BUSINESS CYCLE ACCOUNTING IN A SMALL OPEN ECONOMY: THE CASE OF TURKEY

by
HOSSEIN HOSSEINI

Submitted to the Institute of Social Sciences
in partial fulfillment of the requirements for the degree of
Master of Arts

Sabancı University
July 2018

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THE CASE OF TURKEY

APPROVED BY:

Doç. Dr. İnci Gümüş ....
(Thesis Advisor)

Dr. Öğretim Üyesi Remzi Kaygusuz ....

Doç. Dr. Sadettin Haluk Çitçi ....

DATE OF APPROVAL: 12.07.2018

ABSTRACT

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HOSSEIN HOSSEINI

Economics, M.A. Thesis, July 2018

Thesis Supervisor: Assoc. Prof. İnci Gümüş

In this study, we analyze the business cycles in the Turkish economy for the period 2000:Q1-2017:Q3 by implementing the Business Cycle Accounting method, proposed by Chari, Kehoe, and McGrattan (2007), in a small open economy model. There are four sources of fluctuations in the model: the efficiency wedge, the labor wedge, the capital wedge, and the bond wedge. The accounting procedure indicates that distortions represented by efficiency and labor wedges are the main factors in explaining the aggregate fluctuations in Turkey. The results also show that the bond wedge is important for the consumption and investment dynamics, while the capital wedge seems to be important mainly for investment.

Keywords: Business Cycle Accounting, Turkish Economy, Efficiency Wedge, Bond Wedge.

ÖZET

KÜÇÜK AÇIK BİR EKONOMİDE İŞ DÖNGÜSÜ MUHASEBESİ:
TÜRKİYE ÖRNEĞİ

HOSSEIN HOSSEINI

Ekonomi, Yüksek Lisans Tezi, Temmuz 2018

Tez Danışmanı: Doç. Dr. İnci Gümüş

Bu çalışmada, 2000 yılı birinci çeyreği ile 2017 yılı üçüncü çeyreği arasında, küçük bir açık ekonomi modelinde Türkiye ekonomisinin iş döngüleri Chari, Kehoe, ve McGrattan (2007) tarafından önerilen İş Döngüsü Muhasebesi yönteminin incelenmiştir. Kullanılan model ekonomideki dalgalanmalar için dört temel kaynak öngörmektedir: verim kıskısı, işgücü kıskısı, sermaye kıskısı ve tahvil kıskısı. Bu muhasebe yöntemi, Türkiye'deki makroekonomik dalgalanmaların başlıca kaynağı olarak verim ve işgücü kıskıları tarafından yaratılan bozukluklara işaret etmektedir. Ayrıca, tahvil kıskısı tüketim ve yatırım dinamikleri için önem teşkil ederken, semaye kıskısının temel olarak yatırım dinamikleri için önemli olduğu görülmektedir.

Anahtar Kelimeler: İş Döngüsü Muhasebesi, Türkiye Ekonomisi, Verim Kıskısı, Tahvil Kıskısı.

ACKNOWLEDGMENTS

I am very thankful to my thesis advisor Dr. İnci Gümüş for her guidance and patience throughout the research and writing of this thesis. I also would like to thank Dr. Remzi Kaygusuz and Dr. Sadettin Haluk Çitçi for being part of my thesis jury and for their valuable comments.

I would like to express my gratitude to all my professors at Sabancı University Economics Department for their contributions to my academic knowledge.

I want to thank all my friends, especially Atakan Açıkgöz and Furkan Sarıkaya for their great friendship during my master degree at Sabancı University.

Finally, I am deeply grateful to my wife "Shiva Eshghollahi" who has supported me to get to this point.

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CHAPTER 1

INTRODUCTION

Statistical analysis of business cycles demonstrates some important characteristics of macroeconomic fluctuations in developing economies which are different from developed economies.[1] The Turkish economy, particularly in the years after 2000, is an interesting case for investigating business cycles and their sources in developing economies. From the year 2000, the Turkish government has implemented many comprehensive reforms to stabilize the economy and increase its integration to the international financial markets. The economy has experienced two crises in the period after 2000, the 2001 crisis and the global financial crisis of 2009, while it grew at a high rate between 2002-2007. To understand more about nature of business cycles in Turkey, we analyze the economy from the first quarter of 2000 until the third quarter of 2017 using the Business Cycle Accounting (BCA) methodology proposed by Chari et al. (2007).

BCA is a quantitative procedure employed in modern macroeconomics to decompose business cycle fluctuations into causal factors. This methodology relies on comparing actual data and predictions of a prototype model economy when just a specific form of wedge is activated in the model. The "wedges" specify as a gap between frictionless model's equilibrium conditions and their data counterparts. For example, technology wedge (analogous to TFP shocks) defines as a value that equates two side of production function when the function is fed with real data.

The wedges can emerge because of exogenous shocks or some frictions which are not considered in the model explicitly, and as explained by Chari et al. (2007) they can be classified based on their targeted equilibrium conditions. The paper lists these targets as: (i) resource constraint, (ii) production function, (iii) intratemporal condition that substitutes consumption and leisure, and (iv) intertemporal substitution of consumption.

[1]Neumeyer and Perri (2005) list these regularities as: high volatility of consumption relative to output, high negative correlation between interest rate and output, and strong countercyclical behavior of net exports.

The BCA method starts by estimating wedges, where they are defined as exogenous shocks in a prototype model economy. In order to understand the relative importance of each wedge in explaining macroeconomic fluctuations: each wedge can be fed in to the model while other wedges are fixed at their mean values. In this situation comparing the model predictions with their data counterparts shows explanatory power of the active wedge in explaining behavior of different macroeconomic variables.

In this study we examine the role of various frictions in explaining the business cycles in Turkey by applying the BCA method to the Turkish economy for the period between the first quarter of 2000 to the third quarter of 2017. For this purpose following Lama (2011) and Hevia (2014), we define a benchmark model for a small open economy with four wedges. The four wedges in the model are the efficiency wedge, the labor wedge, the capital wedge and the bond wedge. The efficiency wedge is equivalent to technology shocks and represents productivity level in the economy; the labor wedge represents labor market's distortions; the capital wedge captures the frictions in the capital market, and the bond wedge accounts for frictions related to borrowing from international financial markets. We estimate the parameters for the wedges using Turkish data for the sample period with a maximum likelihood method. Then, we use the estimated wedges to account for their distortionary role in business cycles in Turkey.

The results point out that the efficiency wedge, which represents the aggregate level of productivity, explains most of the macroeconomic fluctuations in Turkey in the period 2000:Q1-2017:Q3. Labor market frictions captured by the labor wedge are important for explaining output and labor movements, while their importance is relatively less for investment and consumption. The accounting procedure also indicates that the bond wedge plays more important role in consumption and investment dynamics compared to other variables, while capital market frictions, represented by the capital wedge, are important for investment behavior during the studied period.

The rest of the thesis is organized as follows. Second section of current chapter provides a review of the related literature. Then we proceed by discussing the main aspects of Turkey's business cycles in chapter 2. In chapter 3 we describe our benchmark model, and in chapter 4 we estimate the model and present the calculated wedges. Chapter 5 presents the results, and the last chapter provides concluding remarks.

