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OPTIMAL MONETARY AND FISCAL POLICY MIX FOR PRICE STABILITY AND GROWTH: THE CASE FOR THE TURKISH ECONOMY 2007-2013

by

Nazende ÖZKARAMETE COŞKUN

Supervisor

Prof.Dr. Ferda HALICIOĞLU

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SOSYAL BİLİMLER ENSTİTÜSÜ MÜDÜRLÜĞÜ'NE,

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Prof.Dr Ferda Halıcıoğlu (Başkan)
Yeditepe Üniversitesi

Prof.Dr. Vural F. Savaş
Yeditepe Üniversitesi

Prof.Dr. Cevat Karataş
Yeditepe Üniversitesi

Prof. Dr. Bahri Yılmaz
Sabancı Üniversitesi

Y.Doç.Dr. Vedit İnal
Yeditepe Üniversitesi

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LIST OF ABBREVIATION

BOJ	Bank of Japan
CB	Central Bank
CGE	Computable General Equilibrium Model
CPI	Consumer Price Index
EMS	European Monetary System
EMU	European Monetary Union
EU	European Union
FTPL	Fiscal Theory of Price Level
GDP	Gross Domestic Product
GNP	Gross National Product
IMF	International Monetary Fund
IO	Input Output
KK	Keynes-Klein Model
MS	Muth-Sargent Model
OPTCON	Optimal Control
PB	Phillps-Bergstrom Model
PSBR	Public Sector Borrowing Requirement
PVBC	Present Value of Budget Constraint
SEE	State Economic Enterprise
SPG	Stability and Growth Pact
SMP	Staff Monitored Program
SPO	State Planning Organization
TURKPOL	Turkish Economic Policy Model
UK	United Kingdom
US	United States
VAR	Vector Auto Regression
VAT	Value Added Tax
WJ	Walras-Johansen Model
WL	Walras-Leontief Model
WPI	Wholesale Price Index

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ABSTRACT

During the past two decades financial fragility associated with debt crisis showed the importance of the interaction between monetary and fiscal policies. Price stability has become the principal focus of central banks around the world. Monetary policy will not always to be in a position to control inflation unless supported by fiscal policy. If fiscal policy does not react to government's debt, monetary policy loses the ability to control the price level.

In the theory of quantitative economic policy, macroeconomic policy problems are often considered as problems of optimizing an intertemporal objective function under the constraints of a dynamic system. The optimization process is usually implemented on the basis of some designed algorithms in order to achieve the optimal values of the macroeconomic policy. The selection of the control variables for monetary and fiscal policies along with the macroeconomic target variables varies considerably in the optimization process.

This thesis has attempted to develop an optimal monetary and fiscal policy mix for Turkish economy. Optimal monetary and fiscal policy designs have been initiated and implemented for the Turkish economy over the period of 2007-2013. Optimization experiments have been conducted under fixed and flexible exchange rate regimes. The optimization experiment has been carried out using the optimum control algorithm OPTCON, which is based on a quarterly macroeconometric model of the Turkish economy (TURKPOL). The values of major state variables such as the growth rates of real income (GDP), the inflation rates, the unemployment rates, the budget deficits as percentage of the GDP, the trade balance as percentage of the GDP have been computed for the period of 2007-2013 under the selected constraint variables and the selected exchange rate regime. The simulation results are compared and contrasted to those of the targets of the Turkish state planning organization, the Turkish central bank, and the government's own targets, whichever is appropriate. The results displayed in thesis provide some major important policy lessons and tools for the policy makers and researchers in the field of macroeconomic policy designing.

Keywords: Stabilization, economic policy mix, macroeconometrics, optimization, simulation, Turkey.

ÖZET

Son yirmi yılda finansal kırılganlık ile borç krizinin birlikte ortaya çıkması para ve maliye politikalarının etkileşiminin önemi ortaya çıkarmıştır. Fiyat istikrarı bir çok merkez bankası için temel hedef olmuştur. Bu süreçte para politikası, maliye politikaları ile desteklenmedikçe enflasyonun kontrol edilmesinde zorlanılmaktadır. Uygulanan maliye politikaları kamu borçlarına tepki vermiyorsa, para politikası tek başına fiyat düzeyini kontrol etmedeki yeteneğini kaybedebilir.

Teorik uygulamalı ekonomi politikalarında makroekonomik politika problemleri dönemlerarası amaç fonksiyonunun dinamik sistem kısıtı altında optimizasyon problemidir. Optimizasyon süreci bir algoritma şekillendirilmesi ile optimal makroekonomik politika değerlerine ulaşılması şeklinde uygulanır.Para ve maliye politikaları için seçilen kontrol değişkenlerin, hedef değişkenlerle uyumlu olması gözetilmektedir.

Bu tezin amacı Türkiye için optimal para ve maliye politikası bileşimini değişken ve sabit kur sistemi altında geliştirip, optimal para ve maliye politikası bileşeni 2007-2013 dönemi için hesaplayarak analiz etmektir. Optimizasyon uygulaması OPTCON algoritması ve Türkiye ekonomisi için makroekonometrik model (TURKPOL) kullanılarak gerçekleştirilecektir. Kontrol değişkenler para ve maliye politikalarıdır. Temel durum değişkenler büyüme oranı, enflasyon oranı, işsizlik oranı, bütçe açığı (GSYİH %), cari açık (GSYİH %) olarak belirlenmiştir. OPTCON algoritması kullanılarak bulunan sonuçlar Merkez Bankası, Devlet Planlama Teşkilatı ve yıllık hükümet programında belirlenen hedef değişkenlerle karşılaştırılmıştır. Bu tezden elde edilen sonuçlar, politika yapıcıları ve araştırmacılar için politika aracı olarak kullanılabilecektir.

Anahtar Sözcükler: Optimal ekonomi politikaları, makroekonometrik model

CHAPTER 1: Introduction

The term stabilization policy has been used to describe the use of monetary and fiscal policies to smooth business cycle fluctuations. These policies generally encompass discretionary changes in both fiscal and monetary policies. Monetary and fiscal policies can moderate the business cycle by offsetting changes in aggregate demand that would otherwise cause inflationary pressures or weaker economic activity.

Fiscal policy generally refers to the government's choice regarding the use of taxation and government spending to regulate the aggregate level of economic activity. The use of fiscal policy entails changes in the level or composition of government spending or taxation. In a Ricardian fiscal policy regime, primary budget balances are expected to react to government debt in order to ensure fiscal solvency. In a Ricardian regime, monetary authorities are active as the government has to attain primary budget surpluses. In a non-Ricardian fiscal regime the treasury does not commit itself to match the new government debt completely with future taxes since some part of the new debt is to be financed through money. A Ricardian regime is labeled as a regime of monetary predominance since money demand and money supply determine the price level. The non–Ricardian regime is labeled a regime of fiscal predominance as prices are endogenously determined by the government budget constraints.

Monetary policy refers to the central bank`s control of the monetary aggregates in the economy to achieve the broad objectives of the economic policy. This control can be exerted through the monetary system by operating on such aggregates as the money supply, the level and the structure of interest rates, and other conditions affecting credit in the economy. The most important objective of the central bank is to maintain price stability; however, there may be other objectives such as economic growth, exchange rate stability and maintaining financial stability.

Monetary policy discussions in the 1960s, 1970s and early 1980s generally ignored the importance of fiscal policy. During the 1980s, the financial fragility associated with debt crisis showed the importance of the interaction between monetary and fiscal policies. The collapse of European Monetary System (EMS) in 1992, the 1994-95 Mexican crisis, the Turkish crises in 1994 and 2001 and subsequent crises in emerging markets motivated several countries to abandon their predetermined exchange rate systems in favor of a flexible exchange rate system. The flexible exchange rate system is beneficial for the central banks to implement the monetary policy with price stability as its primary objective. After the 1990s, some developed and emerging market economies began to use inflation-targeting as a monetary policy strategy.

During the past two decades, the maintenance of low inflation “price stability” has become the principal focus of central banks around the world. If fiscal policy does not react to the government’s debt, monetary policy loses the ability to control the price level or the real interest rate.

Defining price stability involves deciding between price level stability and low (including zero) inflation. This policy approach requires choosing the appropriate price index and selecting the appropriate level of a quantitative target. It also involves deciding on the role of real variables, like output, in the objectives for monetary policy. Thus, defining price stability boils down to defining the monetary policy loss function as discussed in Svensson (1999).

Sargent and Wallace (1981) argues the link between fiscal and monetary policies and suggests that monetary policy will not always to be in a position to control inflation unless supported by fiscal policy. They also point out that the monetarist arithmetic might be misleading as it ignores the fact that governments are constrained by their intertemporal government budget. According to them, a tight monetary policy may lead to an unsustainable debt financing process and higher inflation in the long run. Within this framework inflation is a fiscal driven monetary phenomenon and nominal monetary growth is endogenously determined to finance the exogenously given deficit to satisfy the budget constraint.

Woodford (2001) asserts that a central bank maintaining price stability cannot be indifferent to how fiscal policy is used. Woodford emphasizes the interaction between monetary and fiscal policy and stresses the effects of monetary policy on the real value of government debt through its effects on the price level, given that the public debt is issued in nominal terms.

Fiscal policy can affect monetary policy directly and indirectly. An expansionary fiscal policy may result in excessive fiscal deficits which may cause to monetary financing by the central banks. An expansionary fiscal policy then leads to an expansionary monetary policy which causes inflationary pressures. This leads to a possible real appreciation of the currency and balance of payments difficulties. Those difficulties can potentially result in a currency and/or banking crisis. Governments may finance their deficits in a non-monetary way and this will cause crowding–out, which may harm economic development and growth. On the external side, there is the risk that excess dependence on foreign funding for domestic debt may result in exchange rate and /or balance of payments risks. The other way in which fiscal policy affects monetary policy is the impact of indirect taxes on the price level. The substantial increases in indirect taxes, sales taxes, and value-added taxes will have direct impacts on prices.

In addition to these direct relationships between fiscal and monetary policy, there are indirect channels through expectations. Perceptions and expectations of large and on-going budget deficits and resulting large borrowing requirements may trigger a lack of confidence in the economic prospects. A lack of confidence in the sustainability of the financial position of the government may become a potential destabilizing factor in bond and foreign exchange markets, which leads to a collapse of the monetary regime.

Sargent and Wallace (1981) emphasize the monetary policy implication of the government budget constraint. High government deficits and debt raise the real interest rate to a level above the growth rate of the economy and the monetary policy aimed at reducing the rate of inflation can have perverse effects and actually increase inflation. Given a particular level of the budget deficit, a decrease in money growth today designed to reduce inflation, will increase the amount of debt relative to the GDP because bond financing replaces monetary financing. This will raise interest payments and the size of the future budget deficits relative to GDP which requires more money growth and higher inflation in the future.

The interactions between monetary policy and fiscal policies identify three sets of issues that have been modeled in the theoretical literature: composition effects, the implications of fiscal solvency and the problems stemming from coordination failures and strategic interactions.

The first set of monetary and fiscal policy interactions is through its effect on the composition of output. The monetary and fiscal policy mix influences the level of real interest rates, the level of investment and government spending. In addition, movements in interest rates will have implications for the exchange rate. This will affect export and import performance. The formalization of this analysis is the IS-LM model. In a static, closed-economy classical model not characterized by Ricardian equivalence, an increase in real government expenditures requires some combination of increased saving and decreased investment (crowding-out) in order to restore equilibrium between savings and investment. The strength of the crowding-out effect will depend on the magnitude of the saving response, access to foreign sources of funds, and the degree of substitutability between bonds and capital in investors' portfolios. By reducing the real interest rate, expansionary monetary policy can, at least in the short-run, offset some of the crowding out at a cost of higher inflation.

A second set of monetary–fiscal policy interactions stems from the implications of the government`s intertemporal (present value) budget constraint. Every fiscal policy action involving an increase in the current budget deficit must be financed either through an increase in future tax revenues or through an erosion in the value of nominally-denominated government liabilities, such as money. This may involve seignorage policy to finance deficits. The intertemporal fiscal balance could be restored through an increase in the price level and reduce the value of outstanding government liabilities if there is no explicit monetary response. The model where intertemporal government budget determines the price level is called as Fiscal Theory of Price Level (FTPL). FTPL argues that the requirements for rational expectations equilibrium to be obtained in a standard model of monetary economy are stricter than is often acknowledged. FTPL demonstrates that prices and output may indeed be influenced strongly by fiscal policy.

Sargent-Wallace (1981) explores the effects of fiscal conditions on optimal monetary policy. In their set-up, the sequence of government expenditures is given exogenously. The problem of the government is to choose the optimal combination of wage taxes, seignorage and debt issuance to finance those expenditures and satisfy the intertemporal budget constraint, for a given initial level and maturity structure of nominal debt obligations.

Leeper (1991) explores the way in which government`s intertemporal budget constraint affects the conduct of monetary policy. Leeper focuses on the interaction of the rules characterizing the behavior of the monetary and fiscal authorities. Leeper makes a distinction between "active" and "passive" policies. The passive or Ricardian policymaker is constrained by the requirement of the satisfaction of intertemporal budget constraint. A passive fiscal policy responds to higher debt levels with tax increases sufficient to balance the intertemporal budget. An active fiscal policy determines tax and spending levels without regard for any intertemporal budget considerations. An active monetary policy pursues its inflation target independent of any fiscal considerations. A passive monetary policy sets interest rates in such a way as to ensure intertemporal fiscal balance.

The third set of considerations arises in models with distinct monetary and fiscal authorities, the possibility of non-cooperative behavior between the two. The two authorities' goals may be in conflict. One source of tension stems from differences in inflation and output targets, and/or the weights on those targets. Another source is the monetary authority's presumed neglect of any costs associated with tax collection or spending. Barro and Gordon (1983) and Dixit and Lambertini (2002) point out the strategic interaction between fiscal and monetary authorities with different loss functions. This thesis will not study the strategic interaction between fiscal and monetary authorities, but rather assumes that an authority jointly sets the optimal monetary and fiscal policies.

The principle aim of this thesis is to develop an optimal monetary and fiscal policy mix for the Turkish economy. Optimal monetary and fiscal policy designs will be presented for the Turkish economy over the 2007-2013 periods. An optimization experiment will be conducted under the fixed exchange rate regime and the flexible exchange rate regime. The optimization experiment is carried out using the optimum control algorithm OPTCON and a macroeconometric model of the Turkish economy (TURKPOL).

It is assumed that Turkish policy makers aim at high GDP growth rate, low inflation rates and low unemployment rates, balanced budget and low current account deficit over the optimization horizon from 2007 to 2013.

The first part of the thesis will concentrate on the literature regarding the interactions between fiscal and monetary policies which can be studied in three different ways. The first approach is related to the coordination of monetary and fiscal policy, especially in the context of EMU. The second approach is the optimal monetary and fiscal policy. The last approach looks at the channels through which the fiscal actions affect monetary variables and focuses on the constraints imposed by fiscal policy on the monetary authority.

The second part of the study will analyze the interaction between monetary and fiscal policy from a theoretical point of view. In this sense, three models will be explained. In the first model, the price level or inflation rate will be determined without reference to fiscal solvency. The second model shows how monetary policy may be influenced by the fiscal solvency of the public sector. Lastly, a more recent approach, the fiscal theory of price level (FTPL) will be summarized. FTPL argues that prices and output may be strongly influenced by fiscal policy and the government's present value budget constraint determines the equilibrium price level. The distinction between Ricardian and non-Ricardian policy regimes will also be explained in this part of the thesis.

The third part of the thesis is reserved for the stabilization programs of the Turkish economy after 1980s. Turkey experienced very severe economic crises in early 1994 and 2001 due to unsustainable fiscal balances, the collapse of the domestic debt markets (banking system), monetization and the expectation of further monetization. This part will explain the disinflation programs in Turkey over the 1980-2006 periods. Persistent inflation, populist cycles, crises and volatile growth rates have been the dominating macroeconomic issues during the last 25 years of the Turkish economy. Fiscal imbalances, current account deficits and high inflation rates were features of the economy. Several stabilization programs were implemented under the guidance of the IMF to restore stability in the economy. In all stabilization programmes, the importance of fiscal discipline was emphasized. However, the policies to attain fiscal discipline were delayed or abandoned because of the lack of political commitments and structural deficiencies in the process of implementing these policies in Turkey.

The fourth part of the thesis will present a macroeconometric model. This part of the study presents the specification and estimation of a macroeconometric model for Turkey (TURKPOL; Turkish Economic Policy Model). It consists of 13 behavioral equations. The TURKPOL model combines Keynesian and neoclassical elements. The model is based on Keynesian macroeconomic theory in the sense of conventional IS-LM, aggregate demand-aggregate supply models. The supply side incorporates neoclassical features. The model contains behavioral equations for consumption, investment, export, import, money demand, interest rate, exchange rate, labor supply, labor demand, wage and consumer price index. The macroeconometric considers the money market, foreign exchange market, factor market and the goods markets. The public sector contains equations for net tax revenues and government expenditures on goods and services. Expectations are assumed to be adaptive. This is modeled by using the partial-adjustment dynamic specification that includes the lagged dependent variable in almost all behavioral equations. The inclusion of lags is also justified by the existence of adjustment costs. The model is based on quarterly data and the model is better able to take into account short-term developments in key variables. The macroeconometric model for Turkey is estimated with quarterly data over the 1987-2006 periods and the estimation results of the macroeconometric model is used as an input for the OPTCON algorithm.

The fifth part of the thesis is reserved for the optimal control, which is a formulation of dynamic optimization problems. It focuses on one or more control variables that serve as the instruments of optimization. Its aim is to find the optimal time path for the control variables.

In the theory of quantitative economic policy, macroeconomic policy problems are often considered as problems of optimizing an intertemporal objective function under the constraints of a dynamic system. The OPTCON algorithm will be used for the optimal values of the macroeconomic policy. In this case, the controls are monetary and fiscal policy variables, and the states are macroeconomic target variables. The major state variables are growth rate of the real GDP, inflation rate, unemployment rate, budget deficit as a percentage of the GDP, trade balance as a percentage of the GDP. The OPTCON algorithm has been implemented in the statistical programming system "GAUSS". This thesis is the first study which uses the OPTCON algorithm for the Turkish economy.

The optimal monetary and fiscal policy mix for Turkish economy will be presented for the next seven years (2007-2013) under a fixed exchange rate regime and a flexible exchange rate regime. The optimum values of the growth rate, inflation rate and unemployment rate that are calculated by OPTCON algorithm will be compared to the targeted or proposed in the ninth development plan of Turkey.

The last part of the thesis will be devoted to the conclusions and policy recommendations.

The contributions of the thesis into the existing knowledge of the literature are summarized under the following topics:

i. An extensive and up to date literature survey on the interaction between monetary and fiscal policies in three different approaches is presented with own critical analyses and views.
ii. The stabilization programmes of the Turkish economy for 1980-2006 period is outlined and analyzed with particular references the macroeconomic instability process.
iii. A quarterly macroeconometric model for the Turkish economy for the 1987-2006 period is designed and implemented. The macroeconometric model includes the equations for consumption, investment, exports, imports, money demand, interest rate, exchange rate, labor demand, labor supply, tax revenues and government expenditures. Estimated values of parameters, covariance matrix of parameters and covariance matrix of error terms are used in the optimal control problem.
iv. The thesis provides several policy simulations for optimal monetary and fiscal policy mix under fixed exchange and flexible exchange rate regimes. The optimal values of growth rate, inflation rate and unemployment rate are computed with the OPTCON algorithm over the periods of 2007-2013.
v. The OPTCON algorithm is designed and implemented in this thesis which has not been used before for the Turkish economy. This algorithm can be modified and utilized for the researchers in this field for further economic policy simulations.

CHAPTER 2: Literature Survey

2.1 Introduction

This part of the thesis will examine the literature concerning the interaction between monetary and fiscal policy. The economic literature on the interaction between monetary and fiscal policy can be studied in terms of three different approaches. The first approach is the channels through which the fiscal actions affect monetary variables and focuses on the constraints imposed by fiscal policy on the monetary authority. The second approach is the optimal monetary and fiscal policy mix and the last approach is related to the coordination of monetary and fiscal policy especially in the context of the European Monetary Union (EMU). This part of the thesis will refer to all of these three approaches.

2.2 The Government Budget Constraint and Monetary Policy

The first set of monetary and fiscal interactions stems from the implications of the government's intertemporal (present value) budget constraint. Every fiscal policy action involving an increase in the current budget deficit must be financed through an increase in either future tax revenues or the value of nominally denominated government liabilities, such as money. This is the "unpleasant monetarist arithmetic" of Sargent and Wallace (1981). The study of Sargent and Wallace (1981) is briefly summarized because it is the first study which mentions the interaction between monetary and fiscal policy.

Sargent and Wallace (1981) define an economy that satisfies monetarist assumptions. The monetarist economy has two characteristics: the monetary base is closely connected to the price level and the monetary authority can raise seignorage. Under certain circumstances, the monetary authority's control over inflation in a monetarist economy is very limited even though the monetary base and the price level remain closely connected. They demonstrate that when monetary and fiscal policies are coordinated in a certain way and the public`s demand for interest–bearing government debt has a certain form. The public`s demand for interest bearing government debt (government bonds) constrains the government of a monetarist economy in at least two ways. One way the public's demand for bonds constrains the government is by setting an upper limit on the real stock of government bonds relative to the size of the economy. The second way is by affecting the interest rate the government must pay on bonds. The extent to which these constraints bind the monetary authority and thus possibly limit its ability to control inflation permanently partly depends on the way fiscal and monetary policies are coordinated.

The first possibility is that the monetary policy dominates fiscal policy. The monetary authority independently sets monetary policy, for example announcing growth rates for base money for the current period and all future periods. By doing this, the monetary authority determines the amount of revenue it will give the fiscal authority through seignorage. The fiscal authority then faces the constraints imposed by the demand for bonds since it must set its budgets so that any deficits can be financed by a combination of the seignorage chosen by the monetary authority and bond sales to the public. With such a coordination scheme, the monetary authority can permanently control inflation in a monetarist economy because it is completely free to choose any path for base money.

The second possibility is that the fiscal policy dominates monetary policy. The fiscal authority independently sets its budgets, announcing all current and future deficits and surpluses, thus determining the amount of revenue that must be raised through bond sales and seignorage. In this situation, the monetary authority faces the constraints imposed by the demand for government bonds, for it must try to finance with seignorage any discrepancy between revenue demanded by the fiscal authority and the amount of bonds that can be sold to the public. Although such a monetary authority might still be able to control inflation permanently, it is less powerful than a monetary authority under the first possibility. If the fiscal authority's deficits cannot be financed solely by new bond sales, then the monetary authority is forced to create money and tolerate additional inflation.

In this second situation, where the monetary authority faces the constraints imposed by the demand for government bonds, the form of this demand is important in determining whether or not the monetary authority can control inflation permanently. For example, suppose that the demand for government bonds implies an interest rate on bonds greater than the economy`s rate of growth. Then, if the fiscal authority runs deficits, the monetary authority is unable to control either inflation or the growth rate of the monetary base.

The monetary authority`s inability to control inflation permanently under these circumstances follows from the arithmetic of the constraints it faces. Being limited simply to dividing the government debt between bonds and base money and getting no help from budget surpluses, a monetary authority trying to fight current inflation can only do so by holding down the growth of base money and letting the real stock of bonds held by the public grow. If the principal and interest due on these additional bonds are raised by selling still more bonds, so as to continue to hold down the growth in the base money, then because the interest rate on bonds is greater than the economy`s growth rate, the real stock of bonds will grow faster than the size of the economy. This cannot go on forever, since the demand for bonds places an upper limit on the stock of bonds relative to the size of the economy. Once that limit is reached, the principal and interest due on the bonds already sold to fight inflation must be financed, at least in part (seignorage) requiring the creation of additional base money. Sooner or later, in a monetarist economy, the result is additional inflation.

Leeper (1991) extends the Sargent and Wallace analysis to the stochastic environment and explains the monetary and fiscal policy interactions in a stochastic maximizing model. Policy is active or passive depending on its responsiveness to government debt stock. Leeper couches active and passive policy in terms of the constraints a policy authority faces. An active authority pays no attention to the state of government debt and is free to set its control variable as it sees fit. A passive authority responds to government debt shocks. Its behavior is constrained by private optimization and the active authority's actions. Leeper analyzes the stochastic equilibria produced by a class of monetary and fiscal policy rules suggested by actual policy behavior. The monetary authority sets the nominal interest rate as a function of the current inflation rate and the fiscal authority chooses a level of direct taxes that depends on the quantity of real government debt held by the public.

Dahan (1998) uses an IS-LM framework to examine the budgetary implications of monetary policy measures. The study outlines the channels of influence that tight monetary policy and consequent higher interest rate have on the budget deficit: price, expenditure, revenue, debt, seignorage, sterilization and swapping effects. Each single effect could be small yet the overall effect of the monetary policy on the budget deficit could be relatively large. The overall impact of monetary policy measures on the budget deficit relies also on the political economy game between the government and the central bank. That game is crucial for the degree of credibility and plays a major role in determining the size of the budgetary cost. The revenue and the debt effect depend negatively on the degree of credibility whereas the sterilization effect depends positively on the degree of credibility. It is important to point out that the flow effects are accompanied by a stock effect. A higher domestic interest rate may affect the budget deficit through the cost of servicing the public debt (the debt effect) although, at the same time it tends to reduce the market value of domestic debt of the central government.

Giannitsarou and Scott (2006) analyze the inflation implications of rising government debt. They apply a log linearised version of the intertemporal budget constraint to consider the government's fiscal position. They tried to answer three questions: Is current fiscal policy sustainable? How have OECD governments financed their fiscal deficits in recent decades? What are the implications for inflation of the expected rising deficits? They answer the first question by estimating a measure of current fiscal imbalance for each country (the US, Japan, Germany, the UK, Italy and Canada) VAR methodology. They defined the fiscal imbalance as the ratio between current liabilities and the primary deficit. For all countries, the current measure for this imbalance was within the historical range of variation suggesting that current policies are sustainable, with the possible exception of Japan. They analysed how in previous years governments had achieved fiscal balance using the log linearised version of the intertemporal budget constraint. They found an overwhelming role for changes in the primary surplus with a minor role for inflation, growth and interest rate effects. They also found that fiscal imbalances had only a very weak forecasting role for future inflation at nearly all horizons, with some mild evidence that fiscal imbalances could help predict inflation three to four years ahead. For the period under consideration (1960-2005) and for the US, Japan, Germany, the UK, Italy, and Canada fiscal imbalances are mostly removed through adjustments in the primary deficit (80-100%), with less important adjustments through inflation (0-10%) and GDP growth (0-20%). The relationship between fiscal imbalances and inflation suggests extremely modest statistical interactions between the two, implying that widely anticipated increases in fiscal deficits due to demographic factors are not necessarily predictors of higher future inflation.

Baig et al., (2006) examine the two main aspects of the interaction between fiscal and monetary policy in emerging market economies. Their study first explores the interest rate-inflation relationship in economies with different levels of external and domestic debt using panel-and cross-section data. The analysis of the interest rate inflation in emerging economies with different levels of debt suggests that monetary policy efficacy is weaker with higher levels of overall and external public debt. They utilize high frequency data from Brazil, Turkey and Poland to examine how market-determined variables react to economic news. They show that when vulnerabilities are high, budget news has the most significant impact on spreads and the interest rate and the impact of the monetary policy is weakened. This effect is seen clearly for Turkey during 2001 and 2002, but not when subsequent data are added to the regressions. Their interpretation for this evidence of reduced fiscal dominance over time is that Turkey`s vulnerabilities had been significantly reduced by 2003, and thus fiscal news was no longer having a disproportionate impact on the conduct of monetary policy.

Benhabib and Eusepi (2005) study the emergence of multiple equilibria in models with capital and bonds under various monetary and fiscal policies. They consider two different fiscal policies. The first one is a balanced budget rule that keeps the total amount of real debt constant. The second is a fiscal rule requiring taxes to respond to deviations of real bonds from a target that is normalized to zero. The second fiscal rule can be passive or active. In the passive case, the growth rate of government debt is lower than the real interest rate. This implies that the government sets fiscal policy to satisfy its intertemporal budget constraint. In the active case, the government conducts fiscal policy disregarding the effects on its intertemporal budget constraint so that other variables such as the price level need to be adjusted to guarantee the solvency of the fiscal authority. An active policy rule might not be sufficient to achieve the inflation target and stabilize the economic system. In fact, multiple equilibria may arise once the global dynamics of the model are taken into consideration. Benhabib and Eusepi (2005) consider two cases: First they discuss the model with capital abstracting from the fiscal authority; i.e. no government liabilities and no taxation. Second, they consider the model with the government and without capital accumulation. Their results indicate that, unless extreme monetary and fiscal policies are adopted, a policy rule that responds only to actual inflation can lead to welfare reducing outcomes.

Zoli (2005) analyses how fiscal policy affects monetary policy in emerging economies. The study conducts a test for fiscal dominance by using VAR methodology and finds that the evidence points clearly to a regime of fiscal dominance in the case of Argentina and Brazil during the 1990s and early 2000s. For Colombia, Mexico, Thailand and Poland the results are mixed. The paper estimated the monetary authority`s reaction function for seven emerging market economies (Brazil, Argentina, Chile, Colombia, Mexico, Poland and Thailand). The results reveal that in the countries under consideration the conduct of monetary policy is not directly affected by the fiscal stance.

2.3 Optimal Monetary and Fiscal Policy Mix

David et al., (2004) consider the implications of monetary and fiscal policy switching for two empirical issues. First, the price puzzle that plagues monetary VAR is a natural outcome of periods when monetary policy fails to obey the Taylor principle and taxes do not respond to the state of government indebtedness. Second, the dynamic correlations between fiscal surpluses and government liabilities which have been interpreted as consistent with Ricardian Equivalence can be produced by an underlying equilibrium that is non-Ricardian. A computational model illustrates that because agents's decision rules embed the probability that policies will change in the future, monetary and tax shocks always produce wealth effects. When it is possible that fiscal policy will be unresponsive to debt at times, an active monetary policy (like a Taylor rule) in one regime is not sufficient to insulate the economy against tax shocks in that regime and it can have the unintended consequence of amplifying and propagating the aggregate demand effects of tax shocks.

Schmitt-Grohe and Uribe (2004) compute optimal monetary and fiscal policy in a real business cycle augmented with sticky prices, a demand for money, taxation and stochastic government consumption. They consider simple policy rules that the nominal interest rate is set as a function of output and inflation, while taxes are set as a function of total government liabilities. They found that the size of the inflation coefficient in the interest rate rule plays a minor role for welfare. It matters only insofar as it affects the determinancy of equilibrium. Their second finding is that optimal monetary policy features a muted response to output and interest rate rules which feature a positive response of the nominal interest rate to output can lead to significant welfare losses. Their last finding is that the optimal fiscal policy is passive whereas the welfare losses associated with the adoption of an active fiscal stance are negligible.

Benassy (2003) studies how the conduct of fiscal policy interacts with the choice of optimal monetary rules by a central bank. The study considers a non-Ricardian model with nondistortionary fiscal policies and compares two policy packages, one where fiscal and monetary policies are simultaneously optimized and the other where monetary policy optimized under a given fiscal policy. The results of the study would not appear in the traditional Ricardian framework for two reasons. First of all, the optimal monetary rule may be activist when fiscal policy is kept inactive whereas it is becomes non-activist when fiscal policy is optimized. Secondly, combining optimally fiscal and monetary policies may lead to far superior outcomes even when the government is allowed to react to much less information.

Chari and Keheo (1999) provide an introduction to optimal fiscal and monetary policy using the primal approach to optimal taxation. This approach characterizes the set of allocations that can be implemented as a competitive equilibrium by distorting taxes with two simple conditions: a resource constraint and an implementability constraint. The implementability constraint is the consumer budget constraint in which the consumer and the firm first–order conditions are used as substitutes for prices and policies. The optimal allocations are solution to a simple programming problem. They refer to this optimal tax problem as the Ramsey problem and to the solutions and the associated policies as the Ramsey allocations and policies. They use the primal approach to address how fiscal and monetary policy should be set over the long run and over the business cycle. They study optimal fiscal and monetary policy in variants of neoclassical growth models. This analysis leads to four substansive lessons for policymaking: (i) capital income taxes should be high initially and then roughly zero (ii) tax rates on labor and consumption should be roughly constant (iii) state-contingent taxes on assets should be used to provide insurance against adverse shocks (iv) monetary policy should be conducted so as to keep nominal rates close to zero.

Benigno and Woodford (2003) propose an integrated treatment of the problems of optimal monetary and fiscal policy for an economy in which prices are sticky and the only available sources of government revenue are distorting taxes. They show how a linear-quadratic policy problem can be derived to yield a correct linear approximation to the optimal policy rules from the point of view of the maximization of expected discounted utility in a dynamic stochastic general equilibrium model. They find that variations in the level of distorting taxes should be chosen to serve the same objectives as those emphasized in the literature on monetary stabilization policy: stabilization of inflation and the output gap. Their conclusion that monetary policy should take into account the requirements for government solvency does not imply anything as strong as the result of Chari and Keheo (1999) for a flexible–price economy with government debt according to which surprise variations in the inflation rate should be used to completely offset variations in fiscal stress so that tax rates need not vary (other than as necessary to stabilize the output gap). The tradeoff between variations in inflation and in the output gap depends not only on the way these variables are related to one another through the aggregate-supply relation, but also on the way that each of them affects the government budget in the case of distorting taxes.

Siu (2004) considers the role of state-contingent inflation as a fiscal shock absorber in an economy with nominal rigidities. He studies the Ramsey equilibrium in a monetary model with distortionary taxation, nominal state-contingent debt and sticky prices. With government spending calibrated to the post war data for the US economy, the Ramsey solution prescribes essentially constant deflation, even when the fraction of sticky price firms is small. Hence, responses in the real value of inherited government liabilities are largely attenuated. Tax distortions can essentially be characterized as being smoothed over time. Persistent spells of high spending are accompanied by increasing tax collection and the accumulation of debt; spells of low spending by lower taxes and the reduction of debt. This imparts a high degree of persistence in tax rates and real debt holdings, regardless of the persistence in the underlying shock process. For government spending processes resembling the post-war experience, introducing sticky prices generates striking departures in optimal policy from the case of flexible prices. For even small degrees of price rigidity, optimal policy displays very little volatility in inflation. Tax rates display greater volatility compared to the model with flexible prices. With sticky prices, tax rates and real government debt exhibit behavior similar to a random walk.

Schmitt-Grohe and Uribe (2003) study the optimal fiscal and monetary policy under imperfect competition in a stochastic, flexible price, production economy without capital. They analytically show that in this economy the nominal interest rate acts as an indirect tax on monopoly profits. Unless the social planner has access to a direct 100 percent tax on profits, he will always find it optimal to deviate from the Friedman rule by setting a positive and time–varying nominal interest rate. The second central result of their study is that while the first moments of inflation, the nominal interest rate and tax rates are sensitive to the degree of market power in the Ramsey allocation, the cyclical properties of these variables under imperfect competition are similar to those arising in perfectly competitive environments. In particular, it is optimal for the government to smooth tax rates and to make the inflation highly volatile. Thus, as in the case of perfect competition, the government uses variations in the price level as a state-contingent tax on financial wealth.

Schmitt-Grohe and Uribe (2005) study the Ramsey optimal fiscal and monetary policy in a medium scale model of the US business cycle. The model features a rich array of real and nominal rigidities that have been identified in the recent empirical literature as salient in explaining observed aggregate fluctuations. The study addresses the classic question in macroeconomics of how a benevolent government should conduct stabilization policy. The main result of the study is that price stability appears to be a central goal of an optimal monetary policy. The optimal rate of inflation under an income tax regime is half a percent per year with volatility of 1.1 percent. Under an income tax regime, the optimal income tax rate is quite stable with a mean of 30 percent and a standard deviation of 1.1 percent. The Ramsey outcome features a near random walk in real public debt. Taken together these results suggest that shocks to the fiscal budget are financed neither through surprise inflation (as in models with flexible nominal prices) nor through adjustments in the income tax rate but rather through variations in the fiscal deficit. When the fiscal authority is allowed to tax capital and labor income at different rates, an optimal fiscal policy is characterized by a large and volatile subsidy on capital.

Crettez and Wigniolle (2002) study the optimal monetary and fiscal policies within the framework of an overlapping generation's model with cash in advance constraints. The decentralization of the optimal growth path does not require one to follow the Friedman rule; indeed, all that is needed is to equate the return on total saving to the marginal social value of capital.

Leopold von Thadden (2003) offers a simple analytical framework to study effects of monetary policy on the valuation of outstanding government debt from a dynamic general equilibrium perspective, which takes the desirability of a mix of active monetary and passive fiscal policy as given. The study illustrates that monetary policy may indeed constrain fiscal policy depending on whether monetary policy accepts stabilizing revaluations of government debt or not. There is a comparison of the properties of two stylized monetary policy rules. First a policy of a constant money growth rule allows for temporary deviations of inflation from target and there is scope for revaluations of public debt in response to shocks. The other policy is strict inflation targeting. This policy fixes the value of government debt in real terms and precludes, thereby stabilizing, revaluations. This feature implies that additional fiscal restraints may be needed under strict inflation targeting, which is not required under a constant money growth rate.

Ferrero (2005) studies the problem of the joint conduct of fiscal and monetary policy in a currency union. He first shows the existence of a symmetric steady state which entails zero inflation and constant positive debt. The central result is that fiscal policy plays a key role in appropriately smoothing the impact of idiosyncratic exogenous shocks. Fiscal rules that respond to a measure of real activity have the potential to accurately approximate the optimal plan and lead to large welfare gains as compared to balanced rules. Monetary policy should focus on maintaining price stability. The main finding of the paper is that a regime characterized by flexible debt rules for fiscal policy and strict inflation targeting for monetary policy accurately approximates the optimal plan.

Iwamura et al., (2005) analyze the monetary and fiscal policy in a liquidity trap. They characterize monetary and fiscal policy rules to implement optimal responses to a substantial decline in the natural rate of interest and compare them with policy decisions made by the Japanese central bank (BOJ) and government in the 1999-2004 period. They test whether the Japanese central bank and the government have adopted appropriate policies to escape from the liquidity trap. They find that the optimal commitment solution can be implemented through history dependent inflation targeting in which the target inflation rate is revised depending on the past performance of monetary policy. They compare the optimal rule with the BOJ` s policy commitment of continuing monetary easing until some conditions regarding the inflation rate are satisfied. They find that the BOJ rule lacks history dependence in the sense that the BOJ had no intention of revising the target level of inflation in spite of the occurrence of various shocks to the Japanese economy. Moreover, the term structure of the interest rate gap (i.e. the spread between the actual real rate of interest and its natural rate counterpart) was not downward sloping, suggesting that the BOJ’s commitment failed to have sufficient influence on the market’ s expectations about the future course of monetary policy. They also find time-series evidence that the primary surplus in 1999-2002 was higher than predicted by the historical regularity. By comparing private sector forecasts with the corresponding actual values, they find a combination of an unexpectedly low government debt and an unexpectedly small deficit. Such evidence of the government`s behaviour suggests that the Japanese government deviated from Ricardian fiscal policy toward fiscal tightening. The optimal commitment solution obtained under the assumption of non-Ricardian fiscal policy implies that, given such government behavior, the central bank should continue a zero interest rate policy longer.

