A NEOCLASSICAL ANALYSIS OF THE 2001 CRISIS IN TURKEY

by
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Submitted to the Graduate School of Arts and Social Sciences
in partial fulfillment of
the requirements for the degree of
Master of Arts

Sabancı University
August 2008

dedicated to my dear husband Ferhan

ACKNOWLEDGEMENTS

I would like to express my sincere appreciation to all those who gave me support towards the completion of this thesis. First of all, I am greatly thankful to my advisor Asst. Prof. Dr. İnci Gümüş, whose precious help, stimulating suggestions and sincerity encouraged me in all the time I worked for this thesis. I am also deeply indebted to Asst. Prof. Dr. Otsu from Sophia University, who inspired me to research for and kindly helped me with the writing of this thesis.

I want to thank all the people who enabled me to complete this thesis in the Department of Economics, Sabancı University, especially my professors Remzi Kaygusuz and Toker Doğanoğlu for their helpfulness and my sweet friends İlke Toygür and Sinan Karadayı for their amity.

I especially want to thank my beloved family, my brother Kortan Erder, my mom Kadriye Erder and my dad Kemal Erder, whose continuing support made me able to complete this work. And lastly, I would like to give my special thanks to my dear spouse Ferhan, who helped me with all the details of my thesis with his patient love.

A NEOCLASSICAL ANALYSIS OF THE 2001 CRISIS IN TURKEY

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Economics, MA Thesis, 2008

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Keywords: Small open economy, Real business cycles, TFP, Country risk, Turkish 2001 crisis

ABSTRACT

In early 2001, Turkey experienced a severe economic crisis and many researchers attempted to qualitatively explain this downturn through analyzing the facts that caused the crisis and the effects it had on the economy. The focus of this paper is to complement these studies by quantitatively analyzing the economic fluctuations during the 2001 crisis in the light of the neoclassical growth theory. In this paper, it is shown that a standard dynamic stochastic small open economy model with exogenous productivity and real interest rate shocks, parameterized and calibrated to Turkish data from 1998 to 2006, is consistent with the observed features of fluctuations during the 2001 Turkish crisis. With both preference cases we consider, namely Cobb-Douglas and Greenwood-Hercowitz-Huffmann (GHH), the neoclassical model we adopted from [Otsu, 2008] predicts the contraction of the economy correctly. We examine the channels through which variables respond to productivity and interest rate shocks separately and find out that having both shocks together results in successful performance of both preference cases, except for labor in the GHH case and consumption in the Cobb-Douglas case. Although both cases successfully generate a countercyclical trade balance, GHH case performs better in generating a highly volatile consumption and Cobb-Douglas case performs better in capturing the modest shrink in labor.

2001 TÜRKİYE KRİZİNİN NEOKLASİK ANALİZİ

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Ekonomi, MA Tezi, 2008

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Anahtar Kelimeler: Küçük ve dışa açık ekonomi, Reel konjonktür dalgalanmaları, Toplam faktör verimliliği, Ülke riski, 2001 krizi

ÖZET

2001 yılı başlarında, Türkiye ciddi bir ekonomik kriz yaşamış ve birçok araştırmacı krize sebep olan unsurları ve krizin ekonomide yarattığı etkileri inceleyerek bu darboğazı nitel olarak açıklamaya çalışmıştır. Bu çalışmalara tamamlayıcı olarak, bu tezin odak noktası 2001 krizi sırasında yaşanan ekonomik dalgalanmaları neoklasik büyüme teorisi ışığında nicel olarak açıklamaktır. Bu çalışmada, dışkaynaklı verimlilik ve reel faiz şokları içeren, 1998-2006 arası Türkiye datası parametreleri ile kalibre edilmiş standart bir dinamik stokastik küçük ve dışa açık ekonomi modelinin 2001 Türkiye krizi sırasında gözlenen dalgalanmalara uygun olduğu gösterilmiştir. [Otsu, 2008] makalesindeki neoklasik model, göz önünde bulundurulan her iki tercih fonksiyonu ile de, bunlar Cobb-Douglas ve Greenwood-Hercowitz-Huffmann (GHH), ekonomideki küçülmeyi doğru şekilde tahmin etmiştir. Değişkenlerin verimlilik ve faiz şoklarına tepki verdiği kanallar ayrı ayrı araştırılmış ve iki şok birlikte hesaba katıldığında, GHH tercihinde iş gücü ve Cobb-Douglas tercihinde tüketim hariç, her iki tercih fonksiyonunun da başarılı performans gösterdiği bulunmuştur. Her iki fonksiyon da başarılı bir şekilde ters çevrimsel bir dış ticaret dengesi üretse de, tüketimdeki yüksek dalgalanmayı GHH fonksiyonu daha iyi elde etmiş ve işgücündeki ufak daralmayı ise Cobb-Douglas fonksiyonu daha iyi yakalamıştır.

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Chapter 1

INTRODUCTION

Economists have always been intrigued by economic fluctuations but the initiation of "real business cycle approach" by the pioneering work of [Kydland and Prescott, 1982] inspired many more researchers to study business cycles during the last decades. This study shows for the first time that, stochastic dynamic optimizing models work well in explaining the observed business cycle facts in closed economy environments, without using any nominal variables. In [Kydland and Prescott, 1982], a dynamic-stochastic general equilibrium model without money is shown to account for a large part of the fluctuations in the post-war US economy. Thus, real factors have proven to be the driving force of business cycles in the economy.

The research on business cycles is extended to open economies so that the models can also account for international business cycle facts such as the countercyclical trade balance and positively correlated savings and investment.[1] The novelty in open economy models as described in the initiator work of [Mendoza, 1991] is that, trade in foreign assets finances trade imbalances and plays a crucial role in explaining the dynamics of savings and investment in open economies. In [Mendoza, 1991], it is shown that a small open economy model calibrated to post-war Canadian economy is able to mimic the stylized facts for international business cycles. Following [Mendoza, 1991], [Lundvik, 1992] presents a stochastic dynamic-optimizing model applied to Swedish data and obtains consistent results with the observed facts similarly. In [Correia et al., 1995], using Portuguese data also delivers data-consistent results but it is proposed that the reason for all these models to perform well is a simple class of time-separable preferences they all utilize.

[1] See [Baxter, 1995] and [Backus et al., 1993] for a detailed documentation of international business cycle facts.

More recently, many business cycle studies have focused on emerging economies like some Latin American and Asian countries, where severe financial crises and business cycle swings have taken place for the last decades. Using small open economy models, they try to explain the high consumption volatility common in emerging economies as opposed to the consumption smoothing theory. Among these works are [Uribe et al., 2006], where a real business cycle (RBC) model driven by productivity shocks is shown to well explain the business cycle fluctuations in Argentina; and [Aguiar and Gopinath, 2007], where a standard dynamic stochastic small open economy model is shown to account for the fluctuations in both Mexico and Canada. There are also RBC studies specifically focusing on depressions in emerging economies, such as [Kydland and Zarazaga, 2002], where a neoclassical model with exogenous total factor productivity is shown to satisfactorily replicate the "lost decade" of Argentina in 1980s and [Otsu, 2008], where a small open economy neoclassical model with exogenous productivity and real interest rate shocks is shown to successfully account for Korean 1997 crisis.

In this paper, it is questioned whether a standard dynamic stochastic small open economy model with exogenous productivity and real interest rate shocks can also account for the observed features of 2001 crisis in Turkey. This paper adopts the neoclassical model used in [Otsu, 2008] and analyzes the economic crisis that Turkey experienced in early 2001 using annual data for Turkey between 1998-2006, which also covers the precrisis period and the subsequent recovery. There are some studies analyzing the factors that led to the 2001 crisis and the effects it had on the economy. Among them are [Akyüz and Boratav, 2002], [Özatay and Sak, 2002] and [Öniş and Alper, 2002], in which the exchange rate peg, the IMF stabilization program and the banking sector vulnerabilities are discussed in detail as possible reasons of the financial crisis. However, the focus of this paper is not to discuss the factors that caused the crisis but to quantitatively analyze how well the fluctuations during the crisis can be accounted for by a dynamic stochastic general equilibrium model with exogenous shocks to productivity and real interest rates. Related to Turkish business cycles, there are empirical studies documenting the stylized facts for Turkey such as [Aruoba, 2001], [Alper, 1998] and [Alper, 2002]. What we try to do is to extend these studies to the period 1998-2006 and complement them by theoretically analyzing the real macroeconomic fluctuations for this period through an open economy model.

The main finding in this paper is that, with both productivity and real interest rate shocks, models with two separate preference cases, namely Cobb-Douglas and Greenwood-Hercowitz-Huffman (GHH), successfully explain the contraction in the economy during the crisis. Although the movements in most of the variables are simulated correctly, the model predicts faster recoveries for investment and capital stock than those of data for both preference cases. Moreover, in GHH case volatility of labor is overestimated and in Cobb-Douglas case volatility of consumption is underestimated in the models with both productivity and real interest rate shocks. Furthermore, in order to determine the effects of each shock separately, we also examine the models with individual shocks. In the model with only productivity shocks, GHH case performs better because it is more accurate in capturing the high consumption volatility and countercyclical trade balance in the data, which are very common facts for emerging market economies. For other variables, models with productivity shocks generate higher volatilities than those of data for both preference cases. However, in the model with only real interest rate shocks, both cases fail to explain the shrink in the economy during the crisis. Real interest rate shocks have modest effects on labor, output and consumption in the model with GHH preferences and they generate counterfactual rises in these variables in the model with Cobb-Douglas preferences. Having both shocks together balances the individual effects of each shock out and both cases attain close estimates to data. Overall Cobb-Douglas case generates better results than GHH case does, except for explaining the high drop in consumption in the data.

The organization of the remaining part is as follows. In Chapter 2, empirical regularities of the Turkish economy for the period 1998-2006 are presented. Chapter 3 presents the description and the solution of the standard neoclassical small open economy model. Chapter 4 presents the calibration of the model and the analysis of the simulation results . Chapter 5 concludes.

Chapter 2

TURKISH ECONOMY: 1998-2006

In this chapter, we review empirical regularities of the Turkish economy using the data for the period 1998-2006.[1] Moreover, following [Otsu, 2008] we characterize the aggregate productivity and real interest rate shocks to study their contributions to the fluctuations in the economy. We identify the fluctuations in the supply and demand sides of the economy by documenting the behavior of inputs, output, components of spending and real interest rates. Table (2.1) displays the statistical results. All variable series, except for interest rates, are in real terms and per adult population. Real interest rates are presented in gross terms. We linearly detrend the logarithm of all variable series and present them in the figures as log-deviations from their trends.[2]

Table 2.1: Data Statistics

Standard Deviations			Cross correlations with Output				
x	σ_x	σ_x/σ_y	Lag = -2	-1	0	1	2
GDP (y)	0,0577	1,0000	0,1425	0,2619	1,0000	0,2619	0,1425
Consumption	0,0682	1,1820	-0,0322	0,2426	**0,9574**	0,4723	0,2011
Investment	0,2276	3,9465	-0,0578	0,1998	**0,9449**	0,4853	0,2572
Government Exp.	0,0408	0,7082	-0,4346	-0,3973	0,2614	0,2399	**0,6741**
Net Exports/GDP	0,0449	0,7784	0,1240	-0,2248	**-0,8255**	-0,4020	-0,2081
Labor	0,0199	0,3449	-0,0359	0,3079	**0,8806**	0,4985	0,2050
Capital Stock	0,0142	0,2460	-0,3849	-0,4749	0,2104	0,3839	**0,6297**
TFP	0,0642	1,1137	0,4373	0,4427	**0,6924**	-0,0530	-0,2377
Interest Rate	0,0155	0,2688	-0,3865	**-0,5404**	-0,5251	0,1189	0,3716
Spread	0,0188	0,3255	-0,0314	-0,3530	**-0,9372**	-0,3641	-0,1065

* Bold values indicate cyclicality of the variables.

