EXTENSIONS OF THE STANDARD REAL BUSINESS CYCLE MODEL: THE CASE OF TURKEY

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ABSTRACT

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In this paper, I analyze a real business cycle model augmented with variable capital utilization, preference shocks, government spending shocks and financial frictions following Letendre (2004) and Garcia-Cicco, Pancrazi, and Uribe (2010). Calibrating the model to Turkey, the results suggest that endogenous capital utilization generates a stronger countercyclicality of trade balance close to that observed in the data. Productivity and government spending shocks analyzed with a higher debt-elasticity of risk premium are able to produce excess consumption volatility observed in the data while preference shocks and interest rate shocks have a negligible role in explaining business cycles in Turkey.

ÖZET

STANDART REEL İŞ ÇEVRİMİ MODELİNE EKLENTİLER: TÜRKİYE ÖRNEĞİ

BERNA KÖTEHNE

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Anahtar Kelimeler: Reel iş çevrimi modeli, Küçük açık ekonomi, Türkiye, Gelişmekte olan piyasalar

Bu çalışmada, Letendre (2004) ve Garcia-Cicco, Pancrazi, and Uribe (2010) makalelerini takip ederek değişken sermaye kullanımı, talep şokları, devlet harcaması şokları ve finansal friksiyonlar ile genişletilmiş reel iş çevrimi modeli incelenmektedir. Türkiye'ye kalibre edilen modelin sonuçlarına göre endojen sermaye kullanımı veride görülene yakın şekilde daha güçlü bir konjonktür karşıtı ticaret dengesi meydana getirmektedir. Verimlilik şokları ve devlet harcamaları şokları, daha yüksek borç esnekliğine sahip bir risk primi ile birlikte analiz edildiğinde verilerde gözlemlenen aşırı tüketim oynaklığını üretebilirken, tercih şokları ve faiz oranı şokları Türkiye'deki iş çevrimlerini açıklamada önemli bir rol oynamamaktadır.

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1. INTRODUCTION

Business cycles in emerging market economies are characterized by strong current account reversals and excess volatility of consumption relative to that of output. The standard small open economy real business cycle (RBC) model fails to match these common empirical regularities observed in emerging market economies. Many papers have tried to reproduce the aforementioned business cycle characteristics by making different extensions to the standard RBC model. Aguiar and Gopinath (2007) extended the baseline RBC model by including trend growth shocks. Neumeyer and Perri (2005), Uribe and Yue (2006) and Chang and Fernández (2013) incorporated financial frictions in the baseline RBC model. Drechsel and Tenreyro (2018) analyzed shocks to commodity prices for commodity exporting countries. Mendoza (1995) studied terms of trade shocks as a potential source of macroeconomic fluctuations.

In this paper, I combine certain extensions of the standard RBC model analyzed in Letendre (2004) and Garcia-Cicco, Pancrazi, and Uribe (2010) in order to study the performance of the augmented model in matching Turkish business cycle facts.

Letendre (2004) augmented the baseline small open economy RBC model by endogenous capital utilization, habit formation in consumption, interest rate shocks and government spending shocks; calibrated the model to Canada. He found that adding capital utilization improved the match of the model in terms of labor, output and investment volatility; and adding moderate amount of habit formation improved the fit of current account dynamics whereas interest rate shocks and government spending shocks did not improve the fit of the model with endogenous capital utilization and habit formation. I borrow endogenous capital utilization, government spending shocks and interest rate shocks from Letendre (2004). I do not extend the model with habit formation in consumption since the baseline RBC model already fails to reproduce the excess consumption volatility observed in emerging markets and adding habit formation would decrease consumption volatility even further.

Garcia-Cicco, Pancrazi, and Uribe (2010) extended the baseline RBC model by trend growth shocks, government spending shocks, preference shocks and financial frictions (in the form a country risk premium shock and econometrically estimated debt-elasticity of country risk premium). They calibrated the model to Argentina and concluded that financial frictions together with preference shocks were able to match excess consumption volatility, volatility trade balance-to-output ratio and the autocorrelation of trade balance-to-output ratio observed in Argentina whereas they found that adding trend growth shocks and government spending shocks made no improvement in the fit of the model. Both Letendre (2004) and Garcia-Cicco, Pancrazi, and Uribe (2010) added government spending shocks and interest rate shocks which I incorporate in the model. In addition, I borrow preference shocks and use an econometrically estimated debt-elasticity of risk premium in the model following Garcia-Cicco, Pancrazi, and Uribe (2010).

The first extension analyzed in this paper is endogenous capital utilization. In the standard RBC model, capital stock is assumed to be fully utilized every period, put it differently, capacity utilization rate is always equal to 100% and depreciation rate of capital is taken as constant. However, capacity utilization might differ depending on the level of economic activity and capital might depreciate faster when used more intensively, referred to as "wear and tear". Variable capital utilization has been extensively analyzed in the literature. Greenwood, Hercowitz, and Huffman (1988) were the first to formally analyze variable capital utilization in an RBC model. They found that variable capacity utilization was an important mechanism through which investment shocks operated in explaining business cycle fluctuations. In a two-country RBC model applied to the US and Europe, Baxter and Farr (2005) found that variable capital utilization improved the correlations of wages, hours and investment compared to the standard RBC model. Basu (1996) also favored an RBC model with variable factor (both capital and labor) utilization over the standard RBC model and argued that variable utilization was an important propagation mechanism of business cycles.

The second extension studied in this paper is preference shocks. In the literature, preference shocks have generally been put forth as a response to the seminal work of Kydland and Prescott (1982) who built the RBC model. Kydland and Prescott (1982) argued that macroeconomic fluctuations could be explained by shocks to productivity in a setting with perfect competition and intertemporally utility maximizing agents. As a reaction to their findings, many researchers analyzed technology shocks and preference shocks together by building different models rather than using the canonical RBC model. Bencivenga (1992) investigated preference shocks, which may be interpreted as deriving from shocks to household production as a mechanism for generating variation in hours in a model with no intertemporal substitution. He found that the model was able to generate sufficient variation in hours relative to productivity and consumption relative to output. Building a model with preference shocks, technology shocks and government spending shocks, Hall (1997) found that preference shifts, as opposed to shocks to technology or government purchases, could explain most of the aggregate fluctuations observed in the Great Depression. In another paper, Galí and Rabanal (2004) concluded that demand factors as opposed to technology shifts were the main operating force behind the positive co-movement of output and labor hours which they considered as the hallmark of macroeconomic fluctuations. Different from the aforementioned papers, Weder (2006) analyzed preference shocks in an RBC model. He found that preference shocks, coupled with variable capital utilization and mildly increasing returns to scale in production, could explain aggregate fluctuations observed in the Great Depression. In this paper, following Garcia-Cicco, Pancrazi, and Uribe (2010), I extend the RBC model by including a preference shock. Different from most of the previous literature, the preference shock analyzed in this model serves the purpose of increasing consumption volatility without generating additional variation in hours.

Government spending shocks are another extension examined in this paper. Government spending shocks have been extensively analyzed in the literature as potential sources of macroeconomic fluctuations from various angles including multiplier effects of temporary and permanent shocks to government expenditures financed by lump-sum taxes (Aiyagari, Christiano, and Eichenbaum 1992; Baxter and King 1993), government spending shocks financed by distortionary taxes (McGrattan 1994), dynamic effects of shocks to government purchases and taxes on output (McGrattan 1994). More relevant to the analysis in this paper, Hirata, Kim, and Kose (2007) studied the sources of aggregate fluctuations in Middle East and North Africa and found that government spending shocks explained a relatively small part of aggregate fluctuations. Ghate, Gopalakrishnan, and Tarafdar (2016) found that embedding fiscal policy into the RBC model created by Neumeyer and Perri (2005) was able reproduce countercyclicality of trade balance and excess consumption volatility observed in India.

The final extension analyzed in this paper is financial frictions. There is a considerable literature devoted to analyzing financial frictions of different forms as important determinants of business cycles, especially in emerging market economies. Neumeyer and Perri (2005) built a model in which real interest rate is composed of an international rate and country spread. They found that country spread, which is negatively related to expected productivity, together with a working capital requirement could explain business cycle regularities of Argentina. Arellano (2008) found that a small open economy model augmented with default risk closely matched excess consumption volatility and countercyclicality of trade balance in Argentina. Similarly, Yue (2010) found that the model featuring sovereign default and debt renegotiation was able to reproduce countercyclical bond spreads and trade balance in Argentina. Mendoza (2010) built a small open economy model with a collateral constraint which affects cost of borrowing and working capital loans through distortions to external risk premia and found that the model performed well in matching the dynamics of sudden stops observed in Mexico.

In this analysis, the standard RBC model is augmented with endogenous capital utilization, preference shocks, government spending shocks and financial frictions. In the model, interest rate is modelled as a strictly increasing function of aggregate debt-to-GDP ratio. I econometrically estimate the parameter governing debt-elasticity of country risk premium instead of setting it to a small value to induce stationarity. The estimated debt-elasticity will act as a reduced form of financial frictions. Second component of financial frictions is interest rate shocks. Compared to the baseline model, the augmented model is able to generate excess volatility of consumption while preserving a sufficiently countercyclical trade balance. Government spending shocks and productivity shocks together with a higher risk premium explain most of the variation in endogenous variables while preference shocks and interest rate shocks do not have an important effect on macroeconomic fluctuations in Turkey.

