\gamma}\right)\bar{k} \tag{28}$$

the firm's first order condition with respect to capital

$$\alpha = \left(\frac{1}{1+\gamma}\right)\frac{\bar{r}\bar{k}}{\bar{y}}, \tag{29}$$

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

$$\bar{r} = \bar{R} - 1 + \delta. \tag{30}$$

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

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

$$\bar{w} = \psi\nu\bar{l}^{\nu-1}, \tag{31}$$

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

$$\bar{w} = \left(\frac{1-\mu}{\mu}\right)\frac{\bar{c}}{1-\bar{l}}. \tag{32}$$

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 are summarized in Table 2.

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 (27). 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 studies that confirm the official 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

Table 2: Parameters

Definition of the parameter	Symbol	GHH	CD
Coefficient of relative risk aversion	σ	3.65	3.65
Labour curvature (GHH)	ν	1.6	-
Ratio of time devoted to work	$\bar{l}$	0.365	0.365
Wage elasticity of labour supply (GHH)	$1/(\nu-1)$	1.67	-
Wage elasticity of labour supply (CD)	$(1-\bar{l})/\bar{l}$	-	1.74
Labour weight in GHH utility	ψ	25.82	-
Consumption share in CD utility	μ	-	0.53
Real interest rate (quarterly)	$\bar{R}$	1.038	1.038
Depreciation rate (quarterly)	δ	0.033	0.033
Rate of technical progress (quarterly)	γ	0.0054	0.0054
Ratio of wage bill paid in advance	θ	0.41	0.41
Discount factor (adjusted)	$\tilde{\beta}$	0.969	0.969
Discount factor	β	0.983	0.976
Capital's exponent	α	0.65	0.65
Bond holding cost	κ	0.0005	0.0001
Capital adjustment cost†	ϕ	5.352 / 7.996	6.967 / 9.243

† The first value in the cell corresponds to the exogenously-determined country-spread model, and the second one corresponds to the endogenously-determined country-spread model.

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 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 adjust 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.

$$\left(\frac{wl}{y}\right)_{\text{Adjusted}} = \left(\frac{wl}{y}\right)\left(\frac{\#\text{Employee} + \#\text{Own-Account} + \#\text{Family}}{\#\text{Employee}}\right) \tag{33}$$

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 $\alpha = 0.70$ 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 (28), (29), and (30). 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

$$\delta = \frac{\left(\frac{\bar{x}}{\bar{y}}\right)\left(\bar{R} - 1\right) - \alpha\gamma}{\alpha - \left(\frac{\bar{x}}{\bar{y}}\right)}. \tag{34}$$

Equation 34 is plotted in Figure 1, which clearly shows 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.

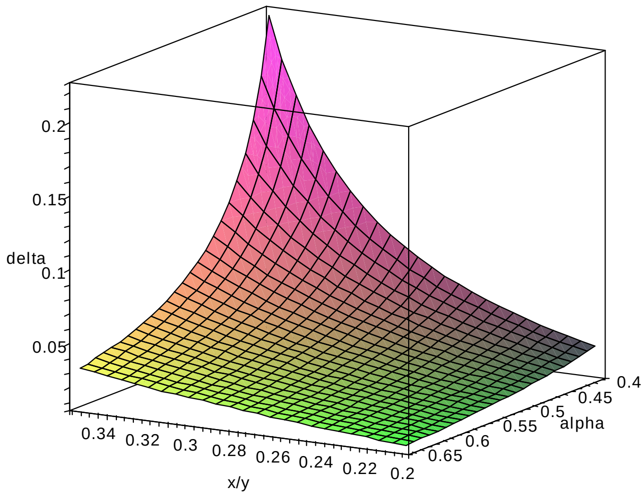

Figure 1: Perturbation of the depreciation parameter δ

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 observed from 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.

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

$$\hat{A}_{t+1} - \hat{A}_t = (\hat{y}_{t+1} - \hat{y}_t) - \alpha\left(\hat{k}_t - \hat{k}_{t-1}\right) - (1-\alpha)\left(\hat{l}_{t+1} - \hat{l}_t\right), \qquad (35)$$

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, they 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

$$\hat{A}_t = \rho_A \hat{A}_{t-1} + \varepsilon_t^A \tag{36}$$

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

$$\begin{aligned} \hat{A}_t &= \rho_A \hat{A}_{t-1} + \varepsilon_t^A && (37) \\ \hat{R}_t^* &= \rho_{R^*} \hat{R}_{t-1}^* + \varepsilon_t^{R^*} && (38) \\ \hat{D}_t &= \rho_D \hat{D}_{t-1} + \varepsilon_t^D. && (39) \end{aligned}$$

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

$$\begin{aligned} \hat{A}_t &= \rho_A \hat{A}_{t-1} + \varepsilon_t^A && (40) \\ \hat{R}_t^* &= \rho_{R^*} \hat{R}_{t-1}^* + \varepsilon_t^{R^*} && (41) \\ \hat{D}_t &= \eta E_t \hat{A}_{t+1} + u_t, \qquad u_t = \rho_u u_{t-1} + \varepsilon_t^u. && (42) \end{aligned}$$

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 more the 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

Table 3: Estimation of the productivity and interest rate processes

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

Note: Equations are estimated by ordinary least squares. Standard errors are given in round brackets.