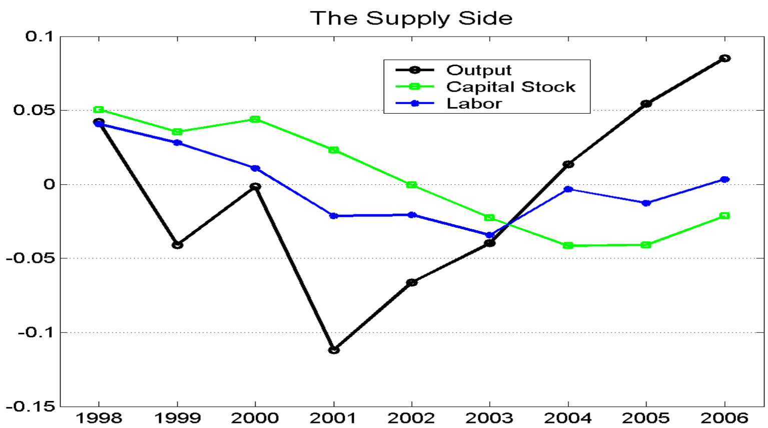
[1] See appendix for a detailed description and sources of the data.

[2] We do not take the logarithm of net exports but express it as net exports to GDP ratio.

Standard deviations reported in Table (2.1) measure the magnitude of the fluctuations. The statistics σ_x and σ_x/σ_y denote the volatilities of the variables x and relative volatilities of them with respect to output volatility, respectively. Thus, volatility corresponds to the standard deviation of the percentage deviation from trend. Cross correlations with output measure the direction, amplitude and the timing of the comovement of a variable with real GDP. Values with a positive sign correspond to procyclicality, and values with a negative sign correspond to countercyclicality. Values close to 1 (-1) indicate strong procyclicality (countercyclicality), whereas movements with no clear pattern indicate acyclicality. Lags measure the timing of changes in variables relative to that of output. Positive values correspond to lagging a cycle and negative values correspond to leading a cycle. The results in Table (2.1) are analyzed in the following sections.

2.1 Aggregate Supply

Figure 2.1: Output and Factors of Production

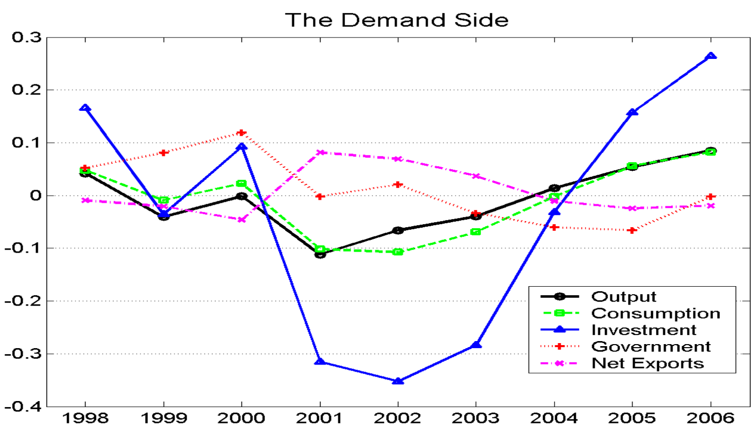


Output and two factors of production, labor and capital stock for Turkey between 1998-2006 are presented in Figure (2.1). Output is real GDP, labor is total hours worked, which we compute as weekly hours worked per worker times the number of workers, and capital stock is tangible assets owned by the whole economy. As we see from the figure, in 1999 and 2001 economy is hit by negative shocks. The first one is due to the impact of Asian and Russian crises and the Marmara earthquake in 1999, in which output per adult drops about 5 percent below its trend. The one in 2001 is due to the financial crisis, which occurred following the collapse of the exchange rate peg that was part of an IMF stabilization program. In 2001, output per adult drops about 10 percent below its trend, which amounts to a more than 5 percent shrink in the economy. However, in 3 years the economy recovers back to its pre-crisis level and continues to grow thereafter. On the other hand, the figure depicts no sharp movements in the inputs as in the output.

According to the results in Table (2.1), both production factors seem to be procyclical with cross correlations of 88 percent for labor and 63 percent for capital stock. Labor is more strongly procyclical than capital stock and moves contemporaneously with output, whereas capital stock moves smoother and lags output by 2 years. This is because current capital stock is determined by past realizations of investment and it takes time to build or remove capital stock. Volatilities of labor and capital stock are approximately 25 percent and 35 percent of the volatility of output respectively, which are insufficient to account for all the movement in GDP. Thus, in order to explain the rest of the volatility, we include the effect of total factor productivity in section (2.3).

2.2 Aggregate Demand

Figure 2.2: Output and Expenditures



Output and the aggregate demand components, namely consumption, investment, government expenditures and trade balance for Turkey are presented in Figure (2.2). Consumption is private final consumption expenditure, investment is gross fixed capital formation, government expenditure is public final consumption expenditure and trade balance is net exports of goods and services divided by GDP.

The figure depicts that, during the crisis consumption moves along with output closely and investment also moves in the same direction with output but fluctuates more than the output does. According to the Table (2.1), consumption and investment are strongly procyclical with cross-correlation values around 95 percent. Consumption volatility is 1.18 times the output volatility and investment volatility is 3.95 times the output volatility. Higher consumption volatilities are common for developing countries as pointed out in [Neumeyer and Perri, 2005], although theory tells the opposite should hold because of consumption smoothing. In our case, consumption falls more than output during the crisis, and recovers back with output in 3 years. On the other hand, the figure displays a negative comovement between net exports and output, which is specified in Table (2.1) as a coincidental cross correlation around -83 percent. Thus, net exports are strongly countercyclical and with a relative volatility of 78 percent, they fluctuate less than output as also typical in emerging markets. Government spending is the least fluctuating variable during the crisis, with a relative volatility of 71 percent. Government spending tends to be acyclical for several OECD and G-7 countries as denoted in [Kydland and Zarazaga, 1997] but according to [Riascos and Vegh, 2003] in emerging economies it tends to be procyclical because of capital market imperfections. For Turkey 1998-2006, government spending is procyclical with a cross-correlation of 67 percent and a 2-year lag.

2.3 Total Factor Productivity

Fluctuations in the production inputs cannot fully account for the fluctuations in output. We use another factor called the total factor productivity (TFP) in order to account for the fluctuations unexplained by the factors of production. In order to compute TFP, which is also known as the Solow residuals, we use the following method:

We assume that the output is produced using a Cobb-Douglas technology

$$Y_t = z_t K_t^{\theta} (X_t l_t)^{1-\theta} \tag{2.1}$$

where Y_t stands for non-detrended real output per adult, z_t is the detrended TFP, K_t is non-detrended real capital stock per adult, X_t is labor augmenting technical progress, l_t is labor input per adult and θ is the capital share which we set at 0.297 as in [Otsu, 2008]. We assume that X_t grows at a constant rate γ, thus $X_t = (1+\gamma)X_{t-1}$. Labor input per adult is defined as

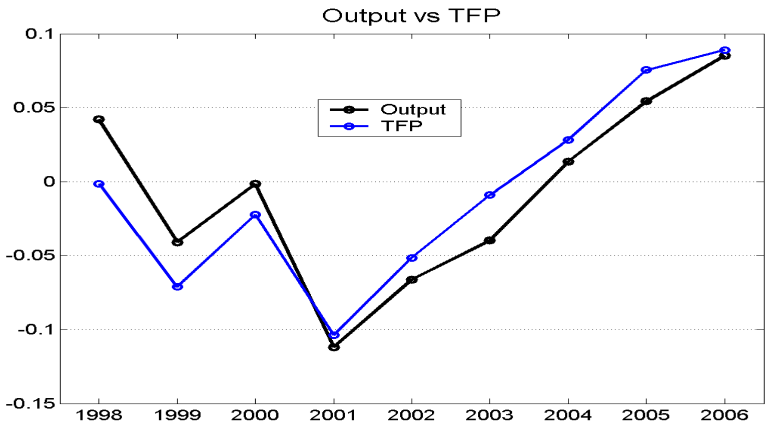
$$l_t = \frac{h_t}{14 * 7} \frac{e_t}{N_t} \tag{2.2}$$

where h_t is weekly hours worked per worker, which is 40 on average; e_t is the number of employed workers and N_t is the adult population. Given that h_t never exceeds weekly 14*7 hours, l_t is always between zero and one. Now if we take the logarithm of equation (2.1), we get

$$ln(Y_t) - \theta ln(K_t) - (1-\theta)log(l_t) = ln(z_t X_t^{1-\theta}) \tag{2.3}$$

where $ln(z_t X_t^{1-\theta})$ is the log of the Solow residuals $SR_t = z_t X_t^{1-\theta}$.

Figure 2.3: Output and Total Factor Productivity



In Figure (2.3), we present GDP and the computed TFP for Turkey in the form of log deviations from their trends. Figure depicts that TFP closely and instantaneously follows output and this implies that a large part of the fluctuation in output comes from the fluctuations in productivity. Table (2.1) verifies this fact with a relative volatility value of 1.11 and a coincidental cross correlation value of 69 percent for TFP, which imply that it is procyclical and fluctuates 11 percent more than GDP.

In order to determine the shocks to TFP, we assume that γ is the growth trend of $SR_t = z_t X_t^{1-\theta}$ and the fluctuations around this trend are driven by the fluctuations in z_t. Since $lnSR_t = (1-\theta)lnX_t + lnz_t$ and by definition $lnX_t = tln(1+\gamma)lnX_0$, we obtain the equation

$$lnSR_t = (1-\theta)lnX_0 + (1-\theta)ln(1+\gamma)t + lnz_t. \tag{2.4}$$

Thus, if we regress $lnSR_t$ on a linear trend and a constant such that

$$lnSR_t = \alpha_1 + \alpha_2 t + \epsilon_t \tag{2.5}$$

we find

$$\begin{aligned}
\alpha_1 &= (1-\theta)lnX_0 && (2.6)\\
\alpha_2 &= (1-\theta)ln(1+\gamma) && (2.7)\\
\epsilon_t &= lnz_t. && (2.8)
\end{aligned}$$

Hence, we can estimate the growth rate of labor augmenting technical progress γ using

$$\gamma \approx ln(1+\gamma) = \frac{\alpha_2}{1-\theta} \tag{2.9}$$

and by definition residuals ϵ_t are the exogenous TFP shocks.

2.4 Real Interest Rates

In this paper, the interest rates we are interested in are the real rates at which domestic agents can borrow in the international financial markets. Thus, assuming that the real rate of return on 3-month US treasury bills is a proxy for the world real interest rate, we compute real interest rate for Turkey as a combination of world real interest rate and the country specific interest rate premium, or the country spread. Real interest rates for US are computed as the difference between nominal interest rates and expected inflation rates, which are determined from the inflation in the GDP deflator by taking the average of the current and the three preceding years' actual inflation values.