The rest of the paper is organized as follows: in Section 2, I present empirical regularities of business cycles in Turkey. In Section 3, I introduce the augmented model including all extensions. In Section 4, I explain calibration and estimation of parameters. In Section 5, using impulse responses and simulation results, I discuss the implications of endogenous capital utilization, preference shocks, government spending shocks and financial frictions. Finally in Section 5, I summarize the main findings of the analysis.

2. BUSINESS CYCLES IN TURKEY

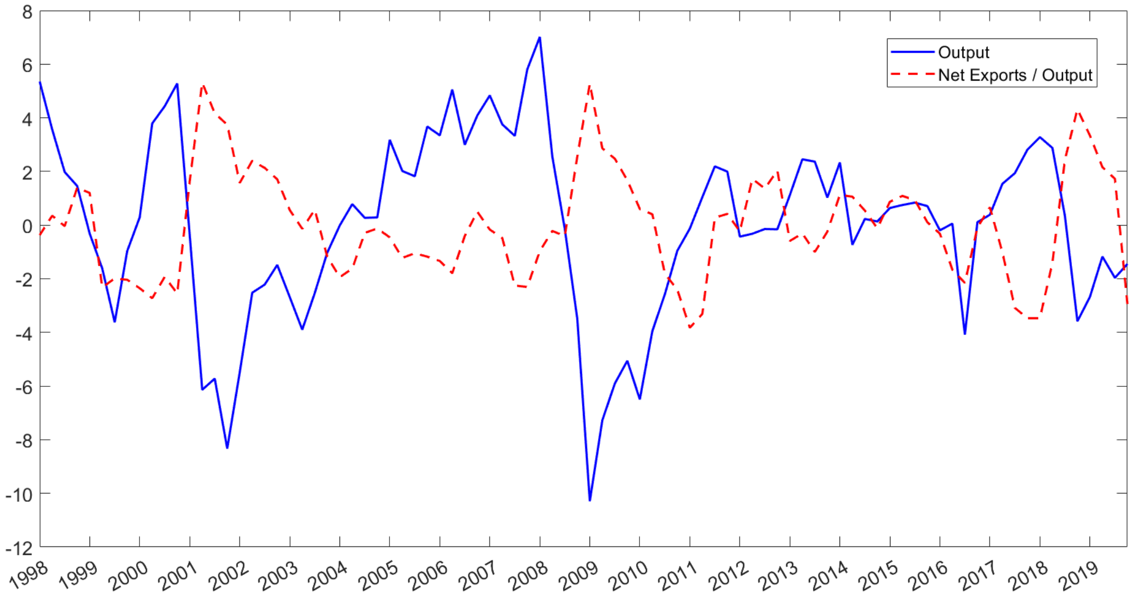
Business cycles in emerging market economies are different from those in developed economies in certain dimensions. One of the most prominent differences is strong current account reversals (also referred to as "sudden stops") observed in emerging market economies. The current account reversals are characterized by sudden and large net capital outflows in times of crisis which generate strong countercyclicality in trade balance. The current account reversals in Argentina, Mexico, Brazil and Philippines, among other emerging markets, are documented in Aguiar and Gopinath (2007) and Neumeyer and Perri (2005).

Output and net exports-to-output ratio in Turkey for the period 1998Q1-2019Q4 is plotted in Figure 2.1. The strongest sudden stops were experienced in 2001 Turkish economic crisis and 2007-2009 Global Financial Crisis. In general, there is a clear negative relationship between output and net exports-to-output ratio. The correlation between these two variables is equal to -0.59 in the data (see Table 2.1).

Another important difference between business cycles in emerging market countries and developed countries is the excess volatility of consumption relative to volatility of output. To give an example, excess consumption volatility in Mexico and Argentina are reported in Garcia-Cicco, Pancrazi, and Uribe (2010), Aguiar and Gopinath (2007) and Neumeyer and Perri (2005). This empirical regularity can also be observed in the Turkish data displayed in Figure 2.2. Consumption is procyclical and is slightly more volatile than output. Ratio of consumption volatility to output volatility is equal to 1.01 (see Table 2.1).

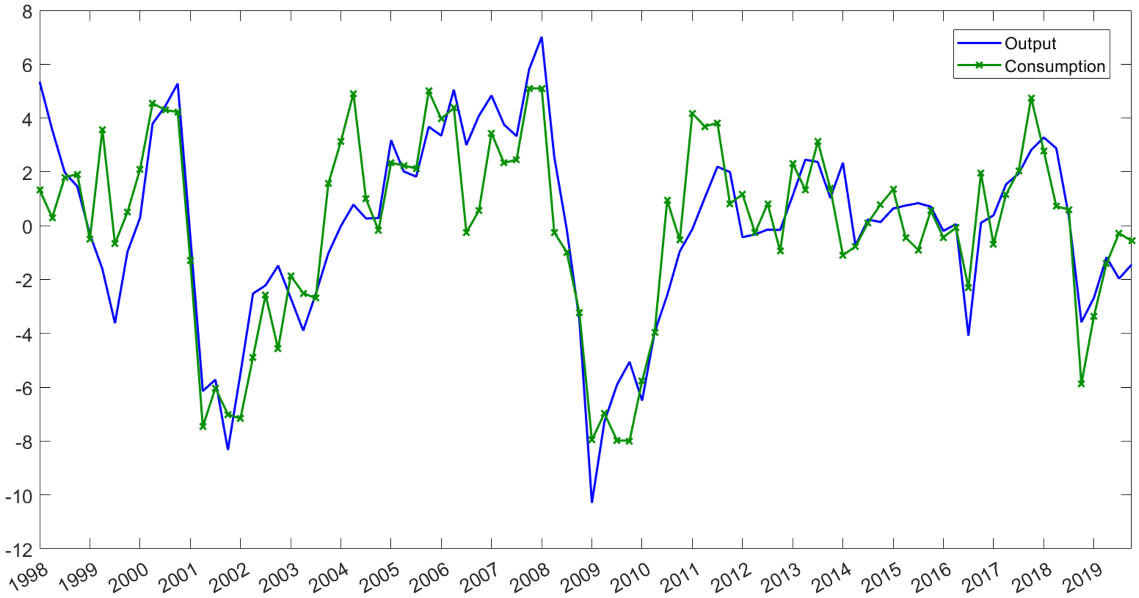
Compared to the volatility of output, investment is more than three times more volatile, net exports-to-output ratio is moderately less volatile and labor supply is almost as volatile. Investment, consumption and labor supply are all procyclical while net-exports-to-output ratio is strongly countercyclical (as discussed above). All variables have a first-order autocorrelation coefficient of at least 0.70. Business cycle statistics and descriptions of variables can be found in Table 2.1.

Figure 2.1 - Output and Net Exports in Turkey



Notes: Output is logged and HP-filtered real GDP per capita. Net exports are defined as imports minus exports. Net exports to output ratio is HP-filtered.

Figure 2.2 - Output and Consumption in Turkey



Notes: Output is logged and HP-filtered real GDP per capita. Consumption is logged and HP-filtered private final consumption expenditure per capita.

Table 2.1 - Business Cycle Statistics of Turkey

Standard Deviation		*Correlation with output*		*Autocorrelation*	
$\sigma(y)$	3.35			$\rho(y, y_{-1})$	0.81
$\sigma(i)/\sigma(y)$	3.29	$\rho(y, i)$	0.94	$\rho(i, i_{-1})$	0.84
$\sigma(c)/\sigma(y)$	1.01	$\rho(y, c)$	0.86	$\rho(c, c_{-1})$	0.74
$\sigma(nx/y)/\sigma(y)$	0.60	$\rho(y, nx/y)$	-0.59	$\rho(nx/y, nx/y_{-1})$	0.72
$\sigma(n)/\sigma(y)$	0.96	$\rho(y, n)$	0.79	$\rho(n, n_{-1})$	0.73

Notes: Business cycle statistics of Turkey are calculated using quarterly data for the period 1998Q1-2019Q4. y is output, i is investment, c is consumption, nx is net exports and n is labor. Output, investment, consumption and labor supply are logged and HP-filtered with smoothing parameter 1600. Net exports are HP-filtered with smoothing parameter 1600. Standard deviations are in percentages.

3. MODEL

The model is a standard small open economy model augmented with endogenous capital utilization, shocks to preference and government spending and financial frictions (in the form of interest rate shock and econometrically estimated debt-elasticity of country premium, ψ_2). The economy is populated with a large number of identical agents who produce a single good and trade a single asset. I solve the social planner's problem in order to derive the optimality conditions and the steady state equations. I combine the models used in Letendre (2004) and Garcia-Cicco, Pancrazi, and Uribe (2010).

The representative household maximizes its lifetime expected utility given by,

$$E_0 \sum_{t=0}^{\infty} \beta^t \pi_t \frac{(c_t - \mu n_t^{\nu})^{1-\alpha}}{1-\alpha}, \qquad 0 < \beta < 1,\ \alpha > 0,\ \mu > 0,\ \nu > 1 \tag{3.1}$$

where E_0 is the information set available to the representative household at time 0, β is the discount factor, μ is the labor weight in utility, ν is the parameter governing the intertemporal elasticity of substitution in labor supply, α is the coefficient of relative risk aversion. c_t, n_t and π_t represent consumption, labor supply and preference shock, respectively. Momentary utility function takes the form used in Greenwood, Hercowitz, and Huffman (1988). This functional form has the property that elasticity of intertemporal substitution between consumption and labor supply is equal to 0. GHH utility function is used in both Letendre (2004) and Garcia-Cicco, Pancrazi, and Uribe (2010).