Table 4: Residual correlations in estimated equations

X models				N models			
	$\hat{A}$	$\hat{R}^*$	$\hat{D}$		$\hat{A}$	$\hat{R}^*$	$\hat{D}$
$\hat{A}$	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

that shocks to total factor productivity in Turkey are more volatile than in Argentina. 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.[4] 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 η for Turkey is found to be -0.60, smaller than the Neumeyer and Perri's η of -1.04 for Argentina.

4 The effect of interest rates

The transmission of real interest rate and productivity shocks should be made clear before the simulation analysis. The transmission mechanism of the international rate and the country spread components of real interest rate are the same. However, because of the differences in the nature of the shocks hitting each interest rate component, they lead to varying degrees of persistence and volatility in the business cycle.

The log-linearized version of the interest rate equation (11) is given by

$$\hat{R}_t = \hat{R}_t^* + \hat{D}_t. \tag{43}$$

Log-deviations of the world interest rate from its trend follow an AR(1) process,

$$\hat{R}_t^* = \rho_{R^*} \hat{R}_{t-1}^* + \varepsilon_t^R. \tag{44}$$

Following Neumeyer and Perri (2005), we consider two alternatives for the determination of the country spread. In the first one, we take a rather

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

agnostic view and fit an AR(1) process to the log-deviations of the country spread from its trend, which takes the following form

$$\hat{D}_t = \rho_D \hat{D}_{t-1} + \varepsilon_t^D. \tag{45}$$

In the second alternative, the country spread is a function of the expected productivity in the next period, that is,

$$\hat{D}_t = \eta E_t \hat{A}_{t+1} + u_t, \qquad \eta < 0. \tag{46}$$

As we noted before, labour demand functions vary with the specification of the period utility functions. Under GHH preferences, we see in equation (20) that labour demand is independent of consumption, while in equation (23) labour demand is a function of both the wage rate and consumption. This creates a different labour supply response to both productivity and interest rate shock through consumption.

Labour demand is also sensitive to interest rate shocks when there exists a working capital requirement, that is $\theta > 0$. Combining the log-linear versions of the production function and the labour demand equation under GHH preferences, we obtain the following labour demand condition

$$\hat{l}_t = \left(\frac{1}{\alpha}\right)\hat{A}_t + \hat{k}_{t-1} - \left(\frac{1}{\alpha}\right)\hat{w}_t - \left(\frac{1}{\alpha}\right)\left(\frac{\theta\bar{R}}{1+\theta\left(\bar{R}-1\right)}\right)\hat{R}_{t-1}. \tag{47}$$

At a given wage rate and holding the level of capital constant, a positive productivity shock contemporaneously raises firm's demand for labour, while a positive interest rate shock has an impact only after one period because the interest rate at which the firm borrows is fixed in the previous period. The lagged response of labour demand to an interest rate shock is sensitive to the value of θ in the following way

$$\frac{\partial \hat{l}_t}{\partial \hat{R}_{t-1}} = \begin{cases} -\left(\frac{1}{\alpha}\right), & \theta = 1 \\ -\left(\frac{1}{\alpha}\right)\left(\frac{\theta\bar{R}}{1+\theta\left(\bar{R}-1\right)}\right), & 0 < \theta < 1 \\ 0, & \theta = 0 \end{cases}. \tag{48}$$

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

$$\hat{l}_t = \left(\frac{1}{\alpha+\nu-1}\right)\left[\hat{A}_t + \alpha\hat{k}_{t-1} - \left(\frac{\theta\bar{R}}{1+\theta\left(\bar{R}-1\right)}\right)\hat{R}_{t-1}\right]. \tag{49}$$

Labour supply does not respond 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, $1/(\nu-1)$.

Under Cobb-Douglas preferences, equation (49) becomes

$$\hat{l}_t = \left(\frac{1}{\alpha + \bar{l}/\left(1-\bar{l}\right)}\right)\left[\hat{A}_t + \alpha\hat{k}_{t-1} - \hat{c}_t - \left(\frac{\theta\bar{R}}{1+\theta\left(\bar{R}-1\right)}\right)\hat{R}_{t-1}\right]. \quad (50)$$

5 Impulse responses

In this section we analyze the responses of the main variables to shocks in productivity, country spread, and world interest rate. The analysis is divided into two broad categories in terms of the specification concerning the determination of the country spread. We also highlight the differences under GHH and Cobb-Douglas preferences. Impulse responses to technology, country spread and international rate shocks are plotted in Figures 2, 3, and 4. Note that 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.