1.1 Literature Review

Chari et al. (2007) develop a simple framework to quantitatively assess performance of alternative explanations for aggregate fluctuations in an economy. They begin to introduce the BCA methodology by defining a benchmark prototype economy with efficiency, labor, investment and government spending wedges. Chari et al. (2007) define state of prototype economy as bijective function of wedges and show that the realization of each wedge can be translated to its equivalent detailed economy [2]. In the second step, they examine to what extent the wedges in the benchmark economy are responsible for observed movements in aggregate variables. They proceed by implementing the method to study the great depression in the United States and find that efficiency and labor wedges are the main factors responsible for output fluctuations during the considered period.

The BCA method has been developed in two ways in the literature. The first approach uses the assumptions of Chari et al. (2007) and their four-wedge benchmark model to investigate the sources of aggregate fluctuations. For example, Kersting (2008) shows the vital role of the labor wedge in the 1980s recession and the subsequent recovery of the UK economy. Bridji (2013) studies business cycles in France during the great depression era. The author shows that efficiency and labor wedges are the main reasons for output drop during the period. He also explains that the investment wedge is responsible for the decline in aggregate consumption. Cho and Doblas-Madrid (2013) study the mechanisms by which financial crises lead to output drops in various economies. Their study includes an episode from Turkey and concludes that the efficiency wedge is invariably the most important one and the relevance of the labor and investment wedges varies depending on the size of the output drop and the severity of banking problems. There are many other similar papers (e.g. Orsi and Turino, 2014; Gunaratna and Kirkby, 2016) that use the standard Chari et al. (2007) approach in their analysis.

The second approach extends the BCA method and defines different wedges in a new framework to investigate particular questions and theories. Šustek (2010) defines two new wedges and introduces financial market and monetary policy distortions to study the relationship between output and inflation in the U.S. economy. Rahmati and Rothert (2014) define two additional wedges (trend shock and country risk) to account for the ag-

[2] Detailed economy refers to models which use specified terms and hypotheses, instead of wedges, to explain distortions in an economy.

gregate fluctuations, particularly in trade balance and current account, during the Tequila Crisis in Mexico. Lama (2011), which is one of the main papers that we follow in this study, uses an open economy version of the neoclassical growth model and extends the Chari et al. (2007) approach to evaluate the effect of financial markets on output drops in six Latin American countries during 1990-2006. His results show that the bond wedge, which can be interpreted as distortionary effect of financial market frictions, does not play a significant role in output movements in the studied countries. The other paper that we closely follow, Hevia (2014) develops a small open economy model with four regular wedges plus one new wedge, called the country spread wedge. The study evaluates the effect of frictions caused by international interest rate volatility on business cycles in Mexico and Canada. He concludes that the country spread wedge contributes to output and consumption volatility in both countries.

Elgin and Çiçek (2011) apply the BCA method to Turkey using both annual data for 1968-2009 and quarterly data for 2000-2009. In the paper they follow Chari et al. (2007) benchmark model, however unlike the original model they consider two separate wedges for trade balance and government spending. They find that efficiency and labor wedges are important sources of Turkey's aggregate fluctuations in the both annual and quarterly data sets, while trade balance and government spending wedges do not account for most of the macroeconomic movements. Our study differs from Elgin and Çiçek (2011) on two main points. First, we use small open economy literature to define a benchmark prototype model, which lets us to study effect of distortions induced by international financial markets (bond wedge) on Turkish economy. Second, we estimate our model's stochastic processes using longer quarterly data set covering 2000:Q1-2017:Q3.

CHAPTER 2

BUSINESS CYCLES IN TURKEY

The Turkish economy had an acute banking crisis, which started in the last quarter of 2000 and continued into 2001. However, most of the years after 2001 were productive for Turkey's economy. The economy expanded at an annual rate of 7.2% on average between the years 2002 and 2007. It also recovered quickly after the global financial crisis: after a slowdown in GDP growth to just 0.8% in 2008 and a subsequent recession, with a 4.7% contraction in 2009, the economy strongly restored, generating 9.2% and 11.1% growth in 2010 and 2011, respectively[1].

The economic success was the consequence of reforms conducted by the government during the 2001 economic crisis and afterward. The reforms' agenda were continued by the Justice and Development Party after it gained a parliamentary majority in the 2002 elections, which stabilized the country's political scene. Focus of the economic reforms was on privatization of state-owned enterprises, which was followed by an unprecedented inflow of foreign direct investment. The reforms also extended to the banking system, which protected the country's economy against the fallout from the global financial crisis. In addition, Turkey adopted a floating exchange rate system, removed restrictions on foreign capital inflows, improved fiscal discipline, increased the independence of the Central Bank, and controlled inflation.

2.1 Regularities of Turkey's Business Cycles

Given the context, we explore the main characteristics of Turkish business cycles by examining the volatility, serial correlations, and cross correlations of main macroeconomic aggregates. The variables are transformed by removing the seasonal patterns(if it was necessary), dividing by working population, and taking natural logarithms (except for

[1] The growth statistics are taken from the World Bank database.

net exports), then they are linearly detrended. Our sample covers the period from the first quarter of 2000 to the third quarter of 2017.

Figure 2.1 reports the evolution of main macroeconomic variables for Turkey. The significant conditions observed in graphs are the two major contractions during the 2001 and 2009 crises. These crises, after the year 2000, were the most important break points in Turkey's business cycles, where large declines in output, investment and consumption are observed. High volatility of the variables is another significant feature that draws attention.