2.4 Coordination of the Monetary and Fiscal Policy in the EMU

The introduction of the Economic and Monetary Union (EMU) on 1 January 1999 has lead to a new framework for monetary and fiscal policy in the European Union (EU). The EMU is the replacement of national currencies by a common currency and there is a replacement of national central banks to a common central bank to manage the common monetary policy.

The formation of the Euro area raises new questions about the coordination of monetary and fiscal policy because there are twelve countries and each has its own tax and spending policies. If the 12 countries have to apply common monetary policy, then the following questions have to be answered:

1. Does the common monetary policy have the same effect in each of the countries and the same implications for fiscal policy?
2. How does the existence of twelve separate fiscal policies affect the European Central Bank's ability to control inflation?

To answer these questions, the design, implementation and transmission of monetary and fiscal policy in a monetary union has gained importance. Information sharing and coordination between the euro area` s fiscal authorities is important. Individually, each fiscal authority will have only a limited impact on the European Central Bank' s decision making, but collectively they can have a large effect.

In principle, policy co-ordination can bring substantial gains, helping to produce a better mix and supporting overall economic stabilization. In the euro area framework, characterized by a single monetary authority with a number of decentralized fiscal authorities (currently), policy coordination is intrinsically more complex because of the need for coordination and information sharing among the various fiscal authorities (fiscal-fiscal coordination) as well as effective coordination between the fiscal and monetary authorities (fiscal-monetary coordination), as discussed in Aarle et al., (2005).

The European fiscal framework has been in operation since 1999. It was designed in the Maastricht Treaty and redefined in 1997 with the creation of the Stability and Growth Pact

(SGP) and SGP are reformed in 2005 and SGP consisted of simple, quasi-mechanical rules as put forward by Coeure and Pisani-Ferry (2005).

The Stability and Growth Pact (SGP) is the key mechanism for fiscal policy coordination in the euro area. The surveillance processes set up under the SGP enables the euro area countries to share information with each other about their fiscal policy plans and thereby aid policy co-ordination. Information sharing and coordination between the fiscal authorities and monetary authorities is also important in order to achieve an appropriate policy mix across the euro area as a whole. There are no formal mechanisms for fiscal-monetary coordination in the euro area. However there are several mechanisms for information sharing to help the fiscal and monetary authorities to enhance understanding of each others reaction functions: the ECB is party to all Economic and Financial Committee and Eurogroup discussions of fiscal policy. The Commission and the chair of Eurogroup have the opportunity to attend ECB Governing for information sharing to help the fiscal and monetary authorities to enhance understanding of each other's reaction functions, see details at www.hm-treasury.gov.uk; EC (2002), and ECB (2003).

2.5 Literature on Monetary and Fiscal Policy Mix in the EU

Canzoneri et al., (2005) investigate how monetary and fiscal policy interacts in the European Monetary Union. The formation of the Euro area raises new questions about the coordination of monetary and fiscal policy. They show that a common monetary policy responding to area-wide aggregates has asymmetric effects on countries within the union depending on whether they are large or small or whether they have high or low debts using a New Neoclassical Synthesis model. They analyze the implications of these asymmetries for the various countries' welfare and for their fiscal policies. They also study rules for setting national tax and spending rates, rules that constrain movements in the deficit to GDP ratio.

Their question is whether these rules are necessary for the common monetary policy to harmonize national inflation rates and their effects on national welfare. The results of the study can be summarized as follows:

1. Productivity shocks and idiosyncratic monetary policy shocks explain 70 percent of the volatility in the deficit to GDP ratio in the average and large countries and 80 percent in the

high debt country. Rules try to discipline fiscal policy by requiring governments to limit the unconditional standard deviation of the debt to GDP ratio seem rather perverse in this context.
2. Productivity shocks are the dominant source of inflation differentials in all different country groups and idiosyncratic monetary shocks are the second source of inflation. Shocks to tax rates and spending policy play a minor role. The large differences among the countries in the Euro area do not point to the need for the coordination of national fiscal policies.
3. Their model suggests that constraints on deficits are deemed necessary in the Euro area. Such a constraint may actually be welfare enhancing since government spending crowds out private consumption in the model.
4. Deficits are more sensitive to interest rates in high debt countries due to the burden of debt service. High debt countries tend to have higher tax rates, increasing tax distortions and making tax revenues more sensitive to changes in the tax base. These factors lead to welfare costs: the typical household in the high debt country would be willing to give up 1.3% of its consumption each period to live in the average country.
5. The common monetary policy favors larger countries in the Euro area since their inflation rates are more highly correlated with aggregate inflation.

Aarle et al., (2003) study the macroeconomic effects of monetary and fiscal policy in the Euro area by using a structural VAR analysis. Short-run and medium term effects of monetary policy and fiscal policy innovations and demand and supply shocks are estimated. They found that (i) on the level of the Euro area as a whole the estimated adjustments to the various structural shocks are by and large found to be comparable to the case of Japan and the US. (ii) Relatively similar adjustment dynamics occur across the different EMU countries in response to supply and demand shocks (iii) However, large differences in the country adjustments are induced by monetary and fiscal policy innovations. (iv) There are also considerable cross-country differences in the interdependencies between macroeconomic policy instruments.
Common monetary and/or co-ordinated fiscal stabilization policies (be they automatic or rule-based) that seek to counteract such a demand or supply shock will not induce large divergent adjustments of output and prices. The third and fourth results are more worrisome; however, since they suggest that innovations in the common monetary policy and/or fiscal policy instruments could produce divergent dynamics of output, prices and fiscal balances across the EMU.

Gali and Monacelli (2005) analyze the optimal fiscal policy in a monetary union. First, they determine the monetary and fiscal policy rules that maximize a second-order approximation to the integral utilities of the representative households inhabiting the different countries in the union. They show that it is optimal for the common monetary authority to stabilize inflation in the union as a whole. Their findings provide a rationale for a monetary policy strategy like the one adopted by the European Central Bank (attaining price stability for the union as a whole). It is important to stress, however, that the optimality of that policy is conditional on the national fiscal authorities that simultaneously implement their part of the optimal policy package. In the absence of such coordinated response by the national fiscal authorities, the union's central bank may find it optimal to deviate from a strict inflation targeting policy. Under the optimal policy arrangement, each country's fiscal authority plays a dual role, trading off between the provisions of an efficient level of public goods and the stabilization of domestic inflation and output gap. They find that the existence of such a stabilizing role for fiscal policy is desirable not only from the viewpoint of each individual country, but also from that of the union as a whole. Their simulations under the optimal policy mix of a representative economy's response to an idiosyncratic productivity shock show that the strength of the counter-cyclical fiscal response increases with the importance of nominal rigidities.

Lambertini (2005) also analyzes optimal fiscal policy rules in a monetary union where monetary policy is decided by an independent central bank. Lambertini considers a two country model with trade in goods and assets augmented with sticky prices, labor income taxes and stochastic government consumption. It is optimal to finance an increase in government spending in part by running deficits and in part by raising income tax, even though the tax is distortionary. Real public debt and tax rate display a random walk behavior. Optimal fiscal policy becomes tighter as the debt to GDP ratio grows. Optimal monetary policy is less aggressive in response to a government spending shock than the policy implied by an interest rate rule. The welfare cost of monetary policy delegation is 0.3 percent of steady state consumption. Optimal fiscal policy delivers lower variability of the income tax rate than a deficit limit of Stability and Growth Pact. The welfare cost of the SGP is between 0.001 and 0.036 percent of the steady state consumption. The main findings of the study can be summarized in three steps. First in response to a government spending shock, it is optimal to raise taxes and run budget deficits in the country where the shock originates. Other countries find it optimal to also raise tax rates, which lead to budget surpluses and an improved long-run equilibrium. Second, real public debt and taxes display random walk behavior. Following a government shock, for example, the optimal fiscal policy implies an increase in real debt and therefore a worsening of the net asset position of the country. Third, the optimal fiscal policy changes with the level of debt. Optimal fiscal policy becomes tighter as the steady state debt to GDP ratio increases, which means that primary budget deficits get smaller in response to shocks.

Hughes et al., (1990) underline the costs deriving from the lack of cooperation between fiscal and monetary policy. They find that the fiscal expansion monetary restriction mix is efficient and results from a cooperative game in which the government dominates and the central bank is allowed the freedom to fight inflation.

Nordhaus (1994) considers the strategic relationship between a fiscal and monetary authority aiming at choosing optimally their respective instruments in order to minimize their loss functions. When a Nash game is played, he finds that the lack of cooperation is responsible for an inefficient policy mix, often observed in reality, resulting in an excessively restrictive monetary and an excessively expansionary fiscal policy. The solution of a Stackelberg game (with the fiscal authority playing as a leader; i.e. taking the central bank's monetary rule into account) Pareto dominates the Nash outcome. This result is explained by the difference in the objectives of the two authorities. The fiscal authority tries to fight unemployment by means of an expansionary policy, but the central bank reacts by means of a contractionary monetary policy to keep inflation under control. The outcome is an overly expansionary fiscal policy in the Nash equilibrium. When the fiscal authority takes such behavior into account (i.e. when it plays the role of a Stackelberg leader), it will act in a less expansionary way so as to allow the central bank to follow more relaxed policy. He describes such a case as characterized by a monetary rule, arguing that the fiscal authority would be obliged to optimize its utility function, subject to the rules strictly followed by an independent and conservative central bank.

De Bonis and Della Posta (2004) analyze the different features of the strategic relationship between monetary and fiscal authorities in the US and in the EU. They show that cooperation among fiscal authorities are welfare improving only if they also cooperate with the central bank. When this condition is not satisfied, fiscal rules such as those envisaged in the Maastricht Treaty and in the Stability and Growth Pact may work as coordination devices that improve welfare. They also conclude that the relationship between several treasuries and a single central bank makes the fiscal leadership solution collapse to the Nash, which is contrary to the findings of Nordhaus (1994) and Dixit and Lambertini (2001). When moving from the Nash solution to the Stackelberg solution, fiscal discipline no longer applies. They also argue in favour of fiscal rules in a monetary union.

Dixit (2001) and Dixit and Lambertini (2001) provide additional reasons for the introduction of fiscal constraints in a monetary union. Fiscal rules are useful mainly to make the central bank's commitment to low inflation credible. They show that with monetary leadership, fiscal discretion may destroy monetary commitment. When fiscal authorities do not care about monetary independence, fiscal policy will keep on being expansionary even in the presence of a restrictive monetary policy, so that monetary authorities end up acting in an expansionary way in order to avoid a debt explosion. With fiscal leadership, the fiscal authorities will take into account the monetary authority's reaction function so that fiscal policy will become more moderate.

Gali and Perotti (2003) examine the role of discretionary fiscal policy using OECD country data over the 1980-2002 period. Their primary concern is how the Maastricht Treaty and The Stability and Growth Pact affected the fiscal management style of EU countries. They found that fiscal policy was more countercyclical in the post-Maastricht period (1992-2000) from their panel data estimation. They grouped 19 countries as 11 EMU countries, 3 non-EMU EU countries and 5 other OECD countries and ran a panel data regression for each group. For a group of EMU countries, fiscal policy was procyclical in the pre-Maastricht period (1980-1991) but the coefficient was not significant in the post-Maastricht period. In the other two panel data, fiscal policy moved from an automatic stabilizer to countercyclical.

2.6 Summary and Conclusion

This part of the thesis reviews the literature on the interaction between monetary and fiscal policy. The first study on the interaction between monetary and fiscal policy is Sargent and Wallace (1981). Every fiscal policy action involving an increase in the current budget deficit must be financed through an increase in either future tax revenues or the value of nominally denominated government liabilities, such as money. This is known as the “unpleasant monetarist arithmetic”. Then Leeper (1991) extends the Sargent Wallace analysis to the stochastic environment, explaining the monetary and fiscal policy interactions in a stochastic maximizing model. Policy is active or passive depending on its responsiveness to government debt stock. There are other studies which concentrate on the optimal monetary and fiscal policy under different assumptions such as liquidity trap, overlapping generation’s model, sticky prices and distorting taxes.

The introduction of the EMU in 1999 has lead to a new framework of monetary and fiscal policy in the European Union. The national central banks were replaced by the European Central Bank, as a result of which monetary policy was put under the control of European Central Bank (ECB). The SGP is the main mechanism for fiscal policy for the member countries and it gives numerical targets to budget deficit to GDP and debt to GDP for the member countries.

CHAPTER 3: Theoretical Part

3.1 Introduction

Three models will be explained in this part of the thesis. In the first model, the price level or inflation will be determined without reference to fiscal solvency. In the second model, how the monetary policy may be influenced by the fiscal solvency of the public sector. In the third model, Fiscal Theory of Price Level is explained. In all three models utility function of the representative agent is maximized under the budget constraint.

3.2 Model 1: No Reference to Fiscal Solvency

The model is constructed around a finite horizon model, followingBlanchard (1985) and Yaari (1965). The similar models can be seenin Buiter (1990), Cardia (1991), Chadha and Nolan (2002). The model is in discretime time the market structure is imperfectly competitive and there is price stickiness in the manner of Calvo (1983). A similar model in continous time is developed by Leith and Wren-Lewis (2000) in order to analyse the joint requirements of monetary and fiscal policy that might be required for control inflation.

The utility function for the representative agent, j, is given by

$$V_0 = E_0 \sum_{t=0}^{\infty} \{ \left(\frac{1}{1+\delta}\right)^t \left(\frac{1}{1+\lambda}\right)^t U\left(C_t^j, \frac{M_t^j}{P_t}, L_t^j\right) \} \tag{3.1}$$

Here, δ is the subjective discount rate and λ is the probability of death. Those parameters are assumed to be constant.

Expected utility is maximised subject to a sequence of per period budget constraints:

$$P_t C_t^j + M_t^j + \frac{B_t^j}{(1+i_t)} \leq (1+\lambda) M_{t-1}^j + (1+\lambda) B_{t-1}^j + P_t Y_t^j - T_t^j \tag{3.2}$$

where $P_t C_t^j = \int_0^1 \int_0^1 p_t(k,z) c_t^j(k,z) dz dk$, and

$P_t Y_t^j = \int_0^1 \int_0^1 P_t(j,z) y_{\in}(j,z) dz$ for all $t \geq 0$ and in each state of nature.

Here $c_t^j(k,z)$ denotes the representative agent's consumption of good (k,z) where z indexes agents in the economy. Similarly $y_t(j,z)$ indicates the amount of output produced by the agent. This formulation follows Woodford (1997) and assumes that each agent is a monopoly supplier, of all goods that if supplier while each agent also consumes a basket of all goods. B_t^j denotes the bond portfolio, M_t^j denotes money balances, P_t is the aggregate price level, Y_t denotes non-financial income and T_t^j denotes lump-sum taxes. The evolution of wealth is given by;

(3.3)

$$W_t^j = (1+\lambda)M_{t-1}^j + (1+\lambda)B_{t-1}^j$$

It is assumed by following Blanchard (1985) that perfect capital markets return all financial wealth to the population, as windfall dividends in the event of death. Using equation (2) and equation (3),

(3.4)

$$W_t^j = \left(\frac{1}{1+i_t}\right)\left(\frac{1}{1+\lambda}\right)E_t W_{t+1}^j + P_t C_t^j - P_t Y_t^j + \frac{i_t}{1+i_t} M_t^j$$

which implies if

$$\lim_{T\to\infty}\left(\frac{1}{1+\lambda}\right)^T E_0 \Pi_{j=0}^{T-1}(1+i_{t+j})^{-1} W_{t+T}^j \to 0,$$

that (3.5)

$$W_t^j = -E_t \sum_{s=t}^{\infty} \Pi_{j=t}^{s-1}\{\left(\frac{1}{1+i_{t+j}}\right)\left(\frac{1}{1+\lambda}\right)^{s-t}\left[P_s(C_s^j - Y_s^j) + T_s^j + \frac{i_s}{1+i_s} M_s^j\right]$$

Equations (4) and (5) now reflect the probability faced by the agent of not being alive in any subsequent period. This effect means that the probability of death serves merely to act to increase the effective rate of discount.

Consumption is defined over the Dixit-Stiglitz aggregator function,

(3.6)

$$C_t^j \equiv \left[\int_0^1 \int_0^1 c_t^j(k,z)^{\frac{\Theta-1}{\Theta}} dz dk\right]^{\frac{\Theta}{\Theta-1}}$$

with the aggregate price level defined accordingly as:

(3.7)

$$P_t \equiv \left[\int_0^1 \int_0^1 p_t(j,z)^{1-\ominus} dz dj\right]^{\frac{1}{1-\ominus}}$$

Let $\{\mu_s\}_{s=t}^{\infty}$ denote the sequence of positive undetermined multipliers, Langrangian function can be written as follows;

$$\begin{aligned} L &= E_0 \sum_{t=0}^{\infty} \{ \left(\frac{1}{1+\delta}\right)^t \left(\frac{1}{1+\lambda}\right)^t \cup \left(C_t^j, \frac{M_t^j}{P_t}, L_t^j\right) \} \\ &+ E_0 \sum_{t=0}^{\infty} \{ \left(\frac{1}{1+\delta}\right)^t \mu_t^j \left[(1+\lambda) M_{t-1}^j + (1+\lambda) B_{t-1}^j \right. \\ &+ \left. P_t Y_t^j - T_t^j - \frac{B_t^j}{(1+i_t)} - M_t^j - P_t C_t^j \right] \} \end{aligned}$$

(3.8)

The Demand Side

The first order conditions of the representative agent are familiar except the effect of the probability of death. At each date and in each state, the optimum conditions will be characterised by the following equations.

$$\left(\frac{1}{1+\lambda}\right)^t U_c'(C_t^j, M_t^j/P_t, L_t^j) = \mu_t^j P_t \qquad (9)$$

$$\left(\frac{1}{1+\lambda}\right)^t U_M'(C_t^j, M_t^j/P_t, L_t^j)/P_t + \left(\frac{1}{1+\delta}\right)(1+\lambda) E_t \mu_{t+1}^j = \mu_t^j \qquad (10)$$

These three expressions can be combined and yield the following two expressions:

(3.11)

$$\frac{1}{1+\delta} \frac{E_t U'(C_{t+1}^j)}{P_{t+1}} (1+i_t) = \frac{U'(C_t^j)}{P_t}$$

(3.12)

$$\frac{U_M^j(C_t^j, M_t^j/P_t, L_t^j)}{U_c^j(C_t^j, M_t^j/P_t, L_t^j)} = \frac{i_t}{1+i_t}$$

Despite the probability of death, there is no tilting of consumption towards the present and no reduction in the demand for money. Any windfall gain from agents dying or leaving unconsumed real resources (either in the form of ``unspent" bonds or money) are simply passed on to those agents left alive. However, those agents, in turn,face an excess interest premium (in order o ensure a zero profit equilibrium). These two effects cancel.

Finally, optimality requires that the flow budget constraint holds with equality in each period and each state and the following no-Ponzi finance condition be satisfied.

(3.13)

$$\lim_{T\to\infty}\left(\frac{1}{1+\lambda}\right)^T E_0\{\Pi_{j=0}^{T-1}(1+i_{t+j})\}^{-1}W_{t+T} \to 0$$

The Supply Side

Agents are assumed to meet demand at the posted price, whether or not prices have been changed in the current period. Similar to Calvo (1983) and many others it is assumed a price is set in period t and it will remain at that nominal level with probability, $\alpha(0 \le \alpha \langle 1)$. An agent that reprices some part of her output this period faces the probability α^k of having to charge the same price in k-periods' time. It is considered that the repricing by agent j of one good z. The optimal price is a function of aggregate economy-wide variables only. As a consequence, it can be aggregated across all goods in the economy, given equation (7). It will be convenient now to introduce a specific functional form of the utility function;

$$U(C_t^j, \frac{M_t^j}{P_t}, L_t^j) \equiv \log C + \log(\frac{M}{P}) - \int_0^1 \overline{w}[y_t(j,z)]dz.$$

$\int_0^1 \overline{w}[y_t(j,z)]dz$ denotes the disutility of supplying labor across all z goods. For any individual good, then,it follows that the optimal level of P(z), say, P_t^* will be that which maximises the following function;

(3.14)

$$\Phi = E_0 \sum_{k=0}^{\infty} (\alpha\beta')^k \{\mu_{t+k} p(z) \left(\frac{p(z)}{P_{t+k}}\right)^{-\ominus} Y_{t+k} - \overline{w} \left[\left(\frac{p(z)}{P_{t+k}}\right)^{-\ominus} Y_{t+k}\right]\}$$

Calculate $\frac{\partial\Phi}{\partial p(z)}$

$$E_0 \sum_{k=0}^{\infty} \{(\alpha\beta')^k \mu_{t+k} \left(\frac{p(z)}{P_{t+k}}\right)^{-\ominus} Y_{t+k} P(z) \frac{1-\ominus}{\ominus}\}$$

$$= -E_0 \sum_{k=0}^{\infty} (\alpha\beta')^{k_{\mu_{t+k}}} \left(\frac{p(z)}{P_{t+k}}\right)^{-\ominus} Y_{t+k} \overline{w}' \left[\frac{\left(\frac{p(z)}{P_{t+k}}\right)^{-\ominus} Y_{t+k}}{\mu_{t+k}}\right]\}$$

then,

(3.15)

$$P_t^* = \frac{\ominus}{\ominus - 1} \frac{E_0 \sum_{k=0}^{\infty} \{(\alpha\beta')^k \mu_{t+k} \left(\frac{p(z)}{P_{t+k}}\right)^{-\ominus} Y_{t+k} \overline{w}' [.]\}}{E_0 \sum \{(\alpha\beta')^k \mu_{t+k} \left(\frac{p(z)}{P_{t+k}}\right)^{-\ominus} Y_{t+k}\}}$$

Here μ_{t+k} is a measure of aggregate marjinal utility and $\beta = \beta'(1+\lambda)^{-1}$. Equation (16) indicates that the optimal price is a function of expected future demand and cost conditions. It follows that the evolution of the aggregate price level is given by

(3.16)

$$P_t = [(1-\alpha)_{P_t^{*1-\ominus}} + \alpha P_{t-1}^{1-\ominus}]^{\frac{1}{(1-\ominus)}}$$

Aggregation

The aggregation function is a discrete time analogue of Blanchard (1985)

The size of the cohort burn each period is given by

$$\left(\frac{\lambda}{1+\lambda}\right)\left(\frac{1}{1+\lambda}\right)^t$$

Naturally death means that the size of the cohort decreases monotonically with time, and the sum of all currently alive cohorts in equal to unity, that is

(3.17)

$$\frac{\lambda}{1+\lambda}\sum_{j=-\infty}^{t}\left(\frac{1}{1+\lambda}\right)^{(t-j)}=1$$

This makes aggregating of the model. (Chadha and Nolan, 2002)

In particular, for any variable x_t^a it follows that

(3.18)

$$x_t^a=\frac{\lambda}{1+\lambda}\sum_{s=-\infty}^{t}\left(\frac{1}{1+\lambda}\right)^{t-s}x_{s,t}$$

Aggregate consumption dynamics are given by the following expression, (Chadha and Nolan)

(3.19)

$$E_tP_{t+1}C_{t+1}=(1+i_t)\beta P_tC_t-\lambda\phi E_tW_{t+1}$$

In the infinite horizon case (where $\lambda = 0$) equation (20) is $E_tP_{t+1}=(1+i_t)\beta P_tC_t$ which is the consumption Euler equation. The equation describes how aggregate consumption evolves through time and temporal variations in financial wealth play no role in determining contemporaneous consumption. In other words, in the absence of distortionary taxation, liquidity constraints, deviations from rational expectations and in the presence of a Ricardian fiscal policy it makes no adds to the economy whether taxes are raised now or in the future. Agents will consume out of their present value of net wealth and since lower taxes now resulting in higher taxes in the future does not alter the present value of net wealth, there will be no leverage for fiscal policy to operate in this model via the level of oustanding government debt. However, in the case of finite horizons $\lambda \neq 0$, variations in the temporal allocation of taxes are not ``neutral''.Net wealth is affected by the time profile of taxes. The probability of a currently alive cohort facing a given tax bill has taken and hence the consumption set has expanded.

3.2.1. Monetary and Fiscal Policy

It is considered that policy makers set the interest rate and taxes Policy rules are the following sort; in order to stabilise both output and inflation.

(3.20)

$$i_t = \phi(i)[Y_t, \pi_t, E_t\pi_{t+1}, i_{t-1}]$$

and

(3.21)

$$T_t = \Phi(\tau)[G_t, \gamma B_{t-1}]$$

where i_t is the short-run nominal interest rate set in period t, Y_t is real aggregate output, π_t is the inflation rate in period t, and T_t is the per-period lump-sum taxes. The monetary rule is fairly standard rule. Tax rule is assumed that the process for government expenditure is essentially exogenous. The fiscal authority sets taxes in response to the level of outstanding debt at the start of the period. The parameter γ indicates the proportion of debt that is retired each period. The seigniorage is remitted lump-sum to the private sector.

3.2.2 The Government Budget

γ is a key parameter in ensuring that fiscal policy is Ricardian. The period public-sector budget constraint may be written as,

(3.22)

$$\frac{B_t}{(1+i_t)} = B_{t-1} + P_t(G_t - T_t) - (M_t - M_{t-1})$$

The rule for taxes is given by

(3.23)

$$T_t = \chi_t G_t - \frac{(M_t - M_{t-1})}{P_t} + \gamma \frac{B_{t-1}}{P_t}$$

Equations (3.23) and (3.24) imply that real debt will be

(3.24)

$$\frac{b_t}{1+r_t} = (1-\gamma)b_{t-1} + (1-\chi_t)G_t$$

(1- χ_t) $G_t = D_t$ which the per period deficit.

at t=T equation (3.25) implies;

(3.25)

$$E_t \frac{b_t + T}{\Pi_{j=0}^{T}(1+r_{t+j})} = (1-\gamma)^{T+1} b_{t-1} + E_t \sum_{s=0}^{T} \Pi_{j=0}^{s-1}\Big(\frac{1}{1+r_{t+j}}\Big)(1-\gamma)^{T-s} D_{t+s}$$

To ensure that fiscal solvency is obtained via the fiscal authority's choice over the sequence $\{T\}_{t=0}^{\infty}$,it is assumed that the coefficent γ is sufficiently large. In particular it will ensure that the policy is Ricardian and the present value of budget constraint is satisfied for any feasible path for the relevant variables.

3.2.3. Fiscal Policy

Fiscal policy matters for the level of aggregate demand in this model because it affects the discounted present value of human wealth.

Define human wealth, H_t as equal to the difference between present value income (Y_t denotes the income in period t) and present value of lump-sum taxes ($T_{\in}$ denotes taxes in period t).

(3.26)

$$H_t = \sum_{j=0}^{\infty}\{\Big(\frac{1}{1+r}\Big)^j\Big(\frac{1}{1+\lambda}\Big)^j Y_{t+j}\} - \sum_{j=0}^{\infty}\{\Big(\frac{1}{1+r}\Big)^j\Big(\frac{1}{1+\lambda}\Big)^j T_{t+j}\}$$

Now consider a change in the temporal profile of taxes such that the present discounted value of government surpluses remain unchanged. That is; a variation in taxes at time t offset by one-time change at t+j,

$$T_t(1+\triangle) + \Big(\frac{1}{1+r}\Big)^j (1+\triangle)T_{t+j} = 0$$

That is

(3.27)

$$\triangle T_{t+j} = -(1+r)^j \triangle T_t$$

such that

(3.28)

$$B_{t-1} = \sum_{j=0}^{\infty}\{\left(\frac{1}{1+r}\right)^{t+j}\} - \sum_{j=0}^{\infty}\{\left(\frac{1}{1+r}\right)^{t+j} G_{t+j}\}$$

In the simple representative agent model such an amendment to fiscal policy would leave all real variables unaltered since it would leave the present value of human wealth unchanged, ΔH . Here, however this will not be the case. The change m human wealth will be given by;

(3.29)

$$\triangle H_t = T_t(1+\triangle) + \{\left(\frac{1}{1+\lambda}\right)^j\}(1+\triangle)T_{t+j}$$

It follows that for $\lambda \neq 0$

(3.30)

$$\triangle H_t = \triangle T_t\{1 - \left(\frac{1}{1+\lambda}\right)^j\} \neq 0$$

Clearly, if the representative agent faces a zero (anticipated) probability of death then the change in present-value of human wealth is identically zero, $\Delta H_t = 0$, and the time profile of consumption remains the same despite the temporal reallocation of taxes. So a government that cuts taxes today but leaves fiscal solvency intact can nevertheless influence the level of private sector demand. And the longer the fiscal authority waits to tighten fiscal policy to offset today's relaxation, the larger will be the impact on aggregate demand.

However there are additional affects from fiscal policy. Aggregate demand is simply given by

(3.31)

$$Y_t^d = C_t + G_t$$

The aggregate consumption function at time t is given by

(3.32)

$$C_t = \frac{1+\lambda-\beta}{1+\lambda}\left[b_{t-1} + E_t \sum_{s=t}^{\infty} \Pi_{j=t}^{s-1}\{\left(\frac{1}{1+r_{i+j}}\right)\left(\frac{1}{1+\lambda}\right)^{s-t}(Y_s - T_s)\}\right]$$

The effect of money balances is ignored. The path of taxes negatively affect consumption and it reduces net wealth.

The index of fiscal stance (IFS_t) is constructed by following Blanchard (1985). The index of fiscal stance characterises the net effect of fiscal variables on aggregate demand:

(3.33)

$$IFS_t = G_t - \frac{1+\lambda-\beta}{1+\lambda}\left[E_t \sum_{s=t}^{\infty} \Pi_{j=t}^{s-1}\{\left(\frac{r}{1+r_{t+j}}\right)\left(\frac{1}{1+\lambda}\right)^{s-t} G_s\}\right]$$

$$+\frac{1+\lambda-\beta}{1+\lambda}\left[b_{t-1} + E_t \sum_{s=t}^{\infty} \Pi_{j=t}^{s-1}\{\left(\frac{1}{1+r_{t+j}}\right)\left(\frac{1}{1+\lambda}\right)^{s-t}(G_s - T_s)\}\right]$$

The first time is the effect of government expenditure on aggregate demand when it is financed out of contemporizes taxation, while the second line is the effect of financing via debt issue.

Recall that the government's present value budget is,

(3.34)

$$b_{t-1} = -E_t \sum_{s=t}^{\infty} \Pi_{j=t}^{s-1}\{\left(\frac{1}{1+r_{t+j}}\right)(G_s - T_s)\}$$

Seigniorage term is again partialled out. The index of fiscal stance can be written as,

$$IFS_t = G_t - \frac{1+\lambda-\beta}{1+\lambda}\left[E_t \sum_{s=t}^{\infty} \Pi_{j=t}^{s-1}\{\left(\frac{1}{1+r_{t+j}}\right)\left(\frac{1}{1+\lambda}\right)^{s-t} G_s\}\right]$$

$$+\frac{1+\lambda-\beta}{1+\lambda}\left[E_t \sum_{s=t}^{\infty} \Pi_{j=t}^{s-1}\{\left(\frac{1}{1+r_{t+j}}\right)\left[1-\left(\frac{1}{1+\lambda}\right)^{s-t}\right](G_s - T_s)\}\right]$$

(3.35)

In equation (3.35), if $\lambda = 0$ then the second live is equal to zero and there is no net wealth effect from bonds. If $\lambda \neq 0$ and $b_{t-1} \succ 0$ then outstanding bonds will tend to boost aggregate demand.

3.2.4 Monetary Policy

Monetary policy matters in this framework because of the monetary policy authority's ability to change the short-term real interest rate. A change in the level of the nominal interest rate in the presence of sticky prices means that the real interest rate must have changed and that the marjinal utility of consumption this period compared with next period must have altered. The real rate of interest changes will also affect the government budget constraint.

The complete model and policy rules can be written as,

$$W_t^j = (1+\lambda)M_{t-1}^j + (1+\lambda)B_{t-1}^j$$

$$\frac{1}{1+\delta}\frac{E_t U'(C_{t+1}^j)}{P_{t+1}}(1+i_t) = \frac{U'(C_t^j)}{P_t}$$

$$\frac{U_M'(C_t^j, M_t^j/P_t, L_t^j)}{U_c'(C_t^j, M_t^j/P_t, L_t^j)} = \frac{i_t}{1+i_t}$$

$$= \frac{\ominus}{\ominus - 1}\frac{E_0\sum_{k=0}^{\infty}\{(\alpha\beta')^k \mu_{t+k}\left(\frac{p(z)}{P_{t+k}}\right)^{-\ominus} Y_{t+k}\overline{w}}{E_0\sum_{k=0}^{\infty}\{(\alpha\beta')^k \mu_{t+k}\left(\frac{p(z)-\ominus}{P_{t+k}}\right) Y_{t+k}\}}$$

$$P_t = [(1-\alpha)p_t^{*1-\ominus} + \alpha P_{t-1}^{1-\ominus}]^{1/(1-\ominus)}$$

$$i_t = \phi(i)[Y_t, \pi_t, E_t\pi_{t+1}, i_{t-1}]$$

$$T_t = \phi(T)[G_t, \gamma B_{t-1}]$$

$$\frac{B_t}{1+i_t} = B_{t-1} + P_t(G_t - T_t) - (M_t - M_{t-1})$$

The model will be solved for the evolution of aggregate wealth, consumption, money holdings, inflation, short-term nominal interest rate, the level of taxation, the level of government interest-bearing debt and aggregate output. For this purpose equations (3), (12), (13), (16),(17),(21),(22),(23) are used.

In the set-up policy-makers need to decide on monetary policy and fiscal policy. Rather than simply impose a monetary rule that conforms to the Taylor principle. It is assumed that monetary and fiscal policy are set jointly optimal under the assumption of perfect credibility. There is a single policy maker which determines monetary and fiscal policy jointly subject to a requirement that fiscal policy must at all times ensure that policy is Ricardian.

For given policy rules the policymaker's loss function will be minimized. The aim is to find parameter values which minimizes the loss function.

3.3 Model 2: Reference to Fiscal Solvency

This part of the study will set firstly the fundamental linkages between the government's budget constraint and the setting of interest rate and secondly on the stabilisation issues thrown up by systematic fiscal and monetary policy over the business cycle.

This part will study how monetary policy may be influenced by the fiscal solvency of the public sector. Sargent and Wallace (1981) argued that money stock and taxes were substitutes in the backing of government debt and monetary and fiscal policies are linked via budget constraint. The consolidated public-sector budget constraint is the key equation linking the joint feasible sequences of monetary and fiscal variables through time. A government which runs a persistent deficit may require monetary policy to plug the hole in the public-sector finances. Consequently, for monetary policy to retain control over nominal magnitudes in the economy, fiscal policy must take seigniorage as given and provide a temporal, (state dependent) sequence of net deficits in order that debt satisfies a no-Ponzi condition.

There is an incorporation of the consolidated public sector budget constraint and fiscal policy is set overtime to ensure that PVBC is met. The jointly optimal policies for monetary policy and fiscal policy will be given for price level stability and aggregate demand stability.

3.3.1 Model 1:

Consider a closed economy inhabited by a large number of identical agents. Each agent's utility is defined over the real consumption stream, $\{C_t\}_{t=0}^{\infty}$, an the stream of real money balances, $\left\{\frac{M_t}{P_t}\right\}_{t=0}^{\infty}$.

Money is added to the utility function in the manner of Brock (1975) and Sidrauski (1965) by appealing to the notion that Money eases transactions costs. The discounted present value of utility is given by;

(3.24)

$$V_t = \Sigma_{t=0}^{\infty}\beta^t U(C_t, \frac{M_t}{P_t}),$$

where U(.) denotes a utility function increasing in consumption and real money balances, strictly concave and obeying Inada-type conditions and U(.) is separable in its arguments. It is assumed that;

$$U(.) = U(C_t) + v(\frac{M_t}{P_t})$$

$\beta \in (0,1)$ is the discount factor which equals $(1+\delta)^{-1}$, where $\delta \succ 0$. δ is the subjective rate of time preference. The representative agent maximizes the discounted present value of utility subject to the budget constraint.

(3.25)

$$P_t C_t + M_t + \frac{B_t}{1+i_t} \leq M_{t-1} + B_{t-1} + P_t Y_t - P_t T_t, \forall t > 0$$

M_{t-1} and B_{t-1} are given.

P_t is the price level in period t.

M_t is the nominal money balances in period t.

Y_t is the one period (discounted) nominal debt held at the end of period t.

Y_t is the endowment in period t.

T_t denotes taxes.

First order conditions;

(3.26)

$$\frac{v'(\frac{M_t}{P_t})}{u'(C_t)} = \frac{i_t}{(1+i_t)} \quad \forall \in \geq 0.$$

The relationship between optimal consumption at period t and t+1 through time.

(3.27)

$$\beta \frac{u'(C_{t+1})}{u'(C_t)} \frac{p_t}{(p_{t+1}}, \forall t \in \geq 0.$$

If follows that the price level is non-linear difference equation:

(3.28)

$$P_{t+1} = i_t \beta P_t \left[\frac{u'(C_{t+1})}{v'\left(\frac{M_t}{P_t}\right)} \right]$$

Transversality condition; (No-Ponzi finance condition)

(3.29)

$$\lim_{t \to \infty} \{\Pi_{j=0}^{T-1}(1+i_{t+j})\}^{-1} W_{t+T} \longrightarrow 0$$

$$W_t \equiv M_{t-1} + B_{t-1}$$

The question is that: In what way does the fiscal-monetary framework affect the workings of this simple economy?

Firstly, it is assumed that the economy is at the steady state.

Consider a steady-state in which

(3.30)

$$\frac{M_t}{M_{t-1}} = \frac{P_{t+1}}{P_t} = \mu = \pi_{t+1} + 1.$$

$\beta = \dfrac{1}{(1+\delta)}$ then;

the representative consumer's optimality conditions became

(3.31)

$$\delta = r$$

$$\frac{v'(m)}{u'(c)} = \frac{r}{1+r}$$

(3.32)

and

(3.33)

$$c - (\mu - 1)m - b(\frac{r}{1+r}) = y - t$$

Now the government budget constraint per. period is given by:

(3.34)

$$\frac{B_t}{(1+i_t)} = B_{t-1} + P_t(G_t - T_t) - (M_t - M_{t-1}), \quad \forall t \geq 0$$

Economy wide resource constraint;

(3.35)

$$Y_t = C_t + G_t$$

And since the representative agent's optimal consumption programme is constrained by lifetime resources, it follows the sequence of the government per-period budget constraint

(11). This budget constraint will be consisted with the representative agent's consumption programme if and only if transversality condition of the government's net issue of debt is satisfied.

Transversality condition:

(3.36)

$$\lim_{T \to \infty} \left\{ \Pi_{j=0}^{T-1} (1 + i_{t+j}) \right\}^{-1} W_{t+T} \longrightarrow 0$$

It follows that (34) and (36) together imply that;

(3.37)

$$B_{t-1} + M_{t-1} = \sum_{j=0}^{\infty} \left\{ \Pi_{s=j}^{j-1} \left(\frac{1}{1 + i_{t+s}} \right) \left[P_{t+j}(T_{t+j} - G_{t+j}) + \frac{i_{t+j}}{1 + i_{t+j}} M_{t+j} \right] \right\}$$

Equation (37) determines the necessary discounted value of taxation and seigniorage given the outstanding real value of government liabilities.

Equation (37) is entirely analogous to the representative agent's PVBC and implies that equation (37) is a constraint that holds identically for all feasible price-level sequences. Such a restriction implies that the fiscal-monetary programme will operate to ensure that the real outstanding level of government liabilities should identically equal of the discounted value of taxation and seigniorage revenues.