The production function is the standard Cobb-Douglas production function augmented with utilization rate, u_t,

$$y_t = z_t (u_t k_t)^{\theta} n_t^{1-\theta}, \qquad 0 < \theta < 1, \quad 0 < u_t < 1,\ \forall t \tag{3.2}$$

where y_t is output, z_t is the stationary productivity shock and k_t is the stock of capital. u_t determines the amount of capital used in the production at time t.

The resource constraint for the economy is given by,

$$c_t + i_t + g_t + a_{t+1} = z_t(u_t k_t)^{\theta} n_t^{1-\theta} + R_t a_t \tag{3.3}$$

where i_t is investment, a_t is the stock of foreign assets, R_t is the gross real interest rate and g_t is government spending assumed to be financed by lump-sum taxes.

Capital accumulation equation is formulated as

$$k_{t+1} = (1 - \delta u_t^{\eta}) k_t + i_t - \frac{\phi}{2}\left(\frac{i_t}{k_t} - \delta u_t^{\eta}\right)^2 k_t, \qquad \phi \geq 0 \tag{3.4}$$

where δu_t^{η} is the depreciation rate which implies that the depreciation rate increases as u_t increases in the model with endogenous capital utilization. The depreciation rate is set to $\bar{\delta}$ in the baseline model. Capital accumulation is subject to quadratic adjustment costs determined by ϕ. Steady state of the model is the same with and without adjustment costs.

Following Schmitt-Grohé and Uribe (2003), gross real interest rate is formulated as

$$R_t = R_t^w + P(.) = R_t^w + \psi_2(e^{\psi_1 - a_t/y_t} - 1), \qquad \psi_2 > 0 \tag{3.5}$$

where the interest rate is composed of a world interest rate, R_t^w, and a country-specific interest rate premium, $P(.)$. The functional form of country-specific risk premium implies that interest rate is a strictly decreasing function of the net assets-to-output ratio. Following Schmitt-Grohé and Uribe (2003), the function capturing the risk premium serves the purpose of avoiding unit root in asset accumulation and inducing stationarity in the model without financial frictions. In the model with financial frictions, the parameter governing debt-elasticity of risk premium, ψ_2, will be econometrically estimated (following Garcia-Cicco, Pancrazi, and Uribe (2010)) instead of being set to a small value with the sole purpose of inducing stationarity.

The exogenous variables follow AR(1) processes given by

$$\ln z_t = \rho_z \ln z_{t-1} + \epsilon_{z,t}, \qquad \epsilon_{z,t} \sim N(0, \sigma_z^2) \tag{3.6}$$

$$\ln g_t = \ln g^*(1 - \rho_g) + \rho_g \ln g_{t-1} + \epsilon_{g,t}, \qquad \epsilon_{g,t} \sim N(0, \sigma_g^2) \tag{3.7}$$

$$\ln \pi_t = \rho_\pi \ln \pi_{t-1} + \epsilon_{\pi,t}, \qquad \epsilon_{\pi,t} \sim N(0, \sigma_\pi^2) \tag{3.8}$$

$$\ln R_t^w = \ln \bar{R}(1 - \rho_{R^w}) + \rho_{R^w} \ln R_{t-1}^w + \epsilon_{R_t^w,t}, \quad \epsilon_{R^w,t} \sim N(0, \sigma_{R^w}^2) \tag{3.9}$$

The dynamic optimization problem is formulated such that, given the stochastic processes for the exogenous variables, the social planner maximizes discounted lifetime utility of the representative household subject to the resource constraint and capital accumulation equation. Optimality conditions can be found in Appendix B.

The solution of the model is characterized by a set of allocations $\{c_t, n_t, i_t, k_t, a_t, u_t\}$ that satisfy the optimality conditions, resource constraint and capital accumulation equation.

4. CALIBRATION AND ESTIMATION

I use a combination of calibration and estimation techniques to assign values to model parameters. The parameters α, β, δ, $\bar{\delta}$, η, θ, μ, ν, ϕ, ψ_1, ψ_2, $\bar{R}$, g^* and $\bar{u}$ are set to values either borrowed from related literature, using first-order conditions or using long-run relations in the data. Coefficient of relative risk aversion is set to $\alpha = 2$ and capital exponent in the production funtion is set to $\theta = 0.32$ (Aguiar and Gopinath 2007; Mendoza 1991). μ is set to ensure that agents allocate 20% of their time to labor in the steady state which is common in the literature (Garcia-Cicco, Pancrazi, and Uribe 2010; Neumeyer and Perri 2005). Labor supply elasticity is set to $\nu = 1.7$ (Correia, Neves, and Rebelo 1995). Capital adjustment cost parameter, ϕ, is set to ensure that the ratio of standard deviation of investment to standard deviation of output is exactly equal to 3.29 in the model as in Turkish data. Following Letendre (2004), I set $\psi_1 = -0.39$ which is the long-run quarterly average of net international investment position-to-real GDP ratio in Turkey. Coefficient of risk premium is set to a small number $\psi_2 = 10^{-4}$ (Neumeyer and Perri 2005) in the model without financial frictions. In the model with financial frictions, ψ_2 is econometrically estimated using GMM. Given $\bar{R}$, steady state relationship $\beta = 1/(1+\bar{R})$ implies a discount factor of $\beta = 0.99$. In the baseline model, $\bar{\delta} = 0.02$ which is standard in quarterly calibration in RBC models (Letendre 2004). Long-run average capacity utilization in manufacturing in Turkey is equal to $\bar{u}$=76.07%. Using steady state conditions of the model with endogenous capital utilization, given that $\bar{\delta} = 0.02$ in the steady state and given $\bar{u}$, η is set to 1.48. Given values of $\bar{u}$, η and $\bar{\delta}$, δ is set to 0.03. The equations used in setting the parameter values can be found in Appendix B.

Solow residuals are constructed using the following equation:

$$log(z_t) = log(y_t) - \theta log(k_t u_t) - (1-\theta) log(n_t) \tag{4.1}$$

In the baseline model (where capital utilization rate is implicitly set to 1), the Solow residuals are calculated using the same equation but the term u_t is dropped.

Unconditional mean of gross real interest rate is set to $\bar{R} = 1.0096$ which is the average value of the gross real interest rate that Turkey faces in the international financial markets. Interest rate series is calculated following the procedure used in Neumeyer and Perri (2005). Unconditional mean of government spending shocks, g^*, is set to ensure that the ratio of government spending to output is exactly equal to 0.13 in the steady state which is the average value observed in the data.

Since there is no well-established way to estimate preference shocks from the data, I use GMM to estimate the persistence and volatility of the preference shocks. Processes for government spending and interest rate shocks are directly estimated from the data. A detailed explanation of estimation procedures can be found in the Appendix A. The full set of parameter values are reported in Table 4.1 and Table 4.2.

Table 4.1 - Parameters That Are The Same Across All Models

Description	Parameter	Value
Coefficient of relative risk aversion	α	2
Discount factor	β	0.99
Capital exponent in the production function	θ	0.32
Labor supply elasticity, $\frac{1}{1-\nu}$	ν	1.7
Steady state net assets to output ratio	ψ_1	-0.39

Table 4.2 - Parameters That Differ Across Models

Description	Parameter	Baseline	Utilization	Utilization+ Preference	Utilization+ Spending	Utilization+ Preference+ Spending+ Financial Frictions
Rate of depreciation	$\bar{\delta}$	0.02	-	-	-	-
Rate of depreciation	δ	-	0.03	0.03	0.03	0.03
Exponent of utilization rate	η	-	1.48	1.48	1.48	1.48
Steady state utilization rate	$\bar{u}$	-	76.07%	76.07%	76.07%	76.07%
Capital adjustment cost	ϕ	0.3490	0.1584	0.1594	0.1590	75
Labor weight in utility	μ	3.75	3.30	3.30	3.30	3.30
Persistence of TFP shock	ρ_z	0.52	0.53	0.53	0.53	0.53
Standard deviation of TFP shock	σ_z	1.64%	1.69%	1.69%	1.69%	1.69%
Persistence of preference shock	ρ_π	-	-	0.69	-	0.93
Standard deviation of preference shock	σ_π	-	-	7.40%	-	6.18%
Persistence of government spending shock	ρ_g	-	-	-	0.13	0.13
Standard deviation of government spending shock	σ_g	-	-	-	2.90%	2.90%
Unconditional mean of government spending	g^*	-	-	-	0.07	0.07
Persistence of interest rate shock	ρ_{R^w}	-	-	-	-	0.71
Standard deviation of interest rate shock	σ_{R^w}	-	-	-	-	0.002%
Steady state gross real interest rate	$\bar{R}$	1.0096	1.0096	1.0096	1.0096	1.0096
Debt elasticity of risk premium	ψ_2	0.0001	0.0001	0.0001	0.0001	1.98

5. RESULTS

I will first analyze the effect of incorporating endogenous capital utilization to the baseline model in Section 5.1. Then, I will separately add a preference shock and a government spending shock to the model with endogenous capital utilization and analyze the effects of these shocks in isolation in Section 5.2. Finally, I will analyze the role of financial frictions in a model with endogenous capital utilization, preference shock and government spending shock in Section 5.3.