Figure 2.1: Evolution of macroeconomic variables in Turkey

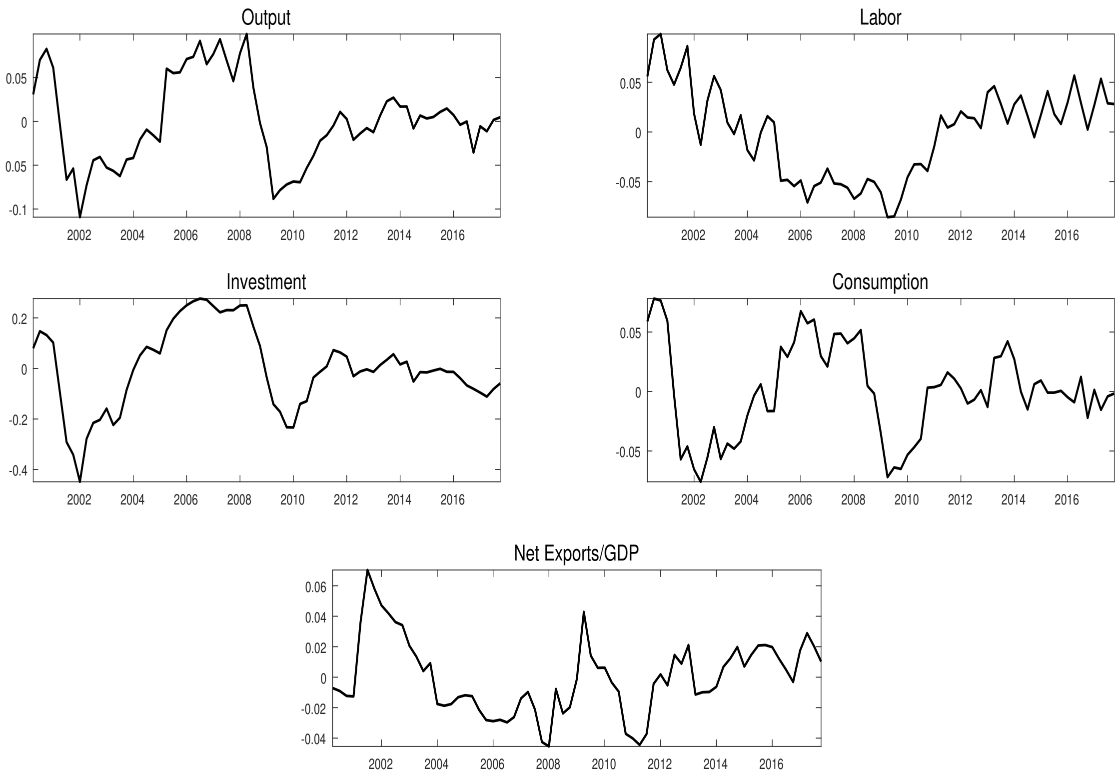


Table 2.1: Descriptive statistics of Turkey's business cycles
2000:Q1-2017:Q3

	(I)	(II)	(III)	(IV)
Variable (z_i)	$\rho(z_i, z_{i,-1})$	$\rho(z_i, y)$	σ_{zi}	$\frac{\sigma_{zi}}{\sigma_y}$
Output (y)	0.871	1	4.94%	1
Labor (l)	0.875	-0.117	4.49%	0.908
Investment (x)	0.927	0.908	16.07%	3.250
Consumption (c)	0.849	0.933	3.86%	0.780
Net Exports /GDP	0.811	-0.319	2.65%	0.484

Table 2.1 documents the main characteristics of business cycles in Turkey during 2000:Q1-2017:Q3. Column (I) of the Table 2.1 shows the autocorrelation of Turkey's aggregate variables. The results indicate that all variables are highly persistent. Column (II) in the table presents cross correlation between aggregate variables and real GDP. As expected the results suggest high contemporaneous correlation between investment and output and between consumption and output. The table reports large negative correlation of net exports and output for Turkey. Strong counter-cyclical behavior of net exports is a general property of the data for developing economies (Aguiar and Gopinath, 2007), and it is explained by the point that developing economies borrow from international capital markets during booms and face borrowing problems in recessions.

The slightly counter-cyclical behavior of labor is another characteristic of our dataset. This suggests dominant wealth effects for large fraction of Turkish households which leads to counter-cyclical labor supply. It is also important to note that in our study, due to data availability problems, labor supply fluctuations stem just from the extensive margin (employment level).Therefore, the data we use may not be capturing all fluctuations in labor supply.

Columns (III) and (IV) of the table summarizes our findings about the volatility of macroeconomic variables. The columns report that, investment is much more volatile than output, while labor supply are about as volatile as output. General pattern for business cycle regularities suggests more volatile consumption than output in emerging economies, which does not hold in our data set. This can be because our consumption data does not include durable goods, which cause lower volatility in consumption. Overall, these statistics show that Turkey's business cycles follow most of the empirical regularities observed in developing countries.

CHAPTER 3

THE MODEL

This chapter starts with describing a prototype small open economy model similar to Lama (2011) and Hevia (2014), then proceed by presenting considered functional forms for the model.

3.1 A Prototype Small Open Economy

The prototype economy is a small open economy with incomplete asset markets and four wedges. Each period, the economy experiences exogenous shocks and the state of the world is given by s^t. The history of the shocks up to (and including time t) is $s^t = (s_0, s_1, ..., s_t)$. The unconditional probability of state s^t is $\pi(s^t)$.

The economy has four exogenous random variables, referred to wedges: (i) the efficiency wedge $A_t(s^t)$, (ii) the capital wedge $\tau_{k,t}(s^t)$, (iii) the labor wedge $\tau_{l,t}(s^t)$ and (iv) the bond wedge $\tau_{b,t}(s^t)$. The prototype economy consists of an infinitely lived representative consumer and a representative producer. Both are price takers in all markets. Defining all quantities in per-capita terms, the consumer maximizes expected lifetime utility over stochastic paths of consumption, $c_t(s^t)$, and hours worked, $l_t(s^t)$, represented by

$$\sum_{t=0}^{\infty} \sum_{s^t} \beta^t (1+\gamma_n)^t u\Big(c_t(s^t), 1 - l_t(s^t)\Big) \pi(s^t) \tag{1}$$

where β is the discount factor and γ_n is the population growth rate. The budget constraint is given by

$$c_t(s^t) + x_t(s^t) + tb_t(s^t) = \Big(1 - \tau_{k,t}(s^t)\Big) v_t(s^t) k_t(s^{t-1}) + \Big(1 - \tau_{l,t}(s^t)\Big) w_t(s^t) l_t(s^t) + T_t(s^t) \tag{2}$$

where $tb_t(s^t)$ defined as

$$tb_t(s^t) = (1+\gamma_n)b_t(s^t) - \Big(1+\tau_{b,t}(s^t)\Big)r_t(s^t)b_{t-1}(s^{t-1}) \tag{3}$$

Here, $tb_t(s^t)$ is total amount of debt and it is assumed that the nation is net debtor (which means tb_t has positive value in each state). $k_t(s^{t-1})$ indicates the capital stock in period t, $x_t(s^t)$ is investment level, $b_{t-1}(s^{t-1})$ is the stock of foreign debt maturing in period t, and $T_t(s^t)$ is a lump-sum transfer. $w_t(s^t)$, $v_t(s^t)$, $r_t(s^t)$ represent the wage rate, the rental rate of capital and the interest rate for bonds, respectively. In the model capital wedge acts like a tax on capital earnings; labor wedge acts like a tax on labor income, and bond wedge affect interest rate for bonds. All the mentioned wedges are positive and distort equilibrium conditions through distorting the prices (v_t, w_t, r_t) in the economy.

Households own the stock of capital and are able to issue one period bonds traded in international financial markets. We assume that all foreign bonds are held by the households. Neumeyer and Perri (2005) assert that the interest rate faced by an emerging economy is the sum of international interest rate plus a country risk spread. Hence, we define the interest rate for bonds as

$$r_t(s^t) = \bar{r} + riskpremium_t(s^t) \tag{4}$$

$$riskpremium_t(s^t) = \psi\Big[exp\Big(b_t(s^t) - B\Big) - 1\Big] \tag{5}$$

where $\bar{r}$ is the world interest rate, B is the steady state level of bonds, and ψ indicates the sensitivity of the risk premium to bonds. The law of motion for capital is defined as

$$(1+\gamma_n)k_{t+1}(s^t) = (1-\delta)k_t(s^{t-1}) + x_t(s^t) - \phi\Big(\frac{x_t(s^t)}{k_t(s^{t-1})}\Big)k_t(s^{t-1}) \tag{6}$$

As explained by Schmitt-Grohé and Uribe (2003) we introduce $\phi(\bullet)$ to match the volatility of investment with it's data counterpart.