Figure 2.4: Output and Interest Rates

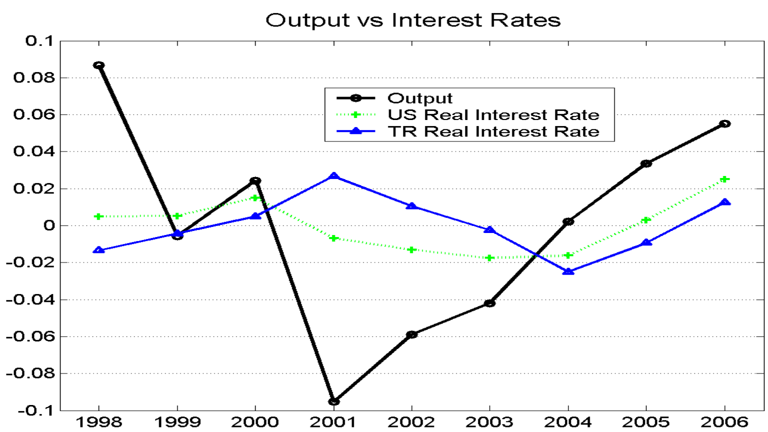
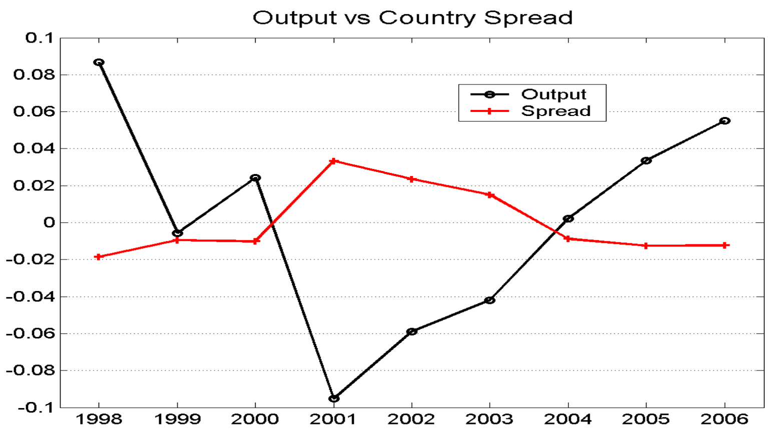


Figure (2.4) shows gross domestic and foreign real interest rate series compared to output for Turkey 1998-2006. As seen in the figure, domestic rates move in the opposite direction of output during the crisis and peaks in 2001. According to Table (2.1), domestic rates are countercyclical with a -54 percent cross correlation with output and they lead the cycle, which is common for many emerging countries as pointed out in [Neumeyer and Perri, 2005]. Since most of the emerging economies are net debtors, the cost of borrowing today anticipates future movements in output via future repayment on loans. On the other hand, the figure depicts that most of the fluctuation in domestic rates should come from the fluctuation in country spread since during the crisis the movements in US rates are rather flat. In table (2.1), relative volatility of domestic rates is documented as 27 percent, whereas relative volatility of country spread is 33 percent. Figure (2.5) shows country spread series compared to the output for Turkey 1998-2006.

Figure 2.5: Output and the Country Spread



Spread is computed as the ratio between domestic real interest rates and the foreign real interest rates.[3] As figure depicts, movements in spread are also in the opposite direction of movements in output. According to Table (2.1), it is strongly countercyclical with a cross correlation of -94 percent and moves coincidental with output. Since international rates do not fluctuate much during the crisis period, we assume that all of the fluctuations in real interest rates come from the fluctuations in country spread. Thus, if we regress the logarithm of the spread on a linear trend and a constant, the exogenous shocks to real interest rates are found as residuals from this regression.

[3]In percentage points, spread amounts to the difference between domestic real interest rates and world real interest rates.

Chapter 3

THE MODEL

In this chapter, following [Otsu, 2008], we describe the benchmark model used for our analysis and present the solution technique to find the competitive equilibrium law of motion for this economy. The benchmark economy is a small open economy consisting of a representative household and a representative firm, a government and foreign investors. The household gets utility from consumption and leisure. The financial market is incomplete. The household can only issue one-period non-state-contingent bonds to foreign investors, the return on which is subject to spread shocks. The firm produces a single good with Cobb-Douglas production technology using capital and labor as inputs. Technology is subject to TFP shocks. Government levies a lump-sum tax to the household and finances its expenditures solely by this tax. All variables except labor in the model are detrended with the labor augmenting technological progress X_t to make the model stationary.

3.1 The Representative Household

The representative household maximizes its lifetime utility by choosing how much to work, consume, invest and borrow,

$$max\ U = E_0 \sum_{t=0}^{\infty} \beta^t u(c_t, l_t) \tag{3.1}$$

where c_t is consumption and l_t is labor. Household maximizes equation (3.1) subject to the budget constraint,

$$w_t l_t + r_t k_t + \frac{\Gamma d_{t+1}}{R_t} = c_t + i_t + d_t + \Phi(\Delta k_t) + \Pi(d_{t+1}) + T_t \tag{3.2}$$

and subject to the law of motion for capital,

$$\Gamma k_{t+1} = i_t + (1-\delta)k_t \tag{3.3}$$

where k_t is capital stock, d_t is foreign debt, i_t is investment, w_t is real wage and r_t is capital rent, R_t is real gross interest rate on d_{t+1} and T_t is lump-sum tax. δ is the depreciation on capital and Γ is the growth trend defined as $\Gamma = (1+\gamma)(1+n)$ where γ is the growth rate of labor-augmenting technical progress and n is the average growth rate of adult population. In small economy models in order to lower the volatility of investment it is common to include adjustment costs on capital stock. We assume that the capital adjustment cost is $\Phi(\Delta k_t) = \phi\frac{(k_{t+1}+k_t)^2}{2}$. Also to induce stationarity in our model with an incomplete market, we include a debt adjustment cost $\Pi(d_{t+1}) = \pi\frac{(d_{t+1}-d)^2}{2}$, where d is the steady state level of foreign debt.[1]

Thus, the household first order conditions are the Euler equation for capital,

$$u_{c_t}\left[\Gamma + \phi(k_{t+1}-k_t)\right] = \beta E_t\{u_{c_{t+1}}\left[r_{t+1} + (1-\delta) + \phi(k_{t+2}-k_{t+1})\right]\} \tag{3.4}$$

the Euler equation for international debt,

$$u_{c_t}\left[\frac{\Gamma}{R_t} - \pi(d_{t+1}-d)\right] = \beta E_t\{u_{c_{t+1}}\} \tag{3.5}$$

and the first order condition for labor

$$\frac{-u_{l_t}}{u_{c_t}} = w_t. \tag{3.6}$$

We consider two cases for the functional form of household preferences. The first one is the GHH preferences

$$u(c_t, l_t) = \frac{(c_t - \chi l_t^{\nu})^{1-\sigma}}{1-\sigma} \tag{3.7}$$

in which we calculate the marginal utilities of consumption and leisure as

$$u_{c_t} = [c_t - \chi l_t^{\nu}]^{1-\sigma} \tag{3.8}$$

$$u_{l_t} = -[c_t - \chi l_t^{\nu}]^{1-\sigma}\chi\nu l_t^{\nu-1}. \tag{3.9}$$

GHH preferences were introduced by [Greenwood et al., 1988] and they are commonly used in RBC literature since then. For GHH preferences there is no income

[1] See [Schmitt-Grohe and Uribe, 2003] for alternative ways of inducing stationarity in a small open economy model.

effect on labor supply and under the interpretation of home production, market labor is costly since it reduces leisure and home production. Here χ stands for the level and ν stands for the curvature of this cost, whereas σ stands for the curvature of the utility function which represents relative risk aversion.

The second preference relation we consider is the Cobb-Douglas function

$$u(c_t, l_t) = \frac{(c_t^{\psi}(1-l_t)^{1-\psi})^{1-\sigma}}{1-\sigma} \tag{3.10}$$

which is also common in macroeconomic literature and alternatively there is an income effect on labor supply for this case. Here $1 - l_t$ stands for leisure and ψ determines the utility weights the household gives to consumption and leisure. We calculate the marginal utilities of consumption and leisure for Cobb-Douglas case as

$$u_{c_t} = \frac{\psi}{c_t}(c_t^{\psi}(1-l_t)^{1-\psi})^{1-\sigma} \tag{3.11}$$

$$u_{l_t} = -\frac{(1-\psi)}{(1-l_t)}(c_t^{\psi}(1-l_t)^{1-\psi})^{1-\sigma}. \tag{3.12}$$

3.2 The Representative Firm

The representative firm produces a single storable good with a Cobb-Douglas production technology,

$$y_t = z_t k_t^{\theta} l_t^{1-\theta} \tag{3.13}$$

where y_t is output, θ is the capital's share in output and z_t is TFP. The firm maximizes its profit

$$max\ \pi_t = y_t - w_t l_t - r_t k_t \tag{3.14}$$

by choosing its capital and labor inputs. Thus, the first order conditions for the firm are the rental rate,

$$r_t = \theta \frac{Y_t}{k_t} \tag{3.15}$$

and the wage rate,

$$w_t = (1-\theta)\frac{Y_t}{l_t}. \tag{3.16}$$

3.3 Government

The government collects a lump-sum tax and finances its purchases solely by this tax, therefore the government budget constraint is

$$g_t = T_t \tag{3.17}$$

where g_t is the government purchases and T_t is the lump-sum tax. We assume for simplicity that the government purchases are constant at g.[2]

3.4 The International Financial Markets

Since our country is a small open economy, it cannot affect the real interest rates. Therefore, the interest rate shocks are exogenously determined in the international financial markets. Real interest rates are defined as the decomposition of world interest rates and country specific interest rate premium,

$$R_t = R_t^* S_t \tag{3.18}$$

where R_t is the domestic real interest rate and R_t^* is the world real interest rate in gross terms; and S_t is the country-specific spread. We take US real interest rates as a proxy for world real interest rates and for simplicity we assume that the world interest rate is constant at R^*.[3] Hence, all fluctuations in domestic real interest rates come from the country-specific spread.

We assume that domestic private borrowers always pay back in full but the local government can confiscate the interest payments to foreign lenders. Thus, the default risk is borne solely by international lenders.

3.5 Shock Processes

We assume that the logarithm of TFP and spread shocks follow AR(1) processes,

$$\begin{bmatrix} ln\, z_t \\ ln\, S_t \end{bmatrix} = \begin{bmatrix} \rho_z & 0 \\ 0 & \rho_s \end{bmatrix} \begin{bmatrix} ln\, z_{t-1} \\ ln\, S_{t-1} \end{bmatrix} + \begin{bmatrix} \epsilon_{z_t} \\ \epsilon_{s_t} \end{bmatrix} \tag{3.19}$$

[2] Adding government spending shocks does not affect the quantitative results much.
[3] Adding world interest rate shocks also makes a very small difference to the quantitative results.

$$\begin{bmatrix} \epsilon_{z_t} \\ \epsilon_{s_t} \end{bmatrix} \sim N \begin{bmatrix} 0, & \begin{bmatrix} \sigma_z^2 & \sigma_{zs} \\ \sigma_{sz} & \sigma_s^2 \end{bmatrix} \end{bmatrix} \tag{3.20}$$

where z is the TFP and S is the spread. ρ_z and ρ_s are the persistence parameters taking values between zero and one.