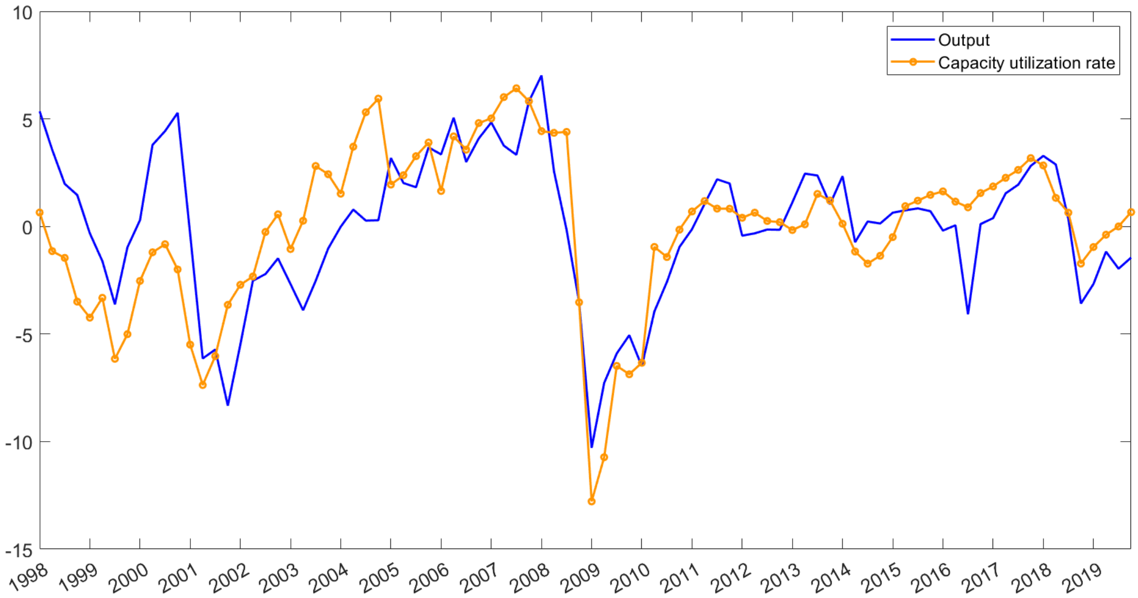
5.1 Model with Endogenous Capital Utilization

In this section, I will analyze the model with endogenous capital utilization in comparison to the baseline model.

The first-order condition with respect to u_t shows that increasing capacity utilization generates more output while increasing depreciation, holding everything else constant (see Equation B.6 in Appendix B). The procyclical behavior of capacity utilization predicted by the model can be verified by the co-movement of output and capacity utilization rate observed in the data (see Figure 5.1).

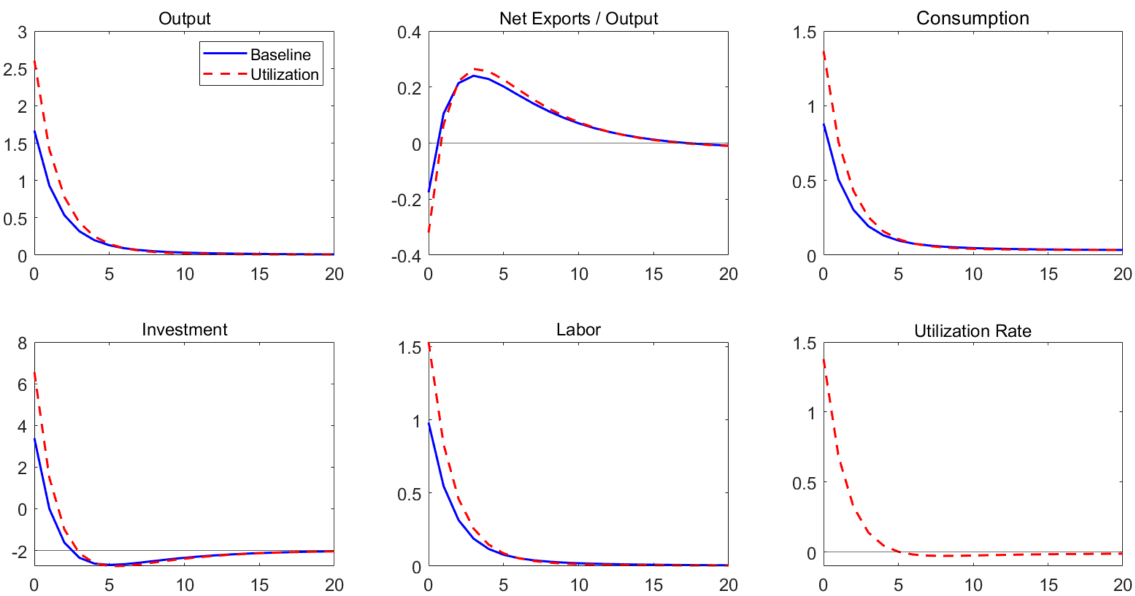
Burnside, Eichenbaum, and Rebelo (1995), Basu (1996), Basu and Kimball (1997), Baxter and Farr (2005), among others, demonstrated that variable capital utilization reduced the required volatility of productivity shocks to match the volatility of output. In these papers, authors argued that true technology shocks are in fact smaller than estimated TFP shocks and variable capital utilization amplified the effects of technology shocks (Rebelo 2005). This is because when the economy is hit by a productivity shock, capacity utilization and depreciation go up which increases the volatility of output. Figure 5.2 shows the impulse responses to a 1% productivity shock in the baseline model and model with capital utilization. Even though the size of the shock is the same, the spike in output is exacerbated in the model with capital utilization by the aforementioned mechanism.

Figure 5.1 Output and Capacity Utilization Rate in Turkey



Notes: Output is real GDP per capita. Both output and capacity utilization rate are logged and HP-filtered.

Figure 5.2 - Impulse Responses to 1% Shock to Productivity



Notes: Output, consumption, labor and investment are logged and HP-filtered with smoothing parameter 1600. Net exports-to-output ratio and utilization rate are HP-filtered with smoothing parameter 1600. Y axis indicates percentage deviations from the steady state.

Increase in output is allocated to consumption and investment. Compared to the baseline model, net exports only slightly decrease to benefit from the productivity shock in the augmented model. Net exports exhibit a hump-shaped behavior in both models. To take advantage of the productivity shock, the economy borrows to increase investment in the first period. Thanks to the sufficient increase in output in the first period, agents can switch to increasing savings to smooth out consumption beginning from the second period after the shock.

Business cycle statistics produced by the baseline model and the model with endogenous capital utilization are displayed in Table 5.1. Compared to the data moments, the baseline model generates a slightly smaller output volatility. The baseline model is not able to reproduce the excess consumption volatility and the strongly countercyclical trade balance. It also generates a volatility of trade balance-to-output ratio smaller than that observed in the data.

Table 5.1 - Simulation Results

	Data	Baseline	Utilization
Standard deviation			
$\sigma(y)$	3.35	2.87	4.63
$\sigma(i)/\sigma(y)$	3.29	3.29	3.29
$\sigma(c)/\sigma(y)$	1.01	0.53	0.52
$\sigma(nx/y)/\sigma(y)$	0.60	0.24	0.20
$\sigma(n)/\sigma(y)$	0.96	0.59	0.59
Correlation with output			
$\rho(y,i)$	0.94	0.94	0.97
$\rho(y,c)$	0.86	1.00	1.00
$\rho(y,nx/y)$	-0.59	-0.29	-0.50
$\rho(y,n)$	0.79	1.00	1.00
Autocorrelation			
$\rho(y,y_{-1})$	0.81	0.45	0.44
$\rho(i,i_{-1})$	0.84	0.37	0.37
$\rho(c,c_{-1})$	0.74	0.45	0.44
$\rho(nx/y,nx/y_{-1})$	0.72	0.66	0.55
$\rho(n,n_{-1})$	0.73	0.45	0.44

Notes: All variables, except net exports-to-output ratio, are logged. All variables are HP-filtered with smoothing parameter 1600. Standard deviations are in percentages. Moments are percentage deviations from the steady state. Moments are averages of 1000 simulations of length 50000.

As discussed above, incorporating endogenous capital utilization in the baseline model reduces the variance of productivity shocks. However, the procyclicality of capacity utilization (see, again, Figure 5.1) generates a slightly larger variance for the productivity shock when Solow residuals are estimated directly from the data. As observed from Table 4.2, the variance of the productivity shock is estimated to be equal to 1.64% in the baseline model and 1.69% in the model with capital utilization.

These two countervailing forces, decrease in required volatility of productivity shocks to match output volatility imposed by the model and higher volatility of productivity shock estimated from the data, lead to a significant increase in output volatility as shown in Table 5.1. As explained above, due to the slight decline in net exports and the greater spike in output, extended model performs better in terms of matching the countercyclical trade balance-to-output ratio observed in the data. The other business cycle moments are very close to those generated by the baseline model.