A key implication of this perspective is that monetary and fiscal policy, in setting the left hand side of (37), are potential substitutes in the backing of outstanding liabilities.

A rise in outstanding interest-bearing liabilities that does not elicit an equal present-valued increase in tax revenue requires necessarily an increase in seigniorage revenue. Equally, there exists an additional requirement upon the joint design of fiscal-monetary policy such that monetary policy is capable of determining the evolution of nominal magnitudes in the economy.

There are a number of useful ways to view the restrictions typically associated with the government's budget constraint. Initially the budget constraint is set out at constant inflation. Now consider what happens in that steady state when it is also characterised by a constant level of interest-bearing debt. In that case the governments budget constraint implies;

(3.38)

$$b = \left[\frac{1+r}{r}\right](G-T) + \left[\frac{1+r}{r}\right](\mu - 1)m$$

Following Calvo (1985) it is assumed that in this steady state the government raises sufficient funds via taxation to cover government expenditure. In that case by (30)

(3.39)

$$\pi = \frac{b}{m}\left(\frac{r}{1+r}\right)$$

Equation (31) pins down the steady-state interest rate τ (making it equal to the subjective rate of discount), while equation (32) determines the steady-state demand for money, given the steady-state level of consumption and the discount rate. Equation (39) implies an positive relationship between inflation and bonds. This equation indicates that a rise in outstanding bonds, absent and change in the steady-state net primary surplus, implies that steady state inflation must be higher. The mechanism is that: The budget constraint needs to be met and if taxes do not adjust then it falls to seigniorage revenues to meet the shortfall.

The second implication of the government per-period budget constaint (equation 11) and transversality condition (equation 13) is the following:

$\frac{P_{t+1}}{P_t} \equiv (1+\pi_{t+1})$ and also for any

variable x_t, deflated by the previous period price level can be

written as;

$$\frac{X_{t+1}}{P_t} = \left(\frac{X_{t+1}}{P_{t+1}}\right)(1+\pi_{t+1}).$$

In real terms, the flow period t constraint may be written as;

(3.40)

$$\frac{b_t}{1+r_t} = b_{t-1} + G_t - T_t - [m_t(1+\pi_{t+1}) - m_{t-1}]$$

where m $\equiv \frac{M}{P}$

Let us assume that the real interest rate is constant. Iterating(equation 15) forward and rearranging;

$$b_{t-1} + m_{t-1} = \frac{b_{t+T} + m_{t+T}}{(1+r)^{T+1}} + \sum_{j=0}^{T} \left[\frac{C(r + (1+r)\pi_{t+j+1}/(1+r)m_{t+j}}{(1+r)^j} \right]$$
$$+ \sum_{j=0}^{T} \left[\frac{\tau_{t+j} - g_{t+j}}{(1+r)^j} \right] \quad (3.41)$$

The other side of the representative agent's transversality condition is an analogous condition on fiscal-monetary sequence, such that as T $\rightarrow \infty$,

(3.42)

$$b_{t-1} + m_{t-1} = \sum_{j=0}^{\infty} \left(\frac{1}{1+r} \right)^j \left[\frac{r + (1+r)\pi_{t+j+1}}{1+r} \right] m_{t+j}$$
$$+ \sum_{j=0}^{\infty} \left(\frac{1}{1+r} \right)^j [\tau_{t+j} - g_{t+j}]$$

since in that case

$$\lim_{T\to\infty} \frac{b_{t+T} + m_{t+T}}{(1+r)^{T+1}} = 0 \quad (3.43)$$

Let N denotes the present value of outstanding liabilities and net of interest deficits. That is,

(3.44)

$$\sum_{j=0}^{\infty}\left(\frac{1}{1+r}\right)^{j}\left[\frac{r+(1+r)\pi_{t+j+1}}{1+r}\right]m_{t+j}=N$$

It is assumed that government is responsible for seigniorage revenue and takes the right-hand side of equation (44) as given. Consider, now, the consequences of a temporary change in seigniorage revenues raised in period t, but compensated for with a one-off rise in period t+T. It follows that,

(3.45)

$$\frac{dm_{t+T}}{dm_t}=-\frac{[r+(1+r)\pi_{t+1}](1+r)^{t}}{r+(1+r)\pi_{t+T+1}}$$

Equation (45) implies that any change in the real money stock requires a larger change in the opposite direction in T-periods time with a factor of proportionality that is rising through time. It appears that postponing the raising of seigniorage runs the risk of a proportionately larger inflation in the future than may be required today.

3.3.2 Constraint on Monetary Policy

Fiscal deficits become more persistent in most countries in the 1980s and the first half of 1990s. These persistent deficits caused to ask the question whether the public sector was satisfying the PVBC or not. (Hamilton and Flavin (1986), Bohn (1995))

How tolerant monetary policy could be of persistent deficits without surrendering defacto control of inflation? How extensive would the effects be on inflation of a run of deficits or even a permanent sequence of deficits?

McCallum (1984) enquired whether or not monetary policy might retain control of the price level in the face of just a sequence of permanent deficits. McCallum defines monetarist equilibrium in which inflation is zero.

Set $\mu=1$. In that case, $\pi=0$, since $\pi=\mu-1$. Alternatively, $m_t(1+\pi_{t+1})-m_{t-1}=0,\forall t$.

It is needed to investigate that the extent to which fiscal policy might exclude such a situation from being a feasible outcome. In that situation equation (17)

can be rewritten as;

(3.46)

$$\frac{b_t}{1+r_t} = b_{t-1} + (g_t - \tau_t)$$

$d = (g_t - \tau_t), \forall t.$

It follows then, assuming a constant interest rate, that

(3.47)

$$b_{t+T} = (1+r)^{T+1} b_{t-1} + (1+r) d \sum_{j=0}^{T} (1+r)^j$$

In turns this implies that:

(3.48)

$$\frac{b_{t+T}}{(1+r)^{T+1}} = b_{t-1} + d \sum_{j=0}^{T} \left(\frac{1}{1+r}\right)^j$$

$$\frac{b_{t+T}}{(1+r)^{T+1}} = b_{t-1} + d \left[\frac{1 - \left(\frac{1}{1+r}\right)^T}{1 - \left(\frac{1}{1+r}\right)} \right]$$

(3.49)

The last term on the right-hand side does not converge to zero through time since as $T \to \infty$

(3.50)

$$\frac{b_{t+T}}{(1+r)^{T+1}} = b_{t-1} + \frac{1+r}{r} d$$

Since PVBC must hold, a zero inflation equilibrium is not feasible under equation (23); permanent deficits in this sense are indeed inconsistent with the monetarist equilibrium.

Now consider a process for debt of the following sort:

(3.51)

$$\frac{b_{t+T}}{(1+r)^{T+1}} = b_{t-1} + \frac{1+r}{r}d$$

where d* demotes the deficit inclusive of interest payments, $d_t^* \equiv (g_t + \frac{rb_{t-1}}{1+r} - \tau_t)$. Furthermore, it is assumed that the fiscal aulthority tries to fix the deficit to its value at time t for all t+j, for j ≥ 0.

This rule implies that at time T the outstanding level of debt will be given by

(3.52)

$$\frac{b_{t+T}}{(1+r)^{T+1}} = \frac{b_{t-1}}{(1+r)^{T+1}} + \frac{(T+1)d^*}{(1+r)^T}$$

The first term on the right-hand side of equation (3.52) clearly converges to zero for $T \to \infty$. The second term on the right hand side of equation (3.52) rising initially before falling. Intuitively, while the numerator is rising linearly through time, the denominator is rising exponentially through time. As T$\to \infty$, it follows then that $\frac{b_{t+T}}{(1+r)^{T+1}} \to 0$, as required. The intuition is that by including interest payments in the deficit, the government repays a sufficient amount of debt each period and hence meets the PVBC. In this sense permanent deficits are a feasible policy for the fiscal authority in the presence of a zero inflation monetary policy.

However, even on this definition of the deficit, there are some unappealing implications for the evaluation of taxes. In particular, the sequence of taxes required to support such a permanent deficit is itself unbounded. It can be shown that the sequence of taxes necessary for $d_t^* = d^*$ for all t is given by

(3.53)

$$\{\tau_{t+j}\}_{j=0}^{\infty} = \{g_{t+j} + \frac{rb_{t-1}}{1+r} + (1-jr)d\}_{j=0}^{\infty},$$

which in turn can be used in equation (29) to yield a formula for the deficit inclusive of interest:

$$\frac{r}{j=0}\left[\sum_{s=0}^{\infty}\{(\sum_{s=0}^{j=1} b_{t+s} - b_{t+s-1}) + (1-jr)d\}\right]$$

where the first term within the summation is a sequence of terms in the growth of outstanding debt. Taxes are rising linearly through time. Although the level of debt is rising through time the constant valued deficit implies a growth in interest payments that is declining through time. Consequently, the growth in taxes is also falling through time but necessarily at a rate initially less than that of the debt service. The primary deficit is therefore constrained in this set up to fall without bound such that taxes raised are sufficient to meet the ever-rising interest bill on the rising stock of debt.

Aiyagari and Gertler (1985) investigates the notion that price level is determined by the money supply. They also investigates whether or not money is unique in its effects on other economic variables, whether it matters if fiscal policy or monetary policy causes variation in the money supply and whether a strict Fisher relation obtains between nominal interest rates and expected money growth.

They conclude that the price level may be closely tried to the level of government debt which is become something of a forerunner of the fiscal theory of the price level.

Consider a rule for raising tax revenues of the following sort,

(3.54)

$$T_t = [G_t + \psi B_{t-1} - \frac{\psi B_t}{1+i_t}]$$

for 0 < φ <1, this says that outstanding government bonds are not completely backed by taxes. Using equation (3.54) in equation (3.34) and simplify

(3.55)

$$\frac{(1-\psi)}{1+i_t}B_t = (1-\psi)B_{t-1} - M_t + M_{t-1}$$

Equation (55) can be expressed in real terms

(3.56)

$$\frac{1+\pi_{t+1}}{1+i_t}\left[(1+i_t)\frac{M_t}{P_{t+1}}+(1-\psi)\frac{B_t}{P_{t+1}}\right]=(1-\psi)\frac{B_{t-1}}{P_t}+\frac{M_t}{P_t}$$

Using equation (25) under the assumption of log separability U= log C+ χ log ($\frac{M}{P}$), χ >0., the following equation is obtained

(3.57)

$$\frac{1}{1+r_t}\left[\frac{M_t}{P_{t+1}}+(1-\psi)\frac{B_t}{P_{t+1}}\right]+\chi C_t=(1-\psi)\frac{B_{t-1}}{P_t}+\frac{M_{t-1}}{P_t}$$

Where we have used that

(3.58)

$$\frac{1}{1+r_t}\left[\frac{M_t}{P_{t+1}}+(1-\psi)\frac{B_t}{P_{t+1}}\right]+\chi C_t=(1-\psi)\frac{B_{t-1}}{P_t}+\frac{M_{t-1}}{P_t}$$

In the steady state C=Y, i=r= δ then; equation (58) becomes:

(3.59)

$$P=\frac{\delta}{1+\delta}\frac{M+(1-\psi)B}{\chi Y}$$

If taxes fully back debt issue, then a steady state equilibrium exists in which the price level will be directly proportional to the money supply. However to the extent that taxes do not fully support debt issue then price level will bear a proportionate relationship to the stock of outstanding debt.

3.3.3 Interest Rates and Fiscal Variables

The PVBC makes clear that monetary and fiscal policy are closely linked.

Financial wealth takes one of two forms: money and bonds. Money earns no interest and nominal bonds earns interest. Fiscal authority sets the fiscal variables (taxes and debt, given expenditure), and a monetary authority determines the path for the interest rate.

The one-period public sector flow budget constraint is given by:

(3.60)

$$\frac{B_t}{1+i_t} = B_{t-1} + P_t(G_t - T_t) - (M_t - M_{t-1})$$

B_{t-1} is the nominal quantity of debt issued last period and maturing this period.

i_t is the nomial interest rate between period t and t+1.

P_t is the aggregate price level

$(G_t - T_t)$ is the real primary deficit in period t.

$(M_t - M_{t-1})$ is seigniorage raised in period t.

A central assumption is that the monetary-fiscal sequences avoid Ponzi schemes, such that,

(3.61)

$$\lim_{T\to\infty} B_{t+T}\left(\Pi_{j=0}^{T}(1+i_{i+j}\right)^{-1} = 0$$

This condition ensures that for a given level of outstanding liabilities at the start of any time period the ensuring intertemporal sequence of net surpluses plus seigniorage revenues is sufficient to meet those liabilities.

The following is the fiscal rules:

(3.62)

$$T_t = \lambda G_t - \frac{(M_t - M_{t-1})}{P_t} + \gamma\frac{B_{t-1}}{P_t}$$

where T_t denotes tax revenue generated in period t. Fiscal policy is characterized by the sequence $\{(\lambda_{t+s}, \gamma_{t+s})\}_{s=0}^{T}$. Fiscal policy determines the amount of debt and the size of the primary deficit (i.e. γ) and $(1\text{-}\lambda_{t+s})G_{t+s})$. If is assumed that $\gamma \in (0,1)$ and fixed for all the time.

Since γ >0, the fiscal authority, looking forward from any time t, will always do enough to repay the outstanding debt in existence at the start of time t,

$$\lim_{T\to\infty}(1-\gamma)^{T+1}B_{t-1}=0$$

Consequently, for monetary and fiscal policy to be consistent with fiscal solvency, there must be a sufficient amount of discounted net surpluses looking forward from date t.

Therefore

$$\lim_{T\to\infty} B_{t+T}\left(\Pi_{j=0}^{t}(1+i_{t+j})\right)^{-1}=0$$ if and only if

(3.63)

$$\sum_{s=0}^{T}\left[\{\Pi_{j=0}^{s-1}(1+i_{t+j})\}^{-1}(1-\gamma)^{T-s}(1-\lambda_{t+s})P_{t+s}G_{t+s}\right]\to 0$$

Two regimes will be analyzed: The first one is a balanced budget regime and the second one is permanent deficits.

(i) A balanced budget regime:

A first regime is a zero balance on the primary deficit. Some debt was issued in the past and the government is committed to repaying that at a constant rate, γ. Fiscal policy is simply the sequence $\{(\lambda,\gamma)\}_{s=0}^{T}$ with $\lambda=1$ and 0< γ < 1, for all s. Monetary policy is the sequence of one-period decisions denoted by $\{i_{t+s}\}_{s=0}^{T}$. In period t, the tax yield is given by equation (64)

(3.64)

$$T_t=G_t-\frac{(M_t-M_{t-1})}{P_t}+\gamma\frac{B_{t-1}}{P_t}$$

Substitute equation (64) into equation (60) gives that

(3.65)

$$\frac{B_t}{(1+i_t)}=(1-\gamma)B_{t-1}$$

Iterating on this expression demonstrates that such a fiscal rule satisfies the no-Ponzi game condition independent from the monetary policy, that is the sequence of interest rates, since

(3.66)

$$\lim_{T\to\infty} B_{t+T}\left(\Pi_{j=0}^{T}(1+i_{t+j})\right)^{-1} = \lim_{T\to\infty}(1-\gamma)^{T+1}B_{t-1} = 0$$

To confirm this result, set $\lambda = 1, \forall s$ in equation (3.66). In this case, there is no linkage between fiscal variables and the interest rate. Outstanding debt will become vanishing small in finite time and there is no constraint on monetary policy.

(ii) Permanent deficits

The existence of a permanent deficit may be taken to imply that $\lambda \in (0,1), \forall \in$. It is assumed that there is a lower bound on taxes determined by the debt repayment parameter γ. The fiscal rule is:

(3.67)

$$T_t = \lambda G_t - \frac{(M_t - M_{t-1})}{P_t} + \gamma \frac{B_{t-1}}{P_t}$$

Substituting equation (3.67) into equation (3.60) gives us;

(3.68)

$$\frac{B_t}{(1+i_t)} = (1-\gamma)B_{t-1} + (1-\lambda)P_t G_t$$

The public sector is now running a deficit in every period. This policy is sustainable if the following expression goes to zero in the limit:

$$B_{t+T}\left(\Pi_{j=0}^{T}(1+i_{t+j}\right)^{-1} = (1-\gamma)^{T+1}B_{t-1}+(1-\lambda)\sum_{s=0}^{T}\left[\{\Pi_{j=0}^{s-1}(1+i_{t+j})\}^{-1}(1-\gamma)^{T-s}P_{t+s}G_{t+s}\right]$$

(3.69)

It is required that the second term on the right-hand side of equation (3.69) converges to zero. A useful special case is where the sequence of nominal government expenditures is fixed.

(3.70)

$$(1-\lambda)P_{t+s}G_{t+s} = (1-\lambda)\overline{PG}, \quad \forall s$$

Substitute equation (3.70) into equation (3.69) and the second expression on the right hand side of the equation (3.69) can be written as;

$$(1-\lambda)\overline{PG}\sum_{s=0}^{T}\left[\{\Pi_{j=0}^{s-1}(1+i_{t+j})\}^{-1}(1-\gamma)^{T-s}\right] \tag{3.71}$$

This expression brings out clearly the potential tension between monetary and fiscal policy. Given the rate of retirement of outstanding debt γ, it is left to monetary policy to ensure convergence of this expression to zero. On the other hand if the monetary authority had a stronger commitment, it can be regarded that (3.71) as determining a bound on γ.

Consider the case where interest rates are set at the level given as follows

$$i_{t+s} = \{(1-\gamma)^{-2}-1\} \quad \forall s \geq 0 \tag{3.72}$$

If monetary policy follows the path (3.72) then (3.71) can be written as;

$$(1-\gamma)^{T}\sum_{s=t}^{T}[(1-\gamma)^{s-t}(1-\lambda)\overline{PG}] \tag{3.74}$$

where the expression in square braces converges to;

$$\frac{1-\lambda}{\gamma}\overline{PG} \tag{3.75}$$

As T $\rightarrow \infty$ (3.75) tends to zero.

It is found that permanent fiscal deficits effectively place an upper bound on the sequence of feasible interest rates and do not imply complete “separability” in the feasible set of monetary and fiscal choices. The bound increasingly constrains the interest rate sequence as the fiscal authority's chosen rate of debt retirement becomes smaller.

Monetary policy and fiscal policy can not be seperable under a regime of permanent fiscal deficits.

Permanent zero balances or permanent fiscal deficits are extreme cases. For example, consider a deficit in period zero that is declining steadily through time. Such a policy may be viewed as a simple form of tax smoothing. Consider a deficit; $D_t = \rho D_{t=1}$, where p>1 and where $D_t \equiv (1-\lambda)P_t G_t$. Then it can be written as;

(3.76)

$$(1-\rho) + i_s - \pi_{s+1} < \gamma \quad \forall s \geq T$$

Equation (3.76) tells us that a regime in which the deficit is temporary but persistent the constraint on monetary policy is clearly eased as compared to permanent deficits. In the case of temporary deficits fiscal policy has constraint on monetary policy.

Short term interest rates is used us the tool of monetary policy, the constraint imposed on monetary policy by a permanent deficit takes the form of an upper bound on the interest rate sequence And even under less extreme fiscal policies, such as a temporary but persistent deficit, monetary policy may be hampered.

The monetary policy makers such as the European Central Bank, may support strict controls on the fiscal policies of member states by using, the stability and Growth Pact. The Stability and Growth Pact is motivated by concerns that fiscal policy may distort monetary policy decisions. Wallace (1981) characterizes the monetary and fiscal policymakers in the United States as having engaged in a game of ``chicken". In the United States authority for choosing processes for M_{t+1}, now i_t, g_t and τ_t and there is decentralized among the across three government agencies, the Federal Reserve, Congress and the executive. As a technical matter of legal authority, the FederalReserve cannot perform the powerful kind of open-market operations in which future tax changes are automatically triggered by open-market exchanges of currency for interest bearing bonds. If congress and the president “go first” and choose plans for $\{g_t\},\{\tau_t\}$ that imply that present value of net-of-interest budget deficit is positive then it is simply not feasible for the Federal Reserve forever to stick to a constant -M rule. Furthermore, the longer the Fed delays in delivering to the Treasury seignorage revenues raised through inflation, the more inflation must eventually occur. On the other hand, if the Federal Reserve views itself as ``going first'' and as being able to sustain a constant M-rule, then despite its lack of formal authority to legislate tax or expenditure changes, the Fed can force the budget into balance in the present value sense. A game of chicken seemed to be occuring in the United States from 1981 to 1985 because the Fed announced a policy that is feasible only if the budget swings toward balance in a present value sense, whereas Congress and the President set in place plans for government expenditures and taxes that imply prospective net - of – interest deficits so large that they are feasible only of the Fed eventually creates more inflation.

3.4 Fiscal Theory of the Price Level (FTPL)

A more recent approach to analyze the interaction between monetary and fiscal policy is the fiscal theory of the price level (FTPL). Fiscal theory of the price level argues that the requirements for a rational expectations equilibrium to obtain in a standard model of monetary economy are stricter than that is often acknowledged. FTPL demonstrates that prices and output may indeed be influenced strongly by fiscal policy.

FTPL developed by Cochrane (2001), Leeper (1991), Sims (1994,1999) and Woodford (1995,1997,1998) FTPL argues that the public-sector budget constraint imposes restrictions on the joint choices for monetary and fiscal policy variables.

In the FTPL government's present-value budget constraint (PVBC) determines the equilibrium price level. That is, if the expected discounted sequence of net surpluses of deficits is not identically equal to outstanding debt, then the price level must change in order to bring these magnitudes into equality. Changes in the price level alter the value of real consumption units for holders of nominal government debt.

FTPL resolves the problem of price level indeterminancy under an interest rate rule. This problem was mentioned by Sargent and Wallace (1975). If the present-value budget constraint ties down the price level, we might consider the monetary authority to be setting the interest rate in a way that may be consistent with how Central Bank act in practice. However this comes at a price as monetary policy no longer controls inflation (although it may still influence expected inflation), and macroeconomic stability may have more to do with fiscal policy than monetary policy.

In this part, fiscal theory of price level determination is explained in the context of a simple representative – household model of a monetary economy.

The economy is made up of identical infinite -lived households, each of which seeks to maximize its lifetime utility

(3.77)

$$\sum_{t=0}^{\infty} \beta^t U(c_t, \frac{M_t}{P_t})$$

where 0< β <1 is a constant discount factor, and the period utility U(c,m) is concave and increasing in both arguments. Here c_t denotes the household's consumption in period t of the single consumption good, p_t is the money price of that good, and M_t denotes the (nominal) money balances held by the household at the end of period t. Woodford (1995) interprets M_t as referring to a household's direct or indirect holdings of the monetary base.

For simplicity only deterministic monetary / fiscal policies and likewise only deterministic or perfect foresight equilibria are considered. As a result it suffices to consider trading in a single kind of financial asset each period in addition to money; there is a market for one-period nominal bonds.

Let R_t^b be the gross nominal return on bonds held from period t to period t+1; that is bonds costing one dollar at date t can be redeemed for R_t^b dollars at date t+1. Similary, let R_t^m be the gross nominal return on money. Then a household chooses in period t a level of consumption c_t end -of-period money holdings M_t and end-of-period bond holdings M_t, subject to the budget constraint

(3.78)

$$P_t C_t + M_t + B_t \leq W_t + P_t Y_t - T_t$$

where W_t denotes the nominal value of beginning-of-period wealth, Y_t denotes real income (treated here as a quantity of consumption goods with which the household is endowed) and T_t denotes the nominal value of net taxes paid in period t (treated here as lump-sum). Nominal wealth in the following period then follows from household's portfolio decision according to the law

(3.79)

$$W_{t+1} = M_t R_t^m + B_t R_t^b$$

The household's consumption/portfolio choice in period t must be such that $M_t \geq 0$. There is no similar non-negativity constraint on B_t; thus borrowing is allowed. But each household is constrained by a borrowing limit, i.e. a lower bound upon the value of W_{t+1} implied by its portfolio. Specifically, the household must begin each period with a debt no larger than the following:

(3.80)

$$W_t \geq -\sum_{j=0}^{\infty} \frac{p_{t+j} y_{t+j} - T_{\in+j}}{\Pi_{s=0}^{j-1} R_{t+s}^b}$$

This debt limit is the tightest limit with the property that any debt that can be repaid in finite is permissible. This corresponds to the concept of borrowing limited only by one's future endowment. (The rate of return on bonds is the relevant one in defining such a limit, because of the constraint that $M_{t+s} \geq 0$.). Some limit is necessary on borrowing in order to be well-defined budget set for the household (otherwise Ponzi schemes would be possible). Equation (3.80) is a borrowing limit because it cannot ever bind unless the household intends never to consume or hold any money at any later date; thus, standard boundary conditions on the utility function suffice to ensure that in equilibrium equation (3.80) will not bind, just as with the non-negativity constraints on c_t and M_t

A household choose lifetime consumption/portfolio plants $\{c_t, M_t, B_t\}$ satisfying (3.78), (3.78) and the non-negativity constraints for all $t \geq 0$, and (4) for all $t \geq 1$, given an initral wealth W_0, the price and interest rate sequences $\{P_t, R_t^m, R_t^b\}$, and the income and net tax sequences $\{Y_t, T_t\}$. These sequences describe a perfect foresight equilibrium the money balances M_t demanded by the representative household each period equal to the money supplied by the government, the bonds B_t demanded similarly equal to the quantity of government bonds issued, and

$$c_t + g_t = y_t \tag{3.81}$$

where g_t denotes government purchases of the good in period t.

The government's monetary/fiscal policy regime specifies some four of the sequences $\{g_t, T_t, R_t^m, R_t^b, M_t, B_t\}$, possibly as functions of the others or of other state variables such as $\{P_t\}$. Only four of these sequences can be independently chosen by government policy. This is because one is implied by the others, through the government's financing constraint

$$p_t g_t = T_t + (M_t - M_{t-1} R_{t-1}^m) + (B_t - B_{t-1} R_{t-1}^b) \tag{3.82}$$

Equation (3.82) must be satisfied each period. In period zero, the government starts with initial oustanding liabilities $\left(M_{t-1} R_{t-1}^m + B_{t-1} R_{t-1}^b = W_0\right)$ Furthermore, the government cannot exogenously specify both the price of goods in terms of money and the quantities of each that will be outstanding; if it determines the quantities that it supplies of each, it must allow the price of bonds to be determined in the market, while if it determines the relative price (by fixing R_t^m and R_t^b, it must allow the private sector to determine the portfolio shares that it desires to allocate to the two assets. Thus, government policy can exogenously specify at most three of the variables $\{R_t^m, R_t^b, M_t, B_t\}$

For example, in the quantity-theoretic tradition, it is common to analyze policy regimes in which the government exogeneously specifies the path of the money supply $\{M_t\}$, and in which there is assumed to be no government borrowing. A complete description of such a monetary-fiscal policy regime would involve exogenous specification of the sequences $\{g_t, R_t^m, M_t, B_t\}$ with $\{T_t\}$ then being implied by equation (3.82) and $\{M_t^b\}$being determined in the bond market.

The specification general assumes $R_t^m = 1, B_t = 0$ for all t and often specifies $g_t = 0$ for all t as well. It is also considered alternative type of regime in which $\{g_t, R_t^m, M_t\}$ are again exogenously specified but $\{T_t\}$ is determined by feedback rule that involves the endogenous variables $\{P_t, R_t^b\}$ and $\{B_t\}$ is then implied by equation (3.82).

As yet another alternative, one might consider a pure interest-rate peg, in which monetary policy exogenously specifies the variables $\{R_t^m, R_t^b\}$, while allowing the composition of government liabilities to be determined by the market. If fiscal policy specifies the time paths of government purchases and tax collections, the evolution of total government liabilities is then implied by equation (3.82), but neither $\{M_t\}$ nor $\{B_t\}$ individually is fixed by government policy.

The requirements for perfect foresight equilibrium in the model are as follows. The budget constraints stated above are equivalent to a requirement that the lifetime consumption and money-holding plants $\{c_t, M_t\}$ satisfy the non-negativity constraints for all t ≥ 0, and the present-value budget constraint is given by (3.83).

(3.83)

$$\sum_{t=0}^{\infty} \frac{p_t c_t + \triangle_t M_t}{\Pi_{s=0}^{t-1} R_s^b} \leq \sum_{t=0}^{\infty} \frac{p_t y_t - T_t}{\Pi_{s=0}^{t-1} R_s^b} + W_0$$

Given the initral wealth W_0, where $\triangle_t = \frac{(R_t^b - R_t^m)}{R_t^b}$

Constraint (7) is of the same kind as for a nonmonetary economy expect that the interest rate differentral Δ_t appears as the ``price" of holding money (due to foregone interest earnings). Woodford (1995) assumes boundary conditions on utility that imply that the non-negativity constraints do not bind. Then the plans $\{c_t, M_t\}$ are optimal for the household if and only if the first order conditions

(3.84)

$$\frac{u_m(c_t, m_t)}{u_c(c_t, m_t)} = \triangle_t$$

$$u_c(c_t, m_t) = \beta(1 + r_t^b)u_c(c_{t+1}, m_{t+1})$$

(3.85)

Hold for all t ≥ 0, where $m_t = \frac{M_t}{P_t}$ represents real balances and $r_t^b = R_t^b(p_t / p_{t+1}) - 1$ is the real rate of return on bonds, and the present value budget constraint (3.83) holds with equality. It is also necessary fort he existence of an optimal plan that both the left-and-right hand side were to be infinite, (3.83) would represent no constraint upon the attainable level of consumption, so that no consumption plan could possibly be the best.

If consumption and real balances are both normal goods, u_m / u_c is increasing in c and decreasing in m, from which it follows that equation (3.84) can be inverted to yield

(3.86)

$$m_t = L(c_t, \triangle_t)$$

Where the liquidity preference function L is increasing in c and decreasing in Δ. Substituting (3.81) into (3.83) then yields the equilibrium condition

(3.87)

$$m_t = L(y_t - g_t, \triangle_t)$$

This is a standart LM equation except that money demand is assumed to depend only upon private purchases. Substituting equation (3.81) into equation (3.84) yields,

(3.88)

$$\lambda(y_\in - g_\in, \triangle_t) = \beta(1 + r_t^b)\lambda(y_{t+1} - g_{t+1}, \triangle_{t+1}$$

Where $\lambda(c, \Delta) = u_c(c, L(c, \Delta))$. This is essentially an intertemporal-optimization-based version of the Hicksian IS equation. Finally substituting equation (3.81) into equation (3.83) and requiring that the budget constraint hold with equality yields

(3.89)

$$\frac{W_0}{p_0} = \sum_{t=0}^{\infty} \frac{(\tau_t - g_t) + \triangle_t m_t}{\Pi_{s=0}^{t-1}(1 + r_s^b)}$$

Where $\tau_t = \frac{T_t}{p_t}$ represents real tax revenues each period. Equation (3.89) states that a present-value budget constraint must hold for the government as well, in equilibrium, owing to the fact that optimizing private households plan to exhaust their own budget constraints. According to this constraint, the present value of future primary government budget surpluses must equal the value of current net government liabilities; government revenues in this calculation include a term $\Delta_t m_{\in}$, indicating interest savings on the government's monetary liabilities.

A perfect foresight equilibrium is then a collection of sequences $\{P_t, R_t^m, R_t^b, M_t, g_{t,} T_t\}$ that are consistent with the monetary-fiscal policy regime, that satisfy equations (3.87) and (3.88) for each t, given the exogenous process $\{y_t\}$, and that satisfy (3.89) given W_0.

At each date t, the real value of net government liabilities must satisfy

$$\frac{W_t}{p_t} = \sum_{s=t}^{\infty} \frac{(\tau_s - g_s) + \triangle_s m_s}{\Pi_{j=t}^{s-1}(1 + r_j^b)} \qquad (3.90)$$

This is the equilibrium condition that determines the price level p_t at date t, given the predetermined nominal value of net government liabilities W_t, and given expectations at date t regarding the current and future values of the real quantities and relative prices enter the expression.

Determination of the price level by equation (3.90) confirms the suggestion of Sargent (1982) that the fiscal policy regime matters fort he equilibrium value of money, like other government debt, depends upon ``private agents" expectations about the revenue streams backing" it. Price level adjusts to satisfy equation (3.90) assuming full price flexibility. An increase in the nominal value of outstanding government liabilities or in the size of the real government budget deficits expected at some future dates, is inconsistent with equilibrium at the existing price level; either change causes households to believe that their budget set has expanded and so they demand additional consumption immediately (as well as planning higher consumption in the future). The consequence would be excess demand for goods (both now and in the future). This forces up prices to the extent that capital loss on the value of net outside assets restores households' estimates of their wealth to ones that just allow them to purchase the quantity of goods that the economy can supply (and that are not consumed by the government). Price level determination thus depends upon a wealth effect of price-level changes, as in the analysis of Patinkin (1956). But in contrast to Patinkin's analysis of the ``real balance effect'', Woodford finds that the effect in question depends upon the value of net outside assets rather than upon the value of the monetary base.

FTPL directs attention to the role played by variables such as net government liabilities and expectations regarding future government liabilities and expectations regarding future government budgets in price level determination. Woodford (1995) argues that changes in such variables do affect the equilibrium price level, quite independently of any changes in the path of the money supply that may be associated with them. And FTPL de-emphasizes the role of the money supply as a determinant of the equilibrium price level and in so doing makes it intuitive that the price level may be perfectly determinate under a regime with a completely elastic money supply.

3.4.1 Price level determination with an exogenous Money supply

In this section, the role of the government budget in price-level determination is considered in the case of a policy regime that fixes the time path of the money supply. It is useful to begin by recalling how quantity-theoretic analyses argue that the path of the price level can be determined in such a case without any reference to the time path of government deficits or of the outstanding government debt.

In the rational-expectations version of the model of Cagan (1956), it is assumed that desired real money balances are a decreasing function of the expected rate of inflation, so that money demand becomes

$$\frac{M_t}{P_t} = f\left(\frac{p_{t+1}}{p_t}\right) \tag{3.91}$$

Where f is a monotically decreasing function. It is admitted that various real factors affect the form of the function f, but it is assumed that the additional arguments can be suppressed on the ground that real and nominal variables dichotomize. It is then argued that in the case of an

exogenously specified evolution $\{M_t\}$ for the money supply, the money supply sequence and money demand alone determine the equilibrium price-level sequence
$\{p_t\}$. Thus, the specification of the time path of the government budget deficit is irrelevant for determination of the price level.

The outstanding government debt and the expected path of government deficit may affect the equilibrium price level, even when they have no effect upon the path of the money supply. Furthermore, it is even arguable that the expected path of the money supply does not matter for price-level determination except through its consequences for the government budget. In order to state an irrelevance proposition it is needed to define what it would mean to neutralize the fiscal effects of a chance in the money supply. For this purpose it is useful to consider a rule for net tax collections for the form:

$$T_t = p_t x_t - \triangle_t M_t \tag{3.92}$$

where $\{x_t\}$ is an exogenous sequence. The exogenity of $\{x_t\}$ thus implies that changes in the path of the Money supply $\{M_t\}$ have no effect on the proportional income tax rate. It can be thought as a rule in which there is a proportional income tax, with the tax rate varying exogenously over time, but with the further stipulation that the government's interest savings from the fact that some of its liabilities are monetary and rebated lump-sum to the private sector.

Conventional quantity-theoretic reasoning; for a contraction of the money supply, by raising the nominal interest rate on bonds, causes total government liabilities to grow faster and this results in a higher eventual price level rather than a lower price level. This result is in the spirit of the "unpleasant monetarist arithmetic" of Sargent and Wallace, although the argument is slightly different. Sargent and Wallace argue that a monetary contraction in the absence of fiscal reform, can be inflationary because it results in faster growth of the government debt that they assume must eventually be monetized. Thus the inflationary result of the policy is linked to the fact that in the long run, the policy change results in a higher rather than a lower Money supply. A permanent reduction in the money supply, with no change in expected paths of the fiscal variables, implies a permanently higher path for the price level. This is because the increased nominal value of total government liabilities is inflationary even if it is never monetized. The connection between higher government liabilities and a higher price level is a direct one, not dependent upon an implication of a eventual increase in the money supply.

3.4.2 Comparing the effects of increases in money and increases in government debt:

A "helicopter drop" of an additional money into an economy with no outstanding government debt results in a permanent, proportional increase in the price level

Now suppose that at date 0 there is an unexpected ``helicopter drop'' of additional currency in the amount of (λ-1)M units, for some $\lambda \succ 1$. The money supply is again expected to remain constant thereafter and no changes are made in the announced paths for government purchases, the tax rate or the interest paid on money. The new policy regime involves a path for the money supply of $M_t = \lambda M$ for all t ≥ 0; real tax revenues of $x_0 = x - (\lambda - 1)\dfrac{M}{p_0}$ while $x_t = x$ for all $t \geq 1$; and unchanged paths for $\{g_t, R_t^m\}$. Again there is a unique perfect foresight equilibrium where the price level is constant for all dates t ≥ 0 but at the higher level of λ_p.

It is the reduction of taxes net of transfers at date t=0, rather than the increase in the money supply, that is responsible for the increase in the equilibrium price level. The price level would increase at date t=0, by exactly the same amount if a fiscal transfer of nominal value (λ-1) M were made at that date, with no change in the expected value of x_t subsequently, even if the path of the money supply were still expected to be $M_t = M$ for all t ≥ 0.

This point is reminiscent of a criticism often raised by Tobin against the strong "monetarist" proposition that only the path of the money supply matters for price level determination (Tobin ,1974). Tobin argues that a "rain" of Treasury bills should also increase prices, not because government liabilities as such should have this effect but because treasury bills are some what money like.

The present analysis accepts the quantity-theoretic assumption of a sharp distinction between money and bonds and assumes that only money provides liquidity services and it is argued nonethless that on increase in government debt can increase the price level. An increase in the government budget deficit can be inflationary even when it implies no increase in the money supply at any later date. The “helicopter drop” of government debt does not imply and change in the expected future path of the money supply nor any change in future seigniorage revenues. It implies an increase in the present value of future net tax collections, equal to the value of the initial transfer. This comes about the feedback rule (3.92) for net tax collections; real net tax collections τ_t increase in so for $\Delta_t M / P_t$ decreases.

As a conclusion, initial price-level effect of the ``helicopter drop" of additional money be the same in the case of a “helicopter drop” of additional government debt, but it would also fail to exist if the money supply were permanently increased by the same amount, but without any increase in net transfers to the private sector; the effect in such a case would be just the opposite of that in the case of a permanent reduction in the level of the money supply. Such effects as a change in the money supply has on the price level, therefore, are quite dependent upon the fiscal aspects of the policy change; injection of new Money through an open-market exchange of money for bonds has very different effects than injection of new money through a transfer to the private sector.

3.5 Ricardian and non-Ricardian Policy Regimes

The quantity equation is the case of a certain kind of specification of fiscal policy, neither the government budget deficit nor the size of the government debt plays any role in price level determination. This is the case of Ricardian policy and there is no problem in traditional quantity-theoretic analysis. However the policy regime may be non-Ricardian policy regime.

As an example, consider a policy regime in which the sequences $\{g, M_t, R_t^m\}$ are exogenously specific and tax revenues are determined by a feedback rule.

$$T_t = p_t g_t - [M_t - R_{t-1}^m M_{t-1}] + \gamma R_{t-1}^b B_{t-1} \qquad (3.93)$$

for some 0< $\gamma \leq 1$. The rule indicates that tax collections of each period equal to the exogenously determined government purchases minus the exogenously determined government purchases minus the exogenously determined level of seigniorage during the period and plus certain fraction of the amount owed by the government on its outstanding debt at the beginning of the period. Under such a rule the government financing constraint (3.82) implies that $B_t = (1-\gamma)R_{t-1}^b B_{t-1}$ and

$$\lim_{t \to \infty} \frac{B_T}{\Pi_{s=0}^{T-1} R_s^b} = 0 \qquad (3.94)$$

regardless of the paths of the price level or of nominal interest rates.