The optimality conditions are:

$$-\frac{U_l(s^t)}{U_c(s^t)} = \Big(1-\tau_{l,t}(s^t)\Big)A_t(s^t)F_l(s^t) \tag{7}$$

$$U_{c,t}(s^t) = \beta\Big[\sum_{s^{t+1}|s^t} \pi(s^{t+1}|s^t)U_{c,t+1}(s^{t+1})(1+R_{k,t+1})\Big], \tag{8}$$

where,

$$(1+R_{k,t+1}) = \Big[1-\phi_k'\Big(\frac{x_t(s^t)}{k_t(s^{t-1})}\Big)\Big]\Big[\Big(1-\tau_{k,t+1}(s^{t+1})\Big)\nu_{t+1}(s^{t+1})$$
$$+\frac{1}{1-\phi_k'\Big(\frac{x_{t+1}(s^{t+1})}{k_{t+1}(s^t)}\Big)}\Big]\Big[(1-\delta)-\phi\Big(\frac{x_t(s^t)}{k_t(s^{t-1})}\Big)+\phi_k'\Big(\frac{x_{t+1}(s^{t+1})}{k_{t+1}(s^t)}\Big)\Big(\frac{x_{t+1}(s^{t+1})}{k_{t+1}(s^t)}\Big)\Big]$$

$$U_{c,t}(s^t) = \beta \sum_{s^{t+1}|s^t} \pi(s^{t+1}|s^t)\Big[\Big(1+\tau_{b,t+1}(s^{t+1})\Big)r_{t+1}(s^{t+1})U_{c,t+1}(s^{t+1})\Big] \tag{9}$$

Here, $Eq.(7)$ is the first order condition for the consumption-leisure decision. $Eqs.(8)$ and (9) are the Euler equations for capital and bonds, respectively. Note that to make the model stationary (where, variables have constant growth along the balanced-growth path) all the variables (except interest rate, rate of return for capital and labor input) are detrended by the rate of technological progress.

Firms rent capital and labor from the households to produce goods where the production function is constant returns to scale:

$$y_t(s^t) = A_t(s^t)F\Big(k_t(s^{t-1}),(1+\gamma_z)l_t(s^t)\Big) \tag{10}$$

where γ_z is the growth rate of labor-augmenting technological progress. The producer maximizes profits, $y_t(s^t) - w_t(s^t)l_t(s^t) - \nu_t(s^t)k_t(s^{t-1})$, by setting the marginal products of capital and labor equal to $\nu_t(s^t)$ and $w_t(s^t)$), respectively. The aggregate resource constraint implies that

$$c_t(s^t) + x_t(s^t) + tb_t(s^t) = y_t(s^t) \tag{11}$$

An equilibrium for this prototype economy is a set of (i) prices: $\{w_t(s^t),\ \nu_t(s^t),\ r_t(s^t)\}$ and (ii) allocations: $\{c_t(s^t),x_t(s^t),l_t(s^t),k_t(s^t),b_t(s^t)\}$ that satisfy the optimality conditions $Eqs.(7),(8)$ and (9), the law of motion for capital $Eq.(6)$, the production function $Eq.(10)$ and the resource constraint $Eq.(11)$.

3.2 Functional Forms

Following the business cycle accounting literature for small open economies (Rahmati and Rothert, 2014; Hevia, 2014), we consider a Cobb-Douglas utility function of the following form:

$$U(c_t, 1-l_t) = \frac{[c_t^{\mu}(1-l_t)^{1-\mu}]^{1-\sigma} - 1}{1-\sigma} \tag{12}$$

where σ is coefficient of relative risk aversion and μ represent consumption share in the utility function where it acquires a value between 0 and 1. The production function is given by:

$$A_t F(k_t, l_t) = A_t k_t^{\alpha} l_t^{(1-\alpha)} \tag{13}$$

and the capital adjustment cost function is as follows:

$$\phi\left(\frac{x_t}{k_t}\right) = \frac{a_k}{2}\left[\frac{x_t}{k_t} - \delta - \gamma_n - \gamma_z\right]^2 \tag{14}$$

This specification ensures that the adjustment costs are zero along the balanced growth path.

CHAPTER 4

ESTIMATION AND CALIBRATION

Following chapter begins with describing dataset which is used in the analysis. Section 4.2 explains process of setting values for model parameters, and Section 4.3 talks about estimation of stochastic processes, where we follow the methodology of Chari et al. (2007). The chapter finishes with presenting estimated wedges.

4.1 Data

This part of the paper describes the data that we use for estimating the model. Working age population and employment statistics are obtained from the Turkish Statistical Institute. Labor input is calculated as; *Average Hours Worked * Employment / Total Available Hours* where *Total Available Hours* is *100 * Working Age Population*. Here, following the literature, we assume 100 available hours per week for work or leisure. Available quarterly data for "average weekly hours worked per worker" does not cover the whole sample period for Turkey. Therefore, based on annual average, we set 48 weekly working hours per worker in the dataset. Accordingly, it is important to note that all the labor input variation in our database comes from the extensive margin (employment level). Annual data for average of weekly hours worked is obtained form the International Labor Organization (ILO) website.

National debt data were acquired from the World Bank database. National accounts data for y_t (per-capita GDP), x_t (investment per-capita), nx_t (net exports per-capita) and c_t (total consumption per-capita) were obtained from the OECD Quarterly National Accounts database. All the time series were divided by working population, deseasonalized (if necessary), converted to log level (except for net exports) and linearly detrended.

4.2 Calibration of Parameters

For some of the parameters, we use the standard values from the small open economy literature (Schmitt-Grohé and Uribe, 2003; Lama, 2011). Hence, the risk aversion coefficient, σ, is set to 2; the world real interest rate, $\bar{r}$, is set to 1 percent on a quarterly basis and ψ, the bond elasticity parameter, takes the value 0.0001. The small value for ψ implies, movements in the debt level have a small impact on the *riskpremium*.

Considering Turkey's debt statistics[1], the steady state level of bonds is set to 40 percent of output on an annual base. We follow Tiryaki (2012) and assume that the value for capital share in output, α, is 0.4. The paper estimates α by adjusting to the fact that the published national income accounts are not corrected for the labor income earned by self-employed workers.

Quarterly depreciation rate is calibrated to satisfy the Euler Equation (8) in steady state:

$$\frac{(1+\gamma_z)}{\beta} - \alpha(1-\tau_k)(\frac{y}{k}) = (1-\delta) \tag{15}$$

where based on Penn World Table Database, we target the value 2.4 for the capital/output ratio on an annual basis [2]. We set τ_k to zero at the steady state. Here and throughout the paper, a variable without a time script denotes its steady state level. The technological progress rate, γ_z, and the population growth rate, γ_n, are obtained from the average growth rates during the studied period and set to 0.87 and 0.37 percent on a quarterly basis, respectively.