5.2 Role of Preference and Government Spending Shocks

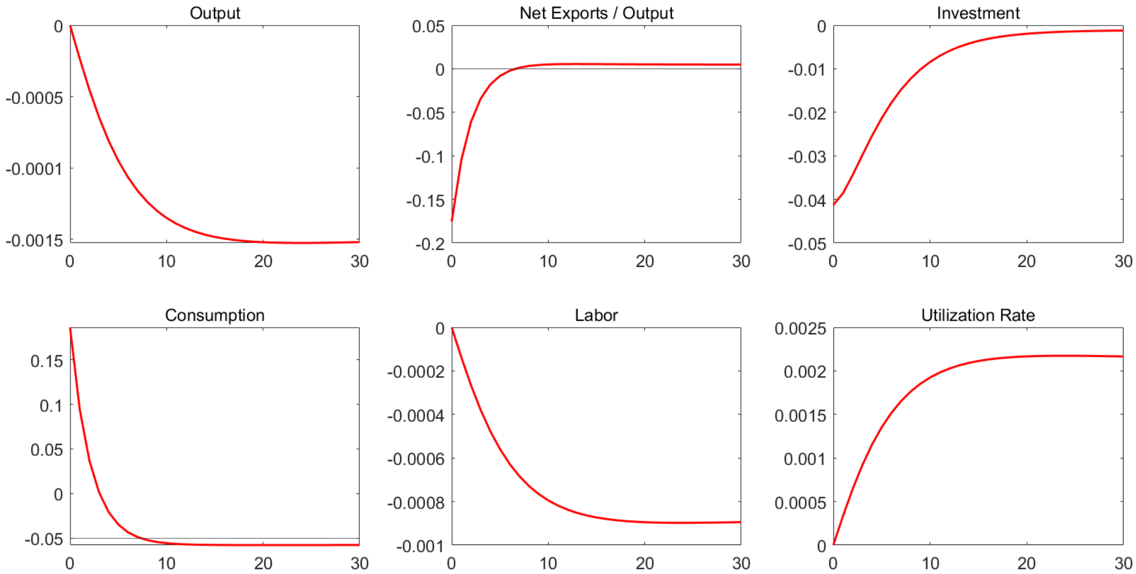
Relative to the baseline model, the model with endogenous capital utilization performs better in terms of matching countercyclical trade balance. However, there is no improvement in the remaining business cycle moments. Therefore, I augment the model with endogenous capital utilization by incorporating a preference shock (following Garcia-Cicco, Pancrazi, and Uribe (2010)) and a government spending shock (following Letendre (2004) and Garcia-Cicco, Pancrazi, and Uribe (2010)). I analyze these shocks separately in order to isolate their effects on business cycle statistics.

Firstly, I analyze the effects of the preference shock. For a given level of output, a positive preference shock leads to an increase in consumption. Giving a preference shock to a GHH utility function implies that, in the absence of a productivity shock, preference shock serves the purpose of increasing consumption volatility relative to output volatility without creating additional variation in labor supply. This is due to the fact that GHH preferences imply that there is no wealth effect on the labor supply, therefore labor supply is determined independent of intertemporal consumption and saving decisions.

The impulse responses to a 1% preference shock are reported in Figure 5.3. Output, labor supply and utilization rate do not change in response to the preference shock in the first period due to the form of the utility function discussed above. Increased consumption must be financed by borrowing and decreasing investment. The reduction in investment leads to a decline in capital accumulation, hence output decreases in the latter periods.

In the absence of a productivity shock, preference shock requires the economy to borrow without increasing its output. The adverse effect of the preference shock is mitigated by adjusting capacity utilization. Referring once again to the first-order condition with respect to u_t (Equation B.6 in Appendix B), the decrease in output is smoothed out by the gradual increase in capital utilization and investment. Had we given a 1% preference shock to the baseline model, the fall in output, investment and net exports would have been more pronounced. Therefore, we can deduce that adjusting capacity utilization enables the economy to pull through a preference shock by being adversely affected to a smaller extent and benefit from a productivity shock to a greater extent.

Figure 5.3 - Impulse Responses to 1% Shock to Preferences



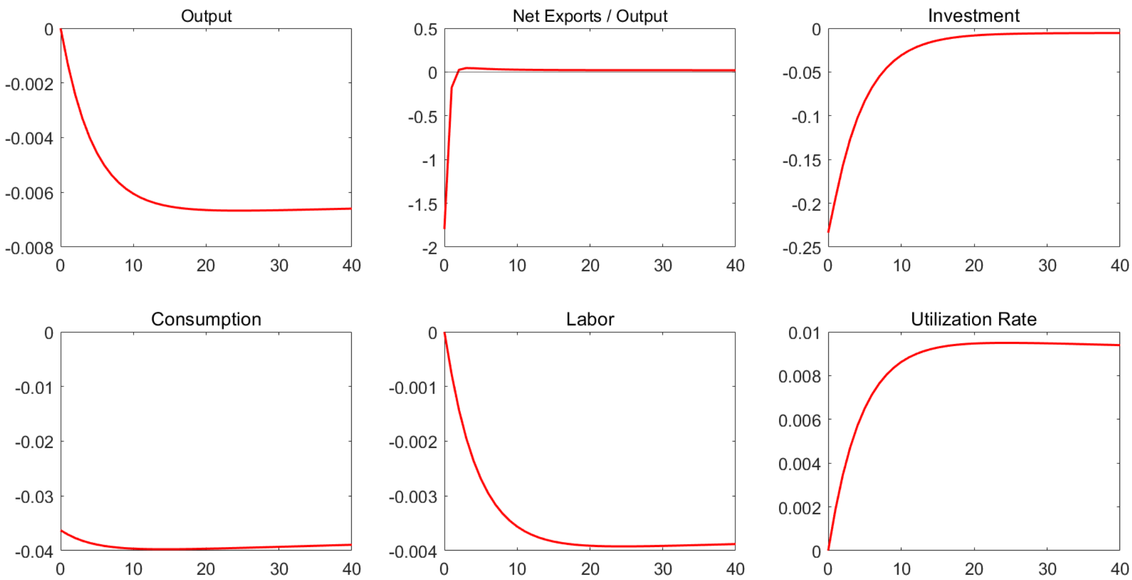
Notes: Output, consumption, labor and investment are logged and HP-filtered with smoothing parameter 1600. Net exports-to-output ratio and utilization rate are HP-filtered with smoothing parameter 1600. Y axis indicates percentage deviations from the steady state.

Impulse responses to a 1% government spending shock are plotted in Figure 5.4. The behavior of output, labor supply, capital and utilization rate are very similar to the behavior of those variables in response to a preference shock, however much more prominent. In the first period, output and labor supply do not change due to the form of the utility function explained above. Government spending is financed by reducing consumption, investment and net exports. Decline in investment reduces capital accumulation and thereby reduces output in the latter periods. Utilization rate exhibits the smoothing out mechanism discussed above. Persistence of government spending shocks in Turkey is equal to 0.129 which is very small. Therefore, after a sharp decrease, net exports converge to the steady state very rapidly.

The high level of borrowing in the first period of the shock leads to a sharp increase in the interest rate. Increased borrowing cost prevents the economy to accumulate more debt. Instead, it has to maintain the consumption level well below the steady state for an extended period of time.

Simulations results are reported in Table 5.2. The model with capital utilization and preference shock produces a weaker countercyclicality of trade balance relative to the model with only capital utilization. This is due to the following mechanism: Figure 5.3 shows that after an initial drop, net exports secularly increase in response to the preference shock. This smooths out the hump-shaped behavior of net exports in response to the productivity shock shown in Figure 5.2. Therefore, countercyclicality of net exports digresses from the magnitude observed in the data. However, the sharp decrease in net exports after a preference shock moderately increases the standard deviation of net exports compared to the utilization case. Also, increase in consumption induced both by the productivity and preference shocks increases the volatility of consumption relative to that of output.

Figure 5.4 - Impulse Responses to 1% Shock to Government Spending



Notes: Output, consumption, labor and investment are logged and HP-filtered with smoothing parameter 1600. Net exports-to-output ratio and utilization rate are HP-filtered with smoothing parameter 1600. Y axis indicates percentage deviations from the steady state.

Compared to the model with capital utilization, the rapid recovery of net exports to its steady state level and gradual decline in output in response to a government spending shock generates an even lower countercyclicality of trade balance since the number of periods in which net exports and output move in the opposite direction markedly decreases. In addition, the high volatility of the government spending shock significantly increases the standard deviation of net exports to output ratio well above the level observed in the data. It takes more than 200 periods for consumption to converge to its steady state level, therefore relative volatility of consumption to that of output is slightly higher in the model with capital utilization and government spending shock relative to the model with capital utilization only.

Table 5.2 - Simulation Results

	Data	Baseline	Utilization	Utilization+ Preference	Utilization+ Spending
Standard deviation					
$\sigma(y)$	3.35	2.87	4.63	4.60	4.61
$\sigma(i)/\sigma(y)$	3.29	3.29	3.29	3.29	3.29
$\sigma(c)/\sigma(y)$	1.01	0.53	0.52	0.67	0.61
$\sigma(nx/y)/\sigma(y)$	0.60	0.24	0.20	0.36	1.10
$\sigma(n)/\sigma(y)$	0.96	0.59	0.59	0.59	0.59
Correlation with output					
$\rho(y,i)$	0.94	0.97	0.97	0.97	0.97
$\rho(y,c)$	0.86	1.00	1.00	0.78	1.00
$\rho(y,nx/y)$	-0.59	-0.29	-0.50	-0.28	-0.12
$\rho(y,n)$	0.79	1.00	1.00	1.00	1.00
Autocorrelation					
$\rho(y,y_{-1})$	0.81	0.45	0.44	0.42	0.42
$\rho(i,i_{-1})$	0.84	0.37	0.37	0.35	0.35
$\rho(c,c_{-1})$	0.74	0.45	0.44	0.45	0.42
$\rho(nx/y,nx/y_{-1})$	0.72	0.66	0.55	0.49	0.05
$\rho(n,n_{-1})$	0.73	0.45	0.44	0.42	0.42

Notes: All variables, except net exports-to-output ratio, are logged. All variables are HP-filtered with smoothing parameter 1600. Standard deviations are in percentages. Moments are percentage deviations from the steady state. Moments are averages of 1000 simulations of length 50000.

