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S. Tolga Tiryaki

Address:
Central Bank of the Republic of Turkey
Head Office
Research and Monetary Policy Department
İstiklal Caddesi No: 10
Ulus, 06100 Ankara, Turkey

Phone:
+90 312 507 54 02

Facsimile:
+90 312 507 57 33

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S. Tolga Tiryaki

Central Bank of Turkey, Research and Monetary Policy Department, Istiklal Cad. No.10, Ulus, 06100, Ankara, Turkey. Phone: +90 312 507 5425. Email: Tolga.Tiryaki@tcmb.gov.tr.

Abstract

This paper explores the sectoral dimension of emerging market business cycles by building a two-sector small open economy real business cycle model featuring a working capital requirement, variable capital utilization and imported inputs in production. The primary finding is that the price of imported inputs and nontradable sector productivity are the two most important sources of macroeconomic fluctuations in a typical emerging market economy. Interest rates and the price of imported final goods also play significant role in driving investment and import fluctuations. The model also produces significant sectoral asymmetry, especially in response to interest rate shocks. Variable capital utilization acts as a strong propagation mechanism.

Keywords: business cycles, emerging markets, imported inputs, capital utilization
JEL: E32, F32

1. Introduction

An important part of business cycle research agenda since the beginning of 2000s has been directed towards accounting for the differences in business cycle characteristics between emerging market economies and more advanced economies. Early research on business cycles in small open developed economies highlights the importance of interest rate shocks (Mendoza, 1991; Correia et al., 1995) or terms of trade shocks (Mendoza, 1995), in addition to productivity shocks. More recently, Elgin and Kuzubaş (2013) empirically analyse the relationship between current account balance and output volatility for a panel of 185 countries, and find that higher current account deficits are associated with higher output volatility, especially in emerging market economies.

Initial small open economy models laid the foundations of recent studies on emerging market business cycles. For example, both Neumeyer and Perri (2005) and Uribe and Yue (2006) start from the observation that emerging markets are prone to paying a (risk) premium over the world interest rate in their borrowing contracts. The interaction of this premium (the country spread) with other factors such as the fundamentals of the economy and world interest rates introduces a strong propagation mechanism. Moreover, a simple financial friction in the form of a working capital requirement also helps to strengthen the effect of interest rate fluctuations on the volatility of other macroeconomic variables.

Arellano and Mendoza (2003) and Mendoza (2006) emphasize the role played by endogenous credit constraints in differentiating business cycles in sudden-stop-prone economies. Aguiar and Gopinath (2007), on the other hand, find that the standard model enriched by shocks to the trend growth rate of the economy is able to differentiate business cycles between emerging market economies and more advanced small open economies. They argue that emerging markets are characterized by dominant trend growth rate shocks in contrast to the case of advanced economies in which stationary productivity shocks take the lead.

In this paper, our main objective is to look at the sources of macroeconomic fluctuations in an emerging market economy using a two-sector dynamic stochastic general equilibrium model. Literature on emerging market business cycles has been mostly concentrated on single-sector models to explain the differences from the business cycles of more advanced small open economies, and the effect of sectoral asymmetries on aggregate fluctuations has not been analysed in detail. Therefore, the main contribution of this paper is that it provides an extensive analysis of the causes and propagation of business cycles in emerging market economies in a setup which highlights the role of sectoral asymmetries and interactions. This will enable us to examine the contribution of each sector to the propagation of various shocks relevant for emerging market economies.

The model consists of tradable and nontradable sectors with a rich production structure involving the use of imported inputs at various stages of production of both tradables and nontradables. Domestic and imported goods are imperfect substitutes, which makes the small open economy more vulnerable to changes in relative prices, or terms of trade. This relatively more complex structure aims to represent the input-output structure of the economy, albeit at a coarse degree of detail.

In the analyses by Neumeyer and Perri (2005) and Tiryaki (2011), the single-sector small open economy business cycle model with working capital requirement and stochastic disturbances to productivity and interest rate components cannot account for the countercyclicality of net exports in emerging markets, unless there is feedback from total factor productivity to country spreads or there is negative exogenous covariation between total factor productivity and country spread shocks. Solow residuals, as proxy for total factor productivity, are highly correlated with capacity utilization and terms of trade. Therefore, any model seeking to explain the role of various shocks in driving business fluctuations should ideally incorporate endogenous capacity utilization and terms of trade. It is for this reason that we build on the model of Neumeyer and Perri by adding tradable and nontradable sectors, variable capital utilization, and imported intermediate goods.

The primary finding of this paper is that the price of imported inputs and nontradable sector productivity are the two most important sources of macroeconomic fluctuations in a typical emerging market economy. Interest rates and the price of imported final goods also play significant role in driving investment and import fluctuations. The model also produces considerable asymmetry between tradable and nontradable sectors, especially in response to interest rate shocks.

We also run an alternative model in order to examine the consequences of variable capital utilization. We find that variable capital utilization significantly improves the model's amplification capability. We also find that the amplification effect of variable capital utilization operates mainly through the tradable sector.

2. Descriptive statistics of business cycles

In this section, we present some key observations on business cycles in Turkey. Table 1 shows standard deviations, relative standard deviations, and first order serial correlations of Hodrick-Prescott-filtered series that represent log-deviations from trend. Table 2 shows contemporaneous correlation coefficients between pairs of Hodrick-Prescott-filtered series. The majority of business cycle statistics are computed using quarterly series between 1987 and 2006, but shorter samples are also used for some series due to data availability.

There is apparent distinction between relative volatilities of tradable and nontradable output. Volatility of gross tradable output (final value of tradable output including imported inputs) is greater than gross domestic product (domestic value added), whereas volatility of gross nontradable output is only 57 percent of GDP volatility. Nontradable output is more persistent than tradable output. Tradable output follows movements in GDP more closely than nontradable output does. Nevertheless, there is still strong comovement between sectoral outputs, with a correlation coefficient of 0.73.

Table 1: Descriptive statistics of business cycles

		Volatility	Relative volatility	Serial correlation
y	GDP	0.0350	1.00	0.66
y^{DT}	gross tradable output	0.0461	1.32	0.62
y^N	gross nontradable output	0.0201	0.57	0.70
c	consumption	0.0229	0.63	0.75
inv	investment	0.1555	4.45	0.61
x	exports	0.0548	1.57	0.56
m	imports of final goods	0.1669	4.77	0.80
z	imported inputs	0.0862	2.47	0.73
nx/y	net exports / output	0.0329	0.94	0.66
u^N	utilization in nontraded sector	n.a.	n.a.	n.a.
u^T	utilization in traded sector	0.0342	0.98	0.56
l	hours worked	0.0139	0.40	0.48
l^N	hours in nontraded sector	0.0217	0.62	0.45
l^T	hours in traded sector	0.0207	0.59	0.65
g	government consumption	0.0388	1.11	0.55
p^M	imports price	0.0922	2.64	0.81
p^Z	imported inputs price	0.1128	3.22	0.64
r	real interest rate	0.0038	0.11	0.67
r^*	world real interest rate	0.0023	0.07	0.86
s	country spread	0.0034	0.10	0.66
y^W	world imports	0.0564	1.61	0.54

Table 2: Correlations between macroeconomic variables

	Contemporaneous correlation with				
	y	p^M	p^Z	r	y^W
y	1.00	-0.35	-0.52	-0.39	0.21
y^{DT}	0.96	-0.53	-0.52	-0.47	0.55
y^N	0.85	-0.47	-0.37	-0.05	0.52
c	0.92	-0.43	-0.48	-0.33	0.24
inv	0.82	-0.52	-0.57	-0.42	0.20
x	0.33	0.01	-0.12	-0.40	0.29
m	0.74	-0.75	-0.45	-0.35	0.60
z	0.84	-0.34	-0.47	-0.63	0.45
nx/y	-0.75	0.66	0.50	0.34	-0.21
u^N	n.a.	n.a.	n.a.	n.a.	n.a.
u^T	0.76	-0.12	-0.43	-0.46	0.13
l	0.23	0.02	0.37	0.41	0.43
l^N	-0.05	0.14	0.34	0.30	0.25
l^T	0.44	-0.18	0.04	0.17	0.32

GDP is negatively correlated with the price of imported final goods, p^M, as well as with the price of imported intermediate goods, p^Z, while the latter correlation is stronger than the former. There is also negative correlation between GDP and real interest rate, as also documented in Tiryaki (2011), as well as in Neumeyer and Perri (2005). Notice that the negative correlation between real interest rate and GDP is, by and large, due to strong and negative correlation between country spreads and GDP. World interest rate is almost acyclical.