Then sequence $\{P_t, R_t^b\}$ describe a perfect foresight equilibrium if and only if equation (3.87) and (3.88) are satisfied.

The initial level of government debt and the level of tax collections are completely irrelevant for the determination of the set of perfect foresight equilibrium paths for the price level and for the interest rates.

Woodford (1995) mentions this irrelevance result, in the spirit of the results of McCallum (1984) and Sargent (1987). This result is an extension of "Ricardian equivalence" proposition regarding the irrelevance of the government debt of real quantities such as the real interest rate. For that reason Woodford proposes to call a policy regime Ricardian. In the case of any such regime, fiscal policy plays no role at all in price level determination, while the money supply determines the price level. Traditional quantity theoretic reasoning is completely valid under Ricardian policy regime.

FTPL argues that the policy regime may be non-Ricardian and this is the case that essential to the effects of fiscal policy upon the price level. The non-Ricardian character of the policy rules implies no internal inconsistency, and in particular does not preclude the existence of a perfect foresight equilibrium in which the expectation that government policy will adhere to the rules stated is fulfilled.

An even simpler example of non-Ricardian policy would be one similar to that advocated by Friedman (1959). Let the money supply $\{M_t\}$ follow an exogenous path and no interest paid on money. Furthermore, let neither real government purchases nor tax rates vary in response to the state of the economy: assuming the sequences of $\{y_t\}, \{g_t\}$and $\{\tau_t\}$ are exogenous and this assumption of Friedman have criticized by Blinder and Solow (1976), Turnovsky (1977), Christ (1979), McCallum (1984) that it would imply an explosive path for the government debt. But this does not mean that independent variations in the various exogenous series (and in the initial net liabilities of the government), over some range, do not continue to be consistant with the existence of equilibrium. What it does mean is that in such a regime, the equilibrium price level will depend upon fiscal policy; and that as a result, merely fixing and appropriate growth rate of the money supply does not suffice to ensure a desired rate of inflation.

The government is not constrained to follow a Ricardian policy. The present value of future primary surpluses must equal to the value of the outstanding government debt, if ``primary surpluses" are defined the excess of tax revenues plus seigniorage revenues over government spending.

3.5 Summary and Conclusion

The interaction between monetary and fiscal policy from the theoretical point of view is studied in this chapter of the thesis. The fundamental linkage is the relation between the government budget constraint and the setting of interest rate. Three different models are explained.

In the first model, the price level or inflation rate is determined without reference to fiscal solvency. However there may be wealth effects associated with government deficits.

In the second model, present value of budget constraint makes clear that monetary and fiscal policies are closely linked. For example the monetary policy makers such as European Central Bank may support strict controls of the fiscal policies of member states by using Stability and Growth Pact.

The last model is the Fiscal Theory of Price Level. The policy regime may be non Ricardian as argued by FTPL. In that case fiscal policy determines the price level in the economy.

Chapter 4: Stabilization Programmes in Turkey (1980-2006)

4.1 Introduction

This part of the thesis will provide an overview of the stabilization programmes of the Turkish economy for the 1980-2006 period by analyzing the macroeconomic instability process. Turkey experienced very severe crises in early 1994 and early 2001 due to unsustainable fiscal balances, the collapse of the domestic debt markets (banking system), monetization and the expectation of further monetization.

Several stabilization programs were implemented under the guidance of the IMF to restore stability in the economy. However the policies were delayed or abandoned for political and structural reasons.

The first IMF stabilization programme with view to reduce inflation and to attain sustainable growth was implemented in 1980. After that IMF stabilization programmes were supported by stand-by agreements in 1994, 1998, 1999, and 2001. Turkey adopted a inflation targeting strategy in 2006 and the inflation targets were announced for 2007, 2008 and 2009 by the Central Bank of Turkey.

4.2 1980 Stabilization Programme

An early attempt to reduce inflation and to attain sustainable growth was made in 1980. The 1980 program mainly depended on liberalization attempts and the export-led growth policy. This program reached its initial targets of lower inflation and higher GDP growth. There was a relatively liberalized external trade regime and financial system in the economy.

In 1980, a package of economic stability measures was adopted to restore the worsened problems that emerged in the late 1970's. With the 1980 Stabilization Programme, Turkey switched its economic policy from "import substituting industrialization" to "export-led growth strategy". Within this framework, the import regime was liberalized to a great extent, export promoting incentives were initiated, supply and demand system in foreign exchange markets was put into practice and the Turkish Lira was left to float in a controlled monetary environment. State intervention in the economy was reduced to a minimum level and considerable efforts were made in favor of a liberal market economy, as discussed in Boratav and Yeldan (2001) (See also Şenses, 1984; Celasun and Rodrik, 1989 and Metin, 1995).

The inflation rate decreased significantly during the first three years of the programme. The main reason for the drop in inflation was the decline in the real wages and the agricultural terms of trade, and high interest rates helped in restraining domestic demand. The competitiveness of the Turkish economy improved significantly with the high devaluations and the economy entered an export-oriented growth path, as discussed in Celasun and Rodrik (1989).

The inflation rate, which had been kept under control between 1981 and 1983, started to increase again after 1984. The monetization of the high budget deficits and the increase in the cost of non-labor factors of production were the important factors behind the higher inflation rate. The contraction in the domestic demand that stemmed from the decline in real wages and the agricultural terms of trade were mainly compensated for by high public expenditures after 1983. Especially in 1986 and 1987, it was observed that public investments increased substantially. In addition, the agricultural support policies and the services provided by the municipalities again gained importance in these years, see for details in Boratav (1987).

The dynamics of the growth performance of the Turkish economy after 1989 can be linked to the unsuccessful disinflationary efforts and debt financing policies of the government, which affected the exchange rate policy. The policymakers started to slow down the depreciation rate of the Turkish lira in part to control inflation, but mainly to be able to borrow easily from the domestic market in 1989, as put forward in Ertuğrul and Selçuk (2001).

4.3 1994 Stabilization Programme and the 16th Standby Agreement

Turkey experienced large and growing fiscal and external imbalances over the 1989-1994 period, which the real exchange rate was appreciated around 20%. PSBR was high (about 10% and 12% of GNP in 1992 and 1993 respectively) and there was a shift towards deficit financing through monetization, see Table 4. 4 for details.

Several auctions of short term maturity Treasury bills were cancelled one after another and the Treasury started to rely on cash advances from the Central Bank instead. The announced budget for 1994 did not include any measures towards tightening. While these caused increasing levels of anxiety in the financial sector, Turkey's credit rating was downgraded by some major international agencies. The commercial banks had engaged in heavy offshore borrowing in 1992-1993. The Central Bank, aiming to defend the currency lost from foreign currency reserves, intervened in the interbank market and raised the overnight rate. Yet the Central Bank continued to lose reserves by selling foreign currency to the commercial banks. The commercial banks which were able to buy foreign currency from the central bank at relatively inexpensive rates began to lose their own reserves as residents started to withdraw their foreign exchange deposits. The liquidity build–up through excessive creation of domestic credit to the public sector in the form of cash advances to the Treasury by the Central Bank and there was a decline in total foreign exchange reserves in the first quarter of 1994, more details can be found in Boratav and Türkcan (1993).

The impact of the decline in foreign exchange reserves was seen in the exchange rate, which was 15, 000 TL/$ in January 1994 and 35, 000 TL/$ by the first days of April 1994. From January to April, Turkish Lira depreciated by 135%. As a result, The Turkish government announced a new stabilization package on the 5th of April 1994. This package especially depended on a reduction in expenditures to correct fiscal imbalances. After the April 1994 stabilization program was announced by the government, the IMF approved a stand-by of 742 million dollars to be extended over a 14 month period and strongly urged the rapid implementation of structural reform measures.

The public sector borrowing requirement of Turkey rose steadily between 1988 and 1993, as can be seen in Table 4.4. The PSBR increased along with the primary deficit, which excludes the interest payments of the non-financial public sector. The gap between the PSBR and the primary deficit started to widen after 1992, as interest payments on existing debts increased, as discussed in Atiyas et al., (1999).

The reasons for the growth of public expenditures were increases in the total wage bill of the government, generous agricultural support policies, the worsening performance of the state owned enterprises (SEE), the increased cost of military operations in the southeastern region and the increased interest payments after 1992, as discussed in Emil et al., (2005).

After 1988, the borrowing of the public sector became increasingly dependent on foreign savings. It was agreed in early 1989 that the Central Bank's financing of the Treasury would not exceed 15% of the total budgetary appropriation. The Central Bank started to implement a monetary program in 1989 with the aim of restructuring its balance sheet. The programme involved target growth rates for different items of the balance sheet. The Central Bank restricted credit to commercial banks, and liquidity was to be created basically against the foreign assets. The financing of public sector deficits was shifted to domestic borrowing and the share of external borrowing was to be reduced. External borrowing was delegated to commercial banks and commercial banks became the main source of demand for domestic debt instruments. As the foreign exchange purchases of the Central Bank became the main source of money creation, the ultimate source of public debt financing were short term capital inflows as discussed in Akyüz and Boratav (2002).

The widening of the fiscal deficit had impacts on the government financing policy mix and the patterns of financing started to change after 1991. In 1991 there was a change in government and the new government announced a program aiming at lowering inflation by reducing the public deficit. In 1992, facing high levels of domestic debt service payments, the government increased the share of money financing. It used almost all its short term advances from the Central Bank up to its legal limit during the first half of the year, shifted towards longer maturities in its domestic financing and abandoned its policy of keeping external borrowing at around the level of principal repayments, and borrowed about 1 million dollars in international bond markets, see Boratav (2001) for details.

In the second half of 1992, however it became evident that reliance on short term cash advances from the Central Bank to keep interest rates from rising resulted in pressure on the TL /$ exchange rate and pressure on the Central Bank's foreign exchange position; thus, the Treasury accepted a 10% increase on the 3 monthly T-bills and also obtained another 1.5 billion dollars in external funds.

With regards to the currency crisis of 1994, the debt financing mix of 1994 should be analyzed. There was a huge increase in public sector expenditures and the financing shifted towards the money financing and Treasury actions were cancelled at the end of 1993, as discussed in Özatay (1996).

Özatay (1996) argues that the Turkish government had already become insolvent by the end of 1992 and the timing of the crisis specifically at the beginning of 1994 was due to interventions in the domestic borrowing market.

There was a radical change in the public sector borrowing requirement. Through the end of 1993 and the first quarter of 1994 the Central Bank advances increased enormously. The sources of the PSBR originated from the consolidated budget deficits, losses of the SEEs and social security institutions, deficit of local governments, municipalities and other fiscal institutions, see Table 4.5 for details.

In Turkey, the public sector borrowing requirement was high and the way of financing PSBR cause a problem in the banking sector. High PSBR led to an increase in government debt instruments, cause a significant deterioration in state-owned banks by accumulating duty losses. Risk accumulation because of domestic debt stock in bank balance sheets is an important element of crisis dynamics. Because of high risk accumulation, the credit lines of some banks were cut off and interest rates increased. The rise in interest rates increased the problem of debt sustainability, which was is also an important problem in Turkey in post-crisis period, as discussed in Van Rickegham (2005).

After the January 1980 program, the PSBR as a percent of GDP decreased immediately. It was 9% in 1980, 3.9% in 1981, and less than 5% until 1986. After 1986, the PSBR as a percent of GDP started to increase and reached 12% in 1993, as displayed in Table 4.4.

The PSBR as a ratio of the GNP stood around 10% on the average over the 1990-1993 periods. The peak of this ratio (12%) was observed in 1993 just before the 1994 crisis. Even though there were some improvements in the borrowing requirements after the 1994 crisis, the PSBR increased again to 9.3% in 1998 and to 15.5% in 1999. There was a change in the deficit dynamics and deficit financing policies of the government after 1987. The share of domestic borrowing in PSBR financing increased and the share of foreign borrowing declined. Table 4 4 presents the details of PSBR financing over the years.

The way the government financed large budget deficits was by accumulating debt and/or printing money. Both ways of financing deficits increased the inflation rates. As there was an increasing demand for debt, there was pressure on the interest rates and the debt maturities were tightened. Monetization or domestic borrowing financed the deficits. Seigniorage contributed on the average about 2-3% to the GNP. After 1996, duty losses also gained importance. 40-45% of government expenditures consisted of interest payments after 1996, the public sector found it easier to finance its borrowing requirements from domestic borrowing by issuing government bonds, as discussed in Celasun (2002).

In the period proceeding the crisis, fiscal stance was poor, the current account deficit was high, the Lira was overvalued the government was lacked liquidity according to international standards and the banking sector was relatively weak, as discussed in Celasun (2002).

The basic elements of the disinflation efforts in the late 1980s were in various forms of nominal anchoring and monetary targeting without any serious effort to reduce the public sector borrowing requirements. This policy needed a higher interest rate on domestic assets and lower depreciation for short-term capital inflows. The new disinflationary strategy which was based on monetary targeting and real appreciation was used after 1989. However, the government did not take the necessary measures on the fiscal side and the disinflationary attempts by the monetary policymakers were futile. The economy experienced a crisis in April 1994 due to unsustainable nature of the fiscal and the external deficit. The government announced a new stabilization programme on 5 April 1994 and a standby arrangement was approved by the IMF. However this programme was also unsuccessful and the standby agreement came to an end in 1995.

For many developing countries, the 1980s was a period of external shocks with faltering export demand, high and volatile real interest rates and a depletion of funds for external finance. By 1980, many developing countries governments were used to relying on external sources for financing their fiscal operations. Under such conditions, constraints on growth were thought to originate from the two gaps of "savings-investments" and "foreign exchange". With the darkening external environment, however, they found themselves in a position where they had to extract resources from internal markets to sustain their fiscal targets. That in turn meant domestic debt accumulation, and the emergence of the so-called "fiscal constraint" as the third gap limiting growth prospects (See Bacha, 1990 and Taylor, 1996).

4.4 1998 IMF Staff Monitoring Programme

In July of 1998, the Turkish government started another disinflation program under the guidance of an IMF Staff Monitored Programme (SMP). The programme achieved some improvements concerning inflation rates and fiscal imbalances but it could not relieve the pressures on the interest rates. The Russian crisis in August 1998, the general elections in April 1999 and two devastating earthquakes in August and October 1999 deteriorated the fiscal balance of the public sector.

In comparison to many developing countries, Turkey had experienced relatively modest accumulated fiscal debts before 1996. However, two additional factors increased the gravity of the problem: the first one was the realization by fiscal authorities that continued seignorage extraction through monetization was no longer feasible that is the Treasury had almost fully exploited the Laffer curve (see Yeldan; 1997 and Selçuk; 1996). The deficit had to be increasingly financed by domestic sources through bond issues at very high real interest rates to cover the risk premia. The second factor is that: the maturity of the domestic debt was very short which gave way to an intensive Ponzi mode of debt management. These combined factors led to excessively high interest rates crowded out private investors, and caused significant strain on the domestic market, as discussed in Yeldan and Pamukçu (2006).

4.5 1999 Programme and the 17th Standby Agreement

The government started implementation of another restructuring and reform program after the general elections of 1999. The aim of the programme was also to reduce inflation and again there was a standby agreement with the IMF in December 1999. The main tool of the disinflation program has been adoption of a crawling–peg regime. A gradually declining monthly rate of depreciation of a basket (1 US dollar + 1.5 DM or 0.75 Euro) was announced for 18 months, after which the basket would left to fluctuate within a band.

Turkey started a new economic program in December 1999 after failed reforms and deteriorated macroeconomic performance. The International Monetary Fund was involved in the design and supervision of the programme. The financial assistance provided by the IMF would be 20.6 billion dollars between 1999 and 2002. The aim of the programme was to decrease the inflation rate to a single digit by the end of 2002. It relied exclusively on a nominally pegged (anchored) exchange rate system for disinflation as the inflation was the main economic problem in Turkey over three decades.

The 1999 stabilization programme consisted of:

1. Financial Sector adjustment (restructuring and reform of the sector)
2. Nominal exchange rate being used as the anchor (preannounced crawling peg regime without a band)
3. Forward looking indexation in the government sector
4. Monitoring the fiscal performance of a comprehensive public sector consolidation
5. Structural reform within the social security system, government budget expenditures, agricultural sector (producing as well as pricing) and infrastructural investments
6. Accelerated privatization
7. Banknote issue only in conjunction with foreign exchange purchases by the Central bank, no sterilization by monetary policy.

During both the 1980s and 1990s, the Turkish economy endured with a high inflation rate stemming mainly from budget deficit and deficit in current accounts. Thus, the devaluation of Turkish Lira was inevitable during that period.

The integration with the world economy after the 1980s made the Turkish economy more vulnerable to international crises. In fact, the economic recession in South East Asia followed by the Russian crisis in August 1998 adversely affected the Turkish economy in 1999. The difficulties became worse with the devastating earthquakes in August and November of that year. The economic losses caused by these natural disasters amounted to roughly 5% of the Turkish GNP. As a result, there was a 6.1% contraction in output in 1999, as discussed in Selçuk and Yeldan (2001).

Incorporated in strict fiscal and monetary policies, this program succeeded in decreasing the inflation rate considerably. The annual consumer price inflation decreased from 65% to 55% in the year 2000. Following a 6.1% contraction in the previous year, in 2000 the Turkish economy registered high growth in real terms with rises of 6.3% in the GNP and 7.2% in the GDP. In November 2000 one year after introducing the program, Turkey experienced another economic crisis.

Pre-crisis economic situation in Turkey

The Turkish government announced a stabilization program based on the exchange rate as nominal the anchor in December 1999. The program was named as "Exchange Rate Based Disinflation Program", aimed at increasing the primary surplus via a tight fiscal policy, realizing structural reforms, accelerating privatization and implementing an incomes policy consistent with the inflation target. The inflation target was to bring down the CPI to 25% and WPI to 20% by the end of 2000. The inflation rate was anchored to the pre-announced crawling peg set in terms of a basket made up of 1 dollar and 0.75 euro. The exchange rate was announced for the period of 1 January 2000- 31 December 2001. The value of the basket in lira was set to increase by 20% for the year 2000, which was the same rate of inflation rate as for the WPI. A gradual shift to a more flexible exchange-rate would begin in July 2001 with the introduction of a band, as put forward by CBRT (2000).

The programme also provided for a quasi-currency board whereby money printing against domestic asset was precluded. For the end of each quarter, an upper ceiling was set for the stock of net domestic assets (NDA) of the Central Bank at the level reached in December 1999. Interest rates became an important policy tool and the relationship between capital flows and interest rates was crucial in the programme. Macroeconomic equilibrium was to be attained through changes in interest rates as there was no sterilization by central bank. If capital inflows were less than the current account deficit, liquidity would be drawn from the system and interest rates would be raised in order to attract more capital inflows, as discussed in Akyüz and Boratav (2002).

Fiscal goals were also included in the programme. The primary balance of the public sector was planned to give a surplus of 2.2% of GNP in 2000. This target was seen to be sufficient to stabilize the public debt-to-GDP ratio over the medium run (See Akyüz and Boratav, 2002).

The 1999 Disinflation Programme was also an exchange rate based program. In Turkey exchange rate based stabilization programs were used and the developments in the Turkish economy after 1987 are in line with stylized facts from exchange rate-based stabilization programs in different countries. Calvo and Vegh (1999) summarized those stylized facts as:

1. Slow convergence of the inflation rate (measured by the CPI) to the rate of change in exchange rates.
2. An initial increase particularly in the real GDP and private consumption, followed by a contraction.
3. Real appreciation of the domestic currency
4. Deterioration of the current account balance
5. A decrease in domestic ex-post interest rates in the initial stages

Calvo and Vegh (1999) explain the reasons for the initial increase in real activity followed by a counteraction in exchange rate based stabilization programs. At the initial stage of slowed down depreciation, the interest rate parity condition leads to a lower domestic interest rate. If the convergence of inflation is slow, the real interest rate will drop leading to an increase in domestic demand (especially for durable and semi-durable goods), consumption and private investment. Eventually, a reduction in consumption and investment and a real depreciation is inevitable because of the resource constraints. As a result, the economy experiences a recession right before or immediately after the programme ends. If the economy goes through several "slowed-own depreciation-correction" cycles, the overall economic activity will also experience boom-bust cycles. The amplitude of these cycles will be higher if the inter-temporal elasticity of substitution is high in the economy.

Akyüz and Boratav (2002) point out that a common problem of exchange rate based stabilization programme is that such programmes rely on arbitrage flows. If the confidence, reliability and credibility of the programme disappeared, foreign creditors would sell their assets and exit the country. This situation situation was observed in Turkey in November 2000 when non-resident withdrawals were estimated to be 5.2 billion dollars. Domestic banks sold liras in an effort to reduce their open positions. The exit from liras created difficulties for bank relying on foreign funds and resulted in a liquidity crunch and a hike in interest rates by draining international reserves. Banks carrying large T-bill portfolios with funds borrowed in overnight markets suffered significant losses and started to bid for funds in the inter-bank market, at the same time unloading large amounts of government paper.

The targets set by the disinflation programme for the nominal exchange rate, net domestic assets and primary deficits were all attained in the first three quarters of 2000. However, targeted inflation rates were not maintained. The average inflation for the year 2000 was reached 55%. As the planned inflation rate was 25% for the CPI and 20% for the WPI, given that the predetermined rates for the nominal exchange rate had been followed, there was a significant appreciation of the currency in real terms in Turkey. The economic growth was about 6% and the current account recorded a record deficit at around 5% of GNP or 9.8 billion dollars. The increase in economic activity and the record deficit were accompanied by a rapid expansion of commercial bank credit, as discussed in Ekinci (2002).

4.6 Economic Crisis of 2000-2001

High inflation, real appreciation of currency and rising public debt created uncertainity over the sustainability of the pegged exchange rates. Political problems between the prime minister and the President caused the peg to break in 19 February 2001. There was a massive flight from TL and overnight interest rates reached 6 200% in uncompounded terms as explained in Keyder (2003).

The Central Bank lost control over the monetary policy, international reserves decreased by 5 billion dollars a day, the government was forced to float the currency, and the IMF supported exchange rate stabilization program was cancelled. The exchange rate was 680 000 TL on 19 February 2001 and 960 000 TL on 20 February 2001 which was 41% devaluation in one day.

The crisis started in the banking sector and the Turkish case initially was a banking crisis and then crisis continued as a currency crisis. There is a strong connection between a banking crisis or collapse and a currency crisis under fixed exchange rate regime.
The drop in the interest rate was faster than that of the inflation rate. The annual rates on 3 month T-bills (treasury bills) averaged around 38% in January-November 2000. This rate had been more than 100% in 1999. The banking sector in Turkey was heavily dependent for its earnings on high yield T-bills associated with rapid inflation and was highly vulnerable to disinflation. There emerged an inconsistency in policy since much of the fiscal adjustment was predicated on declines in the nominal and real interest rates, on which many banks depended for their viability as discussed in Özatay and Sak (2002).

The drop in interest rates brought considerable relief to the budget and played an important role in restraining debt accumulation. The primary surplus in 2000 reached 2.8% of GDP compare to the target of 2.2%. There was a fine balance between interest rates and the capital inflows throughout the first and second quarters of 2000.

Foreign exchange deposits held by residents in domestic banks rose both in absolute terms and as a share of total deposits. The proportion of foreign exchange deposits to total deposits was 42% in 1998, 38% in 1999, 9% in 2000 and 55% in 2001 as displayed in Table 4.6. There was a decline in the ratio of foreign exchange deposits to total deposits in 2000 because people thought that the announced exchange rate would hold. The disinflation programme had high credibility in Turkey initially so people demanded fewer dollars in 2000. The dollarization rate increased after the currency-peg break down in 2001.The dollarization rate was 55% in 2002 and 46% in 2003 as presented in Table 4.6.

Regarding the banking crisis in Turkey, Eichengreen (2001) argues that the problem was with the mid-sized banks that had taken highly-leveraged positions in anticipation of a continued decline in interest rates. Demirbank used a risky mode of financing, which led to enormous risk accumulation in its balance sheet when compared to the rest of the system. The ratio of the government debt instrument portfolio to total assets was about twice higher than other banks. Demirbank was also carried its government debt instrument mainly through short-term repos. The ratio of repos to the total government debt instrument portfolio was around 70% at the end of 1999 and beginning of 2000. Demirbank was also carrying a large, long-term, government debt instrument portfolio by financing its activities mostly through overnight borrowing from other banks. Demirbank had purchased almost 15% of all the Treasury issues earlier in 2000. According to the best scenario, the bank was expecting capital gains towards the end of 2000 when interest rates were expected to fall further in line with the decelerating rate of depreciation, as discussed in Ekinci (2002).

It is hard to identify a single event for most emerging market crises. In Turkey there were economic and political reasons for November 2000 and February 2001 crises. These were fiscal deficits, net capital flows turning negative in September 2000, the rapid exit of capital in November, adverse inflation results of October, unexpectedly high monthly trade deficits, political problems related to privatization, worsening relations with the EU, the disclosure of irregularities in the banking system, and the investigation of several banks taken over by Savings Deposit Insurance Fund (SDIF), as discussed in Celasun (2002).

Özatay and Sak (2002) argue that without a fragile banking system and triggering factors, the high current account deficit and real appreciation of the lira would not have been enough on their own to precipitate the 2000-01 crisis. There was risk accumulation in the banking system in the period preceding the crisis in Turkey. They conclude that the Turkish financial system, which was dominated by banks, was vulnerable to the spikes in both the exchange rate and the interest rate that a sudden capital reversal could cause.

Özatay and Sak (2002) analyze the structural characteristics of the Turkish banking system and give a precise description of the banking sector fragility in the context of Turkey right before the crisis. They argue that the main igniting factors were the delays in reforming the banking sector and the actions that caused the dichotomy in the banking sector (private banks versus state banks) to come to the surface.

The banking system had severe losses because of liquidity and interest rate risks in the November 2000 crisis and exchange rate risks in the February 2001 crisis. Relations between the real sector and the banking sector began to deteriorate, which affected the asset quality of the banking sector adversely. The banking problems in Turkey mostly arise from the asset side of the balance sheets as there was series deterioration in asset quality. Non–performing loans also created problems in the banking sector. Privately owned commercial banks' non-performing loans were increased sharply in 2001 because there were close relationships between certain banks and groups who used credit from their own banks but they did not repay the loans. In Turkey state-owned banks had a problem of duty losses.

The public sector found it much easier to finance its borrowing requirements from domestic borrowing through issues of government debt instruments. This enabled the government to bypass many of the legal instruments. Consequently, with the advent of full-fledged financial liberalization in 1989, PSBR financing relied almost exclusively on issues of government debt instruments to the internal market, especially to the banking sector. In this sense, the financial liberalization seemed to serve mainly the purpose of mode-switching for the Treasury in sustaining the financing requirements of its deficit, away from Central Bank sources of monetization to greater reliance on securitization, see Yeldan and Pamukcu (2006) for details.

The process of financial deepening was directly shaped by the financing needs of the public sector. In the early 1990s, the government granted a series of incentives to the banking sector for holding its debt instruments. All the government debt instruments, treasury bills and bonds (mostly treasury bills) could be used as collateral and be held against liquidity requirements. This process led to two important consequences: first, it substituted the fiscal policy against the monetary policy and hindered the central bank's capacity to conduct monetary policy and second, it enabled the Treasury to assume a monopoly power to regulate the distribution of domestic credit and crowded out the private sector, as discussed in Pamukçu and Yeldan, (2005).

In Turkey fiscal deficits and the way of financing the deficits create problems. Domestic debt financing has become the major source, especially after the mid-1980s. The shift to domestic debt financing from Central bank monetization is often explained as the government avoiding inflation acceleration through the corresponding money supply growth. With the reserve accommodation, commercial banks have become the major source of financing and the size of banking system assets have increased. The relationships between budget deficits, inflation rate and money growth under these conditions are discussed in Tekin-Koru and Özmen (2003).

The fragility of the domestic asset markets gave way to high rates of real interest. Interest payments as a ratio of the GNP increased very rapidly. From 1990 to 1996, the share of interest expenditures on domestic debt in aggregate GNP increased by 300%. The ratio of interest payments to the GNP was 9% in 1996, rose 21% in 2001 and decreased to 14.8% in 2003, as reported in Table 4.3.

The burden of interest payments created problems in the budgetary balances of the central government. The budget deficit to GNP ratio was 3% in 1998, 17.9% in 2001. This point was also mentioned in the fourth paragraph of Letter of Intent of 9 December 1999. "Moreover, these high real interest rates, together with a weak fiscal primary position, have pushed public finances onto an unsustainable path. Public sector debt is projected to increase to 44% of the GNP at the end of 1998 and to 58% of the GNP at end of 1999", as discussed in IMF (1999).

4.7 Strengthening the Turkish Economy and the 18th Standby Agreement

Following the financial crisis in November 2000 and February 2001 the new economic program called Strengthening the Turkish Economy was put into practice in May 2001. The program was supported by the IMF and the World Bank.

The main goals of the programme were stated as: reducing uncertainties in the financial markets by taking urgent measures in the banking sector, the stabilization of interest rates and exchange rates, and completing structural reforms to promote economic efficiency. Fiscal policy was tightened in order to stabilize the increasing debt stock of the public sector and the control of the Central Bank over short-term interest rates was increased while a floating exchange rate regime was adopted, see CBRT (2001) for details.

When the new programme was initiated in May 2001, it started to yield results in fiscal discipline, bank rehabilitation, structural reforms and the floating exchange rate regime. As part of the structural reforms, the Central Bank Law was amended to give the bank independence in instruments and The Central Bank of Turkey started to announce its monetary policy as of January 2002 and its intention of adopting the implicit inflation targeting. The main reason for undertaking implicit inflation targeting was that the necessary conditions for formal inflation-targeting were not in place. Fiscal dominance or public debt dominance was the main factor that marked the 2001-2004 period and this factor limited the efficiency of the post-crisis monetary policy. In economies that had experienced deep credibility crisis and undergone a high debt burden with short maturities and whose debts are mostly either flexible and indexed to foreign currency, central banks cannot exert full control over the general level of interest rates by using short-term interest rates as a policy instrument, as indicated in CBRT, (2005a).

There were significant achievements, especially concerning inflation, on the way to the economic stability in 2002 and 2003. The Turkish economy entered a growth period in 2002 following the recession of 2001. The increased confidence in the economic program and more optimistic expectations for domestic demand were the determining factors in the recovery of the economy. The substantial rise in exports positively affected industrial production and contributed the growth of the economy in 2002, as reported in CBRT (2003).

In Turkey, the economy contracted by 9.5% in 2001 and the inflation rate was 55% and the public debt was nearly 100% of the GNP. After the reforms or post crisis period, the Turkish economy grew by 7.9% in 2002 and 5.9% in 2003. The inflation rate fell dramatically from 55% in 2001 to 25 % in 2003. The inflation figure of 2003, according to Consumer Price Index, was the lowest inflation rate in 25 years. The inflation rates and growth rates between 1980 and 2006 can be seen in Table 4.1.

As of first quarter of 2003, confidence in the economic environment was reestablished as a result of the removal of uncertainties in the economy and the determined implementation of program. There was a sharp decline in inflation and interest rates. The stability in exchange rates and the expectations regarding the continuation of favorable developments resulted in an increase in economic agents using Turkish lira (CBRT, 2003). The dollarization rate started to fall after 2003, see Table 4.6 for details.

The substantial economic achievements became more apparent by the first quarter of 2004. Significant success has been attained in the inflation problem and starting from 2005 one-digit inflation was to be targeted.

The banking sector was strengthened with the banking sector restructuring program. The downward trend in interest rates and exchange rates reinforced the financial structures of the banks. Bank interest margins were significantly narrowed and their income decreased due to a decline in interest rates and exchange rates. Banks currently tend to attach greater importance to growth in order to sustain their profitability. Moreover, they are striving to increase the number of clients and expand their individual credit portfolios, as reported in CBRT (2004).

4.8 Inflation Targeting Strategy and the 19th Standby Agreement

The CBRT adopted inflation targeting as a monetary policy regime in January 2006. Inflation targeting is a monetary policy regime used by developed and developing countries. 20 countries around the world adopted inflation targeting as a monetary policy. The CBRT emphasized in its announcements of early 2002 pertaining to the general framework of monetary policy that the final target of its monetary policy was the adoption of the inflation targeting. It was mentioned that "implicit inflation targeting" would be implemented until the adoption of the inflation targeting regime. Inflation targets were set jointly with the government. The Central Bank uses short term rates to fight against inflation and base money was set as an additional anchor with a view to increasing the reliability of inflation targets. The monetary policy is supported by fiscal discipline, structural arrangements and Central Bank independence, as indicated in CBRT (2005b).

During the 2001-2005 period, arrangements were made for the institutional infrastructure of the monetary policy, which is a pre-condition for the transition to the inflation-targeting regime. The Central Bank rendered its institutional framework more efficient, defined its communication policy in a transparent way, expanded its information set and improved its inflation forecast method, see CBRT (2005a).

The targets of inflation, the CPI, are announced for a three year period. In harmony with the Pre-Accession Program and the three year budget plans, the targets were set as 5%, 4% and 4% for 2006, 2007 and 2008 respectively. These targets are the point targets and the upper and lower bands for uncertainty are also announced by the Central Bank, see Table 4.4 for details.

With the adoption of the inflation targeting regime at the beginning of 2006, within the scope of "IMF Program Requirements", Net International Reserves will continue to be performance criteria. Performance criteria for Money Base and the indicative target for Net Domestic assets will be replaced by the "inflation consultation criteria", as reported in CBRT (2005a).

Tables 4.5 and 4.6 display the quarterly path of inflation consistent with the end-of year targets for 2006 and 2007.

4.6.1 Public Sector's Role in the Inflation Targeting Strategy

Monetary policy is a necessary condition on the way towards price stability, but it is not sufficient. In order to attain price stability, the continuity of fiscal discipline should be maintained. In Turkey, fiscal discipline has the potential to affect the inflation targeting regime through four channels. The first channel comprises long-term expectations. Further enhancement of fiscal discipline through its continuity will increase the effectiveness and predictability of fiscal discipline by monetary policy by extending the borrowing maturities and reducing the risk premium and the volatilities in risk premiums while contributing to the credibility of the inflation targeting regime. The second channel works through the prices of goods and services produced by the public sector itself. Naturally, the consistency between the prices of goods and services produced by the public sector and inflation targets is crucial for attaining price stability. The third channel works through the incomes policy of the public sector. One of the main determinants of the expectations for price and wage inflation in Turkey is the wage increases made by the public sector to its own employees. In this context, the consistent trend of the incomes policy with the inflation target is a sine qua non for the success of the inflation targeting regime. The fourth channel is the direct spending channel. The public sector's direct purchases of goods and services are reflected in inflation via total demand. The powerful position of these channels indicates the critical importance of the continuity of fiscal discipline in a period where the chronic inflation is still fresh. In conclusion, continuity of fiscal discipline and consistent implementation of fiscal policies with targets are fundamentals in the success of the inflation targeting regime, as put forward by CBRT (2005b).

Price stability is essential for increasing the potential of the economy, achieving a high and sustainable growth rate. Monetary policy is necessary but not sufficient for achieving long-run price stability. The roles of fiscal policy and structural reforms are also critical in this process. Developments in structural reforms that would enhance the quality of fiscal discipline in the medium and long run are closely monitored in terms of both macroeconomic stability and price stability, as discussed in CBRT (2007).

4.9 Summary and Conclusion

The lack of credible macroeconomic policies, absence of monetary and fiscal discipline, a history of high and persistent inflation, high levels of domestic and external debts, current account deficits, a high degree of dependence on external capital flows, open capital account regimes and weak industrial export capacities were the problems of the Turkish economy after the 1980s. Persistent inflation, populist cycles, crisis and volatile growth rates have been the dominating macroeconomic issues of the Turkish economy for more than two decades.

The Turkish economy's structure started to change after 1980. Turkey experienced two economic crises after 1990. These were the 1994 crisis and 2000-2001 crisis. In 1994 the inflation rate was more than 100% and it was more than 50% in 2001. Turkish economy contracted by 6% in 1994 and 9.5% in 2001. In both crises, the TL depreciated and interest rates increased dramatically.

The reasons for persistent and long lasting inflation in Turkey can be explained by three approaches. The first one is the relationship between money and prices or monetary approach. The second one is the public finance approach and indicates that monetary expansion occurs in response to fiscal imbalances and the third one is the structural and the cost-push factors. The public finance approach emphasizes that given the limitations on domestic and foreign borrowing dictated by financial market conditions and solvency requirements, monetization is the residual form of deficit financing. The structural and cost push explanation emphasizes the link between the exchange rates and prices, the mark-up on final factor prices due to oligopolistic industrial structure and wage pressures stemming from indexation rules and entrenched inflationary expectations.

This thesis stresses the public finance approach and indicates that monetary expansion occurs in response to fiscal imbalances. Turkish economic policy makers should give greater importance to fiscal balance. The continuity of the fiscal discipline is important in maintaining and sustaining the price stability in the economy. After 2002, the economic program used in Turkey gives priority to fiscal discipline and this time fiscal discipline is maintained. Turkish economy experienced low inflation rates and high growth rates. Comprehensive social security reform is also necessary for the sustainability of public finances in Turkey, together with tax and public expenditures reforms.