5.3 Role of Financial Frictions

In this section, I further augment the model with financial frictions. Specifically, I analyze the model with endogenous capital utilization, preference shocks, government spending shocks and financial frictions. In the previous models analyzed in this paper, ψ_2 is set to a very small number (10^{-4}) with the sole purpose of inducing stationarity (Schmitt-Grohé and Uribe 2003). In this section, I use the econometrically estimated value of ψ_2 (following Garcia-Cicco, Pancrazi, and Uribe (2010)) which serves as a simplified form of financial frictions. Other component of financial frictions is interest rate shocks (following Letendre (2004) and Garcia-Cicco, Pancrazi, and Uribe (2010)).

I construct the interest rate series following Neumeyer and Perri (2005) and then, estimate the AR(1) process. ψ_2 and the parameters of the preference shock process are jointly estimated using GMM. Details of the construction and estimation processes are in Appendix A. The estimated value of ψ_2 is equal to 1.98 which is much higher than the value used in the baseline model, 10^{-4}. The higher value of ψ_2

implies that the interest rate is much more sensitive to a change in aggregate debt-to-GDP ratio compared to smaller values. The estimated ψ_2 will act as a reduced form of financial frictions shaping the model's response to aggregate disturbances.

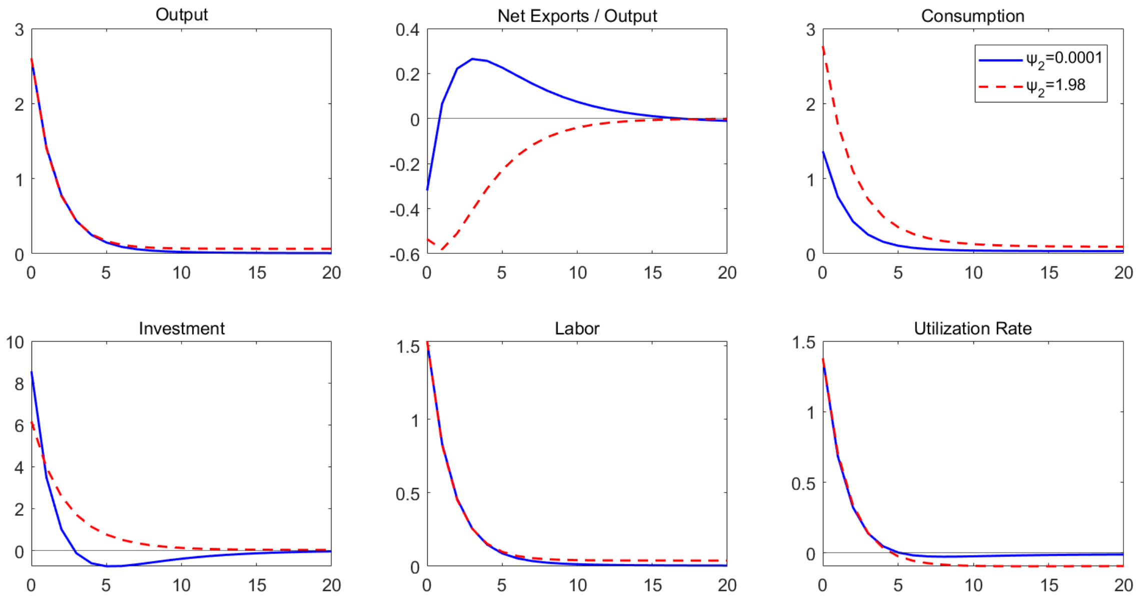
Below are the impulse responses to a 1% productivity shock for different values of ψ_2. The increase in investment as a response to the productivity shock is smaller when ψ_2 is equal to 1.98 compared to the increase in investment when ψ_2 is set to 10^{-4}. Recall that capital adjustment cost parameter, ϕ, is set to ensure that the relative volatility of investment to output is equal to 3.29 in the steady state. To satisfy this condition, capital adjustment cost parameter is set to ϕ=75 in the model analyzed in this section (while ϕ is approximately equal to 0.15 in the models analyzed previously). (Exact values can be found in Table 4.2.) Notice that capital adjustment costs are substantially higher in the model with financial frictions compared to the models without financial frictions. This is because the higher risk premium significantly increases the volatility of investment relative to the volatility of output. A substantially higher capital adjustment cost forces the economy to allocate some portion of the increased output induced by productivity shock to consumption instead of investment.

The higher value of the risk premium renders borrowing more costly. Even if agents borrow less to benefit from the productivity shock, the higher borrowing cost (put it differently, the higher interest rate) causes net exports to output ratio stays below the steady state level for a longer period of time. (Remember that net exports at time t are equal to $a_{t+1} - R_t a_t$.) The bigger value of ψ_2 also increases the number of periods where net exports and output move in the opposite direction, thereby generating a stronger countercyclicality of trade balance.

Impulse responses to a 1% preference shock for different values of ψ_2 are displayed in Figure 5.6. Increased borrowing cost hinders the economy to accumulate debt. Therefore, in response to a 1% preference shock, agents cannot increase their consumption as much when ψ_2=1.98, compared to the model where ψ_2=10^{-4}. In addition, the increase in consumption due to the preference shock leads to a substantial decrease in investment when debt-elasticity of risk premium is high. This causes a significant decline in output and labor in the following periods. Utilization rate exhibits the "smoothing out" mechanism explained in the previous subsections.

Impulse responses to a 1% government spending shock for different values of ψ_2 are displayed in Figure 5.7. Government spending shock is financed by decreasing investment and consumption. Since borrowing is more costly when ψ_2=1.98, compared to the model where ψ_2=0.0001, net exports decrease less and agents are able to switch to saving after the second period. Behavior of output, labor and utilization

Figure 5.5 - Impulse Responses to 1% Shock to Productivity for Different Values of ψ_2



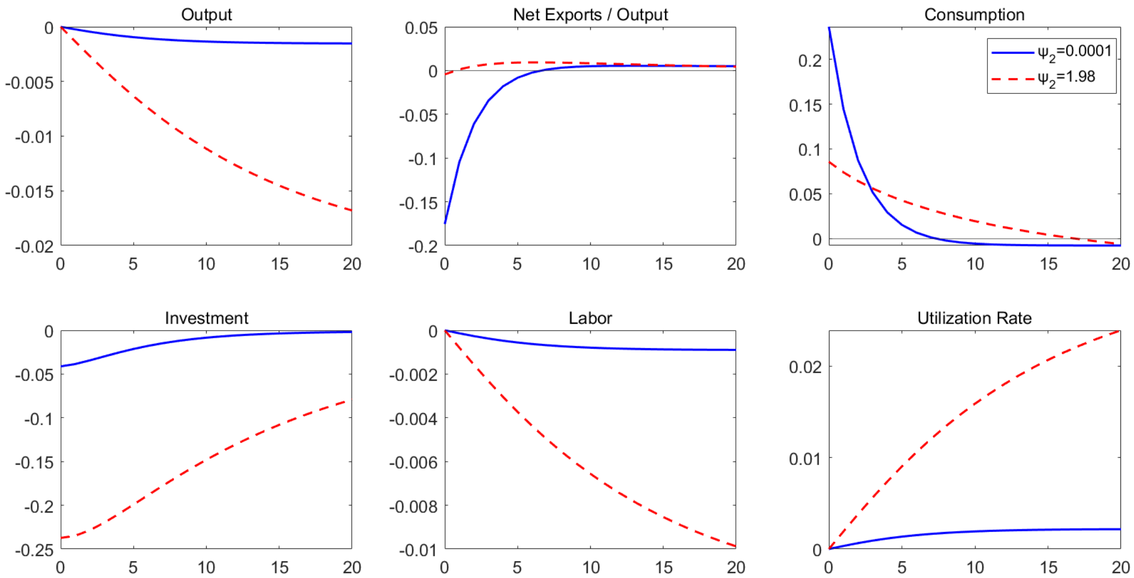
Notes: Output, consumption, labor and investment are logged and HP-filtered with smoothing parameter 1600. Net exports-to-output ratio and utilization rate are HP-filtered with smoothing parameter 1600. Y axis indicates percentage deviations from the steady state.

rate are similar to those in response to 1% preference shock.

Simulation results are reported in Table 5.3. The model with capital utilization, preference shocks, government spending shocks and financial frictions will be referred to as "encompassing model", hereafter. The encompassing model is able to produce excess consumption volatility and increase the volatility of trade balance-to-output ratio. This version of the model outperforms all other models in these two dimensions since it produces the closest estimates to data moments. The encompassing model also generates a sufficiently countercyclical trade balance. Although it performs worse than the model with only endogenous capital utilization, it produces a stronger countercyclicality of trade balance than all the remaining models.