When country spreads are endogenously determined, technology shocks not only affect the productivity of factors of production but also have an influence on the interest rate via their effect on country spreads. An improvement in productivity improves the repayment capability of the borrowers, lessening the probability of default on debt. This, in turn, decreases the risk premium associated with country's borrowing. Therefore, when the expected productivity in the next period increases, it has an immediate impact on today's spread so that a positive productivity shock is amplified through a second channel. This second propagation channel is qualitatively similar to the mechanism observed with country spread shocks under exogenously determined spreads.

The impulse responses of output, consumption, investment, and hours worked to technology shocks are in line with the standard real business cycle literature. When there is a positive productivity shock, i.e. productivity rises by 1 percent from its steady state value, output jumps from its steady state by more than 1 percent instantaneously under all four specifications. The improvement in productivity increases firm's demand for labour for the same wage rate. Note that under GHH preferences household's labour supply is not affected by the productivity shock so that the labour demand curve shift along the labour supply curve; so hours worked follows a similar but less pronounced pattern. However, under Cobb-Douglas preferences labour supply also responds indirectly and negatively to the productivity

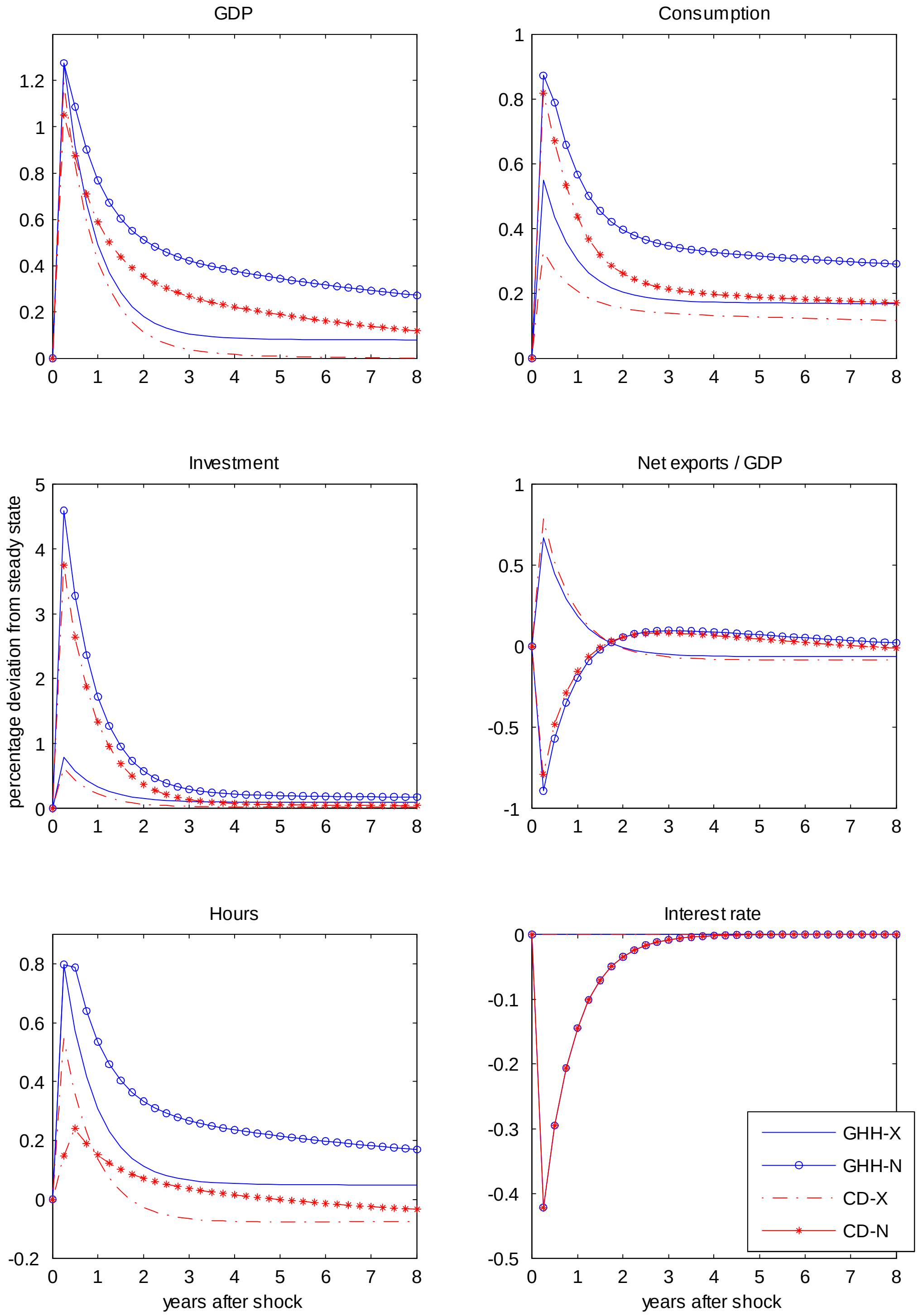

Figure 2: Impulse responses to a shock in productivity

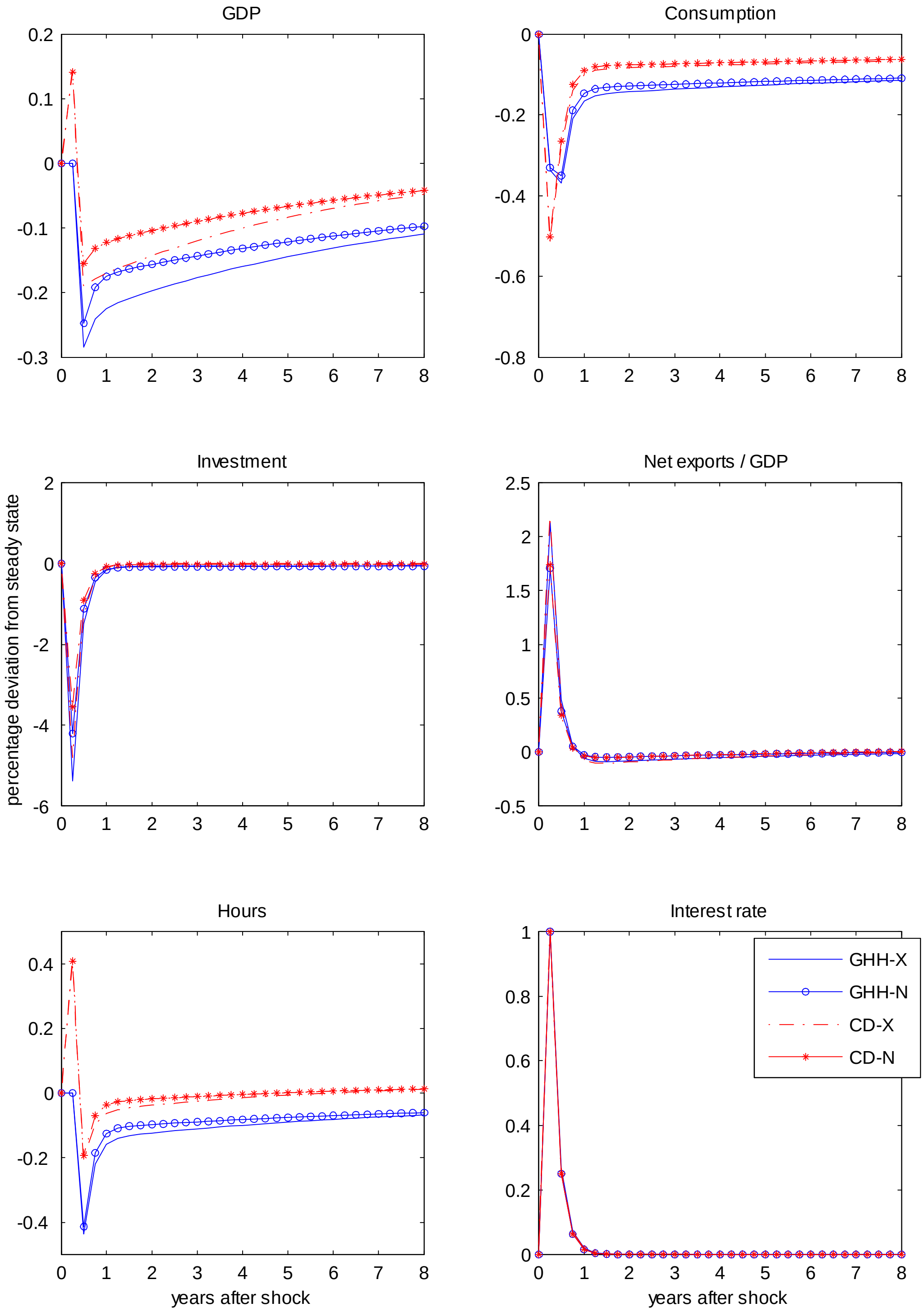

Figure 3: Impulse responses to a shock in country spread

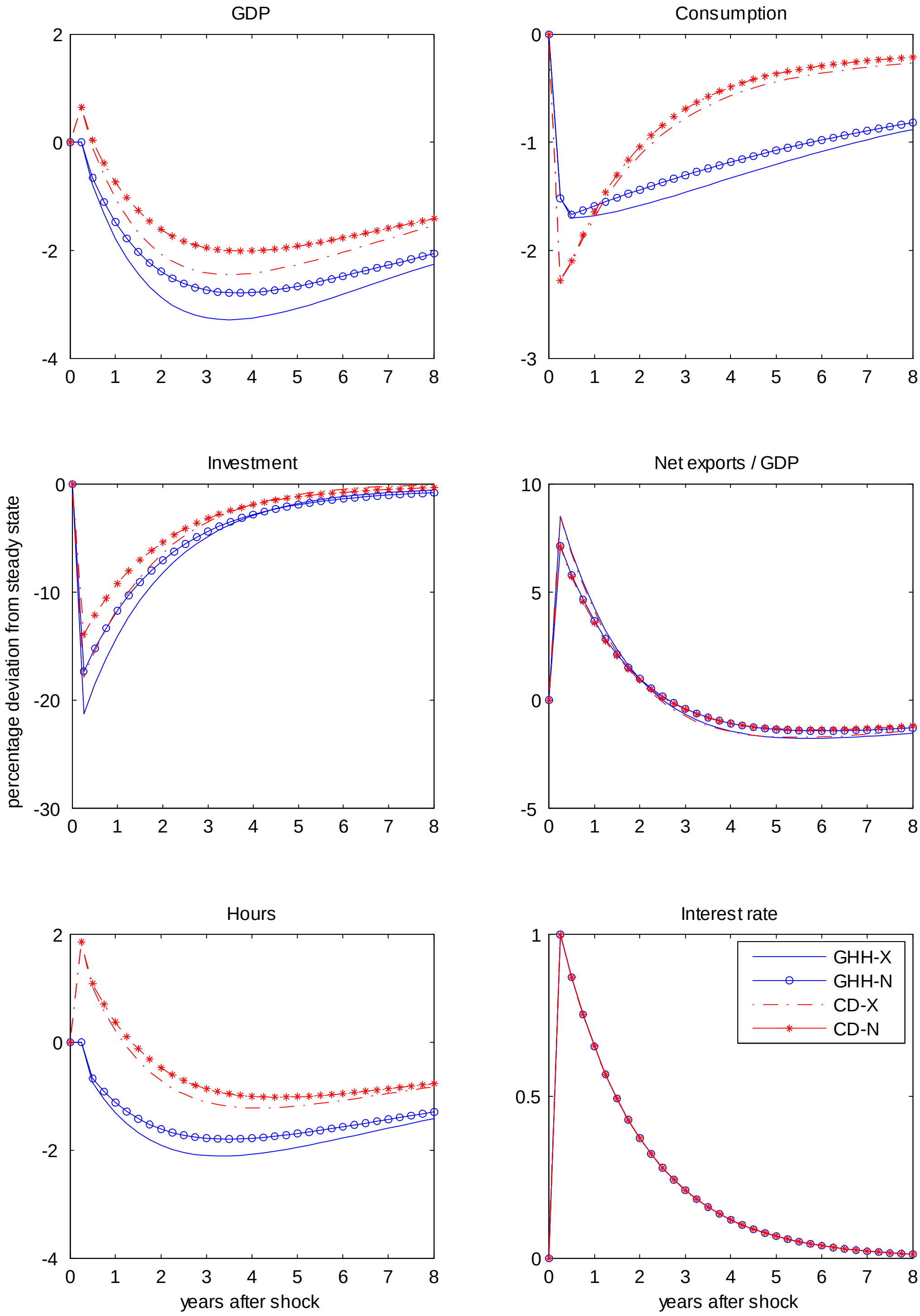

Figure 4: Impulse responses to a shock in world interest rate

shock via consumption. Following a productivity shock, consumption rises as a result of the income effect. Given the wage rate, the more the household consumes, the less it is willing to work. Hence, the hours worked is less affected by a productivity shock under Cobb-Douglas preferences. The Cobb-Douglas specification in the endogenously determined country spread case works even more differently. In addition to the mechanism just described, there is now the effect of the decrease in the interest rate due to the positive productivity shock. This decrease in the interest rate impacts both on the next period labour demand via the working capital constraint and on current consumption.

Demand for capital also rises with increased output, pushing investment upwards to meet the expected increase in output in the future. Savings, as defined by income less consumption, increase by more than investment does, resulting in a surplus in net exports. Note that in the figures net exports are plotted as a percentage of output, which means that a one unit increase in net exports is actually a one percentage point increase in net exports to GDP ratio. One of the main objectives of this paper is to account for the negative correlation of output with interest rate and net exports. A positive productivity shock not only has a direct effect on investment but also affects investment indirectly via the interest rate. Therefore, there is a much stronger response of investment due to the dual propagation mechanism. Compare the initial response of investment under four specifications in Figure 2. When this second propagation mechanism is present, the response of investment to a productivity shock rises above 4 percent, while lack of it creates a rather muted response around 0.6 percent. The strong response of investment under endogenously determined country spreads ultimately causes a trade deficit. A one-percent productivity shock decreases the net exports to GDP ratio by around 0.8 percentage points. On the other hand, the lack of a feedback effect from productivity to country spreads implies that the productivity shock has a greater effect on savings than on investment, which translates into a rise in the net exports to GDP ratio by around 0.7 percentage points.