There are two asymmetries between tradable and nontradable sectors. First, output's correlation with the price of imported inputs is higher in the tradable sector; second, and more significantly, output's correlation with real interest rate is -0.47 in the tradable sector and -0.05 in the nontradable sector. A plausible explanation for the first asymmetry is that the tradable sector have a larger share of imported inputs in production (22 percent) relative to the share of imported inputs in the nontradable sector (4 percent). The second asymmetry may also be related to the fact that tradable goods are more capital-intensive than nontradable goods are (55 percent versus 36 percent). An alternative but not mutually exclusive explanation for the latter asymmetry is that the nontradable sector may be operating with less working capital due to differences in the structure of economic activity. This may be weakening the link between output and the cost of working capital finance.

All aggregate quantities, consumption, investment, exports, imports of both final and intermediate goods, are procyclical; and all are more volatile than GDP. These variables, except exports, are also negatively correlated with both import prices. As a result, the ratio of net exports to GDP is strongly countercyclical as also documented in Tiryaki (2011), and is positively correlated with both import prices and real interest rate. This suggests that simultaneous output drops, interest rate hikes, real exchange rate depreciation, and current account reversals are frequently observed characteristics of Turkish business cycles.

Capacity utilization in the tradable sector is almost as variable as GDP but smaller than tradable output variability. It is strongly procyclical, and also negatively correlated with both imported inputs price and real interest rate. Hours worked series is significantly smoother than output, and slightly procyclical. Unlike capacity utilization, the correlation of hours with the price of imported input or with the interest rate is positive. However, this is, to a large extent, a reflection of the correlations in the nontradable sector, as it employs relatively larger share of the labour supply. These correlations are much smaller in the tradable sector.

3. The model

We build on the two-sector neoclassical small open economy business cycle model by enriching the transmission mechanism along several directions. Stochastic shocks are transmitted and propagated through various channels including variable capital utilization, imported intermediate goods, working capital requirement, capital adjustment cost, bond adjustment cost, asymmetries in factor shares of production in the two sectors, and asymmetries in the composition of final expenditure groups.

3.1. Production structure

There are two sectors in the economy: nontradable goods producing sector and tradable goods producing sector. Domestically produced tradable goods and imported tradable goods are combined to obtain the final composite tradable good using a constant elasticity of substitution aggregator. Then, this composite tradable good is combined with the nontradable good to obtain the final composite good. Note also that different aggregate expenditure groups such as consumption, investment, government spending, or exports have different weights of tradable versus nontradable goods in the final composite good.

Both tradable and nontradable sectors have a production technology in which labour, capital services, and imported intermediate goods are combined by a constant returns to scale Cobb-Douglas production function. The production technology is also open to temporary but persistent productivity shocks. The representative firm in each sector chooses the level of investment to accumulate capital stock and decides how much of the capital stock to utilize in the production process. The capital stock depreciates at a faster rate, the more intensive it is used in production. There are also adjustment costs related to the installation of new capital.

Both firms are subject to a working capital constraint by which they are required to set aside a fraction of their operating expenses. Firms are owned by the representative household so they pay out dividends to the household.

3.1.1. Nontradable sector

The representative firm in the nontradable goods producing sector is owned by the representative household. It hires labour services from the household, imports some inputs from abroad, and manages its capital stock. Capital services obtained from the capital stock are a function of the utilization rate and the level of the capital stock. The constant returns to scale production technology is the following Cobb-Douglas function:

$$y_t^N = a_t^N \left(u_t^N k_{t-1}^N\right)^{\alpha_1} \left(l_t^N\right)^{\alpha_2} \left(z_t^N\right)^{1-\alpha_1-\alpha_2}, \tag{1}$$

where y_t^N is the nontradable output, a_t^N is total factor productivity, u_t^N is the capital utilization rate, k_{t-1}^N is the the capital stock at the beginning of period t, and z_t^N is the imported input.

The representative firm decides on the evolution of the capital stock by choosing the level of investment and utilization rate of the current stock, and also considering the capital adjustment cost. Capital is a composite good involving both nontradable and tradable goods. The stock of capital evolves according to

$$k_t^N = i_t^N + \left(1 - \delta_t^N\right) k_{t-1}^N - \frac{\phi^N}{2} k_{t-1}^N \left(\frac{k_t^N}{k_{t-1}^N} - 1\right)^2, \tag{2}$$

where i_t^N represents investment made in the nontradable sector, δ_t^N is the time-varying depreciation rate, and the last term represents the capital adjustment cost. Depreciation of the capital stock is an increasing function of capital utilization with the following specification

$$\delta_t^N = \frac{h}{1+\zeta} \left(u_t^N\right)^{1+\zeta}. \tag{3}$$

This specification is also used in Greenwood et al. (1988), Burnside and Eichenbaum (1996), Letendre (2004), and Baxter and Farr (2005).

The firm is required to pay in advance a fraction θ of total operating expenses which consist of the wage bill $p_t^C w_t l_t^N$, utilization/maintenance cost of capital $\delta_t^N p_t^I k_{t-1}^N$, and imports of intermediate goods $p_t^Z z_t^N$. The firm borrows at the beginning of the period the required amount of working capital at the prevailing (gross) interest rate r_{t-1}, and pays back at the end of the period the total amount including interest.

The representative firm in the nontradable good producing sector maximizes the discounted present value of expected current and future dividends. It uses the household's discount factor in the maximization problem in order to represent the present value in terms of a metric that is relevant for the owner of the firm, that is, the household.[1] The problem of the firm is expressed as

$$\begin{aligned} \max E_0 \sum_{t=0}^{\infty} \beta^t \frac{U_{c,t}}{U_{c,0}} \frac{p_0^C}{p_t^C} \Big[\, & y_t^N - p_t^C w_t l_t^N - p_t^I i_t^N - p_t^Z z_t^N \\ & -\theta \left(r_{t-1} - 1\right) \left(p_t^C w_t l_t^N + \delta_t^N p_t^I k_{t-1}^N + p_t^Z z_t^N\right) \Big], \end{aligned} \tag{4}$$

[1] Same specification is also used in Benigno and Thoenissen (2008).

where β is the discount factor, $U_{c,t}$ represents household's marginal utility of consumption, p_t^C is the relative price of the composite consumption good, p_t^I is the relative price of the composite investment good, p_t^Z is the relative price of imported intermediate goods. Note that the price of the nontradable good, p_t^N, is chosen as the numeraire and set equal to unity. All other prices are expressed in terms of the nontradable good.

3.1.2. Tradable sector

Domestic production structure of tradables is symmetric to that of the nontradable sector. The representative firm in the tradable goods producing sector maximizes the discounted present value of expected current and future dividends:

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \frac{U_{c,t}}{U_{c,0}} \frac{p_0^C}{p_t^C} \left[p_t^{DT} y_t^{DT} - p_t^C w_t l_t^T - p_t^I i_t^T - p_t^Z z_t^T \right. \tag{5}$$
$$\left. -\theta \left(r_{t-1} - 1\right) \left(p_t^C w_t l_t^T + \delta_t^T p_t^I k_{t-1}^T + p_t^Z z_t^T\right)\right] ,$$

where p_t^{DT} represents the relative price of the domestically produced tradable good. The firm's optimization problem is subject to the production function

$$y_t^{DT} = a_t^T \left(u_t^T k_{t-1}^T\right)^{\gamma_1} \left(l_t^T\right)^{\gamma_2} \left(z_t^T\right)^{1-\gamma_1-\gamma_2} , \tag{6}$$

the law of motion for capital

$$k_t^T = i_t^T + \left(1 - \delta_t^T\right) k_{t-1}^T - \frac{\phi^T}{2} k_{t-1}^T \left(\frac{k_t^T}{k_{t-1}^T} - 1\right)^2 , \tag{7}$$

and the relationship between capital utilization and depreciation

$$\delta_t^T = \frac{h}{1+\zeta} \left(u_t^T\right)^{1+\zeta} . \tag{8}$$

We assume that the capital adjustment cost parameter ϕ, and parameters of the depreciation function, h and ζ, are the same across nontradable and tradable sectors.