For the capital adjustment cost as Chari et al. (2007) and Lama (2011) we follow Bernanke, Gertler, and Gilchrist (1999) and choose a value consistent with the price elasticity of capital with respect to the investment-capital ratio equal to 0.25. In the model the price of capital is defined as $q_k = \frac{1}{(1-\phi_k'(\frac{x}{k}))}$, so that we calibrate the parameter a_k based on the steady state condition $\eta_k = a_k(\delta+\gamma_z+\gamma_n)$, where η_k is the price elasticity of capital.

Setting the value of τ_b and *riskpremium* to zero at the steady state, time preference

[1]Total debt data from World Bank reports an annual average of 42 percent for Turkey's debt-to-GDP ratio during 2000-2016

[2]PWT 2015 reports the annual average 2.4 for capital stock to output ratio during 2000—2014 for Turkey

coefficient, β , is calibrated to satisfy;

$$\beta = \frac{(1+\gamma_z)}{\bar{r}(1+\tau_b)} \tag{16}$$

Observing the ratio of time devoted to work, l, and the output-to-consumption ratio, c/y, from the data and assuming that τ_l equals zero at the steady state, we can calibrate the consumption share in the utility function, μ, using the steady-state labor supply condition

$$(1-\alpha)(1-\tau_l)\left(\frac{1-l}{l}\right) = \left(\frac{1-\mu}{\mu}\right)\left(\frac{c}{y}\right) \tag{17}$$

Table 4.1 presents the model parameter values and their sources.

Table 4.1: Model parameters

Definition of the Parameter	Symbol	Value	Source
Coefficient of Risk Aversion	σ	2	Uribe (2003)
Time Preference Coefficient	β	0.9987	Calibration
Capital Share in Output	α	0.4	Tiryaki (2012)
Capital Adjustment Cost	a_k	5.67	Calibration
Consumption Share in U.F.	μ	0.64	Calibration
Rate of Technical Growth	γ_z	0.0087	Data
Rate of Population Growth	γ_n	0.0037	Data
Depreciation Rate	δ	0.03	Calibration
World Interest Rate	$\bar{r}$	0.01	Uribe (2003)
Bond Elasticity Parameter	ψ	0.0001	Lama (2011)

4.3 Estimation of the Stochastic Processes for Wedges

This section describes how we estimate the stochastic processes for the wedges from the data. By construction, all the wedges are calculated in such a way that when fed into the model simultaneously they perfectly fit the data. Following, Chari et al. (2007) we assume that s_t follows a Markov process given by $\pi(s_t|s_{t-1})$. We define state s_t as $s_t = (s_{At}, s_{lt}, s_{kt}, s_{bt})$ and let the wedges as a function of the state be given by $A_t = s_{At}$, $\tau_{lt} = s_{lt}$, $\tau_{kt} = s_{kt}$ and $\tau_{bt} = s_{bt}$.

Estimation of the Markov process is done by the maximum likelihood method using data on output per-capita, y_t, labor per-capita, l_t, investment per-capita, x_t, and total consumption per-capita, c_t. To estimate the stochastic process for the state it is assumed that event s_t follows a first-order vector autoregressive, AR(1), namely

$$s_t = P_0 + P s_t + \varepsilon_{t+1}, \qquad \varepsilon_t \sim (0, \Sigma) \tag{18}$$

where shock ε_t is i.i.d with mean zero and a covariance matrix Σ. To ensure a positive semi definite estimate of Σ , Q the lower triangle matrix is estimated where $\Sigma = QQ'$. The parameters of P_0, P and Σ of AR(1) process underlying the wedges are estimated using maximum likelihood method.

Table 4.2 contains the estimated parameters of the AR(1) stochastic process for Turkey based on maximum likelihood estimation on quarterly data for the period 2000:Q1-2017:Q3. As a check on the estimation results we check that the AR(1) process is stationary.

Table 4.2: Parameters of vector AR(1) stochastic process

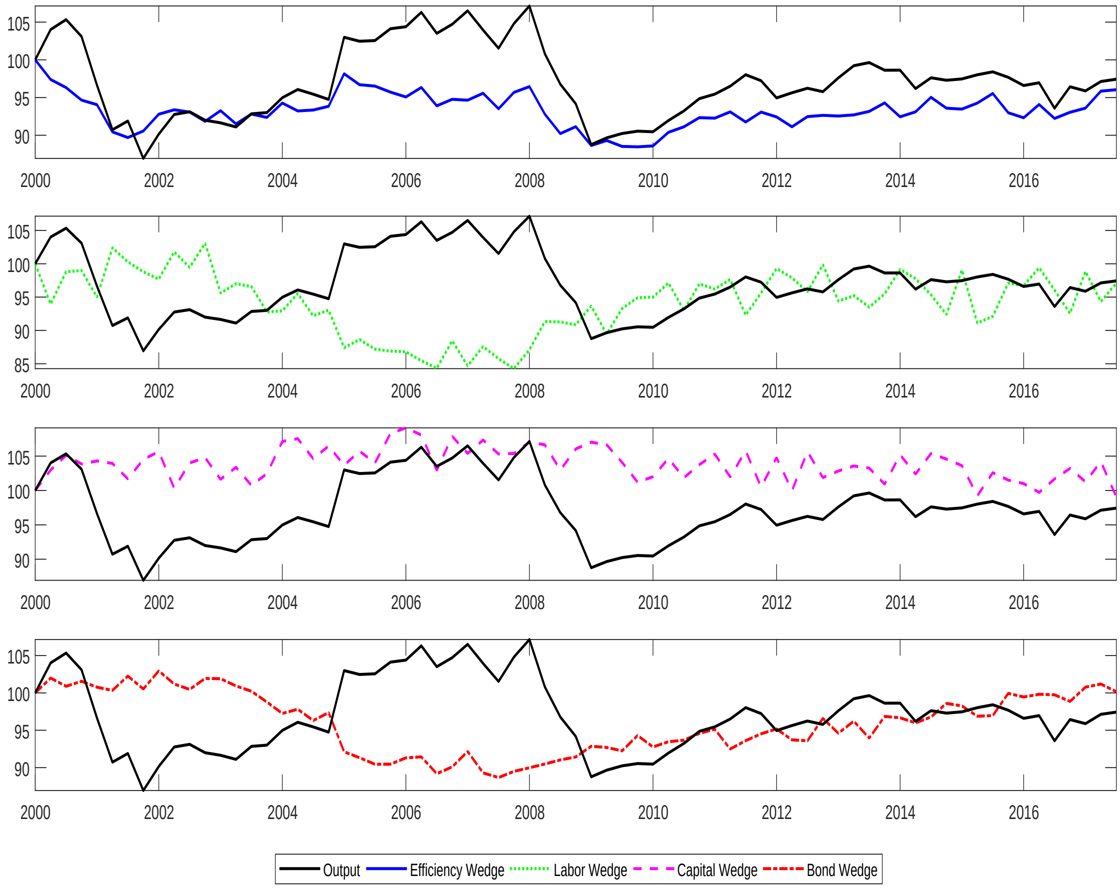
Matrix P on lagged states	Matrix Q where $\Sigma = QQ'$
$\begin{bmatrix} 0.877 & 0.126 & 0.023 & -0.058 \\ -0.071 & -0.145 & 0.156 & 0.394 \\ 0.085 & -0.787 & 0.624 & 0.241 \\ 0.241 & -0.222 & -0.022 & 0.882 \end{bmatrix}$	$\begin{bmatrix} 0.031 & 0.000 & 0.000 & 0.000 \\ 0.002 & 0.081 & 0.000 & 0.000 \\ 0.086 & 0.204 & 0.252 & 0.000 \\ -0.004 & 0.017 & 0.034 & 0.016 \end{bmatrix}$
Matrix P_0 Means of states	
$\begin{bmatrix} -0.001 & 0.069 & 0.047 & -0.013 \end{bmatrix}$	