Table 4.1: Inflation Rates and Growth Rates (1980- 2006)

Years	Inflation Rate (CPI)	Growth Rates
1980	101.4	-2.8
1981	34.0	4.4
1982	28.40	3.1
1983	31.39	4.4
1984	48.40	7.1
1985	44.95	4.3
1986	34.62	6.8
1987	38.85	9.8
1988	73.70	1.5
1989	63.27	1.6
1990	60.30	9.4
1991	65.90	0.3
1992	70.10	6.4
1993	66.10	8.1
1994	106.26	-6.1
1995	89.11	8
1996	80.35	7.1
1997	85.73	8.3
1998	84.64	3.9
1999	64.87	-6.1
2000	54.92	6.3
2001	54.40	-9.5
2002	45.00	7.9
2003	25.30	5.9
2004	10.58	9.9
2005	7.7	7.6
2006	9.8	6.1

Source: Main Economic Indicators of SPO

Table 4.2: Debts as a % of the GNP (1980- 2006)

Years	Domestic Debt/GNP	Foreign Debt/GNP
1980	3.58	26.98
1981	3.09	28.94
1982	3.19	30.62
1983	2.99	33.04
1984	3.93	36.08
1985	4.31	38.69
1986	4.56	43.56
1987	5.77	47.1
1988	5.75	45.5
1989	6.25	38.85
1990	6.11	32.81
1991	6.77	33.74
1992	11.66	35.59
1993	12.77	38.24
1994	13.98	51.07
1995	14.55	43.58
1996	18.55	44.09
1997	20.23	44.82
1998	21.7	48.67
1999	29.28	55.62
2000	29	58.93
2001	69.22	78.1
2002	54.49	71.63
2003	54.45	61.64
2004	52.34	50.64
2005	50.3	46.8
2006	43.7	39.8

Source: Main Economic Indicators of SPO

Table 4.3: Main Fiscal Variables 1980- 2006 (in 000 000s YTL)

Years	Consolidated Budget Deficit	PSBR	Interest Payments	GNP
1980		465	31	5303
1981		319	75	8023
1982		374	87	10612
1983		688	211	13933
1984		1194	441	22168
1985	798	1266	675	35350
1986	1411	1869	1331	51185
1987	2607	4563	2266	75019
1988	3990	6235	4978	129175
1989	7672	12282	8260	230370
1990	11955	29140	13966	397178
1991	33516	64110	24072	634393
1992	47434	116147	40298	1103605
1993	133857	203810	116470	1997353
1994	152180	239573	298284	3887903
1995	316623	390029	576116	7854887
1996	1238128	1294178	1497401	14978067
1997	2235153	2258005	2277917	29393262
1998	3803376	5016736	6176595	53518332
1999	9151620	12189173	10720840	78282967
2000	13264	14848809	20439862	1255966129
2001	29036	29030475	41062226	176483953
2002	39085	35007643	51870659	275032366
2003	40090	33355060	58609163	356680888
2004	30300	20367166	56578001	428932343
2005	8117	-2007294	45731075	486401000
2006	8173	-17293799	46260000	561987715

Source: Main Economic Indicators of SPO

Table 4.4: Main Fiscal Indicators, % of the GNP (1980-2006)

Years	PSBR	Interest
1980	8.7	0.5
1981	3.9	0.93
1982	3.5	0.82
1983	4.9	1.5
1984	5.3	1.99
1985	3.5	1.9
1986	3.6	2.6
1987	6	3.02
1988	4.8	3.85
1989	5.3	3.59
1990	7.3	3.5
1991	10.1	3.72
1992	10.5	3.65
1993	12.0	5.83
1994	6.1	7.6
1995	4.9	7.3
1996	8.6	10
1997	7.6	7.75
1998	9.3	11.54
1999	15.5	13.7
2000	11.8	16,81
2001	16.4	23.27
2002	12.7	18.9
2003	9.3	16.4
2004	4.7	13.2
2005	-0.4	9.4
2006	-0.3	8.23

Source: Own calculations from Main Economic Indicators of SPO

Table 4.5 Composition of PSBR, % of GNP (1990-1999)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Consolidated Budget	3.0	5.3	4.3	6.7	3.9	4.0	8.3	7,6	7.3	11.9
Consolidated Budget*	-0.5	1.5	0.6	0.9	-3.8	-3.3	-1.7	-0.1	-4.3	-1.8
SEE	3.8	3.1	3.3	2.4	1.4	-0.2	-0.6	-0.4	1.3	2.3
Local Authorities	0.0	0.3	0.8	0.7	0.4	0.2	0.3	0.3	0.4	0.4
Revolving Funds	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1
Social Security Institutions	-0.3	0.1	0.2	0.6	0.6	0.4	0.0	0.1	0.4	0.2
Extra Budgetary Funds	0.6	0.9	1.3	0.9	0.9	0.6	0.1	0.0	0.0	0.7
SEEs under Privatization	0.2	0.4	0.7	0.7	0.7	-0.1	0.5	0.1	0.0	0.1
PSBR	7.4	10.2	10.6	12	7.9	5.0	8.6	7.7	9.4	15.5
PSBR*	2.3	4.1	4.4	3.8	-2.9	-4.5	-2.9	-1.2	-3.3	0.2

* indicates without interest payments

Source: Main Economic Indicators of SPO

Table 4.6: Dollarization Rate (1990 - 2006)

Years	Foreign Exchange Deposits (in 000s YTL)	Total Deposits (in 000sYTL)	Dollarization Rate*
1990	21744	93930	0.23
1991	51979	164668	0.32
1992	106024	296150	0.36
1993	197364	522499	0.38
1994	598477	1203149	0.5
1995	1253289	2543786	0.5
1996	2627628	5876127	0.45
1997	5493851	11964591	0.46
1998	9574357	22916822	0.42
1999	17410653	45291813	0.38
2000	25341684	64942983	0.39
2001	60397916	110521576	0.55
2002	74694153	135575188	0.55
2003	71436743	154185095	0.46
2004	79097516	187289520	0.42
2005	79970225	233427879	0.34
2006	104426133	285487831	0.36

Source: own calculations from CBRT

* Dollarization Rate= Foreign Deposits/Total Deposits

Table 4.7: Inflation Path Consistent with the End-of-Year Target and the Uncertainty Band

	2006 March	2006 June	2006 September	2006 December	2007 December	2008 December
Uncertainty band (upper limit)	9.4	8.5	7.8	7	6	6
Path Consistent with the target	7.4	6.5	5.8	5	4	4
Uncertainty Band (lower limit)	5.4	4.5	3.8	3	2	2

Source: Annual Report 2006, CBRT.

Table 4.8: Inflation Path Consistent with the End-of-Year Target and the Uncertainty Band, 2007

	March	June	September	December
Uncertainty Band (upper limit)	11.2	8.7	7.3	6.0
Path Consistent with Target	9.2	6.7	5.3	4.0
Uncertainty Band (lower limit)	7.2	4.7	3.3	2.0

Source: Annual Report 2006, CBRT

Table 4.1: Inflatiın Rates GRCPI (1980-2006)

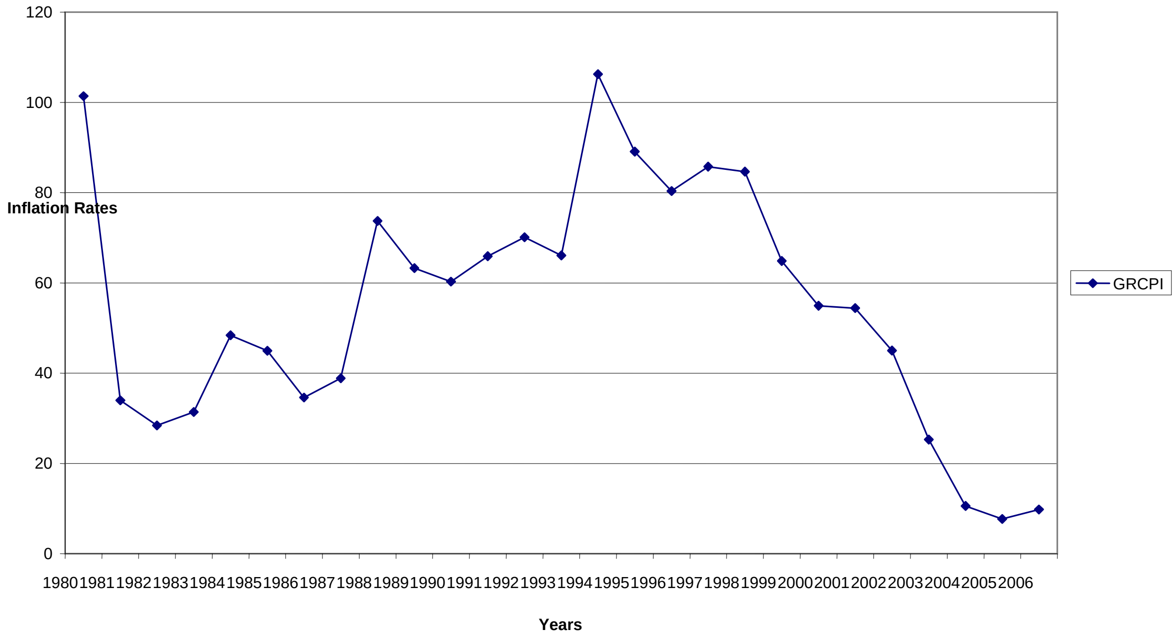
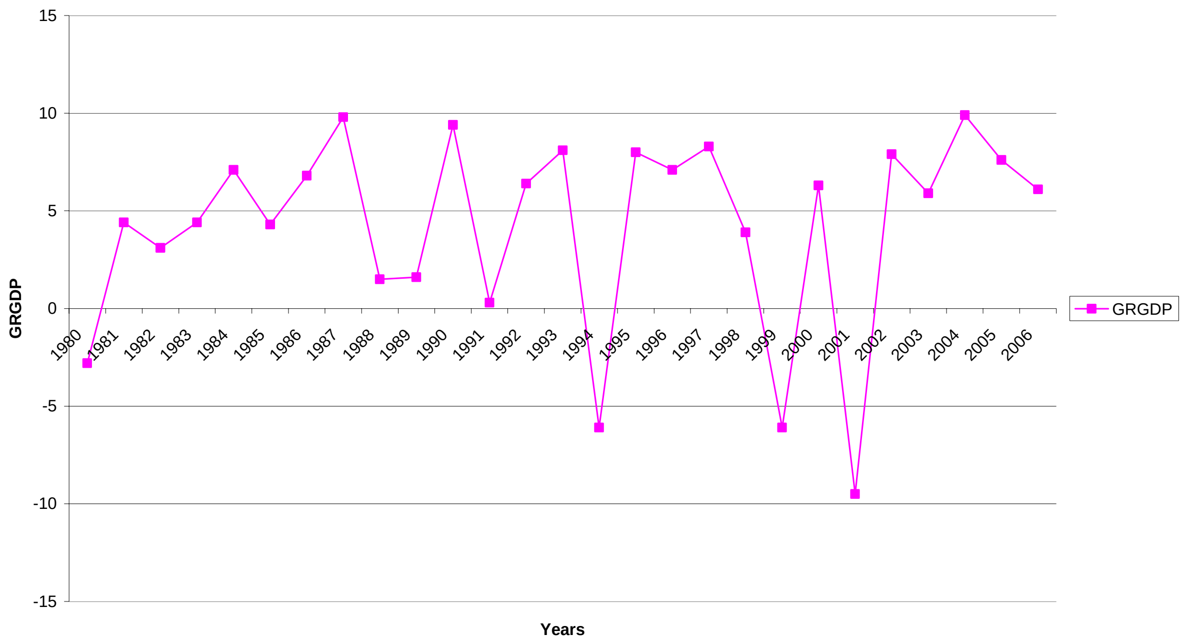


Figure: 4.2 GrowthRate, GRGDP (1980-2006)



Chapter 5: Macroeconometric Model

5.1 Introduction

In this part of the thesis a macroeconometric model for the Turkish economy (TURKPOL) will be presented and estimated. The macroeconometric model presented here is treated as a constraint in the optimization process. The results of the macroeconometric model will be used as an input for the OPTCON algorithm. The macroeconometric model designed here for Turkish economy has features of Keynesian and Neoclassical economic approaches.

5.2 Taxonomy of Macroeconometric Models

A macroeconometric model is a set of behavioural equations, as well as institutional and definitional relationships, representing the structure and operations of an economy, in principle based upon the behavior of individual economic agents.

The origin of macroeconometric modeling dates back to shortly after World War II when Marschak organized a special team at the Cowles Commission by inviting T. Koopmans, K. Arrow, T. Haavelmo, T. W. Anderson, L. Klein, G. Debreu, L. Hurwitz and F. Modigliani (Valadkhani, 2004)

There are five categories of macroeconometric models (See Valadkhani, 2005)

1. The Keynes-Klein (KK) model
2. The Phillps-Bergstrom (PB) model
3. The Walras-Johansen (WJ) model
4. The Walras-Leontief (WL) model
5. The Muth-Sargent (MS) model

The Keynes-Klein (KK) model is mainly used by model builders in developing countries to explain the Keynesian demand-oriented model of macroeconomic fluctuations. They deal with the problems of short-run instability of output and employment using mainly stabilization policies. The basic Keynesian model has been criticized as it does not consider the supply side and the incorporation of production relations. Furthermore, this modeling approach does not adequately capture the role of the money market, relative prices and expectations. As a response to the shortcomings associated with the KK model, the St Louis model was constructed by the monetarist critics in order to highlight the undeniable impacts of money on the real variables in the economy.

The second type of macroeconometric modeling approach is linked to the Phillips-Bergstrom (PB) model. The PB model uses both the Keynesian and Neoclassical theories within a dynamic and continuous time model to analyse stabilization policies. Although the PB model is also a demand-oriented model, differential or difference equations are used to estimate its stochastic structural parameters. In essence, the steady state and asymptotic properties of models are thus examined in a continuous time framework.

The third type of model is based on the Walras-Johansen (WJ) model. This type is a multi-sector model in which the economy is disaggregated into various interdependent markets, each reaching an equilibrium state by profit maximizing behavior of producers and utility maximizing actions of consumers in competitive markets. Similar to an input-output (IO) approach, different sectors in the WJ model are linked together via their purchases and sales from and to each other. It is different from an IO model in that it is highly non-linear and uses logarithmic differentiation.

The fourth type modeling is related to the Walras-Leontief (WL) model. The WL model incorporates an IO table into the Walrasian general equilibrium system, enabling analysts to obtain sectoral output, value added or employment given the values of the sectoral or aggregate final demand components.

The fifth macroeconometric model is derived from the Muth-Sargent model. The MS model is based on the evolution of the theory of rational expectations. The MS model is similar to the KK model in that they are dynamic, non-linear, stochastic and discrete. However, in this model the formation of expectations is no longer a function of previous values of dependent variables. The forward looking expectation variables can be obtained only through solving the complete model. The New Classical School demonstrated the role of the supply side and expectations in a macroeceonometric model with the aim of highlighting the inadequacy of demand management policies.

The subsequent advances in the WJ and WL models resulted in the formulation of the Neoclassical Computable General Equilibrium (CGE) models, which are based on the optimizing behavior of economic agents. CGE models are used to conduct policy analysis on international trade, sectoral production and income distribution, see for example, Capros et al., (1990).

5.3 Macroeconometric Models for the Turkish Economy

There are number of macroeconometric models for Turkish economy. The first macroeconometric model for the Turkish economy was designed in 1962 by von Hohenbalken-Tintner. Other models for the Turkish economy were by Korum (1969), Blitzer (1970), Uğurel (1971) Celasun (1972), Patel (1973), World Bank (1974), IMF (1976), Özmucur (1980) and (1984), Yörükoğlu (1980), Yağcı (1983), Conway (1984), Fair (1984), Celasun (1986), Gupta-Togan (1984), Uygur (1987), Yeldan (1989), Karbuz (1993), Özmucur (1993).

Uygur (1987) provides a good taxanomy of the macroeconometric models for the Turkish economy until the 1980s. Uygur (1987) classifies Korum (1969), Köksal (1970), Uğurel (1971), Özmucur (1980) as first generation models, and these have the following common characteristics as discussed in Uygur (1997). The models emphasize the role of econometric models in the process of economic planning which started in 1961. The models are primarily concerned with the structural analysis of the economy. Özmucur (1980) contains policy simulations. The behavioral equations are all linear in variables and parameters and estimated by OLS. Uygur classifies Yörükoğlu (1980), Yağcı (1983) and Özmucur (1984) as second generation models. These models are primarily concerned with forecasting the immediate future and contain policy simulation. The behavioral equations contain non-linearities in variables and are estimated by annual data like the first simulation model. They are solved by iterative dynamic simulation methods.

Uygur's model (1987) is dynamic, simultaneous, non-linear in variables. The model has output, price, foreign trade, domestic demand, monetary and fiscal variables. The model has some policy simulations to investigate the effects of assumed alternative government policies on the endogenous variables.

Gupta and Togan (1984) employ country specific multi-sectoral general equilibrium model. They analyze the effects of liberal and interventionist policies on the GDP and the income of different classes in the economy.

In this thesis, the macroeconometric models before 1990s were not analyzed because the structure and dynamics of the Turkish economy changed considerably after that date. In this part of thesis, before explaining the macroeconometric model of the thesis, two monetary disequilibrium model and one CGE model for the Turkish economy will be explained as such models emphasize the link between monetary and fiscal policy.

Özatay (1999) developed, estimated and simulated a quarterly macroeconometric model for Turkey. The model is constructed within the framework of a disequilibrium monetary model. The model mentions the substantial inertia in the inflation rate and the high public sector borrowing requirement. Another important aspect of the model is that it explicitly deals with the credibility issue. Stabilization experiments of the model showed that without correcting fiscal imbalances that is without eliminating the fundamental reason for high inflation, using the exchange rate as an anchor or relying on a monetary contraction are fruitless policies. Lack of credibility is shown as a major obstacle to the success of a stabilization policy.

Özdemir and Turner (2005) present a monetary disequilibrium model for the Turkish economy and run several simulation experiments. The focus of the simulations was the link between fiscal policy and money supply. This link is important in the model because it could be one of the sources of monetary disequilibrium. The simulation results show that fiscal discipline is very important in achieving objectives such as sustaining the disinflation process and reducing the high budget deficit in Turkey. In the long term, they conclude that fiscal policies should be mixed with either monetary or debt management policy to avoid excessive monetary contraction as the demand for broad money increases with the disinflation process. They show the output effect of the monetary disequilibrium model.

Agenor et al., (2005) analyze the effects of monetary policy and fiscal adjustment on output and unemployment in Turkey by using the Computable General Equilibrium (CGE) model. This model captures a number of important structural characteristics of the Turkish economy such as rural-urban migration, a large urban informal sector, dollarization in the banking system (on both the asset and liability sides), and the interactions between credibility, default risk, government debt and inflation expectations. They conducted two sets of experiments: a restrictive monetary policy taking the form of a permanent increase in the official interest rates, and fiscal adjustment taking the form of increases in the VAT rate and the tax rate on the income of profit earners. The results highlighted the importance of accounting for the general equilibrium effects on interest rate determination, as well as the link between default risk and credibility in understanding the real and financial effects of adjustment policies.

5.4 TURKPOL Model

This part of the study presents the specification and estimation of TURKPOL (Turkish Economic Policy Model), a macroeconometric model designed for Turkey. It consists of 13 behavioral equations. The model TURKPOL combines Keynesian and neoclassical elements. The model is based on Keynesian macroeconomic theory in the sense of conventional IS-LM /aggregate demand-aggregate supply models. The supply side incorporates neoclassical features. This model contains behavioral equations for the money market, the foreign exchange market, the factor demand, imports, consumption and labor supply. The public sector contains equations for net tax revenues and government expenditures on goods and services. Expectations are assumed to be adaptive. This is modelled by using the partial-adjustment dynamic specification, which includes the lagged dependent variable in almost all behavioral equations. The inclusion of lags is also justified by the existence of adjustment costs. The model is based on quarterly data and the model is able to take better account of short-term developments in key variables.

5.5 Equations of the Macroeconometric Model

This section introduces a modified macroeconometric model of Matulka and Neck (1992) for Turkey. The macroeconometric model's behavioral equations consists of the consumption of private households, gross fixed capital formation, foreign trade, money market, foreign exchange market, labor market and public sector.

Consumption of private households

Households aim at maximizing their utility by deciding upon consumption and labor supply. Consumption is modeled by a simple linear Keynesian consumption function with current income (GDP) as the main explanatory variable. The habit-persistence hypothesis is taken into account by including lagged consumption.

$$\text{Log } CONS_t = a_0 + a_1 \log CONS_{t-1} + a_2 \log GDPR_t + a_3\, RINTRATE_t + \varepsilon_t \qquad (5.1)$$

Gross fixed capital formation

Investment is modeled according to accelerator principle. Since net investment is the change in the stock of capital, it can be explained by the change in a demand variable. The demand variable (DEMAND) is defined as the sum of real GDP and real imports. Investment also depends on real interest rate. Lagged investment is included to allow for adjustment costs moving toward the optimal level of capital stock obtained from profit maximization.

$$\text{Log } INVR_t = a_0 + a_1 \log INVR_{t-1} + a_2 \log DEMAND_t + a_3\, RINTRATE_t + \varepsilon_t \qquad (5.2)$$

Foreign Trade

The foreign sector is analyzed in terms of exports of goods and services and imports of goods and services

Exports of Goods and Services

Exports depend on the real exchange rate and foreign country GDP. The reel effective exchange rate is obtained by deflating the nominal effective exchange rate with price indexes. The reel exchange rate is computed as the weighted geometric average of the price of the domestic country relative to the price of its trade partners.

$$\text{Log } EXP_t = a_0 + a_1 \log EXP_{t-1} + a_2\, REXRATE_t + a_3 \log RGDForeign_t + \varepsilon_t \quad (5.3)$$

Imports of Goods and Services

Real imports of goods and services depend on the final domestic demand and on the real exchange rate.

$$\text{Log } IMP_t = a_0 + a_1 IMP_{t-1} + a_2\, REXRATE_t + a_3 \log RGDP_t + \varepsilon_t \quad (5.4)$$

Money Market

It is assumed that the money market is in equilibrium at any time when the money supplied equals the money demand.

Money Demand

Money demand depends on real GDP and on the short term interest rate.

$$\text{Log}M2R_t = a_0 + a_1 \log M2R_{t-1} + a_2 INTRATEST_t + a_3 \log RGDP_t + \varepsilon_t \quad (5.5)$$

Long-term Interest rate

The long-term interest rate is linked to the short-term interest rate in a term structure equation.

$$INTRATELT_t = a_0 + a_1\, INTRATELT_{t-1} + a_2\, INTRATEST_t + \varepsilon_t \quad (5.6)$$

Foreign Exchange Market

Exchange Rate

The exchange rate equation combines elements from the uncovered interest parity and the purchasing power parity theories.

$$Log\ EXRATE_t = a_{0+}\ a_1\ INTRATEST_{t-1} + a_1 log\ M2N_t + a_2\ LIBOR_{t-1} + \varepsilon_t \quad (5.7)$$

Labor Market

Labor market consists of labor supply, labor demand and wage equations.

Labor Supply (Labor Force)

Labor supply by households depends on lagged labor force, real wage and the population.

$$LogLFORCE_t = a_0 + a_1\ logLFORCE_{t-1} + a_2\ LogPOP_t + a_3\ logANWR_t + \varepsilon_t \quad (5.8)$$

Labor Demand (Employment)

Labor demand is influenced by lagged employment, GDP and real wages.

$$Log\ EMP_t = a_0 + a_1 log\ EMP_{t-1} + a_2 log\ RGDP_t + a_3\ log\ AGWR_t + \varepsilon_t \quad (5.9)$$

Wages

Wage rate is determined by lagged wages, the consumer price index and the unemployment rate.

$$Log\ AGWN_t = a_0 + a_1\ AGWN_{t-1} + a_2\ log\ CPI_{t-1} + a_3\ logUR_t + \varepsilon_t \quad (5.10)$$

Consumer Price Index

The Consumer Price Index depends on lagged wages, utilization rate and exchange rate.

$$Log\ CPI_t = a_0 + a_1 AGWN_{t-1} + a_2\ log\ UTIL_t + a_3\ log\ EXRATE_t + \varepsilon_t \quad (5.11)$$

Public Sector

The public sector includes total government expenditures and tax revenues equations.

Government Expenditures

Total government expenditures are linked to government consumption and to transfer payments to households.

$GR_t = a_0 + a_1 RGDP_t + a_2 TGER_t + \varepsilon_t$ (5.12)

Net Tax Revenues

$NET\ TAXR_t = a_0 + a_1\ TGRR_t + \varepsilon_t$ (5.13)

5.6 Estimation Results

The behavioral equations were estimated by ordinary least squares (OLS) using quarterly data for the 1987-2006 period. The data were provided by the Turkish Statistics Foundation, the Central Bank of Turkey Republic (CBRT), the Ministry of Finance, the US Bureau of Economic Analysis and the British Bankers` Association. Table 5.1 displays the data sources and the explanation of the variables. Estimations were carried out using E-Views 4.0 software. The estimated coefficients of the behavioral equations are given and the *t*-statistics are quoted in parentheses along with the standard error of regressions (SERs). The level of significance for the estimated coefficients are displayed with *, ** representing 5% and 10% statistical significances. Durbin h-test and Durbin d tests, respectively, are used to test the existence of serial correlation in the regression equations. The reported regression results are free from econometric problems. The raw data set and the print outs from E-views are included as appendices.

Consumption of Private Households

$$\text{Log } CONS_t = 0.83 + 0.07 \log CONS_{t-1} + 0.81 \log GDPR_t + 0.0004\, a_3\, RINTRATE_t$$

(3.28)* (2.12)* (27.02)* (1.59)**

$\bar{R}^2=0.95$, $DW_h=2.75$, SER =0.04

The consumption equation is estimated without using the real interest rate, which is because insignificant economically and statistically. The following equation is estimated without the real interest rate

$$\text{Log } CONS_t = 0.87 + 0.08 \log CONS_{t-1} + 0.80 \log GDPR_t$$

(3.44)* (2.30)* (26.88)*

$\bar{R}^2=0.95$, DW-h =1.67, SER=0.04

Gross Fixed Capital Formation

$$\text{Log } INVR_t = 0.19 + 0.31 \log INVR_{t-1} + 0.55 \log DEMAND_t + 0.00082\, RINTRATE_t$$

(0.32) (3.76)* (7.16)* (0.89)

$\bar{R}^2=0.73$, DW-h =1.65, SER=0.14

The investment equation is estimated without using the real interest rate, which is insignificant statistically. The following equation is estimated without the real interest rate

$$\text{Log } INVR_t = 0.26 + 0.34 \log INVR_{t-1} + 0.52 \log DEMAND_t$$

(0.46) (4.37)* (7.39)*

$\bar{R}^2= 0.73$, DW-h =1.69, SER=0.14

Exports of Goods and Services

$$\text{Log } EXP_t = -6.34 + 0.74 \log EXP_{t-1} + 0.95 \log RGDPUSA_t - 0.00028\, REXRATE_t$$
$$(-2.82)^{*} \quad (8.77)^{*} \quad (2.95)^{*} \quad (-0.25)$$

$\bar{R}^2$=0.96, DW-h= 1.03, SER=0.13

Imports of Goods and Services

$$\text{Log } IMP_t = -3.23 + 0.731 \log IMP_{t-1} + 0.026\, REXRATE_t + 0.54 \log RGDP_t$$
$$(-4.68)^{*} \quad (14.82)^{*} \quad (2.17)^{*} \quad (5.92)^{*}$$

$\bar{R}^2$=0.96, DW-h=1.53, SER=0.12

Money Market Equilibrium

$$\text{Log } M2R_t = -2.68 + 0.89 \log M2R_{t-1} + 0.0004 INTRATEST_t + 0.31 \log RGDP_t$$
$$(-6.44)^{*} \quad (38.66)^{*} \quad (1.32)^{**} \quad (6.43)^{*}$$

$\bar{R}^2$= 0.98, DW-h=1.56, SER=0.06

Long-term Interest Rate

$$INT\ RATELT_t = -1.22 + 0.64\, INTRATELT_{t-1} + 0.42\, INTRATEST_t$$
$$(0.6) \quad (13.88)^{*} \quad (8.47)^{*}$$

$\bar{R}^2$= 0.93, DW-h=1.47, SER=6.53

Foreign Exchange Market

$$\text{Log EXRATE}_t = -1.43 + 0.0046\ \text{INTRATEST}_{t-1} + 0.82\log \text{M2N}_t - 0.019\ \text{LIBOR}_{t-1}$$
$$(-2.28)^{*} \quad (1.61)^{**} \quad (28.95)^{*} \quad (-0.44)$$

$\bar{R}^2 = 0.95$, DW-d=1.82, SER=0.6

Labor Market

Labor Supply

$$\text{LogLFORCE}_t = 1.25 + 0.35\ \text{logLFORCE}_{t-1} + 0.47\ \text{LogPOP}_t - 0.00058\text{logANWR}_t$$
$$(2.38)^{*} \quad (3.12)^{*} \quad (5.04)^{*} \quad (-0.026)$$

$\bar{R}^2 = 0.83$, DW-h=1.74, SER=0.03

Labor Demand (Employment)

$$\text{Log EMP}_t = 3.52 + 0.52\log \text{EMP}_{t-1} + 0.14\log \text{RGDP}_t - 0.027\log \text{AGWR}_t$$
$$(4.85)^{*} \quad (5.79)^{*} \quad (4.39)^{*} \quad (-1.013)$$

$\bar{R}^2 = 0.73$, DW-h =1.98, SER=0.04

Wages

$$\text{Log AGWN}_t = 1.53 + 0.69\ \text{AGWN}_{t-1} + 0.00186\log \text{CPI}_{t-1} - 0.08\log \text{UR}_t$$
$$(3.46)^{*} \quad (8.45)^{*} \quad (0.29) \quad (-1.96)^{*}$$

$\bar{R}^2 = 0.73$, DW-h=1.42, SER=0.05

Consumer Price Index

$$\text{Log CPI}_t = 3.27 + 0.0073\text{AGWN}_{t-1} + 0.94\log \text{EXRATE}_t$$
$$(7.46)^{*} \quad (2.4)^{*} \quad (40.47)^{*}$$

$\bar{R}^2 = 0.96$, DW-d=1.88, SER=0.52

Public Sector

Total Government Expenditures

$$GR_t = 5.46 + 0.17 \log RGDP_t + 0.062 \log TGER_t$$
$$(2.28)^* \quad (0.67) \quad (2.73)^*$$

.

$\bar{R}^2 = 0.15$, DW-d=2.77, SER=0.23

Total Government Revenues

$$NET\ TAXR_t = 37.9 + 0.79\ TGRR_t$$
$$(0.19) \quad (75.85)^*$$

$R^2 = 0.98$, DW-d=2.5, SER=0.29

Summary and Conclusions

In this part of the thesis a quarterly macroeconometric model is estimated. The results of the macroeconometric model will be used as an input for the OPTCON algorithm which will be explained in the next part of the thesis. The estimated values of parameters, the covariance matrix of parameters and the covariance matrix of error terms are used in the optimal control problem.

The quarterly macroeconometric model for Turkey was estimated over the 1987-2006 period. The model includes equations for consumption, investment, exports, imports, money demand, interest rate, exchange rate, labor demand, labor supply, wages, prices, government expenditures and government revenues.

The demand side macroeconometric model for Turkey is used because the aim of the thesis is to find the optimal monetary and fiscal policy mix for the Turkish economy. The macroeconometric model TURKPOL is classified as a Phillips-Bergstrom model.

Table: 5.1 Variables List and Data Sources

Abbreviation	Name of the variable	Explanation	Data sources
AGWN	Average wage rate, nominal	Manufacturing/ (000s)	CBRT
AGWR	Average wage rate, real	Manufacturing industry (Public and private)	CBRT
CONS	Household consumption, real	(000 000s)	CBRT, Treasury
DEMAND	Total final demand, real	GDP+ Imports (000 000s)	CBRT, Treasury
EMP	Employment	(000s)	Turkstat
RGDP	Real Gross Domestic Product	(000 000s)	CBRT
GR	Government consumption	(000 000s)	CBRT
INTRATEST	Nominal interest rate, short term	3 months interest rate (%)	CBRT
INTRATELT	Nominal interest rate, long term	12 months interest rate (%)	CBRT
IMP	Imports, real	In USA dollars/ (000 000s)	CBRT
INVR	Real capital formation	(000 000s)	CBRT
M2Y	Money stock, real	(000 000s)	CBRT
CPI	Consumer Price Index	1981=100	CBRT
EXRATE	Nominal exchange rate	TL /$, selling rate	CBRT
REXRATE	Real exchange rate	TL/$	CBRT
RINTRATE	Real interest rate	(%)	Own calculation
RNETTAX	Real net tax receipts	(000 000s)	Ministry of finance
UR	Unemployment rate	(%)	Turkstat
UTIL	Capacity utilization rate	Manufacturing Industry (%)	CBRT
EXP	Exports, real	In USA dollars	CBRT
RGDPUSA	Foreign GDP, real	(000 000s)	www.bea.gov
LIBOR	London interbank offered rate	USA dollars, 3 months	www. bba.org.uk
LFORCE	Labor supply	Labor force/ (000s)	Turkstat
TGER	Total real government expenditures	(000 00s)	Ministry of Finance
TGRR	Total real government revenues	(000 000s)	Ministry of Finance

Chapter 6: Optimal Control Problem

6.1 Introduction

In this part of the thesis, optimal control will be studied. Optimal control, a formulation of dynamic optimization problems, focuses upon one or more control variables that serve as the instruments of optimization. Its aim is to find the optimal time path for the control variable. The basic problem involves one state variable and a single control variable. The control variable is a policy instrument that enables us to influence the state variable.

This part of the thesis will also explain the algorithm used for the optimal control problem. The algorithm used is OPTCON an adopted version of the process, which was developed by Matulka and Neck (1992) for the optimal control of nonlinear stochastic models. The algorithm OPTCON can be applied to any discrete time inter-temporal optimization problem under stochastic uncertainty.

OPTCON algorithm can be used for the macroeconomic policy. In this case, the controls are monetary and fiscal policy variables, the states are macroeconomic target variables and the objective may express social welfare or policy makers' objectives. The application part of the thesis will present the monetary and fiscal policy variables and macroeconomic target variables for the Turkish economy over the period 2007-2013.

6.2 Optimal Control Theory

In the theory of quantitative economic policy, macroeconomic policy problems are often considered as problems of optimizing an inter-temporal objective function under the constraints of a dynamic system. The optimum control theory has been used in several studies to determine optimal policies for econometric models.

The optimal control theory is a mathematical field concerned with control policies that can be deduced using optimization algorithms. The control that minimizes a certain cost functional is called the optimal control. It can be derived using Pontryagin's principle or by solving the Hamilton-Jacobi-Bellman equation, stated in Pindyck (1973).

The first and most widespread application of control theory was for problems in economic growth where the basic problem was to find an optimal allocation of output over time to consumption and investment, see for details in Arrow and Kurz (1970, MacRae (1969), Uzawa (1969).

The formulation of a short-term stabilization policy seems to be the most promising in being amendable to a realistic application of optimal control.

The optimal control problem consists of :

a. a set of differential or difference equations that represent the system to be controlled
b. a set of constraints on the variables of the system
c. a set of boundary conditions on the variables
d. and a cost functional or performance index which is to be minimized.

The system is represented by an econometric model namely a set of difference equations. A set of constraints may be exchange rates or interest rates. The boundary conditions are the initial values of the variables such as desired values for the variables at some terminal time. Finally, the cost function is a quantitative representation of the planner's goals and objectives, as put forward by Pindyck (1973).

In a more general framework, given a dynamic system with input *u(t)*, output *y(t)* and state *x(t)*, one can define what is called a cost functional, which is a measure that the control designer should be able to minimize. It usually takes the form of an integral over time of some function, plus a *final cost* that depends on the state in which the system ends up, see Chiang (1992):

$$J=\int_{o}^{T} l(x,u,t)dt + m(xt)$$

A dynamic optimization problem attempts to determine the optimal magnitude of a choice variable in each period of time within the planning period (discrete-time case) or at each point of time in a given time interval (continous-time case). Therefore, the solution of a dynamic optimization problem is the optimal time path for every choice variable. A standard optimization problem contains a given initial point and a given terminal point, a set of admissible paths from the initial point to the terminal point, a set of path values serving as performance indices associated with various paths and a specified objective (to optimize the path value or performance index by choosing the optimal path). Then the optimal control is a formulation of dynamic optimization problems focuses upon one or more control variables that serve as the instruments of optimization. Its aim is to find the optimal time path for the control variable, as discussed in Cheynel (2006).

6.3 The OPTCON Algorithm

The algorithm of OPTCON was developed by Matulka and Neck (1992). The detailed explanation of the algorithm can be seen in Matulka and Neck (1992). This part of the thesis briefly summarizes the OPTCON algorithm from Matulka and Neck (1992).

OPTCON can deliver approximate solutions for stochastic optimum control problems with a quadratic objective function and a nonlinear multivariable dynamic model in discrete time under additive and parameter uncertainities. The new algorithm solves the same class of control problems (quadratic objective function, nonlinear dynamic system, additive and parameter uncertainty), but adds passive and active learning to the features of the original algorithm.

OPTCON can be applied to obtain approximate numerical solutions of control problems where the objective function is quadratic and the dynamic system is nonlinear. In addition to the usual additive uncertainity, some or all of the parametrs of the model may be stochastic. The optimal values of the control variables are computed in an iterative fashion. First, the time invariant non-linear system is linearized around a reference path and approximated by a time-varying linear system. Second, this new problem is solved by applying Bellman's principle of optimality.

In this algorithm a quadratic loss function is minimized subject to a nonlinear dynamic system. In the intertemporal objective (loss) function, the policy-maker penalizes on quadratic deviations the vector of control and state variables from their target values.

An intertemporal objective function can be written as

$$L = 1/2\begin{pmatrix} x_t - x_t \\ U_t - U_t \end{pmatrix} \cdot \mathrm{W}_t \cdot \begin{pmatrix} x - x \\ U_t - U_t \end{pmatrix} \tag{6.1}$$

where X_t, U_t, X and U are the vector of state variables, the vector of control variables and the vector of desired (target) levels of the state and control variables respectively. $\mathbf{W_t}$ denotes the symmetric positive semi-definite matrix, so:

$$W_t = \alpha_t W \qquad t = S \ldots\ldots. T \tag{6.2}$$

where α is a discount factor, W denotes a constant value matrix and S denotes the initial while T shows the terminal period of the finite planning horizon.

The dynamic system which may be an econometric model of an economy is aasumed to be given by a system of nonlinear difference equations

$$X_t = f(x_{t-1}, x_t, u_t, \theta, z_t) + \varepsilon, \quad t = S \ldots\ldots T \tag{6.3}$$

where X_t denotes an n-dimensional vector of the state variables, summarizing the information available about the system, u_t denotes an m-dimensional vector of the control variables. The n-dimensional vector x_t and the m-dimensional vector u_t denote the given "ideal" levels of the state and control variables, respectively. S denotes the initial and T shows the terminal period of the finite planning horizon. θ denotes a p-dimensional vector of unknown parameters, z_t denotes an t-dimensional vector of non-controlled exogenous variables, ε_t is an n-dimensional vector of additive disturbances. θ and ε are assumed to be independent random vectors with known expectations and $t=S\ldots\ldots T$

The quadratic tracking form of the objective function is very common in economic policy applications of stochastic control theory. It can be interpreted to require deviations of the state variables x_t and the control variables u_t from their ideal levels of x_t and u_t.

As inputs of the algorithm, the user has to supply the following: the system function, the initial value of the state vector, a tentative path for the control variables, the expected value and the covariance matrix of the stochastic parameter vector, the covariance matrix of the additive system noise, the weight matrices of the objective function, the planning horizon, the desired paths for the state and control variables, the tentative path for the control and state variables and a discount rate of the objective function.

The expected optimal path of state variables, the expected optimal path of control variables and the expected optimal welfare loss are the outputs of the algorithm. This algorithm has been implemented in the statistical programming system "GAUSS".

Matulka and Neck (1994) state that the optimum control theory has been used in several studies to determine optimal policies for econometric models, such as Pindyck (1973) and Chow (1975). The framework of the theory of quantitative economic policy has been criticized recently, especially by proponents of new classical macroeconomics. However, it cannot be denied that optimum control studies have provided interesting insights into the structural properties of the econometric models involved and into the possibilities of influencing target variables by policy instruments within given models (e.g. Chow,1981). Typically, econometric models are nonlinear and it is well known that for stochastic optimum control problems with nonlinear dynamic systems only approximations to the true optimum solution can be found. Several algorithms for the optimum control of econometric models have been published so far (see MacRae, 1975; Norman, 1976; Chow, 1987). Either they allow for additive uncertainty only or they rule out nonlinear system equations or they have not been implemented for actual calculations. The OPTCON algorithm can be applied to nonlinear econometric models and takes into account not only additive uncertainty but also the stochastic parameters of the model.