3.1.3. Composite goods and prices

Final composite tradable good, y_t^T, consists of both domestically produced final good, y_t^{HT}, and imported final good, m_t. They are combined by the constant elasticity of substitution (CES) function

$$y_t^T = \left[\mu_T^{1/\chi_T} \left(y_t^{HT}\right)^{(\chi_T-1)/\chi_T} + \left(1-\mu_T\right)^{1/\chi_T} \left(m_t\right)^{(\chi_T-1)/\chi_T}\right]^{\chi_T/(\chi_T-1)} . \tag{9}$$

Given the price of domestically produced tradable good p_t^{DT} and the price of imported goods p_t^M, the price of one unit of composite tradable good that minimizes expenditure $p_t^{DT} y_t^{HT} + p_t^M m_t$ such that $y_t^T = 1$ is given by

$$p_t^T = \left[\mu_T \left(p_t^{DT}\right)^{1-\chi_T} + (1-\mu_T)\left(p_t^M\right)^{1-\chi_T}\right]^{1/(1-\chi_T)}. \tag{10}$$

Derived demand equations for the domestically produced tradable goods and imported goods are written as:

$$y_t^{HT} = \mu_T \left(\frac{p_t^{DT}}{p_t^T}\right)^{-\chi_T} y_t^T \tag{11}$$

and

$$m_t = (1-\mu_T)\left(\frac{p_t^M}{p_t^T}\right)^{-\chi_T} y_t^T. \tag{12}$$

Final goods for consumption, investment, government expenditure and exports are all composite goods consisting of the nontradable goods, as well as tradable goods. Tradable and nontradable goods are imperfect substitutes and brought together by CES functions. Each composite good involves different weights for tradable and nontradable goods.

Aggregate consumption is defined as

$$c_t = \left[\mu_C^{1/\chi_C}\left(c_t^T\right)^{(\chi_C-1)/\chi_C} + (1-\mu_C)^{1/\chi_C}\left(c_t^N\right)^{(\chi_C-1)/\chi_C}\right]^{\chi_C/(\chi_C-1)}. \tag{13}$$

Given the relative prices of tradable goods, this equation gives rise to following demand equations for nontradable and tradable goods in consumption:

$$c_t^T = \mu_C \left(\frac{p_t^T}{p_t^C}\right)^{-\chi_C} c_t \tag{14}$$

and

$$c_t^N = (1-\mu_C)\left(\frac{1}{p_t^C}\right)^{-\chi_C} c_t, \tag{15}$$

where p_t^C is the price of one unit of composite consumption good that minimizes expenditure $p_t^T c_t^T + c_t^N$ such that $c_t = 1$, given by

$$p_t^C = \left[\mu_C\left(p_t^T\right)^{1-\chi_C} + (1-\mu_C)\right]^{1/(1-\chi_C)}. \tag{16}$$

There is only one type of capital good to be used in both sectors. We name the composite investment good used in the tradable sector as i^T, and in the nontradable sector as i^N,

$$i_t^T = \left[\mu_I^{1/\chi_I}\left(i_t^{T,T}\right)^{(\chi_I-1)/\chi_I} + (1-\mu_I)^{1/\chi_I}\left(i_t^{T,N}\right)^{(\chi_i-1)/\chi_i}\right]^{\chi_i/(\chi_i-1)} \tag{17}$$

$$i_t^N = \left[\mu_I^{1/\chi_I}\left(i_t^{N,T}\right)^{(\chi_I-1)/\chi_I} + (1-\mu_I)^{1/\chi_I}\left(i_t^{N,N}\right)^{(\chi_i-1)/\chi_i}\right]^{\chi_i/(\chi_i-1)}, \quad (18)$$

and total investment in the economy is

$$i_t = i_t^T + i_t^N. \quad (19)$$

Analogously, government expenditure, g_t is defined as

$$g_t = \left[\mu_G^{1/\chi_G}\left(g_t^T\right)^{(\chi_G-1)/\chi_G} + (1-\mu_G)^{1/\chi_G}\left(g_t^N\right)^{(\chi_G-1)/\chi_G}\right]^{\chi_G/(\chi_G-1)}. \quad (20)$$

Exports, on the other hand, are slightly different in composition that they do not involve imported tradable goods, m_t. Firms do not import final goods for exporting purposes. Only domestically produced tradable goods, y_t^{DT}, and nontradable goods, y_t^N, are combined to make up the final exported output,

$$x_t = \left[\mu_X^{1/\chi_X}\left(x_t^{DT}\right)^{(\chi_X-1)/\chi_X} + (1-\mu_X)^{1/\chi_X}\left(x_t^N\right)^{(\chi_X-1)/\chi_X}\right]^{\chi_X/(\chi_X-1)}. \quad (21)$$

Notice that exports involve some nontradable output as well as tradable output. Nontradable portion may represent output such as local storage, transportation, freight, financial services, etc. The presence of nontradable output in the final exports good implies that the country's exports are differentiated with respect to other countries' exports. Therefore, the country is able to charge a different price, p_t^X, from the price of other countries' exports.[2] The associated price index p^X for the aggregate export good is given by

$$p_t^X = \left[\mu_X\left(p_t^{DT}\right)^{1-\chi_X} + (1-\mu_X)\right]^{1/(1-\chi_X)}. \quad (22)$$

In equilibrium, nontradable output must be equal to the demand for nontradables, that is,

$$y_t^N = c_t^N + i_t^{TN} + i_t^{NN} + g_t^N + x_t^N. \quad (23)$$

Total demand for final composite tradable good comes from consumption, investment, and government expenditure,

$$y_t^T = c_t^T + i_t^{TT} + i_t^{NT} + g_t^T. \quad (24)$$

[2] Yet, in our calibration, the weight of x^N is set very small relative to x^{DT} so that this effect is not observed in our results to the full extent possible. Still, even if the nontradable component is assumed to be nil, the price of exports p^X is somewhat differentiated from the world import price p^M as p^X depends on p^M only through its effect on p^{DT}, which implies that a shock to the world import price p^M leads to an improvement in the competitiveness of the domestic country's exports.

Demand for the composite tradable good, y_t^T, implies demand for final good imports, m_t, and for domestically produced tradables, y_t^{HT}, hence, in equilibrium

$$p_t^T y_t^T = p_t^{DT} y_t^{HT} + p_t^M m_t. \tag{25}$$

Finally, domestically produced tradables output must equal demand for it,

$$y_t^{DT} = x_t^{DT} + y_t^{HT}. \tag{26}$$

3.2. The representative household

We have an infinitely lived representative household that derives utility from consumption and disutility from work. It has a time allowance normalized to unity, and decides what portion of its time to allocate to labour services and leisure. The household earns a wage w_t per labour hour which is denominated in the composite consumption good, and also receives dividends from the firm. The household can work in both tradable and nontradable sectors, so that labour mobility equates wages across sectors.

The representative household is able to buy and sell bonds, b_t, in the international bond market. The bonds tradable in this market are not state contingent; rather, they pay the same rate of interest in all states of the world. However, bonds are denominated in the price of imported final goods, p_t^M, so that the payoff in terms of the nontradable good is contingent on the import price shock, implying an additional exogenous constraint on household budget.

Government levies a lump-sum tax τ_t on households to finance its expenditure, g_t, and maintains a balanced budget at all times, so that $\tau_t = g_t$.

We adopt a period utility function, due to Greenwood et al. (1988), which has the property that marginal rate of contemporaneous substitution between consumption and hours worked does not depend on consumption. This results in a decrease in the excessive smoothness of consumption observed in models with standard utility.