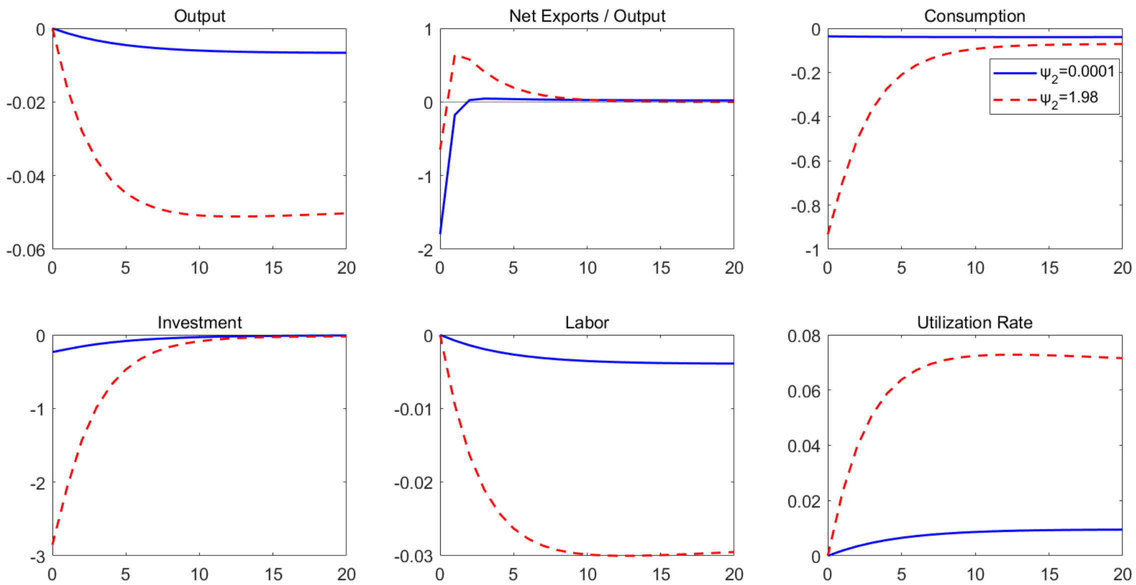
Variance decomposition analysis is reported in Table 5.4. Approximately 72% of the variation in consumption is generated by the productivity shocks and 27% by the government spending shocks. The spike in consumption caused by the productivity shocks (see Figure 5.5) more than offsets the decline in consumption caused by the government spending shock (see Figure 5.7), hence the encompassing model is able to produce excess consumption volatility. Almost 80% of the variation in trade balance-to-output ratio is generated by the government spending shocks. As the impulse responses indicate, 1% shock to government spending generates significantly more variation in net exports to output ratio than 1% shock to productivity and preference generate. The range in which net exports-to-output ratio moves widens

Figure 5.6 - Impulse Responses to a 1% Preference Shock for Different Values of ψ_2



Notes: Output, consumption, labor and investment are logged and HP-filtered with smoothing parameter 1600. Net exports-to-output ratio and utilization rate are HP-filtered with smoothing parameter 1600. Y axis indicates percentage deviations from the steady state.

Figure 5.7 - Impulse Responses to a 1% Government Spending Shock for Different Values of ψ_2



Notes: Output, consumption, labor and investment are logged and HP-filtered with smoothing parameter 1600. Net exports-to-output ratio and utilization rate are HP-filtered with smoothing parameter 1600. Y axis indicates percentage deviations from the steady state.

even more when the variance of the government spending shock is 2.9% (which is the value estimated from data and used in simulations). Therefore, the encompassing model generates a higher volatility of trade balance-to-output ratio.

Garcia-Cicco, Pancrazi, and Uribe (2010) found that government spending shocks

Table 5.3 - Simulation Results

	Data	Baseline	Utilization	Utilization+ Preference	Utilization+ Spending	Utilization+ Preference+ Spending+ Financial Frictions
Standard deviation						
$\sigma(y)$	3.35	2.87	4.63	4.60	4.61	4.55
$\sigma(i)/\sigma(y)$	3.29	3.29	3.29	3.29	3.29	3.29
$\sigma(c)/\sigma(y)$	1.01	0.53	0.52	0.67	0.61	1.29
$\sigma(nx/y)/\sigma(y)$	0.60	0.24	0.20	0.36	1.10	0.78
$\sigma(n)/\sigma(y)$	0.96	0.59	0.59	0.59	0.59	0.59
Correlation with output						
$\rho(y,i)$	0.94	0.97	0.97	0.97	0.97	0.75
$\rho(y,c)$	0.86	1.00	1.00	0.78	1.00	0.84
$\rho(y,nx/y)$	-0.59	-0.29	-0.50	-0.28	-0.12	-0.33
$\rho(y,n)$	0.79	1.00	1.00	1.00	1.00	1.00
Autocorrelation						
$\rho(y,y_{-1})$	0.81	0.45	0.44	0.42	0.42	0.40
$\rho(i,i_{-1})$	0.84	0.37	0.37	0.35	0.35	0.53
$\rho(c,c_{-1})$	0.74	0.45	0.44	0.45	0.42	0.50
$\rho(nx/y,nx/y_{-1})$	0.72	0.66	0.55	0.49	0.05	0.24
$\rho(n,n_{-1})$	0.73	0.45	0.44	0.42	0.42	0.40

Notes: All variables, except net exports-to-output ratio, are logged. All variables are HP-filtered with smoothing parameter 1600. Standard deviations are in percentages. Moments are percentage deviations from the steady state. Moments are averages of 1000 simulations of length 50000.

Table 5.4 - Variance Decomposition Analysis in the Encompassing Model

	Productivity	Preference	Spending	Interest rate	Total linear contribution
Output	99.91	0.01	0.09	0.00	100.01
Investment	57.88	1.82	40.19	0.02	99.91
Consumption	71.66	1.29	27.14	0.01	100.10
Net Exports/Output	15.39	0.05	84.62	0.06	100.13
Labor	99.91	0.01	0.09	0.00	100.01

Notes: Table shows the variance contribution of 1% shock to productivity, preference, spending and interest rate on endogenous variables. All variables, except net exports-to-output ratio, are logged. All variables are HP-filtered with smoothing parameter 1600. Standard deviations are in percentages. Variance contributions are averages of 1000 replications of length 50000. Note that numbers do not add up to 100 due to non-zero correlation of simulated shocks in small samples.

have a negligible role in explaining business cycles in Argentina and excess volatility of consumption is generated by preference shocks. On the contrary, I find that government spending shocks generate significant variation in consumption, investment and net exports to output ratio while preference shocks do not. This might be because government spending shocks in Turkey are two times more volatile than those estimated for Argentina. In addition, variance of preference shocks is estimated to be equal to 51% in Argentina which generates significant variation in consumption, investment and trade balance-to-GDP ratio. On the other hand, estimated variance of preference shocks for Turkey is equal to 6.18% in the encompassing model which is much smaller.

I also find that interest rate shocks are not an important source of aggregate fluctuations in Turkey. This is a striking result since interest rate shocks are shown to be one of the key propagation mechanisms of business cycles in emerging market economies (Chang and Fernández 2013; Garcia-Cicco, Pancrazi, and Uribe 2010; Neumeyer and Perri 2005). Estimated volatility of interest rate shocks in Garcia-Cicco, Pancrazi, and Uribe (2010) is equal to 5.6% for Argentina which generates most of the variation in investment and trade balance-to-output ratio. However, volatility of interest rate shocks is equal to 0.2% in Turkey, which is much smaller. Also note that the model analyzed in this paper does not feature a working capital requirement nor does it formulate country-specific interest rate as a function of expected productivity which are the most important features of the models analyzed in Neumeyer and Perri (2005) and Chang and Fernández (2013). In addition, Tiryaki (2012) found that the model used in Neumeyer and Perri (2005) could not explain business cycles in Turkey and showed that the results of Neumeyer and Perri (2005) depended heavily on the high value of working capital parameter and persistence of productivity shocks.

6. CONCLUSION

In this analysis, the standard RBC model is augmented with endogenous capital utilization, preference shocks, government spending shocks and financial frictions (in the form of an interest rate shock and econometrically estimated debt-elasticity of country risk premium). The model is calibrated to Turkey for the period 1998Q1-2019Q4. Compared to the baseline model, the model with endogenous capital utilization is able to produce a stronger countercyclicality of trade balance which is very close to the value observed in the data. However, adding capital utilization significantly increases the volatility of output. Adding a preference shock to the model with endogenous capital utilization moderately increases the volatility of consumption and trade balance-to-output ratio while moderately decreasing the countercyclicality of trade balance. When the model with endogenous capital utilization is augmented with a government spending shock, volatility of trade balance-to-output ratio jumps to a very high level exceeding the value observed in the data, consumption volatility slightly increases and correlation of output and trade balance-to-output ratio substantially increases. The last extension analyzed in this paper is financial frictions in the form of an interest rate shock and using an econometrically estimated debt-elasticity of risk premium. The encompassing model with endogenous capital utilization, preference shocks, government spending shocks and financial frictions is able to produce excess consumption volatility and reasonably match the trade balance-to-output volatility while preserving a fair level of countercyclicality of trade balance. The results overall show that government spending shocks and productivity shocks together with a higher debt-elasticity of risk premium are important sources of aggregate fluctuations and generate considerable variation in the endogenous variables while preference shocks and interest rate shocks do not have an important effect on aggregate fluctuations in Turkey. Even though the model with higher debt-elasticity of risk premium generates better results, the model requires a very high capital adjustment cost parameter to match the volatility of investment which calls into question the ability of the model in matching the data.