4.4 Estimated Wedges

Given the parameters, the realized wedges (and model predictions) are estimated via Kalman smoother on the log-linearized model. The Kalman smoother computes the expectation of an unobservable state of a linear state space model conditional on all the information in the sample.

Figure 4.1 reports Turkey's output and estimated wedges in the period 2000:Q1-2017:Q3. Here, output and the wedges are normalized to 100 relative to their values at the beginning of the period. As also seen in the literature, the efficiency wedge is closely associated with output and business cycles. Based on the figure, the capital wedge does not vary too much during the studied period. The bond wedge represent frictions that affect the interest rate (bond's price) in the economy and as presented in the figure it has counter-cyclical pattern. As previously mentioned, estimated labor wedge should refer to set of frictions which are related to the employment status of labor force. The figure suggests that it decreases during the booms (2005-2008) and increases during the busts (2001 and 2009).

Figure 4.1: Evolution of output and wedges



CHAPTER 5

QUANTITATIVE ANALYSIS

In this chapter we apply business cycle accounting method to measure the contribution of each wedge in aggregate fluctuations in Turkey for the period 2000:Q1-2017:Q3. We first analyze properties of the estimated wedges in section 6.1, then in section 6.2 we implement accounting procedure for decomposition of the business cycles.

5.1 Properties of the Wedges

Table 5.1 presents correlations of the wedges with each other and with Turkey's output at various leads and lags. This step helps to find some preliminary expectation about accounting step results. In table 5.1 the wedges were HP-filtered with smoothing parameter of 1600. The column σ_w/σ_y reports the standard deviation of the wedges relative to that of output.

First panel of table 5.1 presents summary statistics of estimated wedges in Turkey. The table contents show that efficiency wedge is highly and positively correlated with output. However, correlation of output with labor, capital and bond wedges are negative, with the labor wedge having the highest negative correlation. Second panel of the table reports cross correlations between the wedges. The results show that the efficiency wedge has a negative correlation with all other wedges and the highest negative correlation is with the labor wedge. Also, the labor wedge and the bond wedge have a high positive correlation.

It is important to consider that, the wedges by themselves do not provide enough information regarding their quantitative importance. As mentioned earlier to examine the relative importance of alternative wedges, we conduct the second step in the business cycle accounting approach which consists of feeding the estimated wedges into the model one by one. We evaluate the individual contributions of the estimated wedges by comparing simulations of the model with data counterpart.

Table 5.1: Properties of the wedges

Panel a: Summary statistics		Cross Correlation of Wedge with Output				
Wedges	σ_w/σ_y	-2	-1	0	1	2
Efficiency	0.547	0.618	0.793	0.942	0.701	0.481
Labor	1.290	-0.514	-0.713	-0.841	-0.669	-0.491
Capital	3.468	-0.336	-0.309	-0.211	-0.029	0.097
Bond	1.913	-0.209	-0.372	-0.412	-0.586	-0.664
Panel b: Cross-correlations		Cross Correlation of X with Y				
Wedges(X,Y)		-2	-1	0	1	2
Efficiency, Labor		-0.436	-0.629	-0.894	-0.598	-0.303
Efficiency, Capital		0.073	-0.181	-0.235	-0.436	-0.304
Efficiency, Bond		-0.570	-0.468	-0.363	-0.294	-0.115
Labor, Capital		-0.207	0.082	0.194	0.295	0.168
Labor, Bond		0.623	0.512	0.472	0.395	0.231
Capital, Bond		0.103	0.009	-0.065	-0.234	-0.387

5.2 Decomposition of Aggregate Fluctuations

Now we turn to the implementation of the accounting method and presentation of the results. This step will be informative regarding the importance of each wedge in aggregate fluctuations. Figure 5.1 shows the output prediction of the model with just one active wedge. The solid black lines represent Turkey's real GDP data. The other lines show the prediction of counter-factual economies in which active wedges are set to their estimated values and inactive wedges are set to their mean values. As before, output and the model predictions are normalized to 100 relative to their values at first quarter of 2000.