Matulka and Neck (1994) mention that OPTCON is limited by two simplifications in its present version which prevent the solutions obtained from being truly optimal. Firstly, computations of approximately optimal policies are obtained by applying repeated linearizations to the given nonlinear econometric model. Secondly, Matulka and Neck (1994) exclude any learning about the system parameters. From the present state of knowledge of stochastic optimum control theory, we cannot expect to obtain truly optimal policies either analytically or numerically. OPTCON will have to be compared with various other approximation schemes proposed in the literature on stochastic optimum control with the help of numerical examples. As a general methodology for such comparisons is still lacking, this will have to be done in a trial and error manner. For special cases, OPTCON gives the same solutions as other algorithms. For instance, we have replicated the calculations for the Klein – Goldberger model used by Chow and the example used by Kendrick and Coomes and arrived at exactly the same optimal paths as were obtained with their algorithms. OPTCON should be applied to various econometric models to investigate the properties of the approximately optimal policies it delivers.

6.4 Literature on OPTCON

Matulka and Neck (1994) apply the OPTCON algorithm to two small macroeconometric models for Austria. Several optimization experiments were performed, which showed that within the context of demand-side Keynesian models approximately optimal policies could lead to a considerable stabilization of the time paths of the macroeconomic target variables. These policies do not differ much between the nonlinear and the linear econometric model considered. Incorporating some stochastic parameters into the nonlinear model results in more marked differences is compared to the optimal policies with deterministic model parameters. Taking into account the stochastic nature of all the parameters for a simultaneous-equations linear econometric model, on the other hand, does not cause much of a change in the results of optimal policies as compared to a deterministic–parameter run.

Neck and Karbuz (1996) analyze the optimal budgetary policies for Austria over the period 1993-2000 by using an optimum control approach. In 1996, this was an issue of great political importance for Austria because Austria had to strive to fulfill the Maastricht requirements on public budget and public debt before entering the European monetary union in 1998. Neck and Karbuz (1996) determine numerically the optimal fiscal policies for the 1990s by minimizing an intertemporal objective function subject to the constraints given by an econometric model. The model is a medium-size macroeconometric model for Austria. It relates policy and exogenous variables to objective variables of Austrian economic policies, such as the rate of unemployment, the rate of inflation, the growth rate of real GDP, the balance of current accounts, and the budget deficit. They also postulate an objective function for Austrian policymakers over the years 1993-2000, which penalizes deviations of objective variables from their desired values. The exogenous variables of the model are forecast over the planning horizon using time series methods. They calculate the optimal stabilization policies over the time horizon using the stochastic control algorithm OPTCON.

Neck et al., (2004) analyze the design of macroeconomic policies for Slovenia during the process of integration into the EU. They use the OPTCON algorithm and the model SLOPOL4 model, a medium-sized macroeconometric model of the Slovenian economy. They assume that Slovenian policy makers aim at high GDP growth rates, low rates of inflation and unemployment, balanced budgets and balanced current accounts over the optimization horizon from 2004 to 2008. They first investigate whether a reduction of income taxes and social security contributions can help to reducing unemployment without endangering other policy objectives, especially the goal of a balanced budget. They also address the question of whether the policy objectives can be achieved equally well under flexible exchange rates, crawling peg regimes and fixed exchange rates.

Haber (2001) analyses different sets of optimal fiscal consolidation measures within the framework of an econometric partial disequilibrium model of Germany. Applying the optimization algorithm OPTCON and a quarterly econometric model of the German economy (the "the Konstanzer Modell" or "ZEW-Model"), he performs optimizations aiming at a stabilization of fiscal deficits in Germany in a historical context. Three optimizations in the historical 1981-1992 period are performed. The ZEW-Model is a quarterly model of the German economy and follows the philosophy of "New Keynesian Macroeconomics" with temporary equilibria in the presence of quantity constraints on the microeconomic markets. The exogenous tax component is an effective instrument for controlling German fiscal deficits in the optimization. The fiscal consolidation leads to an increase in overall taxes. The stock of fiscal debts is reduced.

Samimi et al., (2006) apply the optimal control theory in economics. They use the stochastic optimal algorithm OPTCON to calculate optimal fiscal and monetary policies under fixed, flexible and crawling peg exchange rate regimes for the third five year Iranian development plan (2000-2004). The results of the study show that in the absence of active monetary policy instruments, the government expenditures are greater and the optimal tax revenues are lower than the proposed values in the Iran third development plan. However, under a flexible exchange rate regime, the optimal values of government expenditures are lower and the optimal values of tax revenues are greater than those proposed in Iran's third development plan. The study also shows that using optimal macroeconomic policies leads to lower fluctuations in major macroeconomic variables. The main conclusion seems to be is that only under the flexible exchange rate regime can the macroeconomic goals of the plan be achieved. This resulted in the flexible exchange rate regime being recommended as a policy instrument for Iran's fourth five year development plan.

6.5 Application of the OPTCON Algorithm for the Turkish Economy

The algorithm OPTCON can be applied to any discrete–time intertemporal optimization problem under stochastic uncertainty, provided that the objective can be expressed as a quadratic function and the system dynamics fulfill the assumption stated for the functional form.

The OPTCON algorithm can be used for macroeconomic policy. In this case, the controls are monetary and fiscal policy variables, the states are macroeconomic target variables and the objective may express social welfare or policy makers' objectives.

The OPTCON algorithm can be characterized as a tool for determining optimal economic policies for non-linear stochastic dynamic models. The algorithm minimizes an intertemporal objective function of a hypothetical policy maker, subject to the constraint given by an econometric model. The system of equations is taken from a macroeconometric model as explained in Chapter 5 of this thesis. This model includes both the demand and the supply sides of the economy. On the demand side, we defined goods market including a private consumption function, a private investment function, and exports and imports functions. The model also contains money demand, an exchange rate equation and a wage-price system. The wage-price system can be regarded as an enhanced Philips curve. The labor market and potential GDP function are designed in the supply side of the economy.

The objective function penalizes deviations of objective variables from their desired values.

The dynamic system has to be given in a state space representation. The optimization can either be deterministic or stochastic. If it is stochastic additive error terms of the model equations and uncertainties concerning the estimated coefficients are considered.

OPTCON requires as inputs the system function, the initial values of state, policy and exogenous variables, a tentative path of the state variables, the expected value and the covariance matrix of the stochastic parameter vector, the covariance matrix of the additive system noise, the weight matrices of the objective function, and the desired paths of the state and control variables. A discount rate of the objective function has to be specified.

If the stochastic model equations are estimated by OLS, no full covariance matrix of the parameters is available. In this case, only a limited stochastic optimization can be run with the estimated standard errors of the coefficients and the standard errors of the regression equations are taken into account. All the parameters of the model are regarded as known with certainty. The only stochastic influences considered are the additive error terms in the behavioral equations. The covariance matrix of additive terms is assumed to be a diagonal matrix with the squared estimated standard errors of the behavioral equations in the main diagonal.

For the optimum control experiments an intertemporal objective function of a hypothetical policy-maker is specified. The quadratic tracking function is assumed as (1) with (2). For the determination of the approximate solutions to the optimization problem five main objective variables are considered. These variables are the growth rate of the real GDP (GRGDP), the inflation rate (GRCPI), the unemployment rate (UR), the budget deficit as a percentage of the GDP (DEF % GDP), the trade balance as a percentage of the GDP (CA % GDP).

In the weight matrix of the objective function all off diagonal elements are set equal to zero. All the state variables that are not mentioned in table 6.1 are weighted as zero. The main objective variables are weighted as 10 and the minor objective variables are weighted as 5.

Table 6.1: Weights of the Variables

Variable	GRGDP	GRCPI	UR	DEF %GDP	CA % GDP
Weight	10	10	10	5	5

The highest weights are given to the growth of real the GDP, the inflation rate and the unemployment rate because the authority gives more importance to those variables.

In this thesis for the optimization problem growth rate of the real GDP, the inflation rate , the unemployment rate, the budget deficit as a percentage of the GDP, the trade balance as a percentage of the GDP are the main state variables and the highest weights are given to growth, inflation and unemployment rates. The study can be extended by giving different weights to the selected state variables.

For the weighting matrices *Wt* constancy is assumed for whole the period i.e. $\alpha=1$.All off diagonal elements of the weight matrix are set equal to zero and the main diagonal elements are given the weights in Table 6.1.

For the optimum control experiments an intertemporal objective function is specified. A quadratic form is assumed. The planning horizon for the control experiments has been chosen as $S= 2007$ *to* $T=2013$.

The control variables are total government revenues and expenditures and money supply.
The discount rate of the objective function was set equal to one, meaning that all time periods of the optimization horizon get the same weight.

The following experiment is performed under flexible exchange rates and fixed exchange rates: All parameters of the model are regarded as known with certainty. The only stochastic influences considered are the additive terms in the behavioral equations whose variances contribute to the optimal value of the objective function but do not change the optimal policies when compared to a purely deterministic set-up. TURKPOL has been estimated by OLS and there is no estimate of the covariance matrix of the additive error terms. It is assumed that it is a diagonal matrix with the squared estimated standard errors of the behavioral equations in the main diagonal. As in all other experiments, the values of the exogenous non-controlled variables are assumed to be known for all time periods in advance.

The list of the state variables (x), control variables (u) and exogenous non-controlled variables (z) for the Turkish economy is given in the Appendix B.

6.6 Results

This part of the thesis set the optimal monetary and fiscal policy mix for the Turkish economy and optimal monetary and fiscal policy designs will be presented for the Turkish economy for the next seven years (2007-2013). An optimization experiment will be conducted under the fixed exchange rate regime and the flexible exchange rate regime and the optimization experiment is carried out using the optimum control algorithm OPTCON and a macroeconometric model of the Turkish economy.

6.6.1 Experiment I: Flexible Exchange Rate Regime

In the first experiment, it was assumed that the exchange rates are flexible; the money supply can be used as an active policy instrument. The table shows the quarterly results for major state variables and policy instruments of the optimization under flexible exchange rates over the period 2007-2013.

Optimal Control Variables

The following tables show the optimal monetary and fiscal policy mix for the Turkish economy over the period 2007-2013, on a quarterly basis.

Table 6.2: Money Supply (2007-2013)

M2N	QI	QII	QIII	QIV
2007	1165.964	1235.763	1316.491	1378.336
2008	1289.863	1368.101	1458.313	1528.414
2009	1414.971	1501.588	1601.012	1678.519
2010	1538.062	1632.785	1741.043	1825.370
2011	1656.093	1758.444	1874.990	1965.548
2012	1765.961	1875.290	1999.406	2095.505
2013	1882.111	1998.656	2130.597	2232.239

Table 6.3: Total Government Expenditures (2007-2013)

TGEN	QI	QII	QIII	QIV
2007	362.538	401.260	412.182	481.276
2008	398.035	440.137	450.783	530.856
2009	434.499	480.377	491.834	581.826
2010	471.108	520.989	533.551	632.980
2011	507.162	561.000	574.733	683.041

2012	541.892	599.508	614.476	731.026
2013	580.409	642.162	658.889	784.290

Table 6.4: Total Government Revenues (2007-2013)

TGRN	QI	QII	QIII	QIV
2007	363.239	402.119	412.999	483.975
2008	398.952	441.195	451.889	533.280
2009	435.485	481.436	492.893	583.839
2010	472.050	521.902	534.380	634.486
2011	507.962	561.660	575.217	683.995
2012	542.474	599.836	614.533	731.392
2013	580.683	642.061	658.385	783.957

The following tables show the optimal values of the growth rate, the inflation rate, the unemployment rate, the budget deficit and the trade balance quarterly over the period 2007-2013.

Table 6.5: Optimal Growth Rates (2007-2013)

GRGDP	QI	QII	QIII	QIV
2007	3.349	5.159	3.023	4.483
2008	4.365	3.970	3.211	2.745
2009	3.771	3.546	3.370	2.851
2010	3.638	3.456	3.370	2.934
2011	3.469	3.315	3.254	2.907
2012	3.291	3.156	3.109	2.834
2013	3.338	3.238	3.211	3.011

Table 6.6: Optimal Inflation Rates (2007-2013)

GRCPI	QI	QII	QIII	QIV
2007	3.229	2.828	3.911	6.739
2008	3.980	5.005	4.984	5.349
2009	3.384	3.956	4.035	4.135
2010	3.043	3.396	3.465	3.448
2011	2.622	2.852	2.899	2.816
2012	2.308	2.457	2.487	2.368
2013	2.092	2.186	2.207	2.072

Table: 6.7: Optimal Unemployment Rates (2007-2013)				
UR	QI	QII	QIII	QIV
2007	15.111	14.510	14.290	14.258
2008	15.126	14.603	14.370	14.097
2009	15.042	14.572	14.359	14.043
2010	14.931	14.497	14.297	13.995
2011	14.816	14.408	14.216	13.940
2012	14.700	14.310	14.123	13.869
2013	14.565	14.188	14.003	13.766

Table 6.8: Budget Deficit as a % of the GDP (2007-2013)				
	QI	QII	QIII	QIV
2007	-0.087	-0.099	-0.089	-0.270
2008	-0.104	-0.111	-0.111	-0.224
2009	-0.105	-0.104	-0.099	-0.173
2010	-0.094	-0.083	-0.073	-0.122
2011	-0.075	-0.057	-0.040	-0.073
2012	-0.052	-0.027	-0.004	-0.027
2013	-0.023	0.008	0.037	0.023

Table: 6.9: Current Account(CA)* as a % of the GDP				
	QI	QII	QIII	QIV
2007	-2.048	-2.043	-1.840	-4.856
2008	-2.536	-2.894	-3.213	-5.668
2009	-3.013	-3.450	-3.823	-5.901
2010	-3.171	-3.595	-3.960	-5.731
2011	-3.075	-3.450	-3.797	-5.311
2012	-2.774	-3.083	-3.416	-4.712
2013	-2.387	-2.627	-2.951	-4.066

*CA=EXP-IMP

Table 6.10 compares the fiscal policy variables that are calculated by OPTCON algorithm to the targets set by government. The comparison is made on annual basis over the period 2007-2013.

Table 6.10: The Values of the Optimal Control Variables and the Ninth Development Plan (2007-2013)							
	2007	2008	2009	2010	2011	2012	2013
TGEN as % GDP							
Optimal	48.05	48.93	50.0	51.0	52.0	53.0	50.0
Plan target	40.3	40.3	40.3	40.3	40.3	40.3	40.3
TGRN as a % GDP							
Optimal	48.2	49.2	50.2	50.0	51.0	50.0	51.0
Plan target	41.0	41.0	41.0	41.0	41.0	41.0	41.0

The proposed government expenditures and revenues are less than the values that are calculated by the OPTCON algorithm.

Table 6.11 compares the values of the growth rate, the inflation rate and the unemployment rate that are calculated by OPTCON algorithm to the targeted values of the same macroeconomic variables that are targeted either by the government or the Central Bank of Turkey.

Table 6.11: The values of optimal state variables and the ninth development plan's (2007-2013) targets: a comparison							
	2007	2008	2009	2010	2011	2012	2013
GRGDP (%)							
Optimal	4.00	3.57	3.38	3.35	3.24	3.09	3.2
Government Target	5.6	5.5	5.7	5.7			
Plan Target	7.0	7.0	7.0	7.0	7.0	7.0	7.0
GRCPI (%)							
Optimal	16.7	19.3	15.51	13.35	11.20	9.62	8.56
Target of CB	4.0	4.0	4.0				
UR							
Optimal	14.26	19.3	15.51	13.35	11.20	9.62	8.56
Plan Target	9.6	9.6	9.6	9.6	9.6	9.6	7.7

In this thesis three macroeconomic variables are chosen as target variables. These are the growth of the GDP, the inflation rate and the unemployment rate. In Table 6.11 there is a comparison of those three state variables with the optimal values calculated by the OPTCON algorithm and those targeted or proposed in the ninth development plan of Turkey.

Growth Rate

The average growth rate was 7.5% over the period 2002-2005 and the growth rate was 6 % 2006. The proposed growth rate is 7% in the Ninth Development Plan. Table 6.11 shows the calculated growth rates over the period 2007-2013. The calculated growth rates are less than the planned growth rates. The economy will grow around 3.5% on the average over the period from 2007 to 2013. The Ninth Development Plan proposes a 7% growth rate on the average over the same period.

Inflation Rate

In Turkey the main aim of the Central Bank is to attain and sustain price stability. The Central Bank has been using inflation targeting strategy for monetary policy since 2006. Table 6.11 shows the inflation targets of the Central Bank, which allow a confidence interval of 2 points more or less from the target level. For the years 2007, 2008 and 2009 the targeted inflation rate (CPI) is 4 percent each year. This thesis calculated the inflation rate for the period 2007-2013. It can be seen from Table 6.11 that the calculated inflation rates are higher than the rates targeted by the Central Bank.

The table shows the inflation rate on a quarterly basis over the period 2007-2013. It can be seen from the table that the inflation rate will be 6.06% at the end of the second quarter of 2007. The realized inflation rate for a 5 month period (January-May) is 4.06%. The inflation rate calculated by the OPTCON algorithm is very similar to the realized inflation rate.

Unemployment Rate

The unemployment rate calculated is higher than the unemployment rate proposed by the Ninth Development Plan.

6.6.2 Experiment II: Fixed Exchange Rate Regime

As a second experiment the exchange rate is assumed to be fixed at 1 US Dollar = 1.5 YTL during the planning period of 2007 to 2013. With a fixed exchange rate, monetary policy can no longer be used for internal stabilization purposes. The money supply has to be adjusted to hold the nominal exchange rate constant.

In the case of a fixed exchange rate very similar results are obtained for the growth rate of the GDP, the inflation rate, the unemployment rate. This result can be explained as the selected exchange rate is ineffective in the iteration process of our functional form or the proposed exchange rate regime has a very little affect on the saddle path of those variables. The same results are obtained under the crawling-peg regime. The OPTCON output for the fixed exchange rate regime can be seen in Appendix B.

6.7 Summary and Conclusions

The OPTCON algorithm is applied to the Turkish economy and the optimal growth rate, inflation rate and unemployment rate are calculated over the period 2007-2013. This thesis is the first study using the OPTCON algorithm for the Turkish economy.

The optimal values of the growth, inflation and unemployment rates are calculated over the period of 2007-2013 under a flexible exchange rate regime and a fixed exchange rate regime. In three exchange rate regimes, very similar results are obtained for the growth rate of the GDP, the inflation rate and the unemployment rate. These results can be interpreted to mean that the exchange rate is ineffective in the iteration process of our functional form or the exchange rate regime has very little effect on the saddle path of those variables.

This part of the thesis also calculated optimal monetary and fiscal policy mix for the Turkish economy. In Turkey the Central Bank is responsible for price stability, and it uses an inflation targeting strategy. The CBRT announced an annual inflation rate (CPI inflation) of 4% for 2007, 2008 and 2009. However, in this thesis the calculated inflation rates (CPI) are 16.7%, 19.3%, 15.51% for the 2007, 2008 and 2009, respectively. There is a substantial difference between the central bank inflation targets and the rates calculated by using the OPTCON algorithm.

In this thesis for the optimization experiment growth rate of the real GDP, the inflation rate, and the unemployment rate are the main state variables and those three state variables have the same priority. For that reason our calculated optimal values inflation rates are different from the Central Bank targets as the inflation rate is the only target for the Central Bank of Turkey.

Figure 6.1:Inflation Rate (2007-2013)

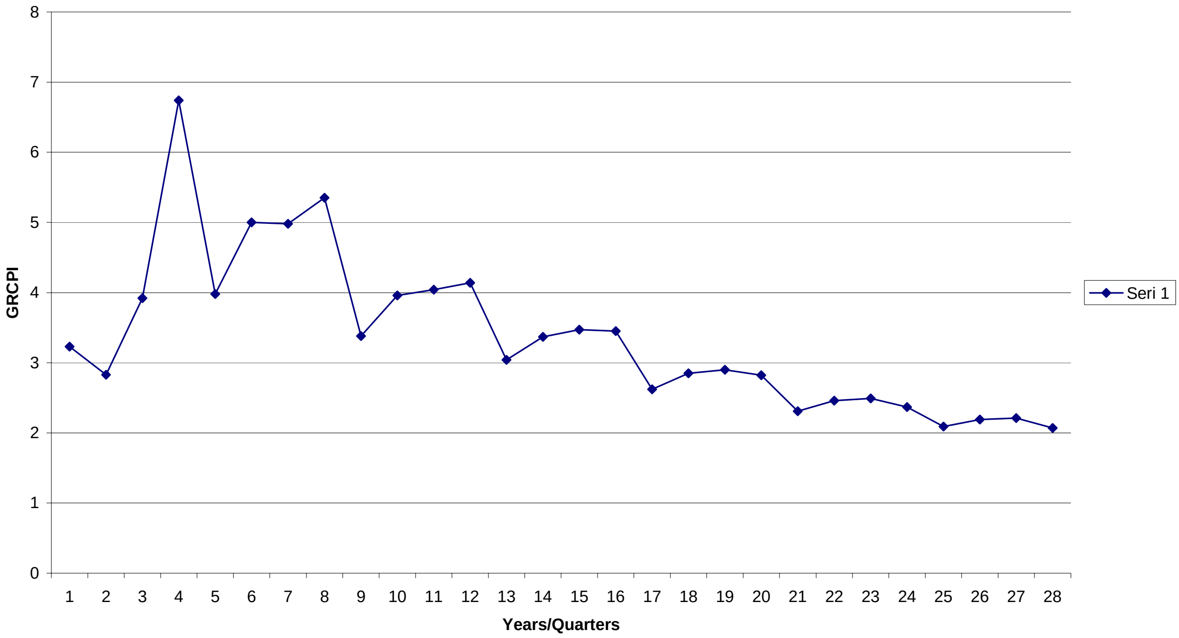
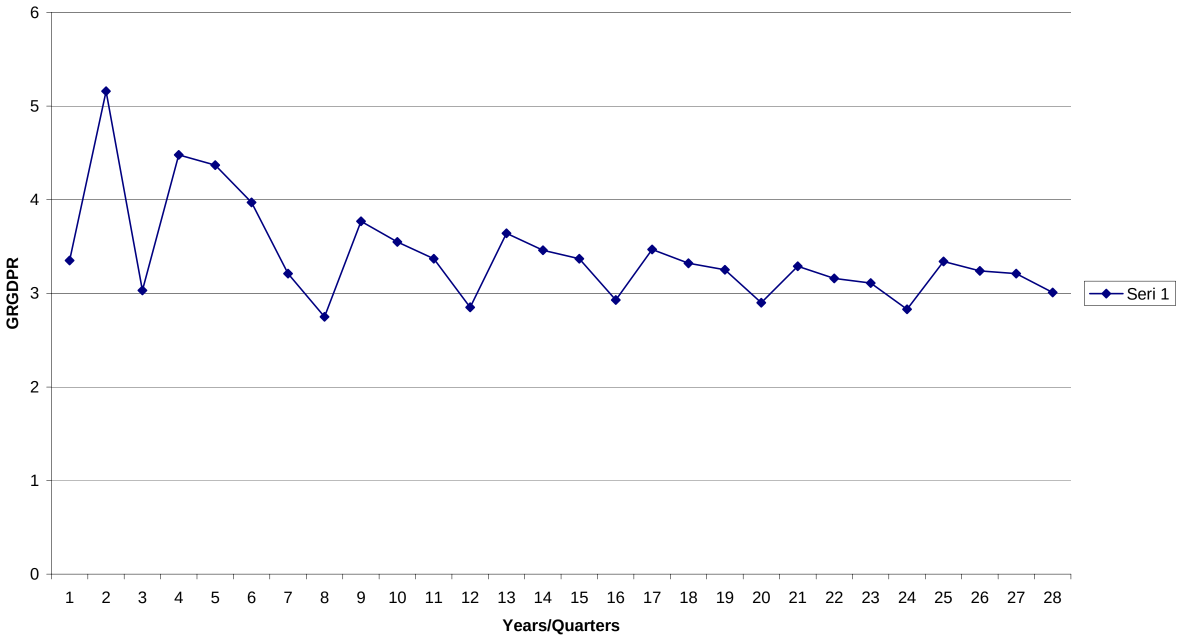


Figure 6.2:Growth Rate (2007-2013)



Chapter 7: Conclusions and Policy Recommendations

The last part of the thesis summarizes the main results, provides the policy implications for Turkey and then makes recommendations for further studies.

This thesis is primarily structured with five main chapters along with some secondary parts. The first part of the thesis studies the interaction between monetary and fiscal policy from a theoretical point of view. In this sense, three models are explained. In the first model, the price level or inflation rate is determined without reference to fiscal solvency. The second model shows how monetary policy may be influenced by the fiscal solvency of the public sector. In the last model, a more recent approach, the fiscal theory of price level (FTPL), is summarized. FTPL argues that prices and output may be strongly influenced by fiscal policy and the government's present value budget constraint determines the equilibrium price level. The distinction between Ricardian and non-Ricardian policy regimes is also distinguished in this part of the thesis.

The second part of the study concentrates on the interactions between fiscal and monetary policies in the literature. The literature regarding the interaction between monetary and fiscal policies is studied by analyzing three different approaches. The first approach is related to the coordination of monetary and fiscal policy especially in the context of the EMU. The second approach is the optimal monetary and fiscal policy and the last approach looks at the channels through which fiscal actions affect monetary variables and focuses on the constraints imposed by fiscal policy on the monetary authority.

The third part of the thesis concerns with the stabilization programmes of Turkish economy after the 1980s. Turkey experienced very severe economic crises in early 1994 and 2001 due to unsustainable fiscal balances, the collapse of the domestic debt markets, monetization and the expectation of further monetization. This part of the thesis explained the disinflation programs in Turkey between 1980 and 2006.

The fourth part of the thesis presents a macroeconometric model. TURKPOL, the Turkish Economic Policy Model, consists of 13 behavioral equations. The model is based on Keynesian macroeconomic theory in the sense of conventional IS-LM, aggregate demand-aggregate supply models. The supply side incorporates neoclassical features. The model contains behavioral equations for consumption, investment, exports, imports, money demand, interest rates, exchange rates, labor supply, labor demand, wages, prices, government expenditures and government revenues.

The fifth part of the thesis comprises the optimal control which is a formulation of a dynamic optimization problem focusing on one or more control variables that serve as the instruments of optimization. Its aim is to find the optimal time path for the control variables. The OPTCON algorithm is used to determine the optimal values for the macroeconomic policy. In this case, the controls are monetary and fiscal policy variables; the states are macroeconomic target variables. The major state variables are the growth rate of real the GDP, the inflation rate, the unemployment rate, the budget deficit as a percentage of the GDP and the trade balance as a percentage of the GDP. The OPTCON algorithm is implemented in the statistical programming system "GAUSS". This thesis is the first study which uses the OPTCON algorithm for the Turkish economy.

This thesis analyzed the optimal monetary and fiscal policy mix for the Turkish economy and calculated the optimal values of the main macroeconomic variables for the Turkish economy over the period from 2007 to 2013. The optimization is conducted based on the assumption of fixed and flexible exchange rate regimes. In both exchange rate regimes, similar results are obtained for the growth rate of the GDP, the inflation and unemployment rates. This result can be interpreted to mean that the exchange rate is ineffective in the iteration process of our functional form or the exchange rate regime has very little affect on the saddle path of the growth, inflation and unemployment rates.

This study has tried to determine the optimal macroeconomic policies required to achieve economic growth, price stability and a low unemployment rate. The ratio of budget deficits to the GDP and the ratio of current account deficits to the GDP were also calculated using a flexible exchange rate. The optimal monetary and fiscal policies are calculated by the optimal control algorithm OPTCON.

The optimal values of growth, inflation and unemployment rates are calculated over the period 2007-2013 under flexible exchange rate regime and fixed exchange rate regime.

In both exchange rate regimes very similar results are obtained for the growth rate of GDP, inflation rate, unemployment rate. This result can be explained as exchange rate is ineffective in the iteration process of our functional form or the exchange rate regime has a very little affect on the saddle path of those variables.

The inflation rates started to decline after 2001 in Turkey. This thesis stresses the public finance approach and indicates that monetary expansion occurs in response to fiscal imbalances. Turkish economic policy makers should give greater importance to fiscal balance. The continuity of fiscal discipline is important to maintain and sustain price stability in the economy. After 2002, the economic programme used in Turkey has given priority to maintaining fiscal discipline, enabling the Turkish economy to experience low inflation rates and high growth rates.

The optimal values of growth rate, inflation rate and unemployment rate are calculated for the Turkish economy over the periods of 2007-2013. The results can be evaluated by considering the relationship between inflation rate and unemployment rate and the relationship between growth rate and unemployment rate. As Phillips curve represents a trade-off between inflation rate and unemployment rate and Okun’s law represents a negative relation between output growth and the unemployment rate. The trade-off between inflation rate and unemployment rate is observed for the Turkish economy over the periods of 2007-2013. The calculated optimal values of inflation rate and unemployment rate represent the Phillips curve relation. The calculated optimal value of the growth rate and the unemployment rate do not represent the Okun’s law for the Turkish economy.

The calculated unemployment rates are 14 percent and the growth rates are 4 percent for the periods of 2007-2013. The high unemployment rates can be explained with the changing structure of the manufacturing industry in Turkey. The capital-intensive techniques in the manufacturing industry seem to replacing particularly after 2003. The share of agriculture in GDP is also decreasing which is a labor-intensive sector. Turkish economy may experience high unemployment rates for the next few years and this thesis is also calculated high unemployment rates for Turkish economy over the periods of 2007-2013.

Price stability and sustained growth are essential for the economy. Monetary policy is necessary but not sufficient to maintain price stability. The role of fiscal policy and structural reforms in helping to attain the price stability cannot be denied. The Turkish experience illustrates the fact that to attain and sustain low inflation rates, fiscal discipline is essential. Just as, monetary policy committee makes suggestions; fiscal policy committee can be constructed to set the fiscal policy rules or targets.

This thesis used an algorithm OPTCON for the optimal control of nonlinear dynamic macroeconometric model with stochastic error terms. The algorithm has been implemented by GAUSS and applied to a macroeconometric model for the Turkish economy. The study can be extended using more stochastic parameters and different economic models. There may be another extension of the study by assuming different state variables as major variables.

In this thesis, the OPTCON algorithm is applied with a macroeconometric model with stochastic additive error terms and stochastic parameters. The optimization experiment shows that optimal policies lead to a considerable stabilization of the time paths of the main objective variables. There are several possible directions of further research; for example greater variety of stochastic parameter patterns and different macroeconometric models.

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APPENDICES

APPENDIX A

E -VİWES OUTPUT

Dependent Variable: LOG(CONS)
Method: Least Squares
Date: 04/20/07 Time: 14:15
Sample(adjusted): 1987:2 2006:2
Included observations: 77 after adjusting endpoints
LOG(CONS)=C(1)+C(2)*LOG(CONS(-1))+C(3)*LOG(RGDP)+C(4)
*RINTRATE

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.827789	0.252134	3.283125	0.0016
C(2)	0.071757	0.033724	2.127800	0.0367
C(3)	0.808573	0.029928	27.01713	0.0000
C(4)	0.000440	0.000277	1.587965	0.1166

R-squared	0.955116	Mean dependent var	9.754032
Adjusted R-squared	0.953272	S.D. dependent var	0.215015
S.E. of regression	0.046479	Akaike info criterion	-3.249079
Sum squared resid	0.157702	Schwarz criterion	-3.127322
Log likelihood	129.0895	Durbin-Watson stat	2.758249

Dependent Variable: LOG(EXPORT)
Method: Least Squares
Date: 08/14/07 Time: 11:09
Sample(adjusted): 1988:2 2006:4
Included observations: 75 after adjusting endpoints
LOG(EXPORT)=C(1)+C(2)*LOG(RGDPUSA)+C(3)*LOG(EXPORT(-1))

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-6.206860	2.168626	-2.862117	0.0055
C(2)	0.938793	0.315328	2.977193	0.0040
C(3)	0.740084	0.083135	8.902169	0.0000

R-squared	0.960723	Mean dependent var	8.827103
Adjusted R-squared	0.959632	S.D. dependent var	0.630385
S.E. of regression	0.126655	Akaike info criterion	-1.255514
Sum squared resid	1.154996	Schwarz criterion	-1.162815
Log likelihood	50.08178	Durbin-Watson stat	2.023311

Dependent Variable: LOG(EXRATE)
Method: Least Squares
Date: 04/03/07 Time: 15:54
Sample(adjusted): 1986:1 2006:4
Included observations: 84 after adjusting endpoints
LOG(EXRATE)=C(1)+C(2)*NINTRATEST(-1)+C(3)*LOG(NOMM2Y)+C(4)*LIBOR

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-1.469487	0.610004	-2.408977	0.0183
C(2)	0.004476	0.002855	1.567873	0.1209
C(3)	0.822169	0.027212	30.21310	0.0000
C(4)	-0.013329	0.042429	-0.314156	0.7542

R-squared	0.957934	Mean dependent var	10.91421
Adjusted R-squared	0.956357	S.D. dependent var	2.876567
S.E. of regression	0.600944	Akaike info criterion	1.865817
Sum squared resid	28.89068	Schwarz criterion	1.981571
Log likelihood	-74.36433	Durbin-Watson stat	1.827710

Dependent Variable: LOG(INVR)
Method: Least Squares
Date: 08/14/07 Time: 11:08
Sample(adjusted): 1987:2 2006:3
Included observations: 78 after adjusting endpoints
LOG(INVR)=C(1)+C(2)*LOG(INVR(-1))+C(3)*LOG(DEMAND)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.267893	0.581166	0.460958	0.6462
C(2)	0.344787	0.078901	4.369867	0.0000
C(3)	0.527781	0.071446	7.387115	0.0000

R-squared	0.742076	Mean dependent var	8.797616
Adjusted R-squared	0.735198	S.D. dependent var	0.279839
S.E. of regression	0.144002	Akaike info criterion	-1.000276
Sum squared resid	1.555245	Schwarz criterion	-0.909633
Log likelihood	42.01075	Durbin-Watson stat	1.695524

Dependent Variable: LOG(LFORCE)
Method: Least Squares
Date: 02/12/07 Time: 12:41
Sample(adjusted): 1988:4 2006:3
Included observations: 72 after adjusting endpoints
LOG(LFORCE)=C(1)+C(2)*LOG(LFORCE(-1))+C(3)*LOG(POP)+C(4)
*LOG(WAGE)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	1.247289	0.523983	2.380401	0.0201
C(2)	0.352645	0.113158	3.116403	0.0027
C(3)	0.474605	0.094205	5.038002	0.0000
C(4)	-0.000583	0.022045	-0.026446	0.9790

R-squared	0.835976	Mean dependent var	10.02127
Adjusted R-squared	0.828740	S.D. dependent var	0.074694
S.E. of regression	0.030911	Akaike info criterion	-4.061452
Sum squared resid	0.064974	Schwarz criterion	-3.934970
Log likelihood	150.2123	Durbin-Watson stat	1.741116

Dependent Variable: LOG(EMP)
Method: Least Squares
Date: 03/16/07 Time: 10:27
Sample(adjusted): 1988:4 2006:3
Included observations: 72 after adjusting endpoints
LOG(EMP)=C(1)+C(2)*LOG(EMP(-1))+C(3)*LOG(RGDP)+C(4)
*LOG(WAGE)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	3.528675	0.713219	4.947530	0.0000
C(2)	0.527732	0.086434	6.105584	0.0000
C(3)	0.120684	0.026823	4.499266	0.0000
C(4)	-0.013951	0.027013	-0.516437	0.6072

R-squared	0.744774	Mean dependent var	9.932775
Adjusted R-squared	0.733514	S.D. dependent var	0.074775
S.E. of regression	0.038601	Akaike info criterion	-3.617133
Sum squared resid	0.101322	Schwarz criterion	-3.490652
Log likelihood	134.2168	Durbin-Watson stat	1.889901

Dependent Variable: WAGE
Method: Least Squares
Date: 08/14/07 Time: 11:13
Sample(adjusted): 1994:1 2006:3
Included observations: 51 after adjusting endpoints
WAGE=C(1)+C(2)*WAGE(-1)+C(3)*LOG(PI(-1))+C(4)*(UR)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	35.31980	15.98739	2.209229	0.0321
C(2)	0.676713	0.081047	8.349636	0.0000
C(3)	0.262067	0.706340	0.371021	0.7123
C(4)	-0.985959	0.524499	-1.879813	0.0663

R-squared	0.725323	Mean dependent var	98.47843
Adjusted R-squared	0.707791	S.D. dependent var	9.935941
S.E. of regression	5.371009	Akaike info criterion	6.275093
Sum squared resid	1355.844	Schwarz criterion	6.426609
Log likelihood	-156.0149	Durbin-Watson stat	2.397274

Dependent Variable: LOG(PI)
Method: Least Squares
Date: 02/16/07 Time: 12:03
Sample(adjusted): 1988:2 2006:4
Included observations: 75 after adjusting endpoints
LOG(PI)=C(2)*LOG(WAGE(-1))+C(3)*LOG(EXRATE(-1))

	Coefficient	Std. Error	t-Statistic	Prob.
C(2)	0.880879	0.055886	15.76193	0.0000
C(3)	0.932785	0.022102	42.20375	0.0000

R-squared	0.958239	Mean dependent var	14.61346
Adjusted R-squared	0.957667	S.D. dependent var	2.507325
S.E. of regression	0.515880	Akaike info criterion	1.540421
Sum squared resid	19.42768	Schwarz criterion	1.602221
Log likelihood	-55.76580	Durbin-Watson stat	1.882666

Dependent Variable: LOG(REALM2Y)
Method: Least Squares
Date: 04/03/07 Time: 15:47
Sample(adjusted): 1987:1 2006:3
Included observations: 79 after adjusting endpoints
LOG(REALM2Y)=C(1)+C(2)*LOG(REALM2Y(-1))+C(3)*LOG(RGDP)
+C(4)*NINTRATEST+C(5)*LOG(REALM2Y(-2))

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-2.695762	0.322658	-8.354854	0.0000
C(2)	0.624328	0.084767	7.365265	0.0000
C(3)	0.302718	0.036480	8.298203	0.0000
C(4)	0.000781	0.000282	2.768665	0.0071
C(5)	0.271117	0.083645	3.241299	0.0018

R-squared	0.987582	Mean dependent var	3.878075
Adjusted R-squared	0.986910	S.D. dependent var	0.482917
S.E. of regression	0.055251	Akaike info criterion	-2.892671
Sum squared resid	0.225896	Schwarz criterion	-2.742706
Log likelihood	119.2605	Durbin-Watson stat	2.026829

Dependent Variable: LOG(IMPORTS)
Method: Least Squares
Date: 03/30/07 Time: 16:34
Sample(adjusted): 1987:1 2006:3
Included observations: 79 after adjusting endpoints
LOG(IMPORTS)=C(1)+C(2)*LOG(IMPORTS(-1))+C(3)*REXRATE+C(4)
*LOG(RGDP)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-3.231491	0.689751	-4.685009	0.0000
C(2)	0.731397	0.049342	14.82308	0.0000
C(3)	0.002575	0.001182	2.178054	0.0325
C(4)	0.531816	0.089804	5.921967	0.0000

R-squared	0.963975	Mean dependent var	9.106726
Adjusted R-squared	0.962534	S.D. dependent var	0.631146
S.E. of regression	0.122165	Akaike info criterion	-1.317574
Sum squared resid	1.119330	Schwarz criterion	-1.197602
Log likelihood	56.04419	Durbin-Watson stat	2.526135

Dependent Variable: NINTRATELT
Method: Least Squares
Date: 02/16/07 Time: 11:53
Sample(adjusted): 1985:2 2006:3
Included observations: 86 after adjusting endpoints
NINTRATELT=C(1)+C(2)*NINTRATELT(-1)+C(3)*NINTRATEST

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-1.221608	2.040136	-0.598788	0.5509
C(2)	0.642910	0.046303	13.88486	0.0000
C(3)	0.416700	0.049193	8.470729	0.0000

R-squared	0.931867	Mean dependent var	63.28244
Adjusted R-squared	0.930226	S.D. dependent var	24.74674
S.E. of regression	6.536817	Akaike info criterion	6.627038
Sum squared resid	3546.588	Schwarz criterion	6.712655
Log likelihood	-281.9627	Durbin-Watson stat	1.476923

Dependent Variable: LOG(TAXRECEIPTS)
Method: Least Squares
Date: 04/11/07 Time: 14:50
Sample(adjusted): 1987:1 2006:3
Included observations: 79 after adjusting endpoints
LOG(TAXRECEIPTS)=C(1)*LOG(TGREV)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.967412	0.004270	226.5705	0.0000

R-squared	0.984990	Mean dependent var	6.974956
Adjusted R-squared	0.984990	S.D. dependent var	2.353838
S.E. of regression	0.288377	Akaike info criterion	0.363483
Sum squared resid	6.486594	Schwarz criterion	0.393476
Log likelihood	-13.35759	Durbin-Watson stat	1.743580

Dependent Variable: LOG(GOVR)
Method: Least Squares
Date: 02/27/07 Time: 14:39
Sample(adjusted): 1994:1 2006:2
Included observations: 50 after adjusting endpoints
LOG(GOVR)=C(2)*LOG(RGDP)+C(3)*LOG(TGE)

	Coefficient	Std. Error	t-Statistic	Prob.
C(2)	0.750482	0.017677	42.45637	0.0000
C(3)	0.033129	0.019598	1.690415	0.0974

R-squared	0.174535	Mean dependent var	7.691498
Adjusted R-squared	0.157338	S.D. dependent var	0.255737
S.E. of regression	0.234758	Akaike info criterion	-0.021348
Sum squared resid	2.645334	Schwarz criterion	0.055132
Log likelihood	2.533712	Durbin-Watson stat	2.970588

APPENDIX B

OPTCON OUTPUT

(C) 1988,1989,1990 by Josef Matulka
Department of Applied Computer Science
Vienna University of Economics and Business Administration
Augasse 2-6, A-1090 Vienna, Austria

Program started at 6/10/07, 13:59:43 (PROC chow0).