3.6 Competitive Equilibrium

The competitive equilibrium for the economy described above is a set of decision rules $\{c_t, l_t, k_{t+1}, d_{t+1}, i_t, y_t, w_t, r_t, R_t\}_{t=0}^{\infty}$ such that:

1. the household optimizes given prices $\{w_t, r_t, R_t\}_{t=0}^{\infty}$ and initial conditions $\{k_0, d_0\}$,
2. the firm optimizes given prices $\{w_t, r_t\}$ and productivity shocks $\{z_t\}_{t=0}^{\infty}$,
3. the resource constraint holds

$$y_t = c_t + i_t + g + tb_t + \phi\frac{(k_{t+1} + k_t)^2}{2} + \pi\frac{(d_{t+1} - d)^2}{2} \tag{3.21}$$

   where the trade balance is defined as,

$$tb_t = -\Gamma\frac{d_{t+1}}{R_t} + d_t \tag{3.22}$$

4. the shocks follow the processes described in equations (3.19) and (3.20).

Trade balance is defined as net foreign borrowing, which arises from the position of net exports of goods and services

$$nx_t = y_t - c_t - i_t - g. \tag{3.23}$$

If imports exceeds exports then the country becomes a net borrower to cover for higher imports. Therefore, in our model $nx_t = tb_t \ \forall \ t$. On the other hand, trade balance reflects net savings, which is savings net of investment $tb_t = s_t - i_t$. Thus, savings are defined as

$$s_t = y_t - c_t - g. \tag{3.24}$$

3.7 The Solution Method

For the solution of the model, we use the methodology introduced by [Uhlig, 1995], which is extensively used for solving nonlinear dynamic stochastic models in the RBC literature. The method is based on log-linearizing the necessary equations characterizing the equilibrium and solving for the recursive equilibrium law of motion with the method of undetermined coefficients. In our model, the necessary equations characterizing the equilibrium are the first order conditions (3.4), (3.5) and (3.6) for the household[4], the production function (3.13), the resource constraint (3.21), the law of motion for capital (3.3), the trade balance equation (3.22) and the interest rate equation (3.18). We log-linearize these equations together with the shock processes (3.19) for the exogenous variables z and S.[5] Thus, we have a system of ten equations in ten unknowns $\{k, d, c, l, y, i, tb, R, z, S\}$ and three constants g, T and R^*, which can be solved by the method of undetermined coefficients.

Log-linearized equations for GHH preference case are the household first order condition for k_{t+1},

$$\begin{aligned}[\hat{c}_{t+1} - \hat{c}_t] - \bar{w}[\hat{l}_{t+1} - \hat{l}_t] - \frac{\beta}{\Gamma}\theta\frac{y}{k}\frac{1}{\sigma}\left[1 - \frac{\bar{w}}{\nu}\right][\hat{y}_{t+1} - \hat{k}_{t+1}] = \\ \frac{\beta}{\Gamma}\phi k\frac{1}{\sigma}\left[1 - \frac{\bar{w}}{\nu}\right]\left[\hat{k}_{t+2} - (1 + \frac{1}{\beta})\hat{k}_{t+1} + \frac{1}{\beta}\hat{k}_t\right]\end{aligned} \tag{3.25}$$

the household first order condition for d_{t+1},

$$[\hat{c}_{t+1} - \hat{c}_t] - \bar{w}[\hat{l}_{t+1} - \hat{l}_t] - \frac{1}{\sigma}\left[1 - \frac{\bar{w}}{\nu}\right]\hat{R}_t = \frac{1}{\beta}\pi k\frac{1}{\sigma}\left[1 - \frac{\bar{w}}{\nu}\right]\hat{d}_{t+1} \tag{3.26}$$

the household first order condition for l_t,

$$\nu\hat{l}_t = \hat{y}_t \tag{3.27}$$

the production function,

$$\hat{y}_t = \hat{z}_t + \theta\hat{k}_t + (1-\theta)\hat{l}_t \tag{3.28}$$

the resource constraint,

$$(1 - \frac{tb}{y})\hat{y}_t = \frac{c}{y}\hat{c}_t + \frac{i}{y}\hat{i}_t + \Delta tb_{y_t} \tag{3.29}$$

[4]In first order conditions for the household, we substitute for rental rate (3.15), wage rate (3.16) and the marginal utilities (3.8) and (3.9) of consumption and labor, respectively.

[5]We do not log-linearize, but linearize the trade balance in equations (3.21) and (3.22).

the law of motion for capital,

$$i\hat{i}_t = \Gamma k\hat{k}_{t+1} - (1-\delta)k\hat{k}_t = 0 \tag{3.30}$$

the trade balance equation,

$$\Delta tb_{y_t} = -\frac{\Gamma}{R}\frac{d}{y}[\hat{d}_{t+1} - \hat{R}_t - \hat{y}_t] + \frac{d}{y}[\hat{d}_t - \hat{y}_t] \tag{3.31}$$

the interest rate equation,

$$\hat{R}_t = \hat{S}_t \tag{3.32}$$

and the shock processes,

$$\hat{z}_t = \rho_z\hat{z}_{t-1} + \epsilon_{z_t} \tag{3.33}$$

$$\hat{s}_t = \rho_s\hat{s}_{t-1} + \epsilon_{s_t}. \tag{3.34}$$

In these equations, $\bar{w} = \frac{wl}{c}$ in (3.25) and (3.26) is the steady state value of the ratio between wage bill and consumption as in [Neumeyer and Perri, 2005]. Variables with a hat represent log deviations from steady state values, which are denoted as the variables without a hat. tb_{y_t} stands for the ratio between the trade balance and output, where Δtb_{y_t} in equations (3.29) and (3.31) represents the simple deviation of tb_{y_t} from its steady state value of $\frac{tb}{y}$.

Log-linearized equations for Cobb-Douglas case differ from GHH case only in the household first order condition for k_{t+1},

$$[\hat{c}_{t+1} - \hat{c}_t] + \frac{(1-\sigma)(\psi-1)}{(1-\sigma)\psi-1}\frac{l}{(1-l)}[\hat{l}_{t+1} - \hat{l}_t] + \frac{\beta}{\Gamma}\theta\frac{y}{k}\frac{1}{(1-\sigma)\psi-1}[\hat{y}_{t+1} - \hat{k}_{t+1}] = -\frac{\beta}{\Gamma}\phi k\frac{1}{(1-\sigma)\psi-1}\left[\hat{k}_{t+2} - (1+\frac{1}{\beta})\hat{k}_{t+1} + \frac{1}{\beta}\hat{k}_t\right] \tag{3.35}$$

the household first order condition for d_{t+1},

$$[\hat{c}_{t+1} - \hat{c}_t] + \frac{(1-\sigma)(\psi-1)}{(1-\sigma)\psi-1}\frac{l}{(1-l)}[\hat{l}_{t+1} - \hat{l}_t] + \frac{1}{(1-\sigma)\psi-1}\hat{R}_t = -\frac{1}{\beta}\pi d\frac{1}{(1-\sigma)\psi-1}\hat{d}_{t+1} \tag{3.36}$$

and the household first order condition for l_t

$$\hat{c}_t + \frac{1}{(1-l)}\hat{l}_t = \hat{y}_t. \tag{3.37}$$

Chapter 4

QUANTITATIVE ANALYSIS

In this chapter, we present the method and results of the quantitative analysis carried out to evaluate the performance of our benchmark model in explaining the 2001 crisis. First we specify the parameter values used in the benchmark model and then we describe the simulation technique used for obtaining variable series for Turkey 1998-2006. Finally we examine the simulation results and try to improve them by carrying out sensitivity analysis.

4.1 Parametrization

We calibrate our benchmark model using the data from Turkey for the period 1988-2006. The capital share θ is obtained from [Otsu, 2008] and all other parameters, except for the country spread shock parameters, are obtained using the Turkish data.[1] Spread shock parameters are computed using the JP-Morgan EMBI+ country spread data for Turkey.

The parameter values are listed in Table (4.1). Steady state values of l, $\frac{y}{k}$, $\frac{g}{y}$ and $\frac{tb}{y}$ are calculated from the data as the averages of each series. The growth trend Γ is calculated as $\Gamma = (1+n)(1+\gamma)$, where the growth rate of adult population n is assumed to be constant and calculated as the average of the data series, and the growth rate of labor-augmenting technology γ is calculated as described in section (2.3). The depreciation rate δ is computed as the average of δ_t from the equation for capital accumulation

$$K_{t+1} = I_t - (1-\delta_t)K_t \tag{4.1}$$

[1] Capital stock series are obtained from [Saygılı et al., 2002] and all other series are obtained from the Turkish Statistical Institute, TurkStat.

Table 4.1: Parameter Values

θ	Capital share	0.297
β	Discount factor	0.9914
Γ	Growth trend	1.0472
δ	Depreciation rate	0.0548
σ	Relative risk aversion	2
ψ	Consumption-leisure parameter of Cobb-Douglas preference	0.1903
ν	Curvature parameter of GHH preference	1.4115
χ	Level parameter of GHH preference	0.4729
π	Portfolio adjustment cost	10^{-5}
ϕ	Capital adjustment cost	varies[2]
ρ_z	Persistence of TFP shocks	0.6242
ρ_s	Persistence of spread shocks	0.4676
σ_z^2	Variance of TFP shocks	0.00412
σ_s^2	Variance of spread shocks	0.00035
σ_{zs}	Covariance of TFP and spread shocks	-0.00077

where K_t and I_t are non-detrended total capital stock and investment respectively. The discount factor β is computed using the steady state Euler equation for capital

$$\Gamma = \beta[\theta\frac{y}{k} + (1-\delta)]. \tag{4.2}$$

The curvature parameter ν is chosen so that the elasticity of labor supply for GHH preferences

$$\left[\frac{\partial l_t}{\partial w_t}\right]^{GHH} = \frac{1}{\nu - 1} \tag{4.3}$$

matches the Frisch labor elasticity for the Cobb-Douglas preferences

$$\left[\frac{\partial l_t}{\partial w_t}\right]^{Cobb-Douglas}_{\bar{u_c}} = \frac{1-\psi(1-\sigma)}{\sigma}\frac{1-l}{l} \tag{4.4}$$

where the consumption-leisure parameter ψ is computed from the steady state labor first order condition for the household in Cobb-Douglas preferences

$$\frac{1-\psi}{\psi} = (1-\theta)\frac{y}{c}\frac{1-l}{l}. \tag{4.5}$$

Thus, the value of ν changes according to the value of relative risk aversion σ. We

[2] ϕ is set differently for each type of models and preference functions to match the associated investment volatility to data.

initially assume that $\sigma = 2$.[3] The level parameter χ is computed using the steady state labor first order condition for the household in GHH preferences

$$\chi \nu l^{\nu-1} = (1-\theta)\frac{y}{l}. \tag{4.6}$$

Steady state foreign debt d is computed from the steady state trade balance equation

$$\frac{tb}{y} = \left[1 - \frac{\Gamma}{R}\right]\frac{d}{y} \tag{4.7}$$

where the steady state Euler equation for debt gives

$$R = \frac{\Gamma}{\beta} \tag{4.8}$$

and the steady state production function gives

$$y = \left[\frac{y}{k}\right]^{\frac{1}{\theta-1}+1} l \tag{4.9}$$

assuming that the steady state productivity shock $z = 0$. We also obtain the steady state values of investment i and consumption c using the steady state law of motion for capital

$$i = [\Gamma - (1-\delta)]k \tag{4.10}$$

and the steady state resource constraint

$$y = c + i + g + tb \tag{4.11}$$

respectively. The parameters ρ_z, ρ_s, σ_z^2, σ_s^2 and σ_{zs} for the shock processes are estimated using the equations (3.19) and (3.20). Following [Otsu, 2008], the debt adjustment cost parameter π is chosen to be arbitrarily small so that it will not affect the model-dynamics and the capital adjustment cost parameter ϕ is chosen to match the investment volatility in each simulated model to that of data for each case.