The household maximizes discounted value of expected lifetime utility

$$\max E_o \sum_{t=0}^{\infty} \beta^t \frac{1}{1-\sigma} \left(c_t - \psi l_t^{\nu}\right)^{1-\sigma} \tag{27}$$

subject to the budget constraint

$$p_t^C c_t + p_t^G g_t + p_t^M b_t + \frac{\kappa}{2} y_t \left(\frac{p_t^M b_t}{y_t} - \frac{p^M b}{y} \right)^2 \leq p_t^C w_t l_t + \pi_t + r_{t-1} p_t^M b_{t-1}, \tag{28}$$

where the last term on the left hand side represents the bond adjustment cost, gross domestic product is defined as $y_t = y_t^N + p_t^{DT} y_t^{DT} - p_t^Z \left(z_t^N + z_t^T\right)$, variables without time subscripts (p^M, b, y) represent steady state values, and π_t represents total dividends paid out by all firms.

3.3. Aggregate resource constraint and balance of payments

In order to write the aggregate resource constraint of the economy, first we combine the budget constraint of the household, equation (28), with profits from all firms. Then, we use the zero-profit implication of CES aggregators in order to aggregate sectoral distribution of expenditure on nontradables and tradables, e.g. $p_t^C c_t = p_t^T c_t^T + c_t^N$, and simplify the resulting expression to obtain

$$p_t^C c_t + p_t^I i_t + p_t^G g_t + nx_t = y_t^N + p_t^{DT} y_t^{DT} - p_t^Z z_t, \tag{29}$$

where nx_t is given by

$$\begin{aligned} nx_t &= p_t^M \left(b_t - r_{t-1} b_{t-1}\right) + \frac{\kappa}{2} y_t \left(\frac{p_t^M b_t}{y_t} - \frac{p^M b}{y}\right)^2 \\ &\quad + \theta \left(r_{t-1} - 1\right) \left[p_t^C w_t l_t + p_t^I \left(\delta_t^N k_{t-1}^N + \delta_t^T k_{t-1}^T\right) + p_t^Z z_t\right]. \end{aligned} \tag{30}$$

The expression on the right hand side of equation (29) can be rewritten by imposing equilibrium conditions (23)-(26) in the goods market, as $p_t^C c_t + p_t^I i_t + p_t^G g_t + p_t^X x_t - p_t^M m_t - p_t^Z z_t$, which reduces equation (29) to

$$\begin{aligned} p_t^X x_t - p_t^M m_t - p_t^Z z_t &= p_t^M \left(b_t - r_{t-1} b_{t-1}\right) + \frac{\kappa}{2} y_t \left(\frac{p_t^M b_t}{y_t} - \frac{p^M b}{y}\right)^2 \\ &\quad + \theta \left(r_{t-1} - 1\right) \left[p_t^C w_t l_t + p_t^I \left(\delta_t^N k_{t-1}^N + \delta_t^T k_{t-1}^T\right) + p_t^Z z_t\right]. \end{aligned} \tag{31}$$

This equation implies that, in equilibrium, net exports of a country must be equal to the change in net foreign assets, inclusive of interest payments/ earnings and costs associated with issuing/holding bonds.

3.4. Rest of the world and exogenous processes

Foreign demand for our small open economy is taken as exogenous. We assume a functional form for the export demand function similar to our economy's demand for imported final goods, equation (12), as follows:

$$x_t = \mu_W \left(\frac{p_t^X}{p_T^M}\right)^{-\chi_W} y_t^*, \tag{32}$$

where y_t^* represents total world imports, and μ_W represents share of domestic economy's exports in world imports.

Interest rate is composed of a world interest rate, r^*, component and a country spread, s, component in the following form:

$$r_t = r_t^* s_t. \tag{33}$$

Demand for imports in the rest of the world, and other exogenous variables, productivity in each sector, government expenditure, prices of both intermediate and final goods imports, world interest rate, and country spreads, are subject to stochastic shocks and assumed to follow independent AR(1) processes:

$$\log y_t^* = (1-\rho_Y)\log y^* + \rho_Y \log y_{t-1}^* + \varepsilon_t^Y, \tag{34}$$

$$\log a_t^N = \left(1-\rho_A^N\right)\log a^N + \rho_A^N \log a_{t-1}^N + \varepsilon_t^N, \tag{35}$$

$$\log a_t^T = \left(1-\rho_A^T\right)\log a^T + \rho_A^T \log a_{t-1}^T + \varepsilon_t^T, \tag{36}$$

$$\log g_t = (1-\rho_G)\log g + \rho_G \log g_{t-1} + \varepsilon_t^G, \tag{37}$$

$$\log p_t^Z = (1-\rho_Z)\log p^Z + \rho_Z \log p_{t-1}^Z + \varepsilon_t^Z, \tag{38}$$

$$\log p_t^M = (1-\rho_M)\log p^M + \rho_M \log p_{t-1}^M + \varepsilon_t^M, \tag{39}$$

$$r_t^* = (1-\rho_R)\, r^* + \rho_R r_{t-1}^* + \varepsilon_t^R, \tag{40}$$

$$s_t = (1-\rho_S)\, s + \rho_S s_{t-1} + \varepsilon_t^S, \tag{41}$$

where the autoregressive parameters ρ_Y, ρ_A^N, ρ_A^T, ρ_G, ρ_Z, ρ_M, ρ_R, and ρ_S all lie between zero and one. Disturbances to exogenous processes are denoted by ε_t^Y, ε_t^N, ε_t^T, ε_t^G, ε_t^Z, ε_t^M, ε_t^R, and ε_t^S whose standard deviations are denoted by σ_Y, σ_A^N, σ_A^T, σ_G, σ_Z, σ_M, σ_R, and σ_S.

4. Calibration

We analyse the dynamics of the model by log-linearizing the equations around their non-stochastic steady state equilibrium. Therefore, we parameterize the model to solve the system of log-linear difference equations. Some of the parameters are preset, either reflecting long-term macroeconomic rates and ratios of the Turkish economy or taken from other studies; while other parameters are calibrated using steady state equilibrium conditions and preset parameters. Long-term averages are calculated using quarterly series between 1987 and 2006, although some of the series are in annual frequency due to data availability at sectoral level. The input-output tables of Turkey we are using belong to 1998, which were the most recent at the time of writing.

We start by calibrating each factor's share in production. Here, we employ the adjustment used by Tiryaki (2011) to overcome the bias in labour share parameters.[3] For each sector defined by the International Standard Industrial Classification (ISIC), we multiply the observed wage payments data in

[3] Tiryaki (2011) discusses the inconsistency between published labour share data and the conceptual wage payments variable used in the model, and offers an adjustment procedure.

national accounts by an adjustment factor calculated by taking into account the number of workers employed under such classifications as own-account workers and contributing family workers, in addition to the usual wage- and salary-earners. This adjustment makes it apparent that there is significant asymmetry in the intensity of labour between nontraded and traded sectors. Over the period from 1988 to 2005, the ratio of wage payments to sectoral GDP is 0.62 in the nontraded sector, and 0.29 in the traded sector.

We normalize the steady state level of gross domestic product to unity so that expenditure groups are expressed as ratios to GDP. Between 1987 and 2006, the average share of consumption was $p^C c = 0.68$, total investment was $p^I \left(i^N + i^T\right) = 0.18$, government's consumption expenditure was $p^G g = 0.18$, and net exports were $nx = -0.04$. A typical problem faced by many small open economy models is that we observe current account deficits *and* net foreign liabilities at the same time for prolonged years in many countries. Therefore, when sample averages for macroeconomic aggregates are plugged into the country's intertemporal budget constraint in steady state, we may encounter a situation in which the intertemporal budget constraint does not hold for that sample period. The same situation is also observed for Turkey's available data sample from 1987 to 2006. In order to respect the budget constraint, we alter the consumption to GDP ratio from $p^C c = 0.68$ to $p^C c = 0.61$, and change final goods imports from $p^M m = 0.09$ to $p^M m = 0.02$ to match net foreign liabilities of Turkey. This also gives a steady state current account surplus of $nx = 0.03$, instead of the actual deficit of $nx = -0.04$.