Figure 5.1: Output and predictions of the model with just one wedge

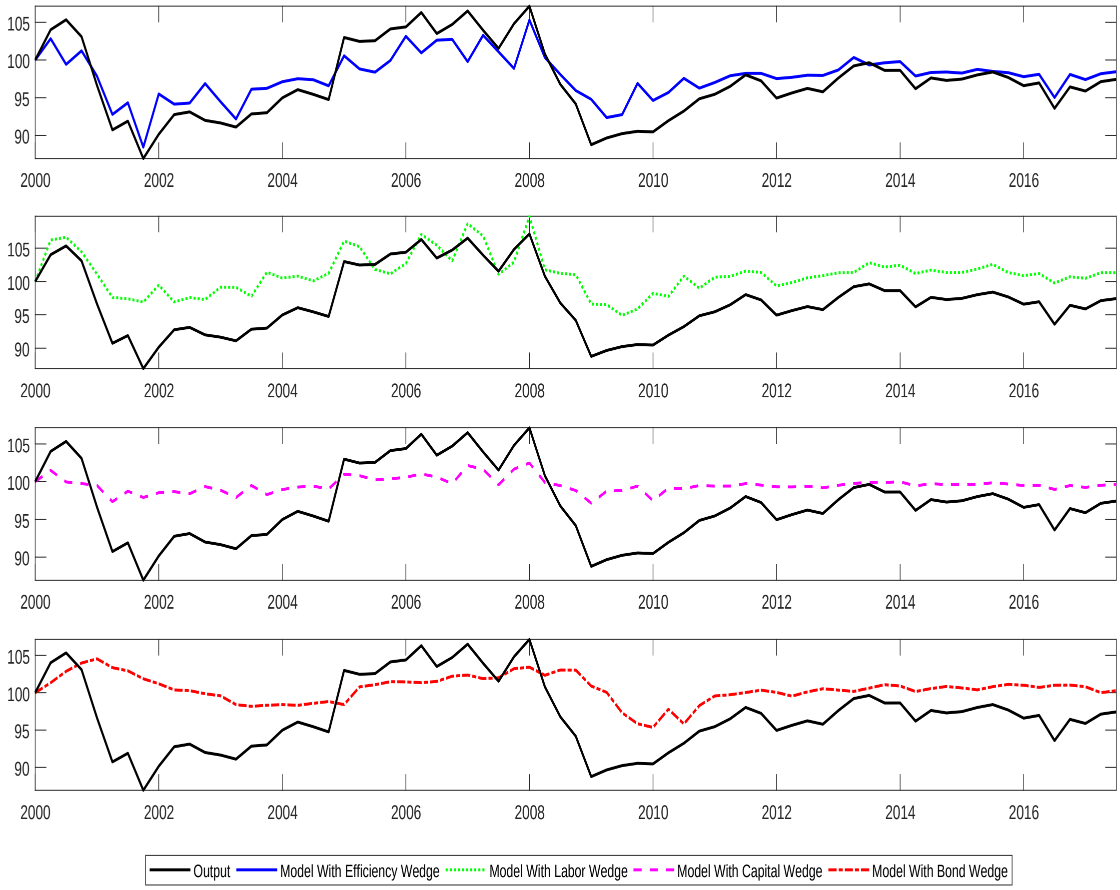


Figure 5.1 shows model with just efficiency wedge matches the evolution of output very closely. The labor wedge also demonstrates relatively high performance in prediction of output movements in Turkey. Capital and bond wedges could not reproduce the output evolution in a reasonable manner. However, the model with only the bond wedge is able to predict the general direction of the GDP fluctuations and has some explanatory power. The results suggest that frictions that impact aggregate efficiency along with the labor market frictions are the main drivers of Turkey's output fluctuations.

Figure 5.2: Labor and predictions of the model with just one wedge

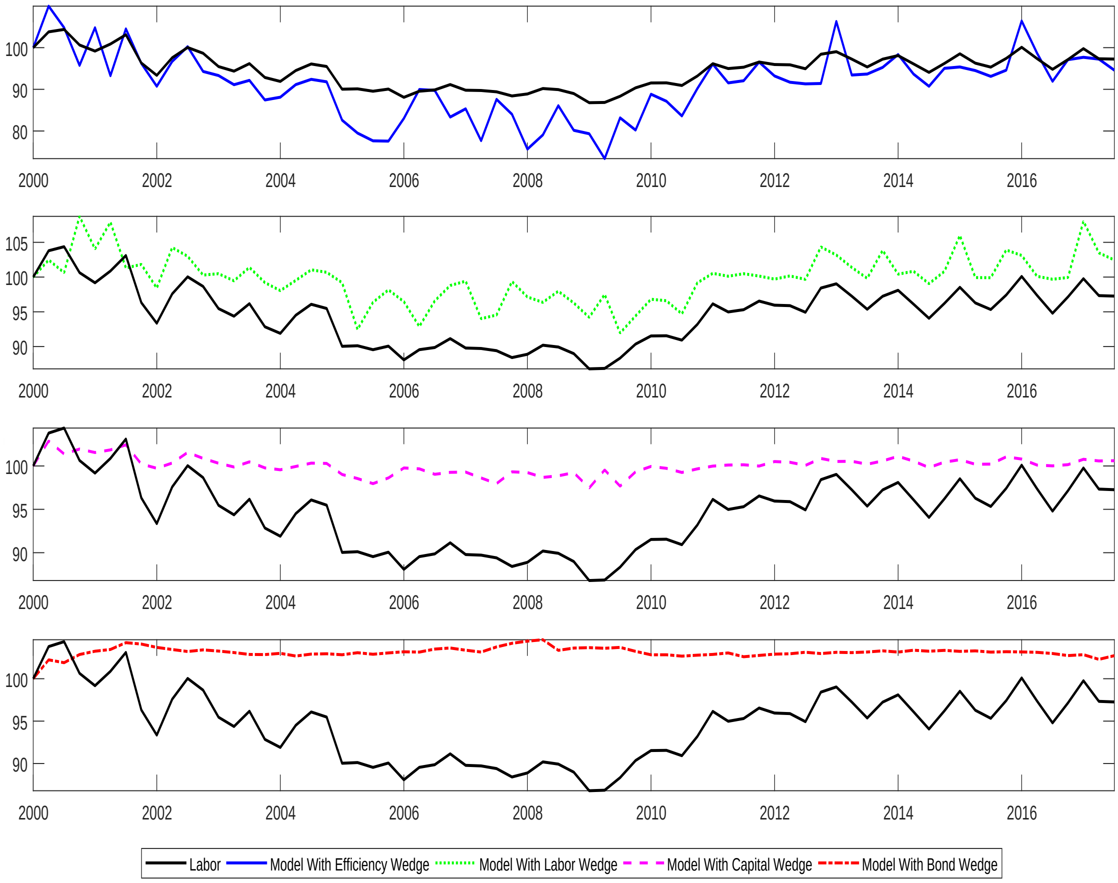


Figure 5.2 presents prediction of labor input with just one active wedge. The figure shows that efficiency and labor wedges are important in explaining the fluctuations in labor, while capital and bond wedges are not able to explain labor dynamics in Turkey. Presented results in figure 5.2 indicate that efficiency and labor wedges are responsible for most of the observed fluctuations in Turkey's labor evolution during the studied period.