4.2 Simulation

In this section, we explain the method used for simulating the fluctuations of the real macroeconomic variables in Turkey for the period 1998-2006. We assume that the economy is growing along a balanced growth path for this period and fluctuations are

[3] We assign different values for σ in section (4.4) for sensitivity analysis.

defined as log deviations from this path.[4] The linear decision rules for endogenous variables are computed using the toolkit in [Uhlig, 1995] as described in section (3.7). These decision rules depend on the endogenous state variables capital stock and international debt, and the exogenous state variables TFP and the country spread. Shocks to TFP and country spread are computed as the residuals from linearly detrending the lns_t and lnz_t series for the period 1998-2006. In order to compute the fluctuations in capital stock and international debt, we substitute these linearly detrended shocks into the linear decision rules for them, assuming that they are at their steady state values in the initial period 1998. Similarly, to compute the fluctuations in the other endogenous variables, we substitute the linearly detrended shocks and the computed fluctuations in capital stock and international debt into the linear decision rules for the other endogenous variables. Finally, we linearly detrend the simulated series to make them comparable to the data series.

4.3 Results

In this section, we present the simulation results for our benchmark model and discuss the underlying reasons for these results. Figures (4.1) and (4.2) illustrate the simulated time series for output, labor, capital stock, consumption, investment and net exports for GHH and Cobb-Douglas preferences, respectively. The quantitative results are presented in Tables (4.2), (4.3) and (4.4). Table (4.2) documents the cross correlations of simulated series with output, Table (4.3) reports the standard deviations of the simulated series relative to data and Table (4.4) reports the correlations of the simulated series with data.

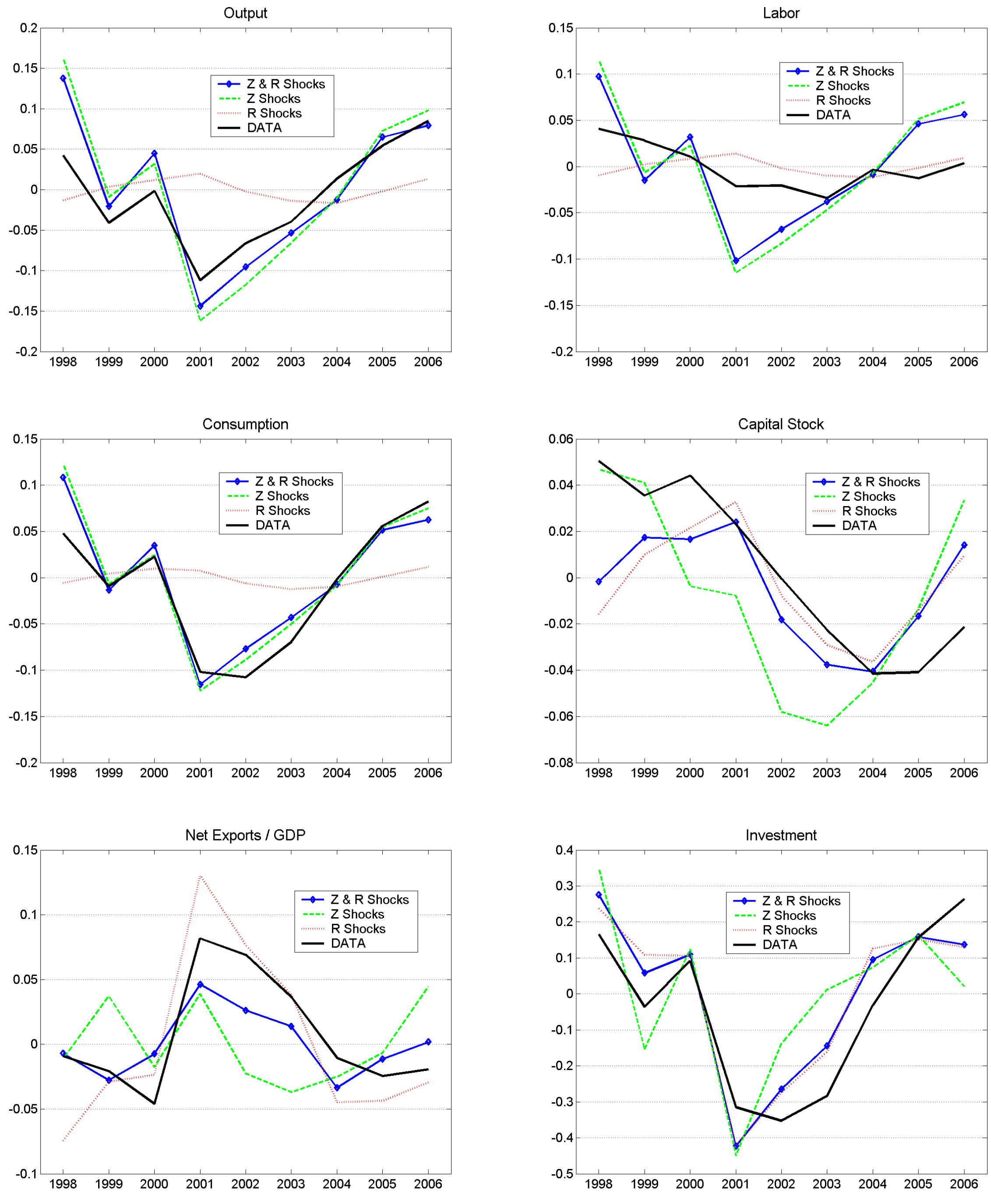
Table 4.2: Benchmark Results: Cross correlations with output

$\sigma = 2$	Correlations:	(y, y)	(c, y)	(l, y)	(k, y)	(i, y)	(nx, y)
DATA		1,00	0,96	0,88	0,63	0,94	-0,83
	Z&R Shocks	1,00	0,90	0,92	0,46	0,88	-0,23
Cobb-Douglas	Z Shocks	1,00	1,00	1,00	0,35	0,84	0,80
Preferences	R Shocks	1,00	-0,90	0,99	-0,76	-0,95	0,97
	Z&R Shocks	1,00	1,00	1,00	0,58	0,95	-0,59
GHH	Z Shocks	1,00	1,00	1,00	0,36	0,86	0,01
Preferences	R Shocks	1,00	0,93	1,00	-0,31	-0,32	0,41

* All results correspond to coincidental correlations with output except for capital stock. Lag 2 values are documented for capital stock.

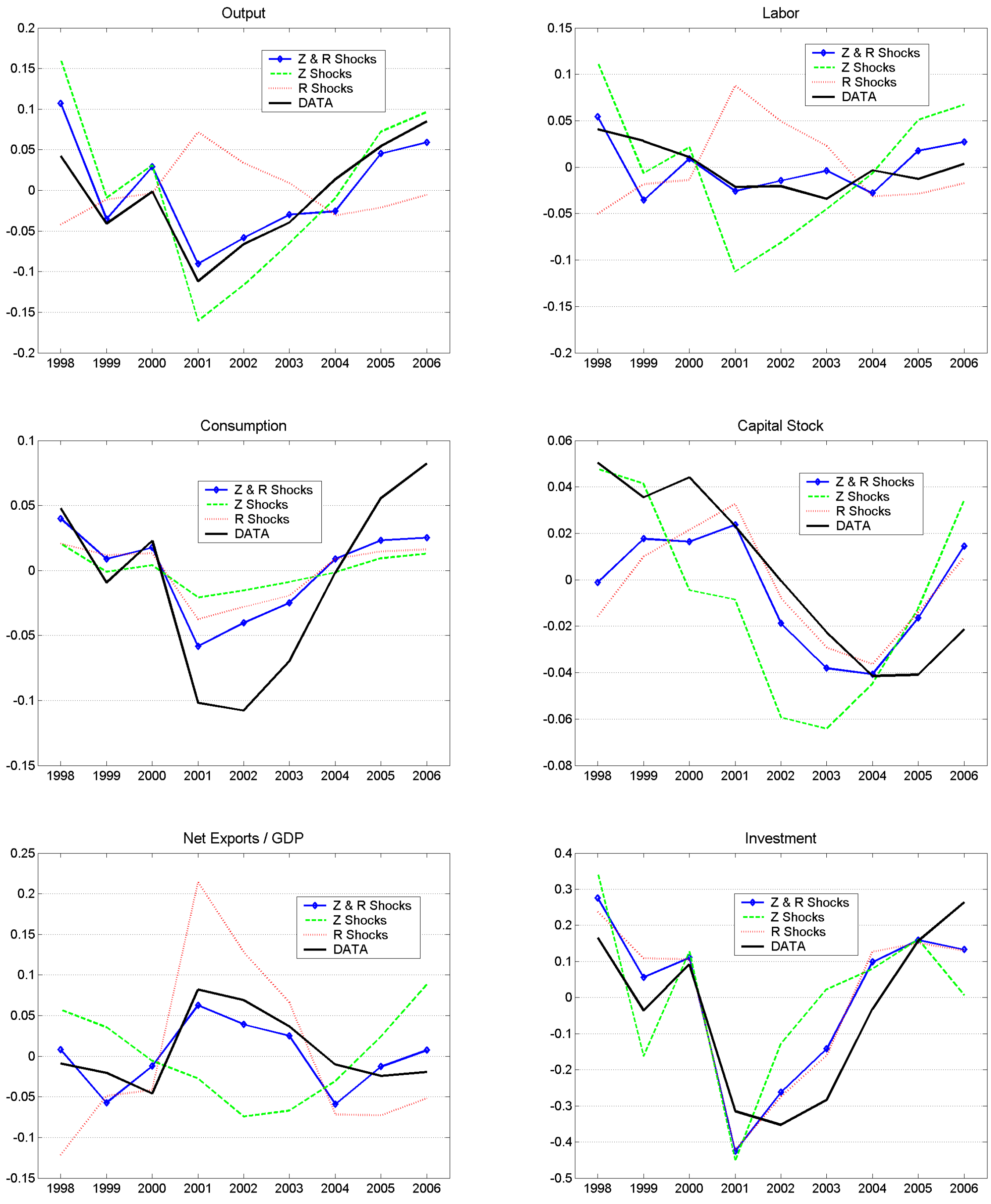
[4]For trade balance, fluctuation is defined as simple deviation from the balanced growth path.

Figure 4.1: Benchmark Results with GHH Preferences, $\sigma = 2$



Notes: Z Shocks, R Shocks and Z&R Shocks correspond to the results of simulating the benchmark model with only TFP shocks, with only real interest rate shocks and with both shocks, respectively.

Figure 4.2: Benchmark Results with Cobb-Douglas Preferences, $\sigma = 2$



Notes: Z Shocks, R Shocks and Z&R Shocks correspond to the results of simulating the benchmark model with only TFP shocks, with only real interest rate shocks and with both shocks, respectively.