The decision of what sectors constitute the traded sector is based on those sectors' openness for international trade. Those sectors whose total volume of trade (i.e., exports plus imports) exceeds 20 percent of GDP are defined as traded sectors. By this definition, mining and quarrying industry, manufacturing industry, wholesale and retail trade services, business and personal services, and services by private non-profit institutions are classified as traded sectors; and agriculture, electricity, gas and water, construction, transportation and communication, financial institutions, ownership of dwellings, and government services are classified as nontraded sectors. The ratio of traded output to total output is 0.48.[4]

The ratio of total imported intermediate goods used in both sectors to GDP is $p^Z \left(z^T + z^N\right) = 0.16$. According to the input output tables, the nontraded sector uses only 14 percent of total imported inputs. This makes

[4] The choice of the 20 percent threshold is ultimately an arbitrary one. The ratio of traded output to total output rises from 0.48 to 0.77 when the threshold is decreased to 15 percent.

aggregate gross output including imported inputs (that is, not in value added terms) equal to 1.16, while sectoral distribution becomes $y^N = 0.54$ and $p^{DT}y^{DT} = 0.62$.

The discount factor β is calibrated to match the reciprocal of the average gross real interest rate r, which is the product of world real interest rate r^W and country-specific interest rate spread $sprd$. For the world interest rate, we use the London Interbank Offer Rate (LIBOR) for 3-month US-dollar deposits deflated by the expected US consumer price inflation; and for the country spread, we use the JP Morgan's Emerging Market Bond Index (EMBI) for Turkey.

Labour's share parameters α_2 and γ_2 in nontraded and traded sectors respectively, are set using labour demand equations in steady state. Exponents of imported intermediate goods in the production function $\alpha_3 \equiv 1 - \alpha_1 - \alpha_2$ and $\gamma_3 \equiv 1-\gamma_1-\gamma_2$ in nontraded and traded sectors respectively are set using their respective demand equations in steady state. Constant returns to scale assumption yields capital's exponent as $\alpha_1 = 1-\alpha_2-\alpha_3$, and $\gamma_1 = 1-\gamma_2-\gamma_3$.

Steady state allocation of investment between sectors is determined by relative shares of capital in each production technology. Using both firms' first order conditions for capital in steady state and capital's law of motion in steady state, and assuming equal depreciation rate across sectors, $\delta^N = \delta^T = \delta$, we obtain sectoral investment levels. Then we use steady state values of investment in each sector to calibrate the depreciation rate δ, by solving the optimality condition and capital's law of motion in steady state for δ.

Having obtained δ, we can calibrate the crucial capital/output ratios k^N/y^N and k^T/y^{DT} in nontraded and traded sectors, respectively. We use the capital/output ratio in the production function in order to solve for the steady state level of productivity.

We previously determined steady state levels of y^N, k^N/y^N, and z^N/y^N above. The only capacity utilization data in Turkey is available for the manufacturing industry, which we classified under the traded sector. It comes from the Business Tendency Survey of the manufacturing industry. We assume that steady state capital utilization is equal across traded and nontraded sector. Thus, for both tradable and nontradable sectors, we set the rate of capital utilization equal to the average observation in manufacturing industry, that is, $u^N = u^T = 0.78$. We normalize time endowment to unity, so that steady state total hours worked per household equals $l = 0.365$. We assume that labour is mobile across sectors, so that there is only one equilibrium wage rate for both sectors. Using this assumption, and also the sectoral breakdown of wage bill from the national accounts database of Turkey, we can work out the allocation of total hours worked among sectors, l^N and l^T. Finally, this leads us to the steady state levels of productivity in each sector.

Following Neumeyer and Perri (2005), we set the wage elasticity of labour supply $1/(\nu-1)$ to 1.67 which implies $\nu = 1.6$. Given the steady states of the wage rate w and hours worked l, the scaling parameter ψ is calibrated from the steady state labour supply equation.

We assume that the functional relationship between capital utilization and depreciation is the same across sectors. This assumption, coupled with our earlier assumption that utilization rate is equal across sectors, $u^N = u^T = u$, implies that steady state depreciation rates are the same as well, that is, $\delta^N = \delta^T = \delta$. Substitute these values into each firm's first order condition at steady state with respect to capital utilization and solve for the utilization elasticity of capital depreciation ζ, and subsequently for h using the relationship between utilization and depreciation $(1+\zeta)\,\delta = hu^{1+\zeta}$.

Shares of tradable goods in total consumption, total investment, total government expenditure, and exports are instrumental in calibrating the share parameters μ in CES aggregators for both quantities and prices. These ratios are set as $p^T c^T / p^C c = 0.30$, $p^T \left(i^{T,T} + i^{N,T}\right) / p^I i = 0.99$, and $p^T g^T / p^G g = 0.16$, respectively. Share of tradables in export goods is set $p^{DT} x^{DT} / p^X x = 0.94$ as a residual to match y^{DT}. Also, the share of imported final goods in final tradable good is $p^M m / p^T y^T = 0.05$.

Note that the elasticities of substitution between tradables and nontradables, χ_C, χ_I, χ_G, χ_X, and between domestic tradables and imports, χ_T, do not appear in the steady state solution, but do take part in log-linear dynamics around steady state. To our best knowledge there are no separate estimates of elasticity of substitution between tradables and nontradables for individual expenditure groups. Ostry and Reinhart (1992) provide estimates of the elasticity for the aggregate economy in both developing and more advanced economies. Following Mendoza (2002, 2005), we use the upper limit of the estimates in developing economies without differentiating for expenditure groups. As for the elasticity of substitution between domestic tradables and imports, we take a value of $\chi_T = 1$, which is standard in the business cycles literature.

We set b to match Turkey's net foreign assets to annual GDP ratio reported in Lane and Milesi-Ferretti (2007), which is $p^M b / y = -0.366$ in annual terms. The bond holding cost parameter κ is set to render b stationary. The capital adjustment cost parameter ϕ is set to match the volatility of aggregate investment relative to output volatility. Coefficient of relative risk aversion (inverse of intertemporal substitution elasticity) is set to $\sigma = 3.65$, the average of two estimates for Turkey by Salman (2005).

Capital utilization and capital stock series are required to construct productivity series for each sector. Lack of data on nontradable sector's capital utilization leads us to create utilization series using the model's op-

Table 3: Parameter values

Parameter	Value	Description
α_1	0.36	Capital share (nontradable)
α_2	0.60	Labour share (nontradable)
α_3	0.04	Import share (nontradable)
γ_1	0.55	Capital share (tradable)
γ_2	0.23	Labour share (tradable)
γ_3	0.22	Import share (tradable)
β	0.9818	Discount factor
σ	3.65	Coefficient of relative risk aversion
ν	1.60	Labour exponent (utility)
θ	0.41	Working capital requirement
ϕ	11.893	Capital adjustment cost
κ	0.0001	Bond adjustment cost
ζ	1.2525	Utilization elasticity of depreciation
h	0.0583	Utilization scaling factor
η	0.1354	Ratio of final goods in total imports
$\chi_C, \chi_I, \chi_G, \chi_X$	0.86	Elasticity of substitution between tradables and nontradables
χ_T	1	Elasticity of substitution between domestic and imported tradables
χ_W	1	Elasticity of substitution between countries
μ_C	0.30	Share of tradables in consumption
μ_I	0.99	Share of tradables in investment
μ_G	0.16	Share of tradables in government expenditure
μ_X	0.94	Share of tradables in exports
μ_T	0.94	Share of domestic tradables in total tradables
μ_W	0.0049	Share of domestic country exports in world imports
μ_C^*	0.40	Share of tradables in world consumption

Estimated parameters for exogeneous processes

ρ_A^N	ρ_A^T	ρ_G	ρ_Z	ρ_M	ρ_R	ρ_S	ρ_Y
0.98	0.95	0.79	0.87	0.97	0.96	0.91	0.98
σ_A^N	σ_A^T	σ_G	σ_Z	σ_M	σ_R	σ_S	σ_Y
0.0091	0.0070	0.0355	0.0866	0.0571	0.0013	0.0027	0.0571