The response of the country spread to productivity shocks depends on two crucial parameters. First one gauges the sensitivity of the country spread to expected productivity, which is captured by η in our model. Since $\eta < 0$, a rise in expected productivity decreases the country spread. The second parameter of importance is the persistence of the total factor productivity parameter, ρ_A. When total factor productivity follows an AR(1) process, a one-unit positive shock to productivity is carried on to next period's expected productivity by ρ_A. Hence, a one-unit productivity shock in period t changes the country spread by $\eta \cdot \rho_A$ in the same period.

Shocks to interest rates, either coming from the country spread or the international rate, operate through the same transmission mechanism. However, there are some marked differences in magnitude and persistence between responses to a shock in country spread and international rate. We already described the transmission under GHH preferences in the previous section. Yet, there is a slight difference under Cobb-Douglas preferences in which labour supply decision depends on consumption as well as the wage rate. A positive interest rate shock induces the household to save and hence reduce its consumption. At the same time, the fall in consumption makes the household work more at the same wage rate, that is, the labour supply curve shifts outwards. Because the rise in interest rate affects the labour demand only in the next period, in the period when the interest rate shock occurs the only effect to be observed is the shift in the labour supply curve, which increases the hours worked in period t. In the next period, $t+1$, though, the response of the labour demand kicks in and dominates the response of labour supply. This decreases the hours worked from period $t+1$ onwards.

There is also considerable difference between the magnitude of responses to the two components of interest rate, which is invariant under either preference specification. Although the country spread series is much more volatile than the international rate, the persistence of country spread shocks are much smaller than the persistence of international rate shocks. The higher persistence of shocks governs agents' responses in a way that amplifies the magnitude of initial reaction to interest rate shocks. For example, household consumption falls more when the household knows that the effects of the shock to the interest rate would last longer. As expected, physical investment responds more dramatically to interest rate shocks, especially to international rate shocks which are more persistent. With savings rising and investment falling, the net exports to GDP ratio starts to rise.

The working capital parameter θ is one of the key parameters that have a substantial influence on the way in which labour market responds to interest rate disturbances. To facilitate the argument, the impulse responses of hours worked and output to a shock in the world interest rate in the GHH-N model are plotted in Figure 5. The left column shows the case when labour's exponent $(1-\alpha)$ equals 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 is larger in the production function.

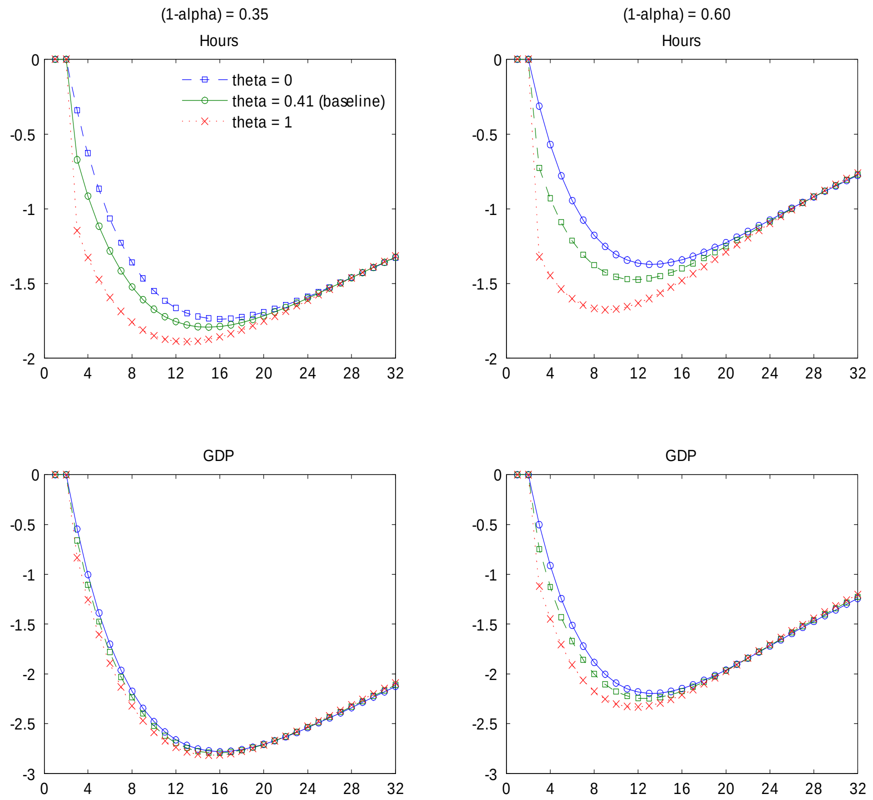

Figure 5: Impulse responses to a shock in world interest rate: sensitivity with respect to α and θ

6 Simulations

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. In addition, we also report in Table 6 the results from simulations carried out 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 time series for all variables were calculated. This process was repeated 2000 times in order to obtain consistent estimates. Note that the results presented in Tables 5 and 6 are similar.