Figure 5.3: Investment and predictions of the model with just one wedge

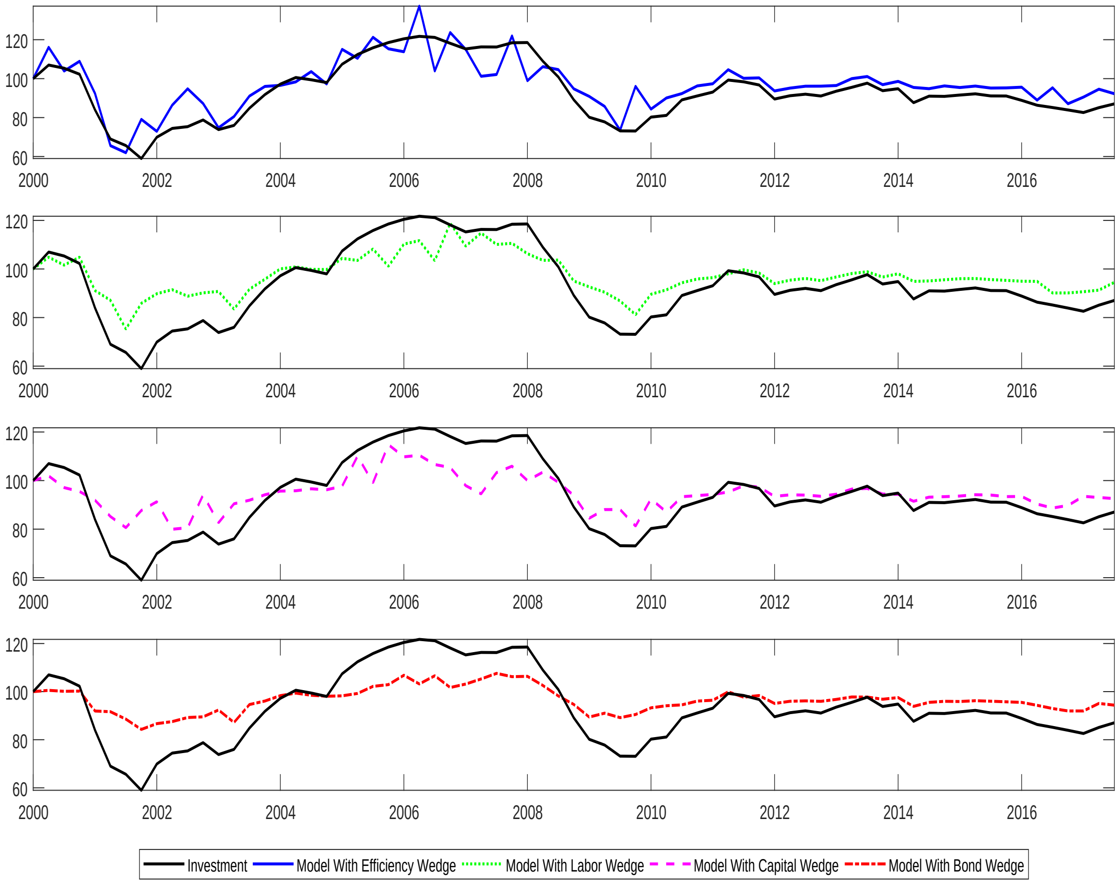


Figure 5.3 shows that the model with efficiency wedge produces a very close match to investment dynamics in Turkey. It is also seen that models with capital and labor wedges can explain the investment dynamics quite well, while the bond wedge can predict the general direction of investment. This part of the decomposition process again points out the efficiency wedge as the main driver of fluctuations in macroeconomic variables in Turkey.

Figure 5.4: Consumption and predictions of the model with just one wedge

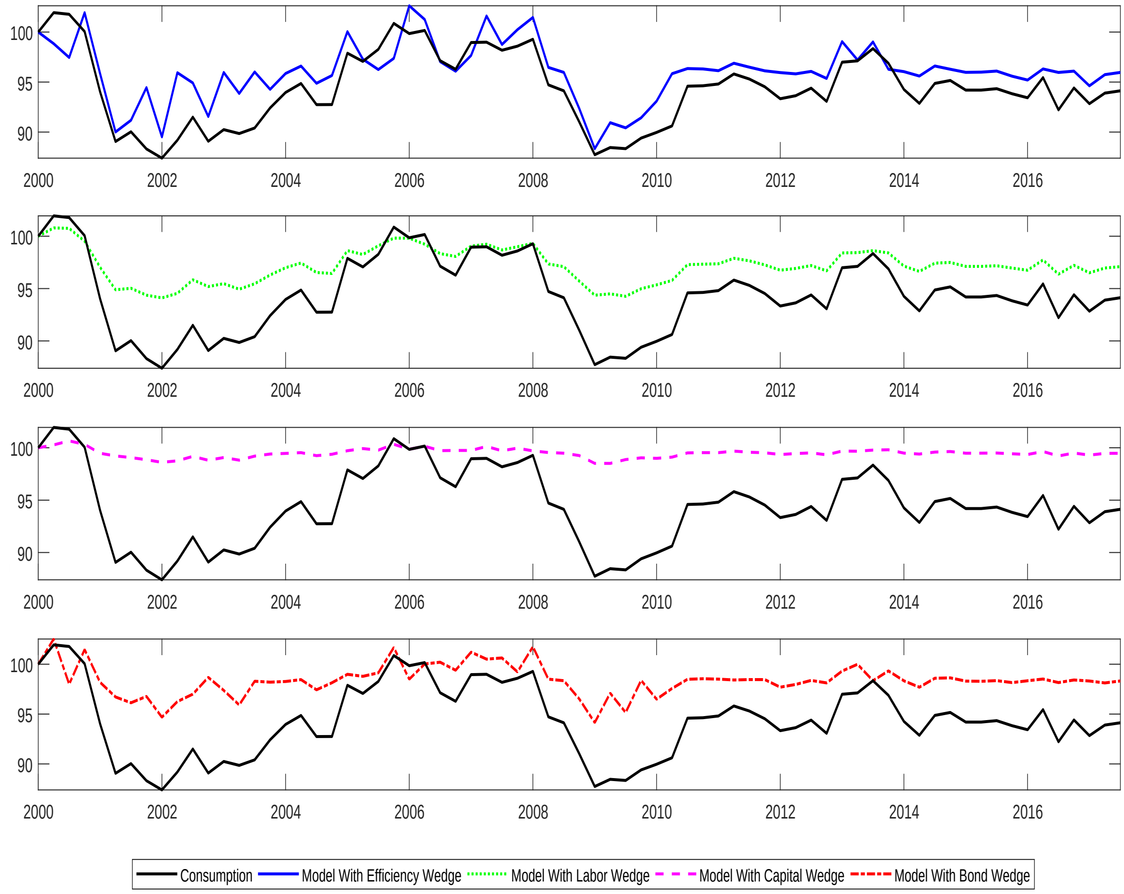


Figure 5.4 displays model performance in prediction of consumption with just one active wedge. Consistent with the previous results, the efficiency wedge is the major source of fluctuations in consumption, while labor and bond wedges also explain the general direction of cyclical patterns. The figure shows that the capital wedge does not have a high explanatory power in consumption movements. As pointed out by the accounting procedure, distortions that are defined under name of efficiency, labor and bond wedges are the main reasons for aggregate consumption fluctuations in Turkey.

To summarize the main findings, the accounting exercise suggests that efficiency and labor wedges are the most important factors for aggregate fluctuations in Turkey. This point is also consistent with previous studies about Turkey (Elgin and Çiçek, 2011; Cho and Doblas-Madrid, 2013). The capital wedge seems to be important for investment dynamics, while the bond wedge is effective in explaining investment and consumption behavior and it has some effect on output movements.

CHAPTER 6

CONCLUSION

For analyzing business cycles in developing economies, Turkey is an interesting case as its economy, particularly in the past two decades, experienced various fluctuations in aggregate variables. In this study, we investigate different forms of macroeconomic frictions to understand the factors that drive business cycles in Turkey in the period 2000:Q1-2017:Q3. For this purpose, following Lama (2011) and Hevia (2014), we define a small open economy model with four (Efficiency, Capital, Labor, and Bond) wedges, where wedges represent general form of frictions which distort the equilibrium conditions of the model. We start by the estimation of the wedges, and then we examine the contribution of each wedge in Turkey's macroeconomic fluctuations using the business cycle accounting method proposed by Chari et al. (2007).

In summary, the accounting procedure shows that efficiency and labor wedges explain most of the aggregate fluctuations in Turkey for the period 2000:Q1-2017:Q3. While the efficiency wedge has an important effect on all variables, the labor wedge seems to be more important for output and labor as opposed to consumption and investment. The accounting procedure also shows that the bond wedge explains a relatively important proportion of fluctuations in consumption and investment although it has a small but nonnegligible role in output dynamics. Decomposition results also reveal that the capital wedge is mainly able to explain investment fluctuations in Turkey and it does not have a major effect on the other variables.

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