Table 4: Correlation matrix of exogenous shocks

	y^W	p^Z	p^M	r^*	a^T	a^N	g	s
y^W	1.00							
p^Z	0.23	1.00						
p^M	-0.15	0.58	1.00					
r^*	0.50	-0.06	-0.16	1.00				
a^T	0.31	-0.31	-0.39	0.51	1.00			
a^N	0.05	-0.51	-0.48	0.34	0.30	1.00		
g	0.24	-0.20	-0.32	0.45	0.29	0.31	1.00	
s	-0.12	0.40	0.23	-0.24	-0.24	-0.36	-0.19	1.00

Note: Shock series are residual series from the estimation of equations (34)-(41).

timality conditions and calibrated parameters.[5] Rewrite equation (3) as $(1+\zeta)\,\delta_t^N = h\left(u_t^N\right)^{1+\zeta}$ and substitute this expression in the optimal capital utilization equation for the nontradable sector to solve for δ_t^N as

$$\delta_t^N = \left(\frac{\alpha_1}{1+\zeta}\right)\left(\frac{y_t^N}{p_t^I k_{t-1}^N}\right)\left(\frac{1}{1+\theta\left(r_{t-1}-1\right)}\right). \tag{42}$$

Now, solve capital's law of motion (2) for k_t^N, and substitute this optimal δ_t^N into the resulting equation so that capital stock series can be constructed starting from the steady state level of capital and by recursively iterating the equation using observable variables in the equation.

Having obtained the capital stock series, we can plug this in equation (42) to obtain series for depreciation and utilization as implied by equations of the model economy.[6] Finally, it is trivial to create productivity series a_t^N from the production function.

We estimate log-linearized versions of equations (34)-(41) as independent AR(1) processes using HP-filtered data.

Parameter values are summarized in Table 3. The covariance matrix of estimated shocks is presented in Table 4.

[5] Burnside and Eichenbaum (1996) estimate a business cycle model with variable capital utilization in which they employ a similar method to create time series for capital utilization.

[6] The same procedure is also applied to the tradable sector. The model-implied capital utilization in the tradable sector mimicks data reasonably well, with a correlation coefficient of 0.65; but it is significantly more volatile than data. Also, model-implied capital utilization is much less volatile in the nontradable sector than in the tradable sector.

Table 5: Model-implied second moments

	Volatility	Relative volatility	Serial correlation
y	0.0350	1.00	0.71
y^{DT}	0.0555	1.59	0.71
y^N	0.0495	1.42	0.73
c	0.0264	0.76	0.72
inv	0.1555	4.45	0.71
x	0.0714	2.04	0.72
m	0.1057	3.02	0.70
z	0.1268	3.63	0.69
nx/y	0.0207	0.59	0.71
u^N	0.0220	0.63	0.73
u^T	0.0302	0.86	0.73
l	0.0251	0.72	0.72
l^N	0.0446	1.28	0.73
l^T	0.0609	1.74	0.73

5. Quantitative results

5.1. Business cycle moments

Model-implied theoretical standard deviations and correlations are presented in Tables 5 and 6. Standard deviations of all shocks are scaled down by 9.56 percent in order to match exactly the standard deviation of output. Model-implied consumption volatility is less than output volatility, and close to actual consumption volatility. The aggregate consumption variable used in this study excludes expenditure on durable consumption goods, as durables are classified as investment both in data and in model. Consumption including expenditure on durables is 13 percent more volatile than output. The capital adjustment cost is set to match exactly the actual ratio of investment volatility to output volatility as in data. The model produces higher volatility for exports, imported inputs, and labour hours, while it yields smaller volatility for imports of final goods, net exports to GDP ratio, and capital utilization as compared to actual volatilities. However, the overall performance of the model in matching the standard deviations of main variables seems satisfactory, and the ordering of volatilities is matched to a great extent.

The baseline parameterization of the model over-predicts output volatility in both tradable and nontradable sectors, but significantly more so in the latter. Output volatility in the tradable sector is predicted to be 1.59 times more volatile than GDP, compared to 1.32 times in the data. On the other hand, nontradable output volatility is predicted to be 1.42 times more volatile than GDP, whereas in data nontradable output volatility is only 57 percent of

Table 6: Model-implied correlations

	Contemporaneous correlation with				
	y	p^M	p^Z	r	y^W
y	1.00	-0.15	-0.64	-0.64	-0.02
y^{DT}	0.87	0.10	-0.59	-0.70	-0.03
y^N	0.47	-0.77	-0.64	-0.01	-0.03
c	0.89	-0.54	-0.78	-0.50	-0.08
inv	0.81	0.05	-0.61	-0.82	-0.34
x	-0.15	0.47	0.46	0.35	0.77
m	0.82	-0.47	-0.77	-0.83	-0.17
z	0.85	-0.26	-0.90	-0.60	-0.17
nx/y	-0.61	0.43	0.75	0.63	0.63
u^N	0.48	-0.77	-0.64	-0.03	-0.03
u^T	0.71	0.45	-0.19	-0.69	0.00
l	0.79	-0.64	-0.81	-0.34	-0.04
l^N	0.28	-0.83	-0.58	0.12	-0.04
l^T	0.60	0.52	-0.12	-0.66	0.01

GDP volatility. This outcome is despite the fact that the estimated standard deviation of productivity shocks in the nontradable sector is about 25 percent greater than the estimated standard deviation of productivity shocks in the tradable sector. Therefore, we can conclude that the model's amplification and propagation channels operate asymmetrically so that non-sector-specific shocks of the model amplify output volatility much stronger in the tradable sector.

The sectoral asymmetry in factors of production, such as labour hours and capital utilization, is also parallel to the asymmetry in sectoral outputs; so the model-predicted volatilities of labour hours and capital utilization are higher in the tradable sector. We cannot confirm this asymmetric finding for capital utilization due to lack of data for nontradable sector's capacity utilization. As for labour hours, the model's prediction of asymmetry in sectoral volatilities is not supported by the data, since hours volatility is comparable in each sector. On the other hand, the model matches the fact that sectoral allocation of labour hours is more volatile than aggregate labour hours.

The model predicts very high contemporaneous correlation between total GDP and tradable output (sectoral outputs, by construction, include the value of imported inputs), which is close to the actual correlation coefficient. The actual degree of procyclicality of sectoral output is weaker in the nontradable sector compared to the tradable sector. The model is successful in replicating this fact, but the predicted correlation coefficient between nontradable output and GDP falls short of the actual correlation (0.85 versus

0.47).

The model is also successful in matching, with remarkable accuracy, the correlation of GDP with consumption, investment, imports of final goods, imported inputs, net exports, and capital utilization. Labour hours worked in tradable sector is moderately procyclical in data, whereas hours worked in nontradable is very slightly countercyclical but the correlation coefficient is virtually zero. The model is able to pin down higher procyclicality of labour hours in tradable sector compared to nontradable sector. However, the degree of procyclicality of labour hours is overestimated to some extent, a typical outcome of many small open economy models especially those using GHH preferences (see, for example, Tiryaki, 2011, for a comparison of the predictions of GHH versus Cobb-Douglas preferences).

The model fares well in matching the countercyclicality of net exports and real interest rates, the main distinctive characteristics of business cycles in developing countries. The model's prediction of the degree of the countercyclicality of net exports is a significant improvement over the predictions of the standard small open economy model, yet it falls slightly short of the actual correlation (-0.61 versus -0.75). Unlike Neumeyer and Perri (2005), in which the countercyclicality of net exports could not be obtained without recourse to assuming a specific form of interaction between country spreads and expected productivity, in our model countercyclicality of net exports is, to a large extent, the outcome of the production structure that relies on imported inputs. The relationship between the countercyclicality of net exports and the use of imported inputs in production is analysed in Tiryaki (2009).

Positive covariation of net exports to GDP ratio with the price of imported final goods and with the price of imported inputs is captured by the model. Also, the model is able to generate positive correlation between net exports and real interest rate as in data.

The model predicts significant negative correlation (-0.64) between real interest rate and GDP, exceeding the actual correlation (-0.39). Yet, the model successfully replicates the sectoral asymmetry with respect to real interest disturbances. Both in data and in the model, tradable output has significant negative correlation with real interest rate, while there is virtually no correlation between nontradable output and real interest rate. The sectoral asymmetry in response to real interest rate shocks is also observed in labour hours and capital utilization. Propagation of real interest rate shocks produces negative correlation with aggregate consumption, investment, imports, and capital utilization and hours worked in the tradable sector.