Check consistency of input (PROC chow0).
Solution of system equation for all periods (PROC GSSyst - improved [ghaber v3.0001b]).

Period: 1
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Period: 2
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Period: 3
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Period: 4
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Period: 5
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Period: 6
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Period: 7
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Period: 8
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Period: 9
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Period: 10
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).

Termination Code: 1

Period: 11
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Period: 12
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Period: 13
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Period: 14
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Period: 15
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Period: 16
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Period: 17
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Period: 18
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Period: 19
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Period: 20
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Period: 21
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Period: 22
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Period: 23
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Period: 24
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Period: 25
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Period: 26
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Period: 27
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Period: 28
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1
... 1 secs for calculating reference path for state variables.

Initialize space on disc (PROC chow0)
... 0 secs for initializing space on disc.

No stochastic parameters detected. COVtheta contains only zero cells.

Time period 28 Iteration 1 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 27 Iteration 1 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 26 Iteration 1 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 25 Iteration 1 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 24 Iteration 1 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 23 Iteration 1 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 22 Iteration 1 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 21 Iteration 1 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 20 Iteration 1 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 19 Iteration 1 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 18 Iteration 1 (PROC chow0).
Linearize system equation (PROC LinSyst).
...   0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
...   0 secs for backward Ricatti equations.

Time period 17 Iteration 1 (PROC chow0).
Linearize system equation (PROC LinSyst).
...   0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
...   0 secs for backward Ricatti equations.

Time period 16 Iteration 1 (PROC chow0).
Linearize system equation (PROC LinSyst).
...   0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
...   0 secs for backward Ricatti equations.

Time period 15 Iteration 1 (PROC chow0).
Linearize system equation (PROC LinSyst).
...   0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
...   0 secs for backward Ricatti equations.

Time period 14 Iteration 1 (PROC chow0).
Linearize system equation (PROC LinSyst).
...   0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
...   0 secs for backward Ricatti equations.

Time period 13 Iteration 1 (PROC chow0).
Linearize system equation (PROC LinSyst).
...   0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
...   0 secs for backward Ricatti equations.

Time period 12 Iteration 1 (PROC chow0).
Linearize system equation (PROC LinSyst).
...   0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
...   0 secs for backward Ricatti equations.

Time period 11 Iteration 1 (PROC chow0).

Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 10 Iteration 1 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 9 Iteration 1 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 8 Iteration 1 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 7 Iteration 1 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 6 Iteration 1 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 5 Iteration 1 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 4 Iteration 1 (PROC chow0).
Linearize system equation (PROC LinSyst).

... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 3 Iteration 1 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 2 Iteration 1 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 1 Iteration 1 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Project optimal state and control variables for
periods 1 to 28 (PROC cpux).

Project state and control variables for time period 1
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 2
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 3
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 4
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 5
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 6

Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 7
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 8
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 9
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 10
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 11
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 12
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 13
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 14
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 15
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 16
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 17
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 18
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 19
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 20
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 21
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 22
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 23
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 24
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 25
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 26
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 27
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 28
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1
... 1 secs for projecting expected state and control variables.

Value of objective function: 81546

Convergence for 505 of 2016 state/control variables.

Time period 28 Iteration 2 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).

Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 27 Iteration 2 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 26 Iteration 2 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 25 Iteration 2 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 24 Iteration 2 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 23 Iteration 2 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 22 Iteration 2 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 21 Iteration 2 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).

... 0 secs for backward Ricatti equations.

Time period 20 Iteration 2 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 19 Iteration 2 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 18 Iteration 2 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 17 Iteration 2 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 16 Iteration 2 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 15 Iteration 2 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 14 Iteration 2 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 13 Iteration 2 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 12 Iteration 2 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 11 Iteration 2 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 10 Iteration 2 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 9 Iteration 2 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 8 Iteration 2 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 7 Iteration 2 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 6 Iteration 2 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 5 Iteration 2 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 4 Iteration 2 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 3 Iteration 2 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 2 Iteration 2 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 1 Iteration 2 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Project optimal state and control variables for
periods 1 to 28 (PROC cpux).

Project state and control variables for time period 1
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 2

Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 3
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 4
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 5
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 6
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 7
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 8
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 9
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 10
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 11
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 12
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 13
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 14
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 15
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 16
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 17
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 18
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 19
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 20
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 21
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 22
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 23
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 24
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 25
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 26
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 27

Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 28
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1
... 1 secs for projecting expected state and control variables.

Value of objective function: 81521

Convergence for 1974 of 2016 state/control variables.

Time period 28 Iteration 3 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 27 Iteration 3 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 26 Iteration 3 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 25 Iteration 3 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 24 Iteration 3 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 23 Iteration 3 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.

Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 22 Iteration 3 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 21 Iteration 3 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 20 Iteration 3 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 19 Iteration 3 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 18 Iteration 3 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 17 Iteration 3 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 16 Iteration 3 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).

Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 15 Iteration 3 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 14 Iteration 3 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 13 Iteration 3 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 12 Iteration 3 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 11 Iteration 3 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 10 Iteration 3 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 9 Iteration 3 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).

... 0 secs for backward Ricatti equations.

Time period 8 Iteration 3 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 7 Iteration 3 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 6 Iteration 3 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 5 Iteration 3 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 4 Iteration 3 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 3 Iteration 3 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 2 Iteration 3 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Time period 1 Iteration 3 (PROC chow0).
Linearize system equation (PROC LinSyst).
... 0 secs for linearizing system equation.
Transforming objective function parameters (PROC cp_w).
Backward integration for one period (PROC Backward).
... 0 secs for backward Ricatti equations.

Project optimal state and control variables for
periods 1 to 28 (PROC cpux).

Project state and control variables for time period 1
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 2
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 3
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 4
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 5
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 6
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 7
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 8
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 9
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 10
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 11
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 12
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 13
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 14
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 15
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 16
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 17
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 18
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 19
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 20
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 21
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 22
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 23

Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 24
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 25
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 26
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 27
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1

Project state and control variables for time period 28
Solution of system equation for one period (PROC GS1Syst - improved [ghaber v3.0001b]).
Termination Code: 1
... 1 secs for projecting expected state and control variables.

Value of objective function: 81521

Convergence for 2016 of 2016 state/control variables.

Control Algorithm converged after 3 iterations.

****
OPTCON Results of 6/10/07, 13:59:48.

The program was active for 0.00 min 5.08 sec.

Initial period: 1
Terminal period: 28
Number of state variables: 69
Number of control variables: 3
Number of exogenous variables: 6
Number of parameters: 40
Number of iterations: 3

Optimal control variables calculated:

20071	20072	20073	20074	20081	20082	20083	20084
20091	20092	20093	20094	20101	20102	20103	20104

20111 20112 20113 20114 20121 20122 20123 20124
20131 20132 20133 20134

M2N 1165.964 1235.763 1316.491 1378.336 1289.863 1368.101
1458.313 1528.414 1414.971 1501.588 1601.012 1678.519 1538.062
1632.785 1741.043 1825.370 1656.093 1758.444 1874.990 1965.548
1765.961 1875.290 1999.406 2095.505 1882.111 1998.656 2130.597
2232.239
TGEN 362.538 401.260 412.182 481.276 398.035 440.137 450.783
530.856 434.499 480.377 491.834 581.826 471.108 520.989 533.551
632.980 507.162 561.000 574.733 683.041 541.892 599.508 614.476
731.026 580.409 642.162 658.889 784.290
TGRN 363.239 402.119 412.999 483.975 398.952 441.195 451.889
533.280 435.485 481.436 492.893 583.839 472.050 521.902 534.380
634.486 507.962 561.660 575.217 683.995 542.474 599.836 614.533
731.392 580.683 642.061 658.385 783.957

Optimal state variables calculated:

20071 20072 20073 20074 20081 20082 20083 20084
20091 20092 20093 20094 20101 20102 20103 20104
20111 20112 20113 20114 20121 20122 20123 20124
20131 20132 20133 20134

GDPR 441.456 466.516 483.918 510.493 460.727 485.039 499.458
524.505 478.101 502.238 516.288 539.458 495.493 519.593 533.689
555.286 512.683 536.817 551.054 571.427 529.554 553.759 568.186
587.624 547.229 571.687 586.430 605.317
YDR 317.506 333.035 349.053 359.786 330.880 346.603 359.889
367.907 341.976 357.861 370.876 375.743 353.161 369.056 382.139
384.114 364.200 380.040 393.245 392.666 375.227 390.982 404.315
401.515 386.095 401.827 415.303 410.511
M2R 651.566 677.805 711.924 719.413 693.212 714.624 751.182
757.240 735.559 754.503 792.703 798.585 775.935 793.478 833.169
839.507 814.133 830.844 871.992 879.215 848.558 864.805 907.293
915.668 885.833 901.979 945.951 955.612
UN 131.666 126.506 124.656 124.455 132.046 127.529 125.535
123.211 131.481 127.409 125.589 122.883 130.657 126.886 125.180
122.590 129.780 126.233 124.599 122.229 128.884 125.496 123.897
121.724 127.822 124.538 122.948 120.914
UR 15.111 14.510 14.290 14.258 15.126 14.603 14.370
14.097 15.042 14.572 14.359 14.043 14.931 14.497 14.297
13.995 14.816 14.408 14.216 13.940 14.700 14.310 14.123
13.869 14.565 14.188 14.003 13.766

PROD 59.686 62.589 64.724 68.208 62.180 65.040 66.768
69.858 64.382 67.242 68.927 71.720 66.563 69.429 71.122
73.705 68.709 71.583 73.293 75.724 70.805 73.688 75.419
77.736 72.989 75.900 77.666 79.914
AGWR 272.630 275.286 275.932 279.024 276.631 278.774 280.305
282.980 280.676 282.900 284.642 287.269 284.394 286.772 288.567
291.136 288.047 290.530 292.335 294.807 291.483 294.018 295.815
298.169 294.712 297.262 299.045 301.272
ANWR 171.757 173.430 173.837 175.785 174.277 175.628 176.592
178.277 176.826 178.227 179.325 180.979 179.168 180.667 181.798
183.416 181.470 183.034 184.171 185.729 183.634 185.231 186.364
187.847 185.669 187.275 188.398 189.801
ANWN 307.355 316.195 321.459 336.790 324.279 336.228 342.829
359.835 340.154 354.702 362.179 380.395 355.148 371.768 379.896
398.807 369.142 387.383 396.011 415.210 382.167 401.665 410.691
429.887 394.486 414.975 424.335 443.362
UTIL 82.999 86.731 88.920 92.581 82.686 86.076 87.601
90.820 81.919 85.091 86.452 89.204 81.080 84.078 85.362
87.735 80.167 83.018 84.251 86.331 79.188 81.913 83.109
84.962 78.325 80.957 82.135 83.828
LTIRLR 10.347 11.172 10.042 8.331 9.735 8.812 8.471
9.051 9.651 9.236 8.782 9.507 9.378 9.264 8.845 9.583
9.326 9.398 9.021 9.728 9.326 9.544 9.206 9.866 9.272
9.556 9.233 9.838
EXC.RATE 58.893 58.439 58.405 57.576 58.224 57.618 57.588
56.729 57.754 57.042 56.998 56.149 57.465 56.688 56.629
55.804 57.258 56.440 56.371 55.577 57.109 56.264 56.189
55.429 57.002 56.142 56.063 55.337
CAPR 4472.447 4507.667 4553.827 4626.481 4655.288 4697.192
4748.729 4821.255 4853.468 4898.230 4951.778 5021.591 5055.420
5100.822 5154.292 5220.182 5253.977 5298.236 5349.945 5411.028
5443.499 5485.298 5534.021 5589.746 5620.428 5659.439 5704.968
5755.728
DEMAND 697.149 736.961 758.638 808.134 728.926 770.431
791.955 837.998 759.280 801.771 823.532 866.408 788.651 831.770
853.825 894.032 816.991 860.571 882.944 920.975 844.331 888.279
911.000 947.278 872.378 916.845 940.073 975.173
PRATIO 1.642 1.672 1.676 1.736 1.691 1.738 1.742
1.810 1.731 1.789 1.795 1.867 1.757 1.822 1.829 1.902
1.777 1.847 1.855 1.927 1.791 1.864 1.873 1.944 1.801
1.877 1.886 1.954
INTDIFF 9.072 10.007 9.601 10.769 9.371 9.472 9.098
10.068 8.665 8.827 8.442 9.289 8.036 8.282 7.922 8.661
7.550 7.861 7.522 8.163 7.229 7.606 7.289 7.845 6.951
7.340 7.030 7.513
CR 251.264 256.125 260.042 262.835 258.493 264.567 269.532
272.905 266.111 273.268 279.121 282.640 274.082 282.189 288.829
292.143 282.344 291.279 298.624 301.464 290.861 300.512 308.489
310.659 299.583 309.859 318.408 319.759

IMPR 255.693 270.445 274.720 297.641 268.199 285.392 292.496
313.493 281.180 299.534 307.244 326.950 293.158 312.177 320.137
338.746 304.308 323.754 331.890 349.547 314.777 334.520 342.814
359.654 325.150 345.158 353.643 369.856
INVR 111.554 124.668 136.313 163.731 121.336 135.010 145.481
167.500 128.638 141.832 151.512 168.849 134.261 146.510 155.487
168.976 138.198 149.339 157.674 168.081 140.691 150.670 158.428
166.405 142.478 151.420 158.718 164.859
EMP 739.637 745.361 747.664 748.434 740.958 745.750 748.055
750.820 742.600 746.911 749.040 752.177 744.394 748.384 750.387
753.393 746.170 749.926 751.852 754.623 747.907 751.490 753.369
755.924 749.744 753.210 755.069 757.465
CPI 178.948 182.318 184.920 191.592 186.071 191.444 194.136
201.840 192.367 199.017 201.969 210.187 198.221 205.776 208.966
217.433 203.418 211.646 215.024 223.557 208.113 216.846 220.370
228.850 212.468 221.586 225.233 233.593
AGWN 487.866 501.897 510.253 534.587 514.729 533.696 544.173
571.167 539.927 563.019 574.888 603.801 563.727 590.108 603.009
633.027 585.940 614.893 628.590 659.063 606.614 637.564 651.890
682.360 626.169 658.690 673.548 703.750
LFORCE 871.303 871.867 872.319 872.889 873.004 873.279 873.591
874.032 874.080 874.320 874.629 875.060 875.052 875.269 875.567
875.984 875.950 876.159 876.451 876.852 876.791 876.986 877.267
877.648 877.566 877.747 878.017 878.378
STIRLN 12.182 12.627 12.601 13.769 12.371 12.472 12.098
13.068 11.665 11.827 11.442 12.289 11.036 11.282 10.922
11.661 10.550 10.861 10.522 11.163 10.229 10.606 10.289
10.845 9.951 10.340 10.030 10.513
LTIRLN 13.577 13.999 13.953 15.070 13.716 13.817 13.454
14.400 13.034 13.191 12.817 13.642 12.421 12.661 12.310
13.030 11.948 12.250 11.920 12.545 11.634 12.001 11.692
12.234 11.364 11.742 11.440 11.911
EXC.RATE 96.731 97.699 97.896 99.930 98.453 100.147 100.333
102.699 99.963 102.047 102.288 104.805 100.975 103.308 103.594
106.160 101.724 104.226 104.544 107.100 102.267 104.880 105.218
107.726 102.671 105.361 105.714 108.154
YPOT 531.879 537.890 544.215 551.401 557.198 563.499 570.152
577.524 583.623 590.236 597.196 604.748 611.113 617.990 625.207
632.911 639.519 646.627 654.064 661.905 668.726 676.033 683.662
691.629 698.660 706.164 713.986 722.097
NETTAXN 221.807 243.362 249.394 288.743 241.606 265.026
270.954 316.078 261.860 287.335 293.687 344.107 282.132 309.770
316.687 372.186 302.041 331.811 339.328 399.634 321.174 352.976
361.124 425.911 342.358 376.386 385.436 455.053
NETTAXR 123.950 133.482 134.866 150.707 129.846 138.435
139.569 156.598 136.125 144.377 145.412 163.715 142.332 150.537
151.549 171.173 148.483 156.777 157.809 178.761 154.327 162.778
163.871 186.109 161.134 169.860 171.127 194.806
GN 160.641 177.798 182.638 213.254 176.370 195.025 199.742
235.222 192.526 212.855 217.932 257.807 208.748 230.850 236.417

280.473 224.723 248.579 254.664 302.655 240.112 265.642 272.274
323.918 257.179 284.542 291.954 347.519
GR 87.681 95.252 96.468 108.717 92.581 99.501 100.494
113.828 97.755 104.465 105.394 119.803 102.861 109.576 110.504
125.992 107.904 114.718 115.680 132.232 112.692 119.653 120.679
138.249 118.228 125.425 126.607 145.310
GDPDEF 183.210 186.661 189.324 196.155 190.502 196.003 198.760
206.647 196.948 203.757 206.779 215.193 202.942 210.677 213.943
222.612 208.263 216.686 220.145 228.882 213.070 222.010 225.619
234.300 217.528 226.863 230.598 239.156
GDPN 808.791 870.803 916.175 1001.357 877.695 950.691 992.721
1083.876 941.612 1023.344 1067.575 1160.874 1005.561 1094.662
1141.792 1236.134 1067.728 1163.209 1213.118 1307.892 1128.320
1229.402 1281.936 1376.805 1190.377 1296.948 1352.294 1447.653
DEFICITN -0.701 -0.858 -0.817 -2.699 -0.916 -1.058 -1.106 -
2.424 -0.986 -1.059 -1.059 -2.012 -0.942 -0.913 -0.829 -1.507
-0.801 -0.660 -0.485 -0.954 -0.582 -0.328 -0.057 -0.365 -0.274
0.101 0.504 0.333
DEF% -0.087 -0.099 -0.089 -0.270 -0.104 -0.111 -0.111 -
0.224 -0.105 -0.104 -0.099 -0.173 -0.094 -0.083 -0.073 -0.122
-0.075 -0.057 -0.040 -0.073 -0.052 -0.027 -0.004 -0.027 -0.023
0.008 0.037 0.023
CAR -9.043 -9.529 -8.905 -24.790 -11.683 -14.039 -16.049 -
29.728 -14.404 -17.327 -19.739 -31.834 -15.711 -18.682 -21.132 -
31.825 -15.763 -18.519 -20.924 -30.350 -14.690 -17.075 -19.410 -
27.689 -13.060 -15.016 -17.303 -24.612
CA% -2.048 -2.043 -1.840 -4.856 -2.536 -2.894 -3.213 -
5.668 -3.013 -3.450 -3.823 -5.901 -3.171 -3.595 -3.960 -5.731
-3.075 -3.450 -3.797 -5.311 -2.774 -3.083 -3.416 -4.712 -2.387
-2.627 -2.951 -4.066
GRGDPR 3.349 5.159 3.023 4.483 4.365 3.970 3.211
2.745 3.771 3.546 3.370 2.851 3.638 3.456 3.370 2.934
3.469 3.315 3.254 2.907 3.291 3.156 3.109 2.834 3.338
3.238 3.211 3.011
GRCPI 3.229 2.828 3.911 6.739 3.980 5.005 4.984 5.349
3.384 3.956 4.035 4.135 3.043 3.396 3.465 3.448 2.622
2.852 2.899 2.816 2.308 2.457 2.487 2.368 2.092 2.186
2.207 2.072
GDPR1 488.589 441.456 466.516 483.918 510.493 460.727 485.039
499.458 524.505 478.101 502.238 516.288 539.458 495.493 519.593
533.689 555.286 512.683 536.817 551.054 571.427 529.554 553.759
568.186 587.624 547.229 571.687 586.430
GDPR2 469.719 488.589 441.456 466.516 483.918 510.493 460.727
485.039 499.458 524.505 478.101 502.238 516.288 539.458 495.493
519.593 533.689 555.286 512.683 536.817 551.054 571.427 529.554
553.759 568.186 587.624 547.229 571.687
GDPR3 443.628 469.719 488.589 441.456 466.516 483.918 510.493
460.727 485.039 499.458 524.505 478.101 502.238 516.288 539.458
495.493 519.593 533.689 555.286 512.683 536.817 551.054 571.427
529.554 553.759 568.186 587.624 547.229

CPI1 179.496 178.948 182.318 184.920 191.592 186.071 191.444
194.136 201.840 192.367 199.017 201.969 210.187 198.221 205.776
208.966 217.433 203.418 211.646 215.024 223.557 208.113 216.846
220.370 228.850 212.468 221.586 225.233
CPI2 177.960 179.496 178.948 182.318 184.920 191.592 186.071
191.444 194.136 201.840 192.367 199.017 201.969 210.187 198.221
205.776 208.966 217.433 203.418 211.646 215.024 223.557 208.113
216.846 220.370 228.850 212.468 221.586
CPI3 177.305 177.960 179.496 178.948 182.318 184.920 191.592
186.071 191.444 194.136 201.840 192.367 199.017 201.969 210.187
198.221 205.776 208.966 217.433 203.418 211.646 215.024 223.557
208.113 216.846 220.370 228.850 212.468
LTIRLN1 13.777 13.577 13.999 13.953 15.070 13.716 13.817
13.454 14.400 13.034 13.191 12.817 13.642 12.421 12.661
12.310 13.030 11.948 12.250 11.920 12.545 11.634 12.001
11.692 12.234 11.364 11.742 11.440
LTIRLN2 15.887 13.777 13.577 13.999 13.953 15.070 13.716
13.817 13.454 14.400 13.034 13.191 12.817 13.642 12.421
12.661 12.310 13.030 11.948 12.250 11.920 12.545 11.634
12.001 11.692 12.234 11.364 11.742
LTIRLN3 19.140 15.887 13.777 13.577 13.999 13.953 15.070
13.716 13.817 13.454 14.400 13.034 13.191 12.817 13.642
12.421 12.661 12.310 13.030 11.948 12.250 11.920 12.545
11.634 12.001 11.692 12.234 11.364
IMP1 277.046 255.693 270.445 274.720 297.641 268.199 285.392
292.496 313.493 281.180 299.534 307.244 326.950 293.158 312.177
320.137 338.746 304.308 323.754 331.890 349.547 314.777 334.520
342.814 359.654 325.150 345.158 353.643
IMP2 247.816 277.046 255.693 270.445 274.720 297.641 268.199
285.392 292.496 313.493 281.180 299.534 307.244 326.950 293.158
312.177 320.137 338.746 304.308 323.754 331.890 349.547 314.777
334.520 342.814 359.654 325.150 345.158
IMP3 260.827 247.816 277.046 255.693 270.445 274.720 297.641
268.199 285.392 292.496 313.493 281.180 299.534 307.244 326.950
293.158 312.177 320.137 338.746 304.308 323.754 331.890 349.547
314.777 334.520 342.814 359.654 325.150
INV1 153.788 111.554 124.668 136.313 163.731 121.336 135.010
145.481 167.500 128.638 141.832 151.512 168.849 134.261 146.510
155.487 168.976 138.198 149.339 157.674 168.081 140.691 150.670
158.428 166.405 142.478 151.420 158.718
INV2 124.912 153.788 111.554 124.668 136.313 163.731 121.336
135.010 145.481 167.500 128.638 141.832 151.512 168.849 134.261
146.510 155.487 168.976 138.198 149.339 157.674 168.081 140.691
150.670 158.428 166.405 142.478 151.420
INV3 115.582 124.912 153.788 111.554 124.668 136.313 163.731
121.336 135.010 145.481 167.500 128.638 141.832 151.512 168.849
134.261 146.510 155.487 168.976 138.198 149.339 157.674 168.081
140.691 150.670 158.428 166.405 142.478
EMP1 743.136 739.637 745.361 747.664 748.434 740.958 745.750
748.055 750.820 742.600 746.911 749.040 752.177 744.394 748.384

750.387 753.393 746.170 749.926 751.852 754.623 747.907 751.490
753.369 755.924 749.744 753.210 755.069
EMP2 748.578 743.136 739.637 745.361 747.664 748.434 740.958
745.750 748.055 750.820 742.600 746.911 749.040 752.177 744.394
748.384 750.387 753.393 746.170 749.926 751.852 754.623 747.907
751.490 753.369 755.924 749.744 753.210
EMP3 748.603 748.578 743.136 739.637 745.361 747.664 748.434
740.958 745.750 748.055 750.820 742.600 746.911 749.040 752.177
744.394 748.384 750.387 753.393 746.170 749.926 751.852 754.623
747.907 751.490 753.369 755.924 749.744
AGW1 495.185 487.866 501.897 510.253 534.587 514.729 533.696
544.173 571.167 539.927 563.019 574.888 603.801 563.727 590.108
603.009 633.027 585.940 614.893 628.590 659.063 606.614 637.564
651.890 682.360 626.169 658.690 673.548
AGW2 472.824 495.185 487.866 501.897 510.253 534.587 514.729
533.696 544.173 571.167 539.927 563.019 574.888 603.801 563.727
590.108 603.009 633.027 585.940 614.893 628.590 659.063 606.614
637.564 651.890 682.360 626.169 658.690
AGW3 468.756 472.824 495.185 487.866 501.897 510.253 534.587
514.729 533.696 544.173 571.167 539.927 563.019 574.888 603.801
563.727 590.108 603.009 633.027 585.940 614.893 628.590 659.063
606.614 637.564 651.890 682.360 626.169
EXCRATE1 95.355 96.731 97.699 97.896 99.930 98.453 100.147
100.333 102.699 99.963 102.047 102.288 104.805 100.975 103.308
103.594 106.160 101.724 104.226 104.544 107.100 102.267 104.880
105.218 107.726 102.671 105.361 105.714
EXCRATE2 94.242 95.355 96.731 97.699 97.896 99.930 98.453
100.147 100.333 102.699 99.963 102.047 102.288 104.805 100.975
103.308 103.594 106.160 101.724 104.226 104.544 107.100 102.267
104.880 105.218 107.726 102.671 105.361
EXCRATE3 93.667 94.242 95.355 96.731 97.699 97.896 99.930
98.453 100.147 100.333 102.699 99.963 102.047 102.288 104.805
100.975 103.308 103.594 106.160 101.724 104.226 104.544 107.100
102.267 104.880 105.218 107.726 102.671
CR1 252.421 251.264 256.125 260.042 262.835 258.493 264.567
269.532 272.905 266.111 273.268 279.121 282.640 274.082 282.189
288.829 292.143 282.344 291.279 298.624 301.464 290.861 300.512
308.489 310.659 299.583 309.859 318.408
CR2 250.645 252.421 251.264 256.125 260.042 262.835 258.493
264.567 269.532 272.905 266.111 273.268 279.121 282.640 274.082
282.189 288.829 292.143 282.344 291.279 298.624 301.464 290.861
300.512 308.489 310.659 299.583 309.859
CR3 248.282 250.645 252.421 251.264 256.125 260.042 262.835
258.493 264.567 269.532 272.905 266.111 273.268 279.121 282.640
274.082 282.189 288.829 292.143 282.344 291.279 298.624 301.464
290.861 300.512 308.489 310.659 299.583
DEMAND1 765.635 697.149 736.961 758.638 808.134 728.926
770.431 791.955 837.998 759.280 801.771 823.532 866.408 788.651
831.770 853.825 894.032 816.991 860.571 882.944 920.975 844.331
888.279 911.000 947.278 872.378 916.845 940.073

DEMAND2 717.535 765.635 697.149 736.961 758.638 808.134
728.926 770.431 791.955 837.998 759.280 801.771 823.532 866.408
788.651 831.770 853.825 894.032 816.991 860.571 882.944 920.975
844.331 888.279 911.000 947.278 872.378 916.845
DEMAND3 704.455 717.535 765.635 697.149 736.961 758.638
808.134 728.926 770.431 791.955 837.998 759.280 801.771 823.532
866.408 788.651 831.770 853.825 894.032 816.991 860.571 882.944
920.975 844.331 888.279 911.000 947.278 872.378

Optimal value of objective function: 81521.123
Deterministic : 81521.123
_hs: 0.000
_hp: 0.000
_hc: 1421538.110

Deviations of optimal states from targets (optimal - target):

20071 20072 20073 20074 20081 20082 20083 20084
20091 20092 20093 20094 20101 20102 20103 20104
20111 20112 20113 20114 20121 20122 20123 20124
20131 20132 20133 20134

GDPR -4.917 2.925 -6.938 -0.082 -5.733 0.586 -13.487 -
9.046 -9.350 -4.015 -19.739 -18.103 -13.893 -9.442 -26.460 -
27.365 -19.625 -16.024 -34.301 -37.443 -26.708 -23.960 -43.510 -
48.646 -34.065 -32.029 -52.793 -59.585
YDR 317.506 333.035 349.053 359.786 330.880 346.603 359.889
367.907 341.976 357.861 370.876 375.743 353.161 369.056 382.139
384.114 364.200 380.040 393.245 392.666 375.227 390.982 404.315
401.515 386.095 401.827 415.303 410.511
M2R 651.566 677.805 711.924 719.413 693.212 714.624 751.182
757.240 735.559 754.503 792.703 798.585 775.935 793.478 833.169
839.507 814.133 830.844 871.992 879.215 848.558 864.805 907.293
915.668 885.833 901.979 945.951 955.612
UN 131.666 126.506 124.656 124.455 132.046 127.529 125.535
123.211 131.481 127.409 125.589 122.883 130.657 126.886 125.180
122.590 129.780 126.233 124.599 122.229 128.884 125.496 123.897
121.724 127.822 124.538 122.948 120.914
UR 1.111 0.510 0.290 0.258 2.126 1.603 1.370 1.097
3.042 2.572 2.359 2.043 3.931 3.497 3.297 2.995 4.816
4.408 4.216 3.940 5.700 5.310 5.123 4.869 6.565 6.188
6.003 5.766
PROD 59.686 62.589 64.724 68.208 62.180 65.040 66.768
69.858 64.382 67.242 68.927 71.720 66.563 69.429 71.122
73.705 68.709 71.583 73.293 75.724 70.805 73.688 75.419
77.736 72.989 75.900 77.666 79.914
AGWR 272.630 275.286 275.932 279.024 276.631 278.774 280.305
282.980 280.676 282.900 284.642 287.269 284.394 286.772 288.567

291.136 288.047 290.530 292.335 294.807 291.483 294.018 295.815
298.169 294.712 297.262 299.045 301.272
ANWR 171.757 173.430 173.837 175.785 174.277 175.628 176.592
178.277 176.826 178.227 179.325 180.979 179.168 180.667 181.798
183.416 181.470 183.034 184.171 185.729 183.634 185.231 186.364
187.847 185.669 187.275 188.398 189.801
ANWN 307.355 316.195 321.459 336.790 324.279 336.228 342.829
359.835 340.154 354.702 362.179 380.395 355.148 371.768 379.896
398.807 369.142 387.383 396.011 415.210 382.167 401.665 410.691
429.887 394.486 414.975 424.335 443.362
UTIL 82.999 86.731 88.920 92.581 82.686 86.076 87.601
90.820 81.919 85.091 86.452 89.204 81.080 84.078 85.362
87.735 80.167 83.018 84.251 86.331 79.188 81.913 83.109
84.962 78.325 80.957 82.135 83.828
LTIRLR 8.347 9.172 8.042 6.331 7.735 6.812 6.471
7.051 7.651 7.236 6.782 7.507 7.378 7.264 6.845 7.583
7.326 7.398 7.021 7.728 7.326 7.544 7.206 7.866 7.272
7.556 7.233 7.838
EXCRATER 58.893 58.439 58.405 57.576 58.224 57.618 57.588
56.729 57.754 57.042 56.998 56.149 57.465 56.688 56.629
55.804 57.258 56.440 56.371 55.577 57.109 56.264 56.189
55.429 57.002 56.142 56.063 55.337
CAPR 4472.447 4507.667 4553.827 4626.481 4655.288 4697.192
4748.729 4821.255 4853.468 4898.230 4951.778 5021.591 5055.420
5100.822 5154.292 5220.182 5253.977 5298.236 5349.945 5411.028
5443.499 5485.298 5534.021 5589.746 5620.428 5659.439 5704.968
5755.728
DEMAND 697.149 736.961 758.638 808.134 728.926 770.431
791.955 837.998 759.280 801.771 823.532 866.408 788.651 831.770
853.825 894.032 816.991 860.571 882.944 920.975 844.331 888.279
911.000 947.278 872.378 916.845 940.073 975.173
PRATIO 1.642 1.672 1.676 1.736 1.691 1.738 1.742
1.810 1.731 1.789 1.795 1.867 1.757 1.822 1.829 1.902
1.777 1.847 1.855 1.927 1.791 1.864 1.873 1.944 1.801
1.877 1.886 1.954
INTDIFF 9.072 10.007 9.601 10.769 9.371 9.472 9.098
10.068 8.665 8.827 8.442 9.289 8.036 8.282 7.922 8.661
7.550 7.861 7.522 8.163 7.229 7.606 7.289 7.845 6.951
7.340 7.030 7.513
CR -4.529 -3.329 -1.882 -0.945 -8.810 -6.563 -4.179 -2.745
-13.220 -10.063 -6.907 -5.414 -17.820 -13.892 -10.070 -8.873 -
22.694 -18.125 -13.726 -13.098 -27.903 -22.816 -17.916 -18.059 -
33.526 -28.018 -22.685 -23.750
IMPR -9.474 -2.119 15.752 8.127 -8.900 0.562 21.875
10.951 -8.389 1.887 24.445 10.794 -9.441 1.136 24.611 8.363
-11.909 -1.284 23.066 4.297 -15.669 -5.144 20.093 -1.132 -
20.166 -9.792 16.400 -7.165
INVR 3.087 3.885 5.780 3.023 7.988 8.792 9.074 -0.440
10.190 9.933 8.967 -6.649 10.482 8.677 6.527 -14.419 8.849

5.303 2.011 -23.567 5.522 0.152 -4.239 -33.867 1.226 -5.871
-11.270 -44.425
EMP 739.637 745.361 747.664 748.434 740.958 745.750 748.055
750.820 742.600 746.911 749.040 752.177 744.394 748.384 750.387
753.393 746.170 749.926 751.852 754.623 747.907 751.490 753.369
755.924 749.744 753.210 755.069 757.465
CPI 178.948 182.318 184.920 191.592 186.071 191.444 194.136
201.840 192.367 199.017 201.969 210.187 198.221 205.776 208.966
217.433 203.418 211.646 215.024 223.557 208.113 216.846 220.370
228.850 212.468 221.586 225.233 233.593
AGWN 487.866 501.897 510.253 534.587 514.729 533.696 544.173
571.167 539.927 563.019 574.888 603.801 563.727 590.108 603.009
633.027 585.940 614.893 628.590 659.063 606.614 637.564 651.890
682.360 626.169 658.690 673.548 703.750
LFORCE 871.303 871.867 872.319 872.889 873.004 873.279 873.591
874.032 874.080 874.320 874.629 875.060 875.052 875.269 875.567
875.984 875.950 876.159 876.451 876.852 876.791 876.986 877.267
877.648 877.566 877.747 878.017 878.378
STIRLN 3.782 4.227 4.201 5.369 4.971 5.072 4.698
5.668 5.265 5.427 5.042 5.889 5.636 5.882 5.522 6.261
6.150 6.461 6.122 6.763 6.829 7.206 6.889 7.445 6.551
6.940 6.630 7.113
LTIRLN 13.577 13.999 13.953 15.070 13.716 13.817 13.454
14.400 13.034 13.191 12.817 13.642 12.421 12.661 12.310
13.030 11.948 12.250 11.920 12.545 11.634 12.001 11.692
12.234 11.364 11.742 11.440 11.911
EXCRATE 96.731 97.699 97.896 99.930 98.453 100.147 100.333
102.699 99.963 102.047 102.288 104.805 100.975 103.308 103.594
106.160 101.724 104.226 104.544 107.100 102.267 104.880 105.218
107.726 102.671 105.361 105.714 108.154
YPOT 531.879 537.890 544.215 551.401 557.198 563.499 570.152
577.524 583.623 590.236 597.196 604.748 611.113 617.990 625.207
632.911 639.519 646.627 654.064 661.905 668.726 676.033 683.662
691.629 698.660 706.164 713.986 722.097
NETTAXN 221.807 243.362 249.394 288.743 241.606 265.026
270.954 316.078 261.860 287.335 293.687 344.107 282.132 309.770
316.687 372.186 302.041 331.811 339.328 399.634 321.174 352.976
361.124 425.911 342.358 376.386 385.436 455.053
NETTAXR 123.950 133.482 134.866 150.707 129.846 138.435
139.569 156.598 136.125 144.377 145.412 163.715 142.332 150.537
151.549 171.173 148.483 156.777 157.809 178.761 154.327 162.778
163.871 186.109 161.134 169.860 171.127 194.806
GN 160.641 177.798 182.638 213.254 176.370 195.025 199.742
235.222 192.526 212.855 217.932 257.807 208.748 230.850 236.417
280.473 224.723 248.579 254.664 302.655 240.112 265.642 272.274
323.918 257.179 284.542 291.954 347.519
GR 87.681 95.252 96.468 108.717 92.581 99.501 100.494
113.828 97.755 104.465 105.394 119.803 102.861 109.576 110.504
125.992 107.904 114.718 115.680 132.232 112.692 119.653 120.679
138.249 118.228 125.425 126.607 145.310