Table 4.3: Benchmark Results: Volatilities relative to data

$\sigma = 2$		σ^y/σ^y_{data}	σ^c/σ^c_{data}	σ^l/σ^l_{data}	σ^k/σ^k_{data}	σ^i/σ^i_{data}	$\sigma^{nx}/\sigma^{nx}_{data}$
	Z&R Shocks	1,10	0,49	1,49	1,74	1,00	0,91
Cobb-Douglas	Z Shocks	1,79	0,20	3,63	3,00	1,00	n.a.
Preferences	R Shocks	n.a.	0,32	n.a.	1,63	1,00	2,47
	Z&R Shocks	1,56	1,05	3.20	1,73	1,00	0,57
GHH	Z Shocks	1,81	1,16	3.72	2,98	1,00	n.a.
Preferences	R Shocks	n.a.	0,13	n.a.	1,63	1,00	1,49

* n.a. stands for not applicable and indicates that there is no explanatory power because the benchmark and data fluctuations are negatively correlated as documented in Table (4.4).

Table 4.4: Benchmark Results: Correlations with data

$\sigma = 2$	Correlations:	(y, y_{data})	(c, c_{data})	(l, l_{data})	(k, k_{data})	(i, i_{data})	(nx, nx_{data})
	Z&R Shocks	0,88	0,95	0,39	0,13	0,90	0,95
Cobb-Douglas	Z Shocks	0,91	0,94	0,70	0,20	0,67	-0,54
Preferences	R Shocks	-0,79	0,94	-0,69	0,02	0,89	0,95
	Z&R Shocks	0,91	0,93	0,67	0,12	0,91	0,95
GHH	Z Shocks	0,91	0,94	0,70	0,23	0,69	-0,55
Preferences	R Shocks	-0,21	0,35	-0,03	0,03	0,89	0,95

* Reported results correspond to coincidental correlations.

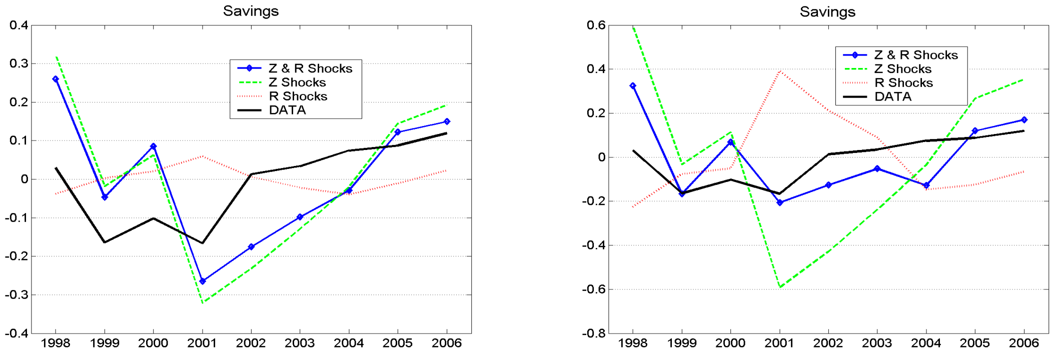
In order to decompose the effects of each shock, we include three types of simulation results; with only productivity shocks, with only real interest rate shocks and with both shocks together. The channels through which productivity and interest rate shocks individually and jointly affect the movements of each variable is discussed in the following sections. In short, results show that, with only productivity shocks GHH case is more successful because it is better in capturing the high consumption volatility in the data and attains improvements in trade balance during the crisis whereas Cobb-Douglas case fails to do so. With only real interest rate shocks, both cases fail to explain the drops in labor and output during the crisis, where GHH case generates very small reductions in these variables and Cobb-Douglas case generates even rises. With both shocks, both cases successfully mimic the movements of each variable during the crisis, except for labor in GHH case and consumption in Cobb-Douglas case. Moreover, the recoveries in capital stock and investment are predicted to happen faster than those of the data in both preference cases. With both shocks, Cobb-Douglas case delivers better results for output, labor and net exports whereas GHH case delivers better results for consumption. Thus we can say that, Cobb-Douglas case is overall more successful in quantitatively explaining the movements of main macroeconomic variables during the 2001 crisis because it is more accurate in matching the data.

4.3.1 Results with only Productivity Shocks

Figures (4.1) and (4.2) depict that, with only productivity shocks, all variables move similarly in both GHH and Cobb-Douglas cases except for consumption and net exports. For both cases, cross correlations with output recorded in Table (4.2) are close to data except for net exports, in which Cobb-Douglas case delivers an 80 percent positive correlation with output in contrast with data and GHH case delivers almost no correlation with output (1 percent). According to Table (4.3), models with only productivity shocks overestimate the movements in output, labor and capital stock in both cases, which generate relative volatilities to data around 1.8, 3.7 and 3, respectively. However, GHH case better catches the high fluctuation in consumption with a relative volatility of 1.16 and generates an improvement in trade balance as in data, whereas Cobb Douglas case only explains 20 percent of the fluctuation in consumption and generates a deterioration in trade balance in contrast with data. Table (4.4) show that, for both cases correlations with data are over 90 percent for output and consumption and around 70 percent for labor and investment; however, both cases generate around 20 percent correlated capital stock to data and 50 percent negatively correlated net exports to data. Thus, with only productivity shocks GHH case is more accurate in explaining the movements in variables but overall both cases are unsuccessful in capturing the contractions in output, labor and capital stock; and the fluctuations in net exports.

In both cases, a temporary drop in productivity reduces marginal products of labor and capital stock, which decreases wage and rental rates. Low wage rates reduce labor and consumption for both cases through substitution effect since wage rate is the relative price of leisure. Meanwhile, low wage and rental rates also cause negative income effects, which increase labor and decrease consumption in Cobb-Douglas case but only decrease consumption and do not affect labor in GHH case. Thus, labor falls unambiguously in GHH case but the result is ambiguous in Cobb-Douglas case. Since figures depict that labor falls equally in both cases, we can say that substitution effect of a wage decline in Cobb-Douglas case is greater than the one in GHH case so that substitution effect dominates income effect in Cobb-Douglas case and labor falls as much as in GHH case. Furthermore, consumption unambiguously falls in both cases through both substitution and income effects but these reductions in consumption are offset by decreases in savings in order to smooth consumption over time. Figure (4.3) depicts that, savings fall in Cobb-Douglas case twice as much as in GHH case, which explains the smaller consumption drop in Cobb-Douglas case. On the other hand, for both cases investment falls because the drop in productivity reduces expected

Figure 4.3: Savings in the Benchmark Models with $\sigma = 2$



(a) GHH Preferences

(b) Cobb-Douglas Preferences

future rental rates, which decreases future capital stock. Thus, with reduced inputs and productivity, output drops for both cases; however, as spending does not fall as much as output because of a smaller consumption drop, trade balance deteriorates in Cobb-Douglas case but improves in GHH case, where domestic absorption falls as much as output. In other words, as savings decrease more than the investment does, trade balance worsens in Cobb-Douglas case but with a same decrease in investment but a smaller drop in savings, trade balance improves in GHH case.

Our results with only productivity shocks are very similar to those of [Otsu, 2008] for both preference cases. Likewise, consumption and net exports behaviors in our models are consistent with those of [Correia et al., 1995], in which the authors conclude that the ability of small open economy models to generate countercyclical trade balance and high consumption volatility mostly depends on the form of momentary utility. GHH preferences generate the desired results but Cobb-Douglas preferences fail to do so because of lack of income effects on labor supply. They further claim that, the reason for the good performance of models in [Mendoza, 1991] and [Lundvik, 1992] is also the adoption of GHH preferences.

4.3.2 Results with only Real Interest Rate Shocks

With only real interest rate shocks, the two cases differ in explaining output, labor and consumption fluctuations but they both deliver similar results for capital stock, investment and net exports. As Figures (4.1) and (4.2) illustrate, real interest rate shocks have modest effects on output, labor and consumption in GHH case, and Cobb-Douglas case counterfactually predicts increases in output and labor during the crisis. Cross correlations with output recorded in Table (4.2) are very inaccurate compared to data since labor and output are incorrectly estimated in both cases, relative volatilities of which are expressed in Table (4.3) as not applicable because of the counterfactual results. On the other hand, Cobb-Douglas case generates reductions in consumption as in data but this accounts for only 32 percent of the fluctuation in data. Both cases overestimate the fluctuations in capital stock and net exports according to Table (4.3) and generate highly correlated investment and net exports with data according to Table (4.4). However, correlations of other variables with data is very inaccurate except for consumption in Cobb-Douglas case, which follows the data with 94 percent correlation as documented in Table (4.4).

Since Turkey is a net borrower, a temporary increase in real interest rates cause negative income effects, which reduces consumption and increases labor in Cobb-Douglas case. Also, given that interest rate is the opportunity cost of current consumption and leisure, savings increase through intertemporal substitution effect, which causes consumption to reduce and labor to rise again. As a result, labor and savings increase but consumption decreases. With an increase in labor, output also increases during the crisis. On the other hand, high real interest rates reduces relative return on capital, which causes investment to decrease in order to reduce the capital stock for the next period. Thus, with an increase in savings and a decrease in investment, net exports rise because of an improvement in net savings. Moreover, decreased capital stock in the next period causes output to rise in the next period, together with the recovery of labor after real interest rates begin to decrease.

In the case of GHH preferences, since there is no income and intertemporal substitution effects on labor, current labor does not change much due to a rise in real interest rates, which also causes current output and consumption not to change at all. Meanwhile, as in Cobb-Douglas case, investment decreases because return on capital falls short of the high real interest rates. Thus, with almost constant savings and decreased investment, net exports rise but not as much as in the Cobb-Douglas case. On the other hand, decrease in current investment causes a reduction in labor and output in the next period through decreased future capital stock. These reductions in turn causes a drop in consumption in the next period, which is shown by the red dotted lines in Figure (4.1).

Results with only real interest rate shocks are also similar to those of [Otsu, 2008], in which real interest rate shocks during the crisis have no effect on output and labor with GHH preferences and have positive effects on them with Cobb-Douglas preferences. Although high real interest rates should have large depressing effects on the economy, real interest rate shocks in our model do not predict contractions expectedly.

As productivity shocks in our model seem to cause excessive shrink in the economy, having real interest rate shocks together with shocks to productivity generates closer estimates to actual movements in the economy as explained in the next section, since the effects of these shocks balance each other out.