The cyclical implications of fluctuations in import prices are of central interest in small open economy models. In accounting for business cycles, our model attributes important role for both the price of imported final goods and the price of imported inputs. Business cycle statistics show that both import prices are negatively correlated with output (both aggregate and sectoral) and consumption, and positively correlated with the net exports to GDP ratio. The model performs quite satisfactorily in replicating these statistics. Model-implied cyclicality with respect to the price of imported inputs is more robust compared to model-implied cyclicality with respect to the price of imported final goods.

The model predicts counterfactually strong export-led boom in response to a positive shock to the price of imported final goods, which effectively leads to a gain in competitiveness, ceteris paribus, through real exchange rate depreciation. This response in the model, which results in small but positive correlation between tradable output and the price of imported final goods, is not observed in data. Moreover, in response to a shock in the price of imported final goods domestic investment rises in the tradable sector to catch up with rising demand for tradables from abroad. This effect gives rise to the model's counterfactual prediction of positive correlation between the price of imported final goods and investment.

This counterfactual behaviour in the model is in spite of the significant positive correlation (0.55) between the prices of imported final goods and imported inputs. The co-movement of the two import prices implies that, when there is a shock to the price of imported final goods that improves the competitiveness of domestically produced tradable goods, the economy is also very likely to be facing a negative supply shock in the form of a rise in the price of imported inputs. The baseline parameterization of the model takes into account the empirical correlation structure between exogenous shocks. When the shock processes are assumed to be orthogonal, so that the variance-covariance matrix of the exogenous shocks is diagonal, the depreciation-led export-oriented output growth becomes much stronger, changing the weak countercyclicality of the price of imported final goods to moderate procyclicality, mainly through strengthening the correlation between the tradable output and the price of imported final goods.

Second possible explanation is related to the extent to which imported and domestically produced tradables can be substituted for each other. When they are close substitutes, we may observe a boost to domestic production of tradables in response to a rise in the price of imported tradables, whereas, when they are complements, smaller demand for imported tradables implies also smaller demand for domestically produced tradables. Therefore, the positive response of domestic tradables production to the price of imported tradables calls for a sensitivity analysis of the elasticity of substitution parameter between imported and domestic tradables.

Table 7: Variance decomposition

	y^W	p^Z	p^M	r^*	a^T	a^N	g	s
y	0.13	44.43	11.82	0.10	0.69	30.05	0.01	12.76
y^{DT}	0.14	36.08	32.50	2.50	5.26	3.56	0.02	19.94
y^N	0.47	50.78	18.76	8.41	0.17	17.23	0.00	4.19
c	0.77	67.39	0.24	0.48	0.76	25.92	0.04	4.41
inv	11.70	30.25	16.91	6.15	2.89	3.71	0.00	28.39
x	59.56	10.65	24.93	1.14	0.42	0.92	0.00	2.38
m	2.87	57.54	0.20	5.46	1.24	6.33	0.03	26.33
z	3.31	78.53	9.12	0.95	0.26	2.08	0.01	5.76
nx/y	40.17	40.65	2.89	1.56	0.47	4.12	0.01	10.13
u^N	0.50	51.55	18.57	8.09	0.17	17.37	0.00	3.75
u^T	0.02	5.23	50.71	6.09	1.33	6.92	0.03	29.66
l	0.38	73.14	2.17	3.19	0.45	19.57	0.00	1.10
l^N	0.41	43.15	31.00	9.49	0.12	7.23	0.01	8.58
l^T	0.08	4.06	54.46	7.88	1.84	2.28	0.03	29.36

5.2. Variance decomposition

Theoretical variance decompositions given in Table 7 quantify how much each shock accounts for business cycle fluctuations in the model. This exercise helps us see whether our model, involving a rich set of exogenous shocks, can alleviate reliance on technology shocks as a source of business cycles. We use Cholesky factorization of the covariance matrix of shocks in order to identify each shock and its contribution to total variability. Therefore, the ordering of the variables in the covariance matrix becomes important, especially when the pairwise correlations between variables are not small. Our general principle in determining the ordering of variables is to write foreign variables before domestic ones, and quantity variables before price variables. The resulting ordering of variables is as follows: ε^Y, ε^Z, ε^M, ε^R, ε^T, ε^N, ε^G, and ε^S. This ordering makes sure that shocks to domestic variables do not affect foreign variables, and also implies that shocks to real variables, e.g. productivity, have contemporaneous effects on financial, e.g. country spreads, and price variables.

In the baseline calibration, that takes into account the correlation structure between exogenous shocks, import prices account for around 56 percent, productivity shocks around 32 percent, and interest rates 13 around percent of GDP volatility. Between import prices, shocks to the price of imported inputs explain 44 percentage points of the total 56 percent. Almost all of productivity shocks' contribution to GDP volatility comes from nontradable sector productivity.[7]

In comparison with total GDP, the weights of final good import price, country spread, and tradable sector productivity are significantly larger in explaining tradable output volatility, whereas the role of nontradable sector productivity is much smaller. As for nontradable output volatility, the role of import prices is relatively stronger and the role of nontradable productivity is small compared to the case of total GDP. Notwithstanding the relatively small share of imported inputs in nontradable output, p^Z shocks account for 51 percent of nontradable output volatility. With much higher share of imported inputs in tradable output, p^Z shocks account for only 36 percent of tradable output volatility. This is due to the fact that the negative correlation between p^Z shocks and a^N shocks is stronger than the correlation between p^Z shocks and a^T shocks (see Table 7). This implies that a positive p^Z shock has a stronger contemporaneous effect on a^N than it has on a^T.

Import prices together account for more than 70 percent of nontradable sector capital utilization and labour hours volatility, and more than 55 percent of tradable sector capital utilization and labour hours volatility. One important asymmetry between sectors is that interest rates account for significantly higher portion of capital utilization and labour hours volatility (36 percent and 37 percent, respectively) in the tradable sector than in the nontradable sector (12 percent and 18 percent, respectively).

Another important asymmetry is the insignificant role played by tradable sector productivity in driving business cycle volatility. The highest fraction of volatility attributed to tradable sector productivity is tradable output volatility, of which only 5 percent is predicted to be due to tradable sector productivity.

The price of imported inputs is the most important source of fluctuations in main aggregates (except for exports), the weight of which ranging from 30 percent in investment to 67 percent in consumption. The runner up source of variation is country spread shocks for investment and imports, nontradable sector productivity shocks for consumption, and external demand shocks for

[7] We also carried out variance decomposition analysis without taking into account the correlation structure between shocks. A general observation that appears from this analysis is that, after eliminating the off-diagonal elements in the covariance matrix, the role of shocks to the price of imported inputs, p^Z, in accounting for total variability becomes much less important for almost all variables. For example, the fraction of GDP volatility that is explained by the price of imported inputs falls from 44 percent to 21 percent. As a consequence, shocks to the price of imported tradables, p^M, and shocks to productivity in both sectors, a^N and a^T, become relatively more important for a number of variables. Details of this analysis are available upon request.