Models with Cobb-Douglas preferences produce less output volatility

Table 5: Second-order moments of the simulated series (estimated shocks)

	(I)	(II)	(III)	(IV)	(V)
Variables (z)	σ_z	σ_z/σ_y	$\rho\left(z_t, z_{t-1}\right)$	$\rho\left(z_t, y_t\right)$	$\rho\left(z_t, R_t\right)$
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.

Table 6: Second-order moments of the simulated series (random shocks)

	(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	3.84	1.00	0.62	1.00	-0.33
Model CD-X	3.41	1.00	0.61	1.00	-0.23
Model GHH-N	3.80	1.00	0.63	1.00	-0.41
Model CD-N	3.10	1.00	0.61	1.00	-0.30
Consumption (c)					
Actual data	2.56	0.71	0.66	0.88	-0.30
Model GHH-X	2.42	0.63	0.58	0.90	-0.64
Model CD-X	2.19	0.64	0.40	0.64	-0.86
Model GHH-N	2.98	0.78	0.62	0.94	-0.67
Model CD-N	2.92	0.94	0.49	0.78	-0.83
Investment (x)					
Actual data	16.61	4.60	0.70	0.85	-0.43
Model GHH-X	18.04	4.70	0.19	0.42	-0.99
Model CD-X	16.09	4.71	0.19	0.30	-0.99
Model GHH-N	18.99	5.00	0.35	0.68	-0.93
Model CD-N	15.82	5.10	0.34	0.58	-0.94
Net exports / GDP (nxy)					
Actual data	3.98	1.10	0.71	-0.69	0.41
Model GHH-X	6.37	1.66	0.16	-0.03	0.95
Model CD-X	6.55	1.92	0.15	0.13	0.93
Model GHH-N	6.06	1.60	0.23	-0.42	0.99
Model CD-N	5.97	1.93	0.20	-0.26	0.99
Hours (l)					
Actual data	0.74	0.21	0.80	0.76	-0.25
Model GHH-X	2.84	0.74	0.60	0.96	-0.33
Model CD-X	1.99	0.58	0.27	0.80	0.28
Model GHH-N	2.87	0.75	0.62	0.96	-0.40
Model CD-N	1.60	0.52	-0.04	0.57	0.47

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.

Table 7: The effect of correlated shocks on the countercyclicality of the 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

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, in other simulations not fully reported here, the X models yield acyclical or weakly procyclical interest rate. These experiments are carried out by drawing random shocks from the estimated distributions assuming that the three shocks were independent. When the shocks are independently distributed, the internal dynamics of the X models are not able to deliver countercyclical 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 7 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.[5]

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

Relative volatilities as reported in column (II) of Table 5 are better captured by N models. All the models exceed the actual volatility of net

[5] In Neumeyer and Perri (2005) the correlation between the world interest rate and the country spread is 0.05. Since they did not have quarterly time series for hours or labour, they assumed an independent AR(1) process for the total factor productivity (Solow residual) uncorrelated with other shocks.

exports to GDP ratio relative to the simulated output volatility but the model GHH-N has 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 actual autocorrelation coefficients. 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.

7 Counterfactual experiments

All in all, as also concluded by Neumeyer and Perri (2005), the model GHH-N performs relatively better than the alternatives, hence we choose it as the baseline model. Following Neumeyer and Perri's similar experiment, we also carry out a kind of variance decomposition of which results are summarized in Table 8. In the first line under each variable is the results from the baseline GHH-N model. The second line gives the outcome when there are 'no A shocks'. 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 the productivity shocks also causes the countercyclicality of the real interest rate and net exports to break down.

Table 8: Counterfactual experiments using the baseline model (estimated shocks)

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.

When the 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. When present, productivity shocks are able to balance 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.

Why the model does not predict such drastic output volatility drops in Turkey as in Argentina? There are several (not mutually exclusive) explanations from the Turkish case. These explanations may be presented using the labour market equilibrium in the GHH case, which involves most of the propagation mechanisms in the model. Equation (49) is reproduced here in equation (51)

$$\hat{l}_t = \left(\frac{1}{\alpha + \nu - 1}\right) \left[\hat{A}_t + \alpha \hat{k}_{t-1} - \left(\frac{\theta \bar{R}}{1 + \theta\left(\bar{R} - 1\right)}\right) \hat{R}_{t-1}\right]. \qquad (51)$$

Obviously, the amplification of shocks via equation (51) depends on the parameters α, ν, θ, and $\bar{R}$.