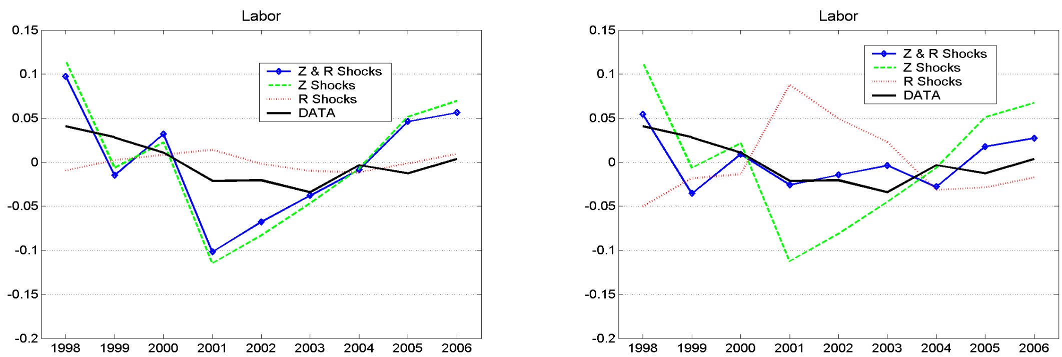
4.3.3 Results with Both Shocks

The main result for the model with both shocks is that, both preference cases are successful in explaining the movements of real macroeconomic variables during the crisis except for labor in GHH case and consumption in Cobb-Douglas case. Cobb-Douglas case better matches the data for labor, where the drop is unexpectedly small and GHH case overestimates this; and GHH case better matches the data for consumption, where the drop is as much as output and GHH case accounts better for this. In the model with both shocks, all variables respond to real interest rate and productivity shocks through the same mechanisms as in the single shock cases and overall reactions are determined by the interaction of the two separate effects. The comparative results for each variable are presented below:

As Figure (4.4) depicts, GHH case with both shocks seems to overestimate the drop in labor during the crisis, whereas Cobb-Douglas case generates closer estimates to data. Although models with only TFP shocks deliver similar results for both cases, labor increasing effect of real interest rates in Cobb-Douglas case offsets the large drop caused by productivity shocks and brings labor closer to the data. Verifying this fact, Table (4.2) reports labor correlation with output 8 percent closer to data with Cobb-Douglas case and Table (4.3) reports that labor volatility

If we look at Figure (4.5) for output, we see that with both shocks both cases

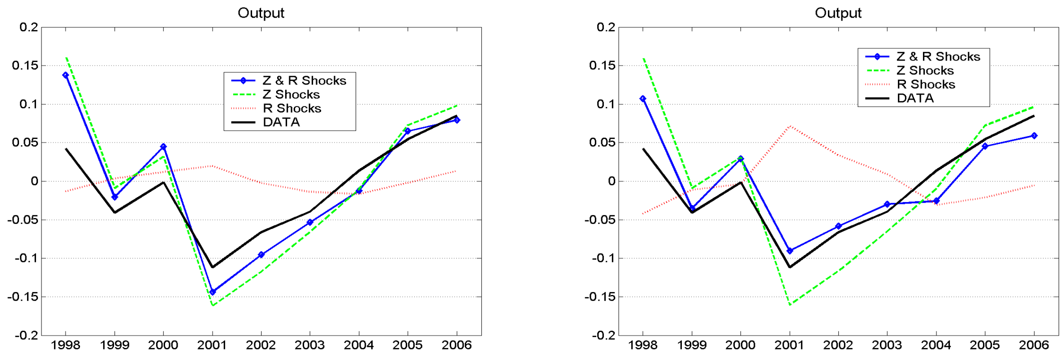
Figure 4.4: Labor in the Benchmark Models with $\sigma = 2$



(a) GHH Preferences

(b) Cobb-Douglas Preferences

Figure 4.5: Output in the Benchmark Models with $\sigma = 2$



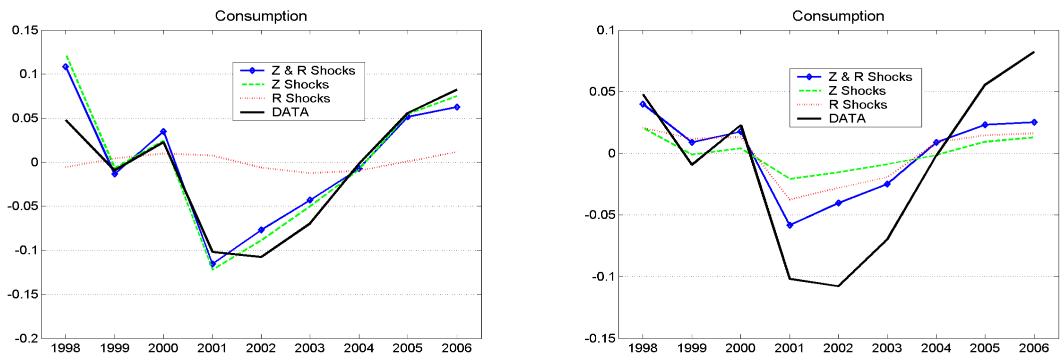
(a) GHH Preferences

(b) Cobb-Douglas Preferences

generate close estimates to data. However, as in the labor case, TFP shocks deliver large output drops for both preferences but this drop is offset by output increasing effect of real interest rates in Cobb-Douglas case, which pulls output closer to the data. As Table (4.3) verifies, Cobb Douglas case has an output volatility of 1.1 relative to data, whereas GHH case has around 1.5 times volatile output than data. Although Table (4.4) reports that, output in both cases follow the data with correlations around 90 percent, as relative volatilities verify, Cobb-Douglas case seems to account better for output movements in data.

Figure (4.6) illustrates that, for consumption GHH case generates far more accurate estimates than Cobb-Douglas case does. Although Table (4.2) reports cross correlations with output very close to data and Table (4.4) reports around 95 percent correlations with data for both cases, according to Table (4.3) GHH case accounts for all of the fluctuations in consumption, whereas Cobb-Douglas case only accounts for half

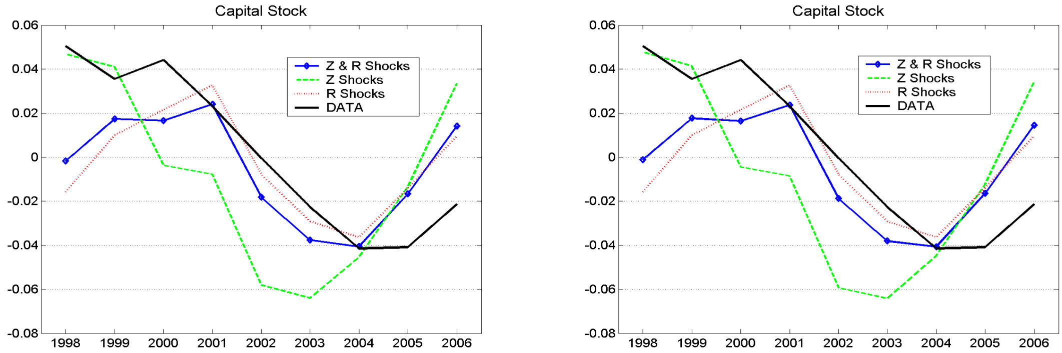
Figure 4.6: Consumption in the Benchmark Models with $\sigma = 2$



(a) GHH Preferences

(b) Cobb-Douglas Preferences

Figure 4.7: Capital Stock in the Benchmark Models with $\sigma = 2$



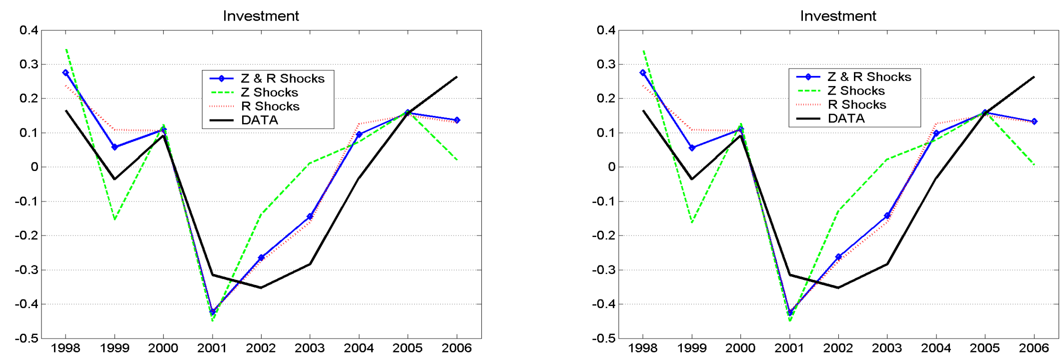
(a) GHH Preferences

(b) Cobb-Douglas Preferences

of them. Because of lack of income effects on labor supply, in GHH case productivity shocks have more depressing effects on consumption, which is not compensated with reduced savings as much as in Cobb-Douglas case.

For capital stock and investment, virtually there is no difference between the two cases as Figures (4.7) and (4.8) depict. Tables (4.2), (4.3) and (4.4) also verify this similarity by reporting very close results for both cases. In Table (4.2), cross correlations of capital stock and investment with output are consistent with data for both cases but GHH case generates closer estimates to data than Cobb-Douglas case does. In Table (4.3), relative volatilities of capital stock to data are about 1.7 for both cases and in Table (4.4), capital stock correlations with data are around 12 percent for both cases. On the other hand, investment volatilities relative to data are set to one and as Table (4.4) reports, correlations of investment with data are around 90 percent for both cases. Thus, investment is more successfully matched by both cases than capital

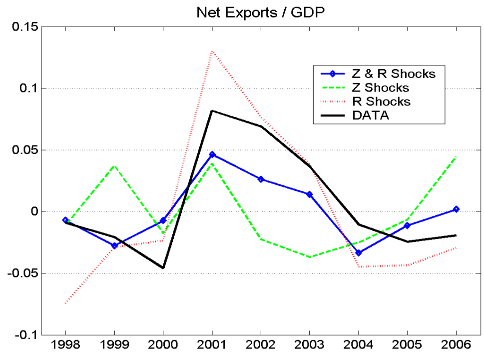
Figure 4.8: Investment in the Benchmark Models with $\sigma = 2$



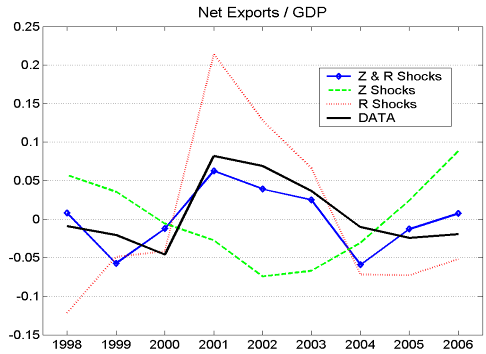
(a) GHH Preferences

(b) Cobb-Douglas Preferences

Figure 4.9: Net Exports / Output in the Benchmark Models with $\sigma = 2$



(a) GHH Preferences



(b) Cobb-Douglas Preferences

stock, relative volatility of which is overestimated and data correlation of which is very low in both cases.

Finally, looking at Figure (4.9), we see that with both shocks both cases successfully generate countercyclical trade balance but GHH case delivers better estimates for correlation with output and Cobb-Douglas case delivers better estimates for volatility relative to data. Table (4.4) reports for net exports that data correlations are 95 percent for both cases but, Table (4.2) documents 59 percent negative correlation with output in GHH case, which is 36 percent closer to data than that of Cobb-Douglas case and Table (4.3) documents 91 percent relative volatility to data in Cobb-Douglas case, which is 34 percent closer to data than that of GHH case.

Comparing our results with both shocks to those of [Otsu, 2008], we see that the model with Cobb-Douglas preferences is not successful in explaining the Korean 1997 crisis unlike for the Turkish 2001 crisis. For Turkey, contractionary effect of productivity shocks dominate expansionary effect of real interest rate shocks and thus the model successfully mimics the drops in labor and output during the crisis. However for Korea, the model with Cobb-Douglas preferences predicts expansions in these variables even with highly depressing productivity shocks. On the other hand, model with GHH preferences can account extremely well for the Korean crisis, whereas the results are less accurate for the Turkish crisis, in which the drop in labor is predicted as 3 times more than that of data.

4.4 Sensitivity Analysis

In this section we carry out a sensitivity analysis to check the firmness of our benchmark results to the parameter values that are not directly calculated from the data. The only two parameters that we do not obtain from the data are the relative risk aversion σ and the capital's share in output θ. We only present benchmark results for volatilities relative to data. Table (4.5) reports the benchmark results for various σ values and Table (4.6) reports the benchmark results for different θ values.