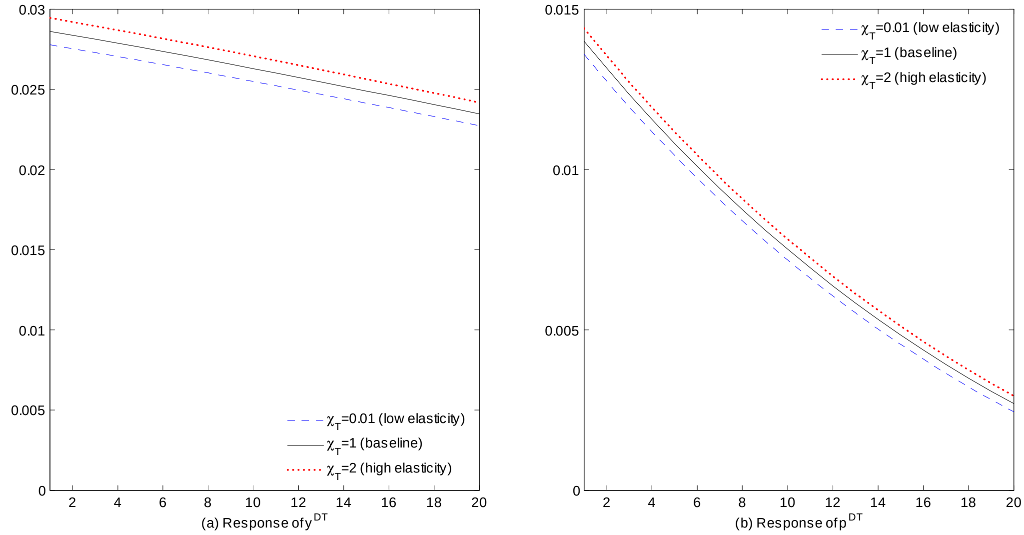

Figure 1: Sensitivity of impulse responses to varying degrees of substitutability between domestic and imported tradables

the net exports to GDP ratio. Variation in exports, on the other hand, is mostly driven by external demand shocks, and import price shocks.

Finally, the model-implied insignificance of government expenditure shocks in driving business cycles should not be interpreted as fiscal policy being inconsequential for business cycles. In our model, similar to Correia et al. (1995), government expenditure shocks are taken as aggregate demand shocks and they are financed by a lump-sum tax. Both the nature of government expenditure shocks (government consumption vs. government investment; temporary or permanent shocks; etc.) and the way government expenditures are financed (lump-sum vs. distortionary taxation) should matter a great deal in accounting for business cycles in emerging market economies.

6. Sensitivity analysis

6.1. Elasticity of substitution between domestic and imported tradables

Following the discussion in section 5 on the excessive positive response of domestic tradables production to shocks to the price of imported tradables, we provide a sensitivity analysis for the elasticity of substitution between domestic and imported tradables.

Figure 1 plots impulse responses of domestically produced tradable output, y^{DT}, and its relative price, p^{DT}, to one standard deviation shock to the price of imported tradables, p^M, at varying degrees of substitutability, χ_T. Contrary to our expectations, the elasticity of substitution between domestic

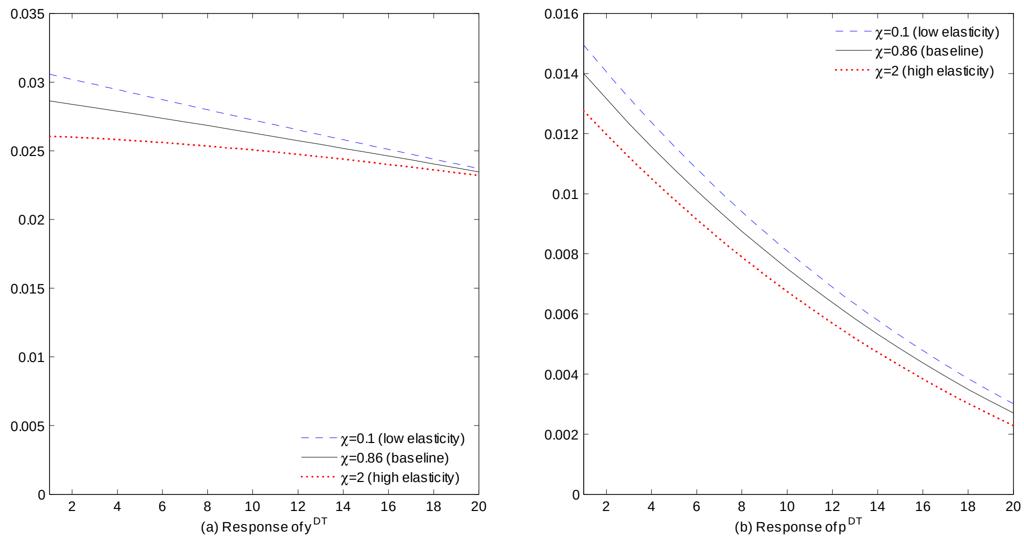

Figure 2: Sensitivity of impulse responses to varying degrees of substitutability between tradables and nontradables

and imported tradables does not have an effect on the dynamic responses of the economy. With such small changes in impulse responses, business cycle statistics implied by the model remain basically unchanged.

6.2. Elasticity of substitution between tradables and nontradables

Figure 2 plots impulse responses of domestically produced tradable output y^{DT} and its price p^{DT} to one standard deviation shock in the price of imported tradables at varying degrees of substitutability between tradables and nontradables. For simplicity, we changed the elasticity for all types of goods together to the same value. The range of initial responses with low and high substitutability between tradables and nontradables is much larger than the range in the case of low and high substitutability between domestic and imported tradables. Therefore, there is noticeable drop in correlation between p^M and y^{DT} as we move from low to high elasticity. Still, this is not sufficient to eliminate the counterfactually positive correlation between p^M and y^{DT}.

6.3. Capital utilization

Variable capital utilization acts as a strong amplification mechanism. The model without variable capital utilization is obtained by fixing both depreciation and capital utilization at their steady state values so that the steady state equilibria of the two models are the same. The model-implied GDP volatility with fixed capital utilization is only 70 percent of GDP volatility predicted by the baseline model. The amplification capability of variable capital utilization is stronger in the tradable sector, as a consequence of relatively small capital-intensity in nontradables production. The model-implied volatility of tradable output is 37 percent smaller in the fixed capital utilization case than in the variable utilization case, and 29 percent smaller for the nontradable output. A similar result is also obtained for sectoral labour hours.[8]

Variable capital utilization does not significantly change model-implied correlations, but correlations of main aggregates, sectoral output, and the prices of both import goods with GDP are in general smaller (in the order of 5 to 10 percentage points) when capital utilization is fixed. Besides, the countercyclicality of net export is weaker, the correlations between net exports and interest rate is relatively smaller in the case of fixed capital utilization.

The variability of capital utilization slightly changes the variance decompositions for GDP, tradable output, and investment. For example, the percentage of GDP volatility that is explained by the price of imported input shocks is 9 percentage points smaller when capital utilization is taken as fixed, while the percentage that is explained by the price of imported final goods is more than 7 percentage points higher. As for tradable output volatility, the shares of imported final good price and the country spread come down and the share of imported input price rises when capital utilization is taken as fixed. Regarding investment volatility, foreign demand and the price of imported inputs become more important factors, while the price of imported final goods and the country spread become less important when capital utilization is taken as fixed.

7. Conclusion

Literature on sectoral analysis of business cycles is relatively scarce in the setup of models containing particular characteristics of emerging-market business cycles. Hence, the objective of this paper was to provide a thorough analysis of the causes of business cycles in a typical emerging market economy, Turkey. For this purpose, we gathered information from disaggregated data to document statistics and highlight asymmetries at the sectoral level. Key observations are that the nontradable sector is less volatile, and less responsive to changes in imports prices as well as real interest rate, due to the fact that, unlike the tradable sector, production is heavily labour-intensive.

[8]Detailed analysis of the case without variable capital utilization is available upon request.

We aimed to reproduce these facts, as well as other key business cycle characteristics such as countercyclical net exports and real interest rate which are specific to emerging market economies, by using a small open economy business cycle model entailing a small financial friction in the form of a working capital requirement, and also liability dollarization (i.e., foreign denominated debt).

Several important results emerge from the analysis of our model. The primary conclusion is that the price of imported inputs and nontradable sector productivity are the two most important sources of macroeconomic fluctuations in a typical emerging market economy. Interest rates and the price of imported final goods also play significant role in driving investment and import fluctuations. The model produces considerable sectoral asymmetry in the dynamics of the economy. For example, interest rate shocks influence the tradable sector much more than the nontradable sector. The same is also true for shocks to the price of imported inputs. The model-based moments match the actual moments reasonably well. Direction of cyclicality for most variables is predicted correctly, including the countercyclicality of net exports and real interest rate, which are distinctive features of emerging market business cycles.

We also examined the consequences of variable capital utilization. We found that variable capital utilization acts as a strong amplification mechanism, which operates more strongly in the tradable sector.

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