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APPENDIX A

Data Description

I used quarterly series between 1998Q1-2019Q4. If the series is not seasonally adjusted, the seasonal component is removed using X-13ARIMA-SEATS Seasonal Adjustment Program. Series are obtained from OECD Statistics database unless otherwise stated.

Population: Annual population estimates are obtained from World Bank-World Development Indicators database. Annual estimates are linearly interpolated to derive quarterly estimates.

Output: Gross Domestic Product in 2009 prices divided by population.

Consumption: Private final consumption expenditure in 2009 prices divided by population.

Government spending: General government final consumption expenditure in 2009 prices divided by population.

Investment: Gross fixed capital formation in 2009 prices divided by population.

Net exports: Net exports are defined as exports of goods and services in minus imports of goods and services in 2009 prices.

Total hours: Weekly hours worked in manufacturing index.

Net foreign assets: Year-end net international investment position of Turkey.

Exchange rate: Quarterly average Turkish Lira per U.S. Dollar from International Financial Statistics database.

World interest rate: Quarterly average 3-month treasury bill yield from U.S. Department of the Treasury website.

U.S. inflation rate: Implicit price deflator of Gross Domestic Product of the U.S. from U.S. Bureau of Economic Analysis.

Utilization rate: Monthly capacity utilization rate from Business Tendency and Consumer Opinion Surveys (MEI) database of OECD. Monthly series is converted to quarterly series taking 3-month averages.

Country risk premium: J.P. Morgan Emerging Markets Bond Index Global-Turkey.

Construction of Solow Residuals

Solow residuals are defined as

$$log(z_t) = log(y_t) - \theta log(k_t u_t) - (1-\theta) log(n_t). \tag{A.1}$$

The term u_t is dropped in the baseline model. Y is output, k is capital stock, u is utilization rate and n is a measure of labor supply. Output is real GDP per capita in 2009 prices. Utilization rate is the capacity utilization rate, labor supply is measured by weekly hours worked in manufacturing. Capital stock at t=0 is approximated following Young (1995):

$$K(0) = E_0 \sum_{t=0}^{\infty} I_{-t-1}(1-\delta)^t = E_0 \sum_{t=0}^{\infty} I_0 (1+g)^{-t-1}(1-\delta)^t = \frac{I_0}{(g+\delta)}, \tag{A.2}$$

where I_0 is investment in the first period, δ is the depreciation rate of investment, g is average growth rate of investment for a specified period of time. Young (1995) takes the average growth of investment in the first five years of investment series. However, benefiting from the longevity of the annual gross fixed capital formation series, I average first ten years of annual growth of investment to achieve a better approximation of g. Capital accumulation is calculated on an annual basis for the period 1970-1998 and I switch to quarterly calculation for the period 1998Q1-2019Q4. Depreciation rate is set to 0.08 for the annual calculations and switched to 0.02 for quarterly calculations.

Construction of Real Interest Rate Series

The real interest rate series is calculated following Neumeyer and Perri (2005). U.S. safe rate is quarterly average 3-month treasury bill rate. Country risk premium is quarterly average J.P. Morgan Emerging Markets Bond Index Global-Turkey. Nominal interest rate is obtained by adding U.S. safe rate and EMBIG-Turkey.

Then, real interest rate series are calculated by subtracting expected U.S. GDP deflator inflation from nominal interest rate series. Expected inflation in period t is defined as the average of quarterly inflation in period t and three preceding periods (Neumeyer and Perri 2005). The real interest rate series are logged and HP-filtered with smoothing parameter 1600. Then, AR(1) process is estimated.

Estimation of Government Spending Shock

AR(1) process for government spending shocks is directly estimated using data of general government final consumption expenditure in 2009 prices divided by population. The government spending series is logged and HP-filtered with smoothing parameter 1600. Then, AR(1) process is estimated.

Estimation of Preference Shock and Debt-Elasticity of Risk Premium

There is no clear way of directly estimating preference shocks and debt-elasticity of risk premium. Therefore, I structurally estimate the AR(1) process of the preference shock using GMM.

Joint estimates of persistence and standard deviation of preference shock in the model with endogenous capital utilization and preference shock are reported in Table A.1. Joint estimates of persistence and standard deviation of preference shock and debt-elasticity of risk premium in the encompassing model are reported in Table A.2.

Moments used in both estimations are as follows: Variance of output, consumption, net exports and investment; first and third order autocorrelation of output, consumption, net exports and investment; contemporary correlation of output and consumption, investment and net exports; correlation of consumption and investment and net exports. All variables, except net exports are logged. All variables are HP-filtered with smoothing parameter 1600. Order of Taylor approximation in perturbation is set to 1. P-values of J-statistic indicates that moments are not rejected at any conventional values of significance levels. Estimates are highly significant and local minimum is achieved for all variables in both estimations.

Table A.1 - Joint Estimates of Preference Shock Parameters

	Estimate	St. Dev.	t-stat
ρ_π	0.6283	0.0230	27.32
σ_π	0.0740	0.0078	19.44
Value of J-statistic	10.63		
p-value of J-statistic	0.97		

Table A.2 - Joint Estimates of Preference Shock Parameters and Debt-Elasticity of Risk Premium

	Estimate	St. Dev.	t-stat
ρ_π	0.9334	0.0057	163.1249
σ_π	0.0618	0.0052	11.8908
ψ_2	1.9817	0.1938	11.8908
Value of J-statistic	12.39		
p-value of J-statistic	0.96		

APPENDIX B

Equations for the Model Solution

Social Planner's problem is solved by maximizing the following function:

$$\begin{aligned}\mathcal{L} = &\sum_{t=0}^{\infty}\beta^t u_t(c_t,n_t) + \sum_{t=0}\lambda_{1,t}(R_t a_t + z_t(u_t k_t)^{\theta} n_t^{1-\theta} - a_{t+1} - g_t - i_t - c_t)\\ &+\sum_{t=0}^{\infty}\lambda_{2,t}\left((1-\delta u_t^{\eta})k_t + i_t - \frac{\phi}{2}\left(\frac{i_t}{k_t} - \delta u_t^{\eta}\right)^2 k_t\right)\end{aligned} \tag{B.1}$$

First-order conditions are as follows:

$$c_t:\ \lambda_{1,t} = \pi_t(c_t - \mu n_t^{\nu})^{-\alpha} \tag{B.2}$$

$$n_t:\ \pi_t \nu\mu n_t^{\nu-1}(c_t - \mu n_t^{\nu})^{-\alpha} = (1-\theta)\lambda_{1,t}\frac{y_t}{n_t} \tag{B.3}$$

$$i_t:\ \lambda_{1,t} = \lambda_{2,t}\left(1 - \phi\left(\frac{i_t}{k_t} - \delta u_t^{\eta}\right)\right) \tag{B.4}$$

$$a_{t+1}:\ \lambda_{1,t} = \beta E_t \lambda_{1,t+1}\left(R_t + \psi_2\left(e^{\psi_1 - \frac{a_{t+1}}{y_{t+1}}} - 1\right)\right) \tag{B.5}$$

$$u_t:\ \theta\lambda_{1,t}\frac{y_t}{u_t} = \lambda_{2,t}\left(\delta\eta u_t^{\eta-1}k_t - \delta\eta\phi\left(\frac{i_t}{k_t} - \delta u_t^{\eta}\right)k_t u_t^{\eta-1}\right) \tag{B.6}$$

$$\begin{aligned}k_{t+1}:\ \lambda_{2,t} = \beta E_t\Bigg(&\theta\lambda_{1,t+1}\frac{y_{t+1}}{k_{t+1}} + \lambda_{2,t+1}\Bigg(1 - \delta u_{t+1}^{\eta}\\ &-\frac{\phi}{2}\left(\frac{i_{t+1}}{k_{t+1}} - \delta u_{t+1}^{\eta}\right)^2 + \phi\left(\frac{i_{t+1}}{k_{t+1}} - \delta u_{t+1}^{\eta}\right)\frac{i_{t+1}}{k_{t+1}}\Bigg)\Bigg)\end{aligned} \tag{B.7}$$

Equations Used in Setting Parameters

In the steady state

$$\frac{\bar{i}}{\bar{k}} = \delta\bar{u}^{\eta}. \tag{B.8}$$

Evaluating equation B.6 in the steady state yields

$$\frac{\bar{y}}{\bar{k}} = \frac{\eta\delta\bar{u}^{\eta}}{\theta} = \frac{\eta\bar{\delta}}{\theta}. \tag{B.9}$$

Using the expression for $\frac{\bar{y}}{\bar{k}}$ and evaluating equation B.7 in the steady state yields

$$\eta = \frac{1+\beta\bar{\delta}-\beta}{\bar{\delta}\beta}. \tag{B.10}$$

Depreciation rate is

$$\delta = \frac{\bar{\delta}}{\bar{u}^{\eta}}. \tag{B.11}$$