Table 4.5: Benchmark Results: Volatilities relative to data for different σ

$\theta = 0,297$		Cobb-Douglas Case			GHH Case		
	$\sigma =$	1	**2**	5	1	**2**	5
σ^y/σ^y_{data}	Z&R shocks	1,11	**1,10**	1,10	1,80	**1,56**	1,34
	Z shocks	2,05	**1,79**	1,54	2,06	**1,81**	1,56
	R shocks	n.a.	**n.a.**	n.a.	n.a.	**n.a.**	n.a.
σ^c/σ^c_{data}	Z&R shocks	0,53	**0,49**	0,46	1,37	**1,05**	0,74
	Z shocks	0,02	**0,20**	0,36	1,49	**1,16**	0,84
	R shocks	0,51	**0,32**	0,15	0,17	**0,13**	0,09
$\sigma^{nx}/\sigma^{nx}_{data}$	Z&R shocks	1,11	**0,91**	0,72	0,56	**0,57**	0,56
	Z shocks	n.a.	**n.a.**	n.a.	n.a.	**n.a.**	n.a.
	R shocks	3,07	**2,47**	1,93	1,51	**1,49**	1,46
σ^l/σ^l_{data}	Z&R shocks	1,74	**1,49**	1,37	4,19	**3,20**	2,28
	Z shocks	4,72	**3,63**	2,59	4,81	**3,72**	2,67
	R shocks	n.a.	**n.a.**	n.a.	n.a.	**n.a.**	n.a.
σ^k/σ^k_{data}	Z&R shocks	1,76	**1,74**	1,72	1,73	**1,73**	1,72
	Z shocks	2,96	**3,00**	2,95	2,91	**2,98**	2,96
	R shocks	1,63	**1,63**	1,64	1,63	**1,63**	1,64

* n.a. stands for not applicable and is used when model and data fluctuations display opposite directions.

Since investment volatility in our model is set to match the data in each case and for each simulation, benchmark results for investment and capital stock do not change due to variations in parameter values; however, there exist small changes in benchmark results for other variables. As Table (4.5) documents, volatilities of all variables other than capital stock diminish as σ increases except for consumption in Cobb-Douglas case. In the model with only productivity shocks, volatility of consumption relative to data increases with higher σ. As described in [Otsu, 2008], due to income effects on labor, in Cobb-Douglas case there exists a trade-off between the fluctuations of consumption and labor, in which higher σ values generate higher fluctuations in consumption and lower fluctuations in labor. On the other hand, higher σ lowers the intertemporal elasticity of substitution and leads consumption and leisure to be less sensitive to real interest rate shocks, which decreases fluctuations in variables. Overall we can say from Table (4.5) that, benchmark results for different σ are fairly robust and $\sigma = 2$ is appropriate for our model.

Table 4.6: Benchmark Results: Volatilities relative to data for different θ

$\sigma = 2$		Cobb-Douglas Case				GHH Case			
	$\theta =$	0,275	**0,297**	0,35	0,4	0,275	**0,297**	0,35	0,4
σ^y/σ^y_{data}	Z&R shocks	1,14	**1,10**	1,03	0,98	1,61	**1,56**	1,46	1,37
	Z shocks	1,84	**1,79**	1,69	1,61	1,84	**1,81**	1,73	1,66
	R shocks	n.a.	**n.a.**	n.a.	n.a.	n.a.	**n.a.**	n.a.	n.a.
σ^c/σ^c_{data}	Z&R shocks	0,47	**0,49**	0,51	0,53	1,08	**1,05**	0,99	0,94
	Z shocks	0,19	**0,20**	0,22	0,24	1,19	**1,16**	1,08	1,02
	R shocks	0,31	**0,32**	0,33	0,33	0,13	**0,13**	0,13	0,13
$\sigma^{nx}/\sigma^{nx}_{data}$	Z&R shocks	0,89	**0,91**	0,94	0,97	0,54	**0,57**	0,61	0,66
	Z shocks	n.a.	**n.a.**	n.a.	n.a.	n.a.	**n.a.**	n.a.	n.a.
	R shocks	2,49	**2,47**	2,39	2,33	1,48	**1,49**	1,52	1,54
σ^l/σ^l_{data}	Z&R shocks	1,59	**1,49**	1,28	1,12	3,29	**3,20**	3,01	2,84
	Z shocks	3,76	**3,63**	3,33	3,08	3,78	**3,71**	3,56	3,43
	R shocks	n.a.	**n.a.**	n.a.	n.a.	n.a.	**n.a.**	n.a.	n.a.
σ^k/σ^k_{data}	Z&R shocks	1,73	**1,74**	1,74	1,74	1,73	**1,73**	1,73	1,73
	Z shocks	2,98	**3,00**	3,04	3,09	2,97	**2,97**	2,96	2,94
	R shocks	1,63	**1,63**	1,63	1,63	1,63	**1,63**	1,63	1,63

* n.a. stands for not applicable and is used when model and data fluctuations display opposite directions.

As Table (4.6) documents, benchmark results converge more to data in Cobb-Douglas case as θ approaches to 40 percent but still half of the volatility in consumption can be explained despite the success in other variables excluding capital stock. Contrarily in GHH case, only consumption volatility is explained fully but other variables are either underestimated or overestimated with the same values for θ. For GHH case to generate the actual output volatility in data, we need a capital share of 70 percent, for which consumption volatility becomes 70 percent relative to data and labor volatility becomes twice as volatile as that of data. Although microeconomic studies show that capital's share in output should be around 30 percent as we consider, $\theta = 0.4$ seems to be more appropriate for our model as inferred from Table (4.6).

Chapter 5

CONCLUSION

In this paper, it has been shown that a standard dynamic stochastic small open economy model with exogenous productivity and real interest rate shocks, parameterized and calibrated to Turkish data from 1998 to 2006, is consistent with the observed features of fluctuations during the 2001 crisis in Turkey. In both Cobb-Douglas and GHH preference cases, with both shocks, the neoclassical model we adopted from [Otsu, 2008] predicts the contraction of the economy correctly. Both cases generate a countercyclical trade balance and GHH case generates a highly volatile consumption, which are common observations for emerging market economies. Despite generating a little faster recovery in capital stock and investment, both preference cases perform well in explaining the movements in the main macroeconomic variables. In order to analyze the channels through which variables respond to TFP and interest rate shocks individually, we examine the effects of each shock separately.

In our model, the main role of productivity shocks is producing fluctuations in output, labor and capital stock, movements of which are predicted identically in both preference cases. A temporary drop in productivity reduces marginal products of labor and capital stock and causes labor supply and investment to decline, which lead output to fall consecutively. On the other hand, the main role of real interest rate shocks is determining the composition of output between consumption, investment and trade balance, movements of which in our model are mostly similar for both preference cases. High real interest rates reduce relative return on capital and induce investment to fall consequently. Moreover they tend to cause negative income effects that decrease consumption and savings, which determine the movements in net exports together with investment.

The key difference between the two preference cases we consider is that, there is no income effect on labor supply in GHH case. With negative productivity shocks, income effect on labor supply reduces consumption volatility in Cobb-Douglas case together with a large decrease in savings, which causes trade balance to deteriorate. Thus, the high drop in consumption during the crisis and the countercyclical trade balance are better matched with GHH case. On the other hand, with real interest rate shocks, absence of income and intertemporal substitution effects causes labor in GHH case to stay unaffected, which also induces output and consumption to stay the same. However, in Cobb-Douglas case these effects cause an expansion in the economy, which is counterfactual during a crisis. When both shocks are considered together, all variables respond to real interest rate and productivity shocks through the same mechanism as in the single shock cases and overall reactions are determined by the interaction of the two separate effects. Having both shocks together results in successful performance of both preference cases, except for labor in GHH case and consumption in Cobb-Douglas case.

The outcomes that real interest rate shocks do not affect current labor and output in our model with GHH preferences and they do have positive effects on these variables with Cobb-Douglas preferences are unexpected because it is thought that high real interest rates have depressing effects on the economy. Thus in our model, if high real interest rates had depressing effects, they must have caused a drop in productivity. Future research for the analysis of Turkish 2001 crisis might include examining channels through which real interest rate shocks cause endogenous fluctuations in productivity and affect the crisis indirectly. On the other hand, there are studies consistent with our result that output increases during a financial crisis as in our model with only real interest rate shocks in the Cobb-Douglas preference case. In [Chari et al., 2005], the sudden stop of capital inflows cause a similar expansion in the model economy as the one caused by real interest rates in our model, which also needs a depressing shock to the production in order to generate an output drop during the crisis.

The result that Cobb-Douglas case is not successful in explaining the consumption volatility is due to the income effects on labor, which causes a trade-off between the fluctuations of consumption and labor in this case. Thus, the negative effect of the wage decrease is shared between consumption and labor, which causes the model to generate smaller fluctuations in these variables. As labor in the data also shows a relatively small drop during the crisis, Cobb-Douglas case attains closer labor movements to data whereas GHH case overestimates the labor drop in the data. Similarly in [Meza and Quintin, 2005], exogenous TFP drops in a neoclassical model analyzing the 1994 financial crisis in Mexico generate a much larger contraction in Mexican labor than in data. The authors conclude that labor hoarding is crucial in explaining the reason for Mexican labor to fall less than the theory predicts. One reason for labor hoarding might be the fast price adjustment in the markets, where wages stay rather sticky because of the law and contracts. Thus, the cost of labor in the production side becomes relatively low as prices increase and labor demand does not fall. One other point for future research might be the analysis of stable labor in Turkey from the perspective of neoclassical growth theory, taking the role of labor hoarding into account.

Chapter A

APPENDIX

A.1 Data Description and Sources

A.1.1 National Accounts

Annual series of output, consumption, investment, government spending, exports and imports in constant prices for Turkey between 1987-2006 are obtained from Turkish Statistical Institute, TURKSTAT. Output is GDP by kind of activity, which is calculated as GDP plus the statistical discrepancy; consumption is private final consumption expenditure, investment is gross fixed capital formation, government spending is government final consumption expenditure, exports are the total exports of goods and services, and imports are the total imports of goods and services.

A.1.2 Employment and Hours

For adult population (population 15 years and over) and employed adults, semi-annual series between October 1988 - October 1999 and annual series between 2000-2006 are obtained from the Household Labor Force Survey of TURKSTAT. Semi annual data is averaged to be annual. For hours worked per worker, we use the quarterly index of production hours worked in manufacturing industry divided by the quarterly index of production workers working in manufacturing industry, which are obtained from the Central Bank of Turkey. We also annualize the hours by averaging the four quarters and normalize the hours to be 40 hours weekly in average, maximum of which is 14*7 hours per week. Finally we calculate labor input as $\frac{\#\ of\ employed\ workers * weekly\ hours\ worked\ per\ worker}{\#\ of\ adult\ population * (14*7)}$, which is between 0 and 1 given that weekly hours do not exceed 14*7.

A.1.3 Capital Stock

For capital stock, we use the annual data obtained from [Saygılı et al., 2002] for the years 1987-2003. In order to extend the data to 2006, we calculate the average depreciation rate of 1987-2003 using equation (4.1) and use it as a proxy for the missing years. By the same equation together with the investment data, we obtain the missing values for capital stock.

A.1.4 Real Interest Rates

Nominal interest rates are the sum of real interest rates and the expected inflation rates. For the US nominal interest rates, we use the annual data from the FED releases and the US GDP deflator inflation is computed using the annual real GDP series obtained from the US Bureau of Economic Analysis. Expected inflation is computed as the average of current and the 3 preceding years' inflation values. Domestic real interest rates consist of the US real interest rates an the country specific risk premium. For the country specific risk premium, we use the JP Morgan EMBI+ data series for Turkey, which starts from 1998 and is reported in a daily basis. We annualize the country spread series by averaging the daily data in a year.

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