First, Neumeyer and Perri (2005) assumes $\theta = 1$ whereas we set it to $\theta = 0.405$. This affects the response of the hours worked in equilibrium relative to the response to a productivity disturbance. 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 (51) is equal to 0.414 in our parameterization for Turkey; however, it drops out when $\theta = 1$. This implies that the equilibrium response of hours under the Turkish parameterization is 41 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. When $\theta = 1$, the reduction in output volatility becomes 16.1 percent.

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 $1/(\alpha + \nu - 1)$ is equal to 0.8 in Turkey, 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.

We discussed the small labour share problem earlier and concluded that the value of α corrected for the adjustment in labour share should be 0.40.

Table 9: Counterfactual experiments using the baseline model with $\alpha = 0.40$ (estimated shocks)

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	5.10	1.00	0.60	1.00	-0.34
No A shocks	1.14	1.00	0.36	1.00	0.00
No D shocks	4.47	1.00	0.59	1.00	0.07
D shocks only via A	4.75	1.00	0.66	1.00	-0.96
No R^* shocks	5.10	1.00	0.60	1.00	-0.34
Consumption (c)					
Model GHH-N	3.84	0.75	0.60	0.97	-0.52
No A shocks	1.45	1.27	0.56	0.79	-0.59
No D shocks	2.32	0.52	0.60	0.99	-0.01
D shocks only via A	3.32	0.70	0.68	1.00	-0.95
No R^* shocks	3.87	0.76	0.60	0.97	-0.52
Investment (x)					
Model GHH-N	23.47	4.60	0.36	0.62	-0.93
No A shocks	16.80	14.79	0.19	-0.05	-0.99
No D shocks	3.97	0.89	0.73	0.54	-0.80
D shocks only via A	15.83	3.34	0.58	0.94	-1.00
No R^* shocks	23.72	4.65	0.37	0.63	-0.94
Net exports / GDP (nxy)					
Model GHH-N	4.67	0.92	0.21	-0.20	0.98
No A shocks	4.37	3.85	0.17	0.09	0.98
No D shocks	2.43	0.54	0.61	0.93	0.42
D shocks only via A	1.58	0.33	0.63	-0.66	0.83
No R^* shocks	4.72	0.93	0.24	-0.23	0.99
Hours (l)					
Model GHH-N	3.80	0.75	0.56	0.98	-0.34
No A shocks	1.47	1.30	0.25	0.97	-0.11
No D shocks	2.79	0.62	0.59	1.00	0.05
D shocks only via A	3.19	0.67	0.70	1.00	-0.95
No R^* shocks	3.80	0.75	0.56	0.98	-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.

Table 10: The percentage drop in output volatility due to eliminating country spread shocks

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

Table 9 reports the results from experiments when $\alpha = 0.40$. Using this value for α, 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 10.

Lastly, there are also differences arising from the interaction between expected productivity and the country spread. Neumeyer and Perri (2005) assume that the persistence ρ_A of productivity in Argentina is 0.95. This implies that the 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 ρ_A is 0.70. Besides, the sensitivity of the country spread to expected productivity is estimated as -0.60 in Turkey, while it is set to -1.04 by Neumeyer and Perri. 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.

8 Conclusion

In this paper, we examined the quantitative role of the interest rate in driving the 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 on 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 were also able to show 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. We also examined the effect of correlated shocks on the countercyclicality of the real interest rate and net exports. This sensitivity to the parameters calls for more rigorous theoretical foundations for the determination of the country spread.

9 Data Appendix

Most of the data are from the database of the Central Bank of Turkey. We use quarterly series between 1987 and 2004. Before applying any other transformation, we removed any significant seasonal component from each series. We used TRAMO-SEATS for seasonal adjustment.

Population We use quarterly total population estimates from the database of the Central Bank of Turkey. This series is total population rather than economically active population. However, 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 and statistical discrepancy in constant 1987 prices divided by total population. CONS1 includes consumption expenditures on durables. CONS2 excludes consumption expenditures on durables.

Investment Consists of gross fixed capital formation and changes in inventories in constant 1987 prices divided by total population. INV1 excludes consumption expenditures on durables. INV2 includes consumption expenditures on durables.

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". Source: OECD Main Economic Indicators.

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. There is evidence in support of this type of expectation formation (see, Celasun, 2006), so this combination of backward- and forward-looking expectations is deemed to be a reasonable choice for Turkey. 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 internet site of the Board of Governors of the Federal Reserve Bank. GDP deflator data come from the internet site of 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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