GDPDEF 183.210 186.661 189.324 196.155 190.502 196.003 198.760
206.647 196.948 203.757 206.779 215.193 202.942 210.677 213.943
222.612 208.263 216.686 220.145 228.882 213.070 222.010 225.619
234.300 217.528 226.863 230.598 239.156
GDPN 808.791 870.803 916.175 1001.357 877.695 950.691 992.721
1083.876 941.612 1023.344 1067.575 1160.874 1005.561 1094.662
1141.792 1236.134 1067.728 1163.209 1213.118 1307.892 1128.320
1229.402 1281.936 1376.805 1190.377 1296.948 1352.294 1447.653
DEFICITN -0.701 -0.858 -0.817 -2.699 -0.916 -1.058 -1.106 -
2.424 -0.986 -1.059 -1.059 -2.012 -0.942 -0.913 -0.829 -1.507
-0.801 -0.660 -0.485 -0.954 -0.582 -0.328 -0.057 -0.365 -0.274
0.101 0.504 0.333
DEF% -0.087 -0.099 -0.089 -0.270 -0.104 -0.111 -0.111 -
0.224 -0.105 -0.104 -0.099 -0.173 -0.094 -0.083 -0.073 -0.122
-0.075 -0.057 -0.040 -0.073 -0.052 -0.027 -0.004 -0.027 -0.023
0.008 0.037 0.023
CAR -9.043 -9.529 -8.905 -24.790 -11.683 -14.039 -16.049 -
29.728 -14.404 -17.327 -19.739 -31.834 -15.711 -18.682 -21.132 -
31.825 -15.763 -18.519 -20.924 -30.350 -14.690 -17.075 -19.410 -
27.689 -13.060 -15.016 -17.303 -24.612
CA% -2.048 -2.043 -1.840 -4.856 -2.536 -2.894 -3.213 -
5.668 -3.013 -3.450 -3.823 -5.901 -3.171 -3.595 -3.960 -5.731
-3.075 -3.450 -3.797 -5.311 -2.774 -3.083 -3.416 -4.712 -2.387
-2.627 -2.951 -4.066
GRGDPR -1.151 0.659 -1.477 -0.017 -0.135 -0.530 -1.289 -
1.755 -0.729 -0.954 -1.130 -1.649 -0.862 -1.044 -1.130 -1.566
-1.031 -1.185 -1.246 -1.593 -1.209 -1.344 -1.391 -1.666 -1.162
-1.262 -1.289 -1.489
GRCPI -3.771 -4.172 -3.089 -0.261 -2.020 -0.995 -1.016 -
0.651 -1.616 -1.044 -0.965 -0.865 -0.957 -0.604 -0.535 -0.552
-0.378 -0.148 -0.101 -0.184 0.308 0.457 0.487 0.368 0.092
0.186 0.207 0.072
GDPR1 488.589 441.456 466.516 483.918 510.493 460.727 485.039
499.458 524.505 478.101 502.238 516.288 539.458 495.493 519.593
533.689 555.286 512.683 536.817 551.054 571.427 529.554 553.759
568.186 587.624 547.229 571.687 586.430
GDPR2 469.719 488.589 441.456 466.516 483.918 510.493 460.727
485.039 499.458 524.505 478.101 502.238 516.288 539.458 495.493
519.593 533.689 555.286 512.683 536.817 551.054 571.427 529.554
553.759 568.186 587.624 547.229 571.687
GDPR3 443.628 469.719 488.589 441.456 466.516 483.918 510.493
460.727 485.039 499.458 524.505 478.101 502.238 516.288 539.458
495.493 519.593 533.689 555.286 512.683 536.817 551.054 571.427
529.554 553.759 568.186 587.624 547.229
CPI1 179.496 178.948 182.318 184.920 191.592 186.071 191.444
194.136 201.840 192.367 199.017 201.969 210.187 198.221 205.776
208.966 217.433 203.418 211.646 215.024 223.557 208.113 216.846
220.370 228.850 212.468 221.586 225.233
CPI2 177.960 179.496 178.948 182.318 184.920 191.592 186.071
191.444 194.136 201.840 192.367 199.017 201.969 210.187 198.221

205.776 208.966 217.433 203.418 211.646 215.024 223.557 208.113
216.846 220.370 228.850 212.468 221.586
CPI3 177.305 177.960 179.496 178.948 182.318 184.920 191.592
186.071 191.444 194.136 201.840 192.367 199.017 201.969 210.187
198.221 205.776 208.966 217.433 203.418 211.646 215.024 223.557
208.113 216.846 220.370 228.850 212.468
LTIRLN1 13.777 13.577 13.999 13.953 15.070 13.716 13.817
13.454 14.400 13.034 13.191 12.817 13.642 12.421 12.661
12.310 13.030 11.948 12.250 11.920 12.545 11.634 12.001
11.692 12.234 11.364 11.742 11.440
LTIRLN2 15.887 13.777 13.577 13.999 13.953 15.070 13.716
13.817 13.454 14.400 13.034 13.191 12.817 13.642 12.421
12.661 12.310 13.030 11.948 12.250 11.920 12.545 11.634
12.001 11.692 12.234 11.364 11.742
LTIRLN3 19.140 15.887 13.777 13.577 13.999 13.953 15.070
13.716 13.817 13.454 14.400 13.034 13.191 12.817 13.642
12.421 12.661 12.310 13.030 11.948 12.250 11.920 12.545
11.634 12.001 11.692 12.234 11.364
IMP1 277.046 255.693 270.445 274.720 297.641 268.199 285.392
292.496 313.493 281.180 299.534 307.244 326.950 293.158 312.177
320.137 338.746 304.308 323.754 331.890 349.547 314.777 334.520
342.814 359.654 325.150 345.158 353.643
IMP2 247.816 277.046 255.693 270.445 274.720 297.641 268.199
285.392 292.496 313.493 281.180 299.534 307.244 326.950 293.158
312.177 320.137 338.746 304.308 323.754 331.890 349.547 314.777
334.520 342.814 359.654 325.150 345.158
IMP3 260.827 247.816 277.046 255.693 270.445 274.720 297.641
268.199 285.392 292.496 313.493 281.180 299.534 307.244 326.950
293.158 312.177 320.137 338.746 304.308 323.754 331.890 349.547
314.777 334.520 342.814 359.654 325.150
INV1 153.788 111.554 124.668 136.313 163.731 121.336 135.010
145.481 167.500 128.638 141.832 151.512 168.849 134.261 146.510
155.487 168.976 138.198 149.339 157.674 168.081 140.691 150.670
158.428 166.405 142.478 151.420 158.718
INV2 124.912 153.788 111.554 124.668 136.313 163.731 121.336
135.010 145.481 167.500 128.638 141.832 151.512 168.849 134.261
146.510 155.487 168.976 138.198 149.339 157.674 168.081 140.691
150.670 158.428 166.405 142.478 151.420
INV3 115.582 124.912 153.788 111.554 124.668 136.313 163.731
121.336 135.010 145.481 167.500 128.638 141.832 151.512 168.849
134.261 146.510 155.487 168.976 138.198 149.339 157.674 168.081
140.691 150.670 158.428 166.405 142.478
EMP1 743.136 739.637 745.361 747.664 748.434 740.958 745.750
748.055 750.820 742.600 746.911 749.040 752.177 744.394 748.384
750.387 753.393 746.170 749.926 751.852 754.623 747.907 751.490
753.369 755.924 749.744 753.210 755.069
EMP2 748.578 743.136 739.637 745.361 747.664 748.434 740.958
745.750 748.055 750.820 742.600 746.911 749.040 752.177 744.394
748.384 750.387 753.393 746.170 749.926 751.852 754.623 747.907
751.490 753.369 755.924 749.744 753.210

EMP3 748.603 748.578 743.136 739.637 745.361 747.664 748.434
740.958 745.750 748.055 750.820 742.600 746.911 749.040 752.177
744.394 748.384 750.387 753.393 746.170 749.926 751.852 754.623
747.907 751.490 753.369 755.924 749.744
AGW1 495.185 487.866 501.897 510.253 534.587 514.729 533.696
544.173 571.167 539.927 563.019 574.888 603.801 563.727 590.108
603.009 633.027 585.940 614.893 628.590 659.063 606.614 637.564
651.890 682.360 626.169 658.690 673.548
AGW2 472.824 495.185 487.866 501.897 510.253 534.587 514.729
533.696 544.173 571.167 539.927 563.019 574.888 603.801 563.727
590.108 603.009 633.027 585.940 614.893 628.590 659.063 606.614
637.564 651.890 682.360 626.169 658.690
AGW3 468.756 472.824 495.185 487.866 501.897 510.253 534.587
514.729 533.696 544.173 571.167 539.927 563.019 574.888 603.801
563.727 590.108 603.009 633.027 585.940 614.893 628.590 659.063
606.614 637.564 651.890 682.360 626.169
EXCRATE1 95.355 96.731 97.699 97.896 99.930 98.453 100.147
100.333 102.699 99.963 102.047 102.288 104.805 100.975 103.308
103.594 106.160 101.724 104.226 104.544 107.100 102.267 104.880
105.218 107.726 102.671 105.361 105.714
EXCRATE2 94.242 95.355 96.731 97.699 97.896 99.930 98.453
100.147 100.333 102.699 99.963 102.047 102.288 104.805 100.975
103.308 103.594 106.160 101.724 104.226 104.544 107.100 102.267
104.880 105.218 107.726 102.671 105.361
EXCRATE3 93.667 94.242 95.355 96.731 97.699 97.896 99.930
98.453 100.147 100.333 102.699 99.963 102.047 102.288 104.805
100.975 103.308 103.594 106.160 101.724 104.226 104.544 107.100
102.267 104.880 105.218 107.726 102.671
CR1 252.421 251.264 256.125 260.042 262.835 258.493 264.567
269.532 272.905 266.111 273.268 279.121 282.640 274.082 282.189
288.829 292.143 282.344 291.279 298.624 301.464 290.861 300.512
308.489 310.659 299.583 309.859 318.408
CR2 250.645 252.421 251.264 256.125 260.042 262.835 258.493
264.567 269.532 272.905 266.111 273.268 279.121 282.640 274.082
282.189 288.829 292.143 282.344 291.279 298.624 301.464 290.861
300.512 308.489 310.659 299.583 309.859
CR3 248.282 250.645 252.421 251.264 256.125 260.042 262.835
258.493 264.567 269.532 272.905 266.111 273.268 279.121 282.640
274.082 282.189 288.829 292.143 282.344 291.279 298.624 301.464
290.861 300.512 308.489 310.659 299.583
DEMAND1 765.635 697.149 736.961 758.638 808.134 728.926
770.431 791.955 837.998 759.280 801.771 823.532 866.408 788.651
831.770 853.825 894.032 816.991 860.571 882.944 920.975 844.331
888.279 911.000 947.278 872.378 916.845 940.073
DEMAND2 717.535 765.635 697.149 736.961 758.638 808.134
728.926 770.431 791.955 837.998 759.280 801.771 823.532 866.408
788.651 831.770 853.825 894.032 816.991 860.571 882.944 920.975
844.331 888.279 911.000 947.278 872.378 916.845
DEMAND3 704.455 717.535 765.635 697.149 736.961 758.638
808.134 728.926 770.431 791.955 837.998 759.280 801.771 823.532

866.408 788.651 831.770 853.825 894.032 816.991 860.571 882.944
920.975 844.331 888.279 911.000 947.278 872.378

Deviations of optimal controls from targets (optimal - target):
20071 20072 20073 20074 20081 20082 20083 20084
20091 20092 20093 20094 20101 20102 20103 20104
20111 20112 20113 20114 20121 20122 20123 20124
20131 20132 20133 20134

M2N -9.428 -12.413 -13.963 -15.541 -8.945 -11.134 -11.838 -
11.821 -7.223 -8.675 -8.803 -8.038 -5.019 -5.850 -5.607 -4.544
-2.719 -3.089 -2.659 -1.610 -0.674 -0.742 -0.290 0.483 0.645
0.681 0.921 1.040
TGEN -0.025 -3.802 -5.974 -14.298 -2.597 -7.457 -11.280 -
16.754 -4.194 -9.739 -14.124 -17.806 -4.874 -10.786 -15.414 -
17.621 -4.519 -10.659 -15.405 -16.355 -3.048 -9.309 -14.020 -
13.830 0.048 -6.228 -10.460 -8.982
TGRN -1.619 1.615 4.936 -3.582 -4.216 -1.361 0.979 -
5.470 -5.984 -3.163 -0.853 -6.093 -6.944 -3.888 -1.335 -5.590
-6.956 -3.565 -0.676 -4.087 -5.915 -2.128 1.207 -1.415 -3.351
0.970 5.192 3.517

End of OPTCON output.

(gauss)

#LINESON

/* Model for TURKEY
EXCHANGE RATE is fixed

state variables:

x[1] : GDPR GDP
x[2] : YDR Real personal disposable income
x[3] : M2R Real money supply M2
x[4] : UN Unemployed persons
x[5] : UR Unemployment rate
x[6] : PROD Labour productivity
x[7] : AGWR Quarterly average gross wage per employee, real
x[8] : ANWR Quarterly average net wage per employee, real
x[9] : ANWN Quarterly average net wage per employee, nominal
x[10] : UTIL Capacity utilization rate
x[11] : LTIRLR Real long term interest rate
x[12] : EXRATER Real exchange rate YTL/DOL
x[13] : CAPR Real capital stock
x[14] : DEMAND GDPR + IMPR
x[15] : PRICERATIO
x[16] : INTDIFF stirln – libor3m
x[17] : CR Real private consumption expenditures
x[18] : IMPR Real imports of goods and services
x[19] : INVR Real investment
x[20] : EMP Employment
x[21] : CPI Consumer price index
x[22] : AGWN Average nominal wage rate per quarter
x[23] : LFORCE labour force
x[24] : STIRLN short term nominal interest rate
x[25] : LTIRLN long term nominal interest rate
x[27] : YPOT Potential GDP
x[28] : NETTAXN Nominal net tax revenues
x[29] : NETTAXR Real net tax revenues
x[30] : GN Nominal government consumption
x[31] : GR Real government consumption
x[32] : GDPDEF GDP deflator
x[33] : GDPN Nominal GDP
x[34] : DEFICITN Nominal budget deficit
x[35] : DEFICIT% Nom. budget deficit as % of nom. GDP
x[36] : CA Current account, real
x[37] : CA% Current account as % of real GDP
x[38] : GRGDPR Annual growth rate of real GDP
x[39] : GRCPI Annual inflation rate
x[40] : GDPR1 GDPR in t-1
x[41] : GDPR2 GDPR in t-2
x[42] : GDPR3 GDPR in t-2
x[43] : CPI1 CPI in t-1
x[44] : CPI2 CPI in t-2
x[45] : CPI3 CPI in t-3
x[46] : LTIRLN1
x[47] : LTIRLN2
x[48] : LTIRLN3

x[49] : IMPR1 IMPR in t-1
x[50] : IMPR2 IMPR in t-2
x[51] : IMPR3 IMPR in t-3
x[52] : INVR1 INVR in t-1
x[53] : INVR2 INVR in t-2
x[54] : INVR3 INVR in t-3
x[55] : EMP1
x[56] : EMP2
x[57] : EMP3
x[58] : AGWN1
x[59] : AGWN2
x[60] : AGWN3
x[61] : EXRATE1
x[62] : EXRATE2
x[63] : EXRATE3
x[64] : CR1
x[65] : CR2
x[66] : CR3
x[67] : DEMAND1
x[68] : DEMAND2
x[69] : DEMAND3

control variables:

u[1] : M2N Money Stock M2, nominal
u[2] : TGEN Total government expenditures, nominal
u[3] : TGRN Total government revenues, nomi
u[4] : TAXRECEIPTS
u(5) : EXRATE
exogenous non-controlled variables:

z[1] : LIBOR LIBOR 3 months (in t-1)
z[2] : RGDPUSA USA GDP
z[3] : EX Real exports
z[4] : TIME Linear timetrend
z[5] : POP Population

*/

```
let labx = "GDPR" "YDR" "M2R" "UN" "UR" "PROD"
        "AGWR" "ANWR" "ANWN" "UTIL"
        "LTIRLR" "EXRATER" "CAPR" "DEMAND"
        "PRATIO" "INTDIFF" "CR" "IMPR" "INVR"
        "EMP" "CPI" "AGWN" "LFORCE"
        "STIRLN" "LTIRLN" "EXRATE" "YPOT" "NETTAXN"
        "NETTAXR" "GN" "GR" "GDPDEF"
        "GDPN" "DEFICITN" "DEF%" "CAR" "CA%"
        "GRGDPR" "GRCPI" "GDPR1" "GDPR2" "GDPR3"
        "CPI1" "CPI2" "CPI3" "LTIRLN1" "LTIRLN2" "LTIRLN3"
        "IMP1" "IMP2" "IMP3" "INV1" "INV2" "INV3"
```

```
        "EMP1" "EMP2" "EMP3" "AGW1" "AGW2" "AGW3"
        "EXRATE1" "EXRATE2" "EXRATE3" "CR1" "CR2" "CR3"
        "DEMAND1" "DEMAND2" "DEMAND3" ;
let labu = "M2N" "TGEN" "TGRN" "TAXR" "EXRATE" ;
let labz = "LIBOR" "GDPUSAR" "EXR" "TIME" "POP"  ;
let labtime = 20071 20072 20073 20074 20081 20082
         20083 20084 20091 20092 20093 20094
         20101 20102 20103 20104 20111 20112
         20113 20114   20121 20122 20123 20124  ;

proc(1)=model(x1,x,u,theta,z,eps) ;
local f;
f = zeros(69,1) ;

f[1] = x[31] + x[17] + x[19] + z[3] - x[18] ;
f[2] = x[1] - x[29] ;
f[3] =  u[1]/x[21]*100 ;
f[4] = x[23] - x[20] ;
f[5] = x[4]/x[23]*100 ;
f[6] = x[1]/x[20]*100 ;
f[7] = x[22]/x[21]*100 ;
f[8] = x[9]/x[21]*100 ;
f[9] = x[22]*0.63 ;
f[10] = x[1]/x[27]*100 ;
f[11] = x[25] - x[39] ;
f[12] = x[26]*z[2]/x[21] ;
f[13] = x1[13]*0.98 + x[19] ;
f[14] = x[1] + x[18] ;
f[15] = x[21]/z[2] ;
f[16] = x[24] - z[1] ;
f[17] = theta[1]+theta[2]*x[64]+theta[3]*x[1]+theta[4]*x[11] ;
f[18] = theta[9]+theta[10]*x[49]+theta[11]*x[12]+theta[12]*z[4] ;
f[19] = theta[5]+theta[6]*x[52]+ theta[7]*x[14]+theta[8]*x[11] ;
f[20] = theta[28]+theta[29]*x[55]+ theta[30]*x[1]+theta[31]*x[7];
f[21] = theta[36]+theta[37]*x[58]+ theta[38]*x[10]+theta[39]*x[12] ;
f[22] = theta[32]+theta[33]*x[58]+ theta[34]*x[43]+theta[35]*x[5] ;
f[23] =theta[24]+theta[25]*(x[23])+theta[26];
f[24] =theta[26]*(x[1]) + theta[27]*(x[3]) + theta[28]*x1[24] ;
f[25] = theta[17]+theta[18]*x[46] + theta[19]*x[24] ;
f[27] = 40000 ;
f[28] = theta[43] + theta[44]*u[2] ;
f[29] = x[28]/x[21]*100 ;
f[30] = theta[40]*u[2] ;
f[31] = theta[40]+theta[41]*x[1]+ theta[42]*u[3] ;
f[32] = x[21]*1.023817 ;
f[33] = x[1]*x[32]/100 ;
f[34] = u[2] - u[3] ;
f[35] = x[34]/x[33]*100 ;
f[36] = z[3] - x[18] ;
f[37] = x[36]/x[1]*100 ;
```

```
f[38] = (x[1]-x1[42])/x1[42]*100 ;
f[39] = (x[21]-x1[45])/x1[45]*100 ;
f[40] = x1[1] ;
f[41] = x1[40] ;
f[42] = x1[41] ;
f[43] = x1[21] ;
f[44] = x1[43] ;
f[45] = x1[44] ;
f[46] = x1[25] ;
f[47] = x1[46] ;
f[48] = x1[47] ;
f[49] = x1[18] ;
f[50] = x1[49] ;
f[51] = x1[50] ;
f[52] = x1[19] ;
f[53] = x1[52] ;
f[54] = x1[53] ;
f[55] = x1[20] ;
f[56] = x1[55] ;
f[57] = x1[56] ;
f[58] = x1[22] ;
f[59] = x1[58] ;
f[60] = x1[59] ;
f[61] = x1[26] ;
f[62] = x1[61] ;
f[63] = x1[62] ;
f[64] = x1[17] ;
f[65] = x1[64] ;
f[66] = x1[65] ;
f[67] = x1[14] ;
f[68] = x1[67] ;
f[69] = x1[68] ;

retp(f) ;
endp ;

/*** data for the model ***/

/*** dimension of the problem ***/
S = 1;    /* 2007:1 */
T = 28;   /* 2013:4 */
n = 68;   /* number of state variables */
m = 5;    /* number of control variables */
l = 6;    /* number of exogenous non-controlled variables */
p = 44;   /* number of unknown parameters */
```

Optimal control variables calculated:

20071	20072	20073	20074	20081	20082	20083	20084
20091	20092	20093	20094	20101	20102	20103	20104

20111 20112 20113 20114 20121 20122 20123 20124
20131 20132 20133 20134

M2N 1165.964 1235.763 1316.491 1378.336 1289.863 1368.101
1458.313 1528.414 1414.971 1501.588 1601.012 1678.519 1538.062
1632.785 1741.043 1825.370 1656.093 1758.444 1874.990 1965.548
1765.961 1875.290 1999.406 2095.505 1882.111 1998.656 2130.597
2232.239
TGEN 362.538 401.260 412.182 481.276 398.035 440.137 450.783
530.856 434.499 480.377 491.834 581.826 471.108 520.989 533.551
632.980 507.162 561.000 574.733 683.041 541.892 599.508 614.476
731.026 580.409 642.162 658.889 784.290
TGRN 363.239 402.119 412.999 483.975 398.952 441.195 451.889
533.280 435.485 481.436 492.893 583.839 472.050 521.902 534.380
634.486 507.962 561.660 575.217 683.995 542.474 599.836 614.533
731.392 580.683 642.061 658.385 783.957

Optimal state variables calculated:

20071 20072 20073 20074 20081 20082 20083 20084
20091 20092 20093 20094 20101 20102 20103 20104
20111 20112 20113 20114 20121 20122 20123 20124
20131 20132 20133 20134

GDPR 441.456 466.516 483.918 510.493 460.727 485.039 499.458
524.505 478.101 502.238 516.288 539.458 495.493 519.593 533.689
555.286 512.683 536.817 551.054 571.427 529.554 553.759 568.186
587.624 547.229 571.687 586.430 605.317
YDR 317.506 333.035 349.053 359.786 330.880 346.603 359.889
367.907 341.976 357.861 370.876 375.743 353.161 369.056 382.139
384.114 364.200 380.040 393.245 392.666 375.227 390.982 404.315
401.515 386.095 401.827 415.303 410.511
M2R 651.566 677.805 711.924 719.413 693.212 714.624 751.182
757.240 735.559 754.503 792.703 798.585 775.935 793.478 833.169
839.507 814.133 830.844 871.992 879.215 848.558 864.805 907.293
915.668 885.833 901.979 945.951 955.612
UN 131.666 126.506 124.656 124.455 132.046 127.529 125.535
123.211 131.481 127.409 125.589 122.883 130.657 126.886 125.180
122.590 129.780 126.233 124.599 122.229 128.884 125.496 123.897
121.724 127.822 124.538 122.948 120.914
UR 15.111 14.510 14.290 14.258 15.126 14.603 14.370
14.097 15.042 14.572 14.359 14.043 14.931 14.497 14.297
13.995 14.816 14.408 14.216 13.940 14.700 14.310 14.123
13.869 14.565 14.188 14.003 13.766

PROD 59.686 62.589 64.724 68.208 62.180 65.040 66.768
69.858 64.382 67.242 68.927 71.720 66.563 69.429 71.122
73.705 68.709 71.583 73.293 75.724 70.805 73.688 75.419
77.736 72.989 75.900 77.666 79.914
AGWR 272.630 275.286 275.932 279.024 276.631 278.774 280.305
282.980 280.676 282.900 284.642 287.269 284.394 286.772 288.567
291.136 288.047 290.530 292.335 294.807 291.483 294.018 295.815
298.169 294.712 297.262 299.045 301.272
ANWR 171.757 173.430 173.837 175.785 174.277 175.628 176.592
178.277 176.826 178.227 179.325 180.979 179.168 180.667 181.798
183.416 181.470 183.034 184.171 185.729 183.634 185.231 186.364
187.847 185.669 187.275 188.398 189.801
ANWN 307.355 316.195 321.459 336.790 324.279 336.228 342.829
359.835 340.154 354.702 362.179 380.395 355.148 371.768 379.896
398.807 369.142 387.383 396.011 415.210 382.167 401.665 410.691
429.887 394.486 414.975 424.335 443.362
UTIL 82.999 86.731 88.920 92.581 82.686 86.076 87.601
90.820 81.919 85.091 86.452 89.204 81.080 84.078 85.362
87.735 80.167 83.018 84.251 86.331 79.188 81.913 83.109
84.962 78.325 80.957 82.135 83.828
LTIRLR 10.347 11.172 10.042 8.331 9.735 8.812 8.471
9.051 9.651 9.236 8.782 9.507 9.378 9.264 8.845 9.583
9.326 9.398 9.021 9.728 9.326 9.544 9.206 9.866 9.272
9.556 9.233 9.838
EXRATE 58.893 58.439 58.405 57.576 58.224 57.618 57.588
56.729 57.754 57.042 56.998 56.149 57.465 56.688 56.629
55.804 57.258 56.440 56.371 55.577 57.109 56.264 56.189
55.429 57.002 56.142 56.063 55.337
CAPR 4472.447 4507.667 4553.827 4626.481 4655.288 4697.192
4748.729 4821.255 4853.468 4898.230 4951.778 5021.591 5055.420
5100.822 5154.292 5220.182 5253.977 5298.236 5349.945 5411.028
5443.499 5485.298 5534.021 5589.746 5620.428 5659.439 5704.968
5755.728
DEMAND 697.149 736.961 758.638 808.134 728.926 770.431
791.955 837.998 759.280 801.771 823.532 866.408 788.651 831.770
853.825 894.032 816.991 860.571 882.944 920.975 844.331 888.279
911.000 947.278 872.378 916.845 940.073 975.173
PRATIO 1.642 1.672 1.676 1.736 1.691 1.738 1.742
1.810 1.731 1.789 1.795 1.867 1.757 1.822 1.829 1.902
1.777 1.847 1.855 1.927 1.791 1.864 1.873 1.944 1.801
1.877 1.886 1.954
INTDIFF 9.072 10.007 9.601 10.769 9.371 9.472 9.098
10.068 8.665 8.827 8.442 9.289 8.036 8.282 7.922 8.661
7.550 7.861 7.522 8.163 7.229 7.606 7.289 7.845 6.951
7.340 7.030 7.513
CR 251.264 256.125 260.042 262.835 258.493 264.567 269.532
272.905 266.111 273.268 279.121 282.640 274.082 282.189 288.829
292.143 282.344 291.279 298.624 301.464 290.861 300.512 308.489
310.659 299.583 309.859 318.408 319.759

IMPR 255.693 270.445 274.720 297.641 268.199 285.392 292.496
313.493 281.180 299.534 307.244 326.950 293.158 312.177 320.137
338.746 304.308 323.754 331.890 349.547 314.777 334.520 342.814
359.654 325.150 345.158 353.643 369.856
INVR 111.554 124.668 136.313 163.731 121.336 135.010 145.481
167.500 128.638 141.832 151.512 168.849 134.261 146.510 155.487
168.976 138.198 149.339 157.674 168.081 140.691 150.670 158.428
166.405 142.478 151.420 158.718 164.859
EMP 739.637 745.361 747.664 748.434 740.958 745.750 748.055
750.820 742.600 746.911 749.040 752.177 744.394 748.384 750.387
753.393 746.170 749.926 751.852 754.623 747.907 751.490 753.369
755.924 749.744 753.210 755.069 757.465
CPI 178.948 182.318 184.920 191.592 186.071 191.444 194.136
201.840 192.367 199.017 201.969 210.187 198.221 205.776 208.966
217.433 203.418 211.646 215.024 223.557 208.113 216.846 220.370
228.850 212.468 221.586 225.233 233.593
AGWN 487.866 501.897 510.253 534.587 514.729 533.696 544.173
571.167 539.927 563.019 574.888 603.801 563.727 590.108 603.009
633.027 585.940 614.893 628.590 659.063 606.614 637.564 651.890
682.360 626.169 658.690 673.548 703.750
LFORCE 871.303 871.867 872.319 872.889 873.004 873.279 873.591
874.032 874.080 874.320 874.629 875.060 875.052 875.269 875.567
875.984 875.950 876.159 876.451 876.852 876.791 876.986 877.267
877.648 877.566 877.747 878.017 878.378
STIRLN 12.182 12.627 12.601 13.769 12.371 12.472 12.098
13.068 11.665 11.827 11.442 12.289 11.036 11.282 10.922
11.661 10.550 10.861 10.522 11.163 10.229 10.606 10.289
10.845 9.951 10.340 10.030 10.513
LTIRLN 13.577 13.999 13.953 15.070 13.716 13.817 13.454
14.400 13.034 13.191 12.817 13.642 12.421 12.661 12.310
13.030 11.948 12.250 11.920 12.545 11.634 12.001 11.692
12.234 11.364 11.742 11.440 11.911
EXRATE 96.731 97.699 97.896 99.930 98.453 100.147 100.333
102.699 99.963 102.047 102.288 104.805 100.975 103.308 103.594
106.160 101.724 104.226 104.544 107.100 102.267 104.880 105.218
107.726 102.671 105.361 105.714 108.154
YPOT 531.879 537.890 544.215 551.401 557.198 563.499 570.152
577.524 583.623 590.236 597.196 604.748 611.113 617.990 625.207
632.911 639.519 646.627 654.064 661.905 668.726 676.033 683.662
691.629 698.660 706.164 713.986 722.097
NETTAXN 221.807 243.362 249.394 288.743 241.606 265.026
270.954 316.078 261.860 287.335 293.687 344.107 282.132 309.770
316.687 372.186 302.041 331.811 339.328 399.634 321.174 352.976
361.124 425.911 342.358 376.386 385.436 455.053
NETTAXR 123.950 133.482 134.866 150.707 129.846 138.435
139.569 156.598 136.125 144.377 145.412 163.715 142.332 150.537
151.549 171.173 148.483 156.777 157.809 178.761 154.327 162.778
163.871 186.109 161.134 169.860 171.127 194.806
GN 160.641 177.798 182.638 213.254 176.370 195.025 199.742
235.222 192.526 212.855 217.932 257.807 208.748 230.850 236.417

280.473 224.723 248.579 254.664 302.655 240.112 265.642 272.274
323.918 257.179 284.542 291.954 347.519
GR 87.681 95.252 96.468 108.717 92.581 99.501 100.494
113.828 97.755 104.465 105.394 119.803 102.861 109.576 110.504
125.992 107.904 114.718 115.680 132.232 112.692 119.653 120.679
138.249 118.228 125.425 126.607 145.310
GDPDEF 183.210 186.661 189.324 196.155 190.502 196.003 198.760
206.647 196.948 203.757 206.779 215.193 202.942 210.677 213.943
222.612 208.263 216.686 220.145 228.882 213.070 222.010 225.619
234.300 217.528 226.863 230.598 239.156
GDPN 808.791 870.803 916.175 1001.357 877.695 950.691 992.721
1083.876 941.612 1023.344 1067.575 1160.874 1005.561 1094.662
1141.792 1236.134 1067.728 1163.209 1213.118 1307.892 1128.320
1229.402 1281.936 1376.805 1190.377 1296.948 1352.294 1447.653
DEFICITN -0.701 -0.858 -0.817 -2.699 -0.916 -1.058 -1.106 -
2.424 -0.986 -1.059 -1.059 -2.012 -0.942 -0.913 -0.829 -1.507
-0.801 -0.660 -0.485 -0.954 -0.582 -0.328 -0.057 -0.365 -0.274
0.101 0.504 0.333
DEF% -0.087 -0.099 -0.089 -0.270 -0.104 -0.111 -0.111 -
0.224 -0.105 -0.104 -0.099 -0.173 -0.094 -0.083 -0.073 -0.122
-0.075 -0.057 -0.040 -0.073 -0.052 -0.027 -0.004 -0.027 -0.023
0.008 0.037 0.023
CAR -9.043 -9.529 -8.905 -24.790 -11.683 -14.039 -16.049 -
29.728 -14.404 -17.327 -19.739 -31.834 -15.711 -18.682 -21.132 -
31.825 -15.763 -18.519 -20.924 -30.350 -14.690 -17.075 -19.410 -
27.689 -13.060 -15.016 -17.303 -24.612
CA% -2.048 -2.043 -1.840 -4.856 -2.536 -2.894 -3.213 -
5.668 -3.013 -3.450 -3.823 -5.901 -3.171 -3.595 -3.960 -5.731
-3.075 -3.450 -3.797 -5.311 -2.774 -3.083 -3.416 -4.712 -2.387
-2.627 -2.951 -4.066
GRGDPR 3.349 5.159 3.023 4.483 4.365 3.970 3.211
2.745 3.771 3.546 3.370 2.851 3.638 3.456 3.370 2.934
3.469 3.315 3.254 2.907 3.291 3.156 3.109 2.834 3.338
3.238 3.211 3.011
GRCPI 3.229 2.828 3.911 6.739 3.980 5.005 4.984 5.349
3.384 3.956 4.035 4.135 3.043 3.396 3.465 3.448 2.622
2.852 2.899 2.816 2.308 2.457 2.487 2.368 2.092 2.186
2.207 2.072
GDPR1 488.589 441.456 466.516 483.918 510.493 460.727 485.039
499.458 524.505 478.101 502.238 516.288 539.458 495.493 519.593
533.689 555.286 512.683 536.817 551.054 571.427 529.554 553.759
568.186 587.624 547.229 571.687 586.430
GDPR2 469.719 488.589 441.456 466.516 483.918 510.493 460.727
485.039 499.458 524.505 478.101 502.238 516.288 539.458 495.493
519.593 533.689 555.286 512.683 536.817 551.054 571.427 529.554
553.759 568.186 587.624 547.229 571.687
GDPR3 443.628 469.719 488.589 441.456 466.516 483.918 510.493
460.727 485.039 499.458 524.505 478.101 502.238 516.288 539.458
495.493 519.593 533.689 555.286 512.683 536.817 551.054 571.427
529.554 553.759 568.186 587.624 547.229

CPI1 179.496 178.948 182.318 184.920 191.592 186.071 191.444
194.136 201.840 192.367 199.017 201.969 210.187 198.221 205.776
208.966 217.433 203.418 211.646 215.024 223.557 208.113 216.846
220.370 228.850 212.468 221.586 225.233
CPI2 177.960 179.496 178.948 182.318 184.920 191.592 186.071
191.444 194.136 201.840 192.367 199.017 201.969 210.187 198.221
205.776 208.966 217.433 203.418 211.646 215.024 223.557 208.113
216.846 220.370 228.850 212.468 221.586
CPI3 177.305 177.960 179.496 178.948 182.318 184.920 191.592
186.071 191.444 194.136 201.840 192.367 199.017 201.969 210.187
198.221 205.776 208.966 217.433 203.418 211.646 215.024 223.557
208.113 216.846 220.370 228.850 212.468
LTIRLN1 13.777 13.577 13.999 13.953 15.070 13.716 13.817
13.454 14.400 13.034 13.191 12.817 13.642 12.421 12.661
12.310 13.030 11.948 12.250 11.920 12.545 11.634 12.001
11.692 12.234 11.364 11.742 11.440
LTIRLN2 15.887 13.777 13.577 13.999 13.953 15.070 13.716
13.817 13.454 14.400 13.034 13.191 12.817 13.642 12.421
12.661 12.310 13.030 11.948 12.250 11.920 12.545 11.634
12.001 11.692 12.234 11.364 11.742
LTIRLN3 19.140 15.887 13.777 13.577 13.999 13.953 15.070
13.716 13.817 13.454 14.400 13.034 13.191 12.817 13.642
12.421 12.661 12.310 13.030 11.948 12.250 11.920 12.545
11.634 12.001 11.692 12.234 11.364
IMP1 277.046 255.693 270.445 274.720 297.641 268.199 285.392
292.496 313.493 281.180 299.534 307.244 326.950 293.158 312.177
320.137 338.746 304.308 323.754 331.890 349.547 314.777 334.520
342.814 359.654 325.150 345.158 353.643
IMP2 247.816 277.046 255.693 270.445 274.720 297.641 268.199
285.392 292.496 313.493 281.180 299.534 307.244 326.950 293.158
312.177 320.137 338.746 304.308 323.754 331.890 349.547 314.777
334.520 342.814 359.654 325.150 345.158
IMP3 260.827 247.816 277.046 255.693 270.445 274.720 297.641
268.199 285.392 292.496 313.493 281.180 299.534 307.244 326.950
293.158 312.177 320.137 338.746 304.308 323.754 331.890 349.547
314.777 334.520 342.814 359.654 325.150
INV1 153.788 111.554 124.668 136.313 163.731 121.336 135.010
145.481 167.500 128.638 141.832 151.512 168.849 134.261 146.510
155.487 168.976 138.198 149.339 157.674 168.081 140.691 150.670
158.428 166.405 142.478 151.420 158.718
INV2 124.912 153.788 111.554 124.668 136.313 163.731 121.336
135.010 145.481 167.500 128.638 141.832 151.512 168.849 134.261
146.510 155.487 168.976 138.198 149.339 157.674 168.081 140.691
150.670 158.428 166.405 142.478 151.420
INV3 115.582 124.912 153.788 111.554 124.668 136.313 163.731
121.336 135.010 145.481 167.500 128.638 141.832 151.512 168.849
134.261 146.510 155.487 168.976 138.198 149.339 157.674 168.081
140.691 150.670 158.428 166.405 142.478
EMP1 743.136 739.637 745.361 747.664 748.434 740.958 745.750
748.055 750.820 742.600 746.911 749.040 752.177 744.394 748.384

750.387 753.393 746.170 749.926 751.852 754.623 747.907 751.490
753.369 755.924 749.744 753.210 755.069
EMP2 748.578 743.136 739.637 745.361 747.664 748.434 740.958
745.750 748.055 750.820 742.600 746.911 749.040 752.177 744.394
748.384 750.387 753.393 746.170 749.926 751.852 754.623 747.907
751.490 753.369 755.924 749.744 753.210
EMP3 748.603 748.578 743.136 739.637 745.361 747.664 748.434
740.958 745.750 748.055 750.820 742.600 746.911 749.040 752.177
744.394 748.384 750.387 753.393 746.170 749.926 751.852 754.623
747.907 751.490 753.369 755.924 749.744
AGW1 495.185 487.866 501.897 510.253 534.587 514.729 533.696
544.173 571.167 539.927 563.019 574.888 603.801 563.727 590.108
603.009 633.027 585.940 614.893 628.590 659.063 606.614 637.564
651.890 682.360 626.169 658.690 673.548
AGW2 472.824 495.185 487.866 501.897 510.253 534.587 514.729
533.696 544.173 571.167 539.927 563.019 574.888 603.801 563.727
590.108 603.009 633.027 585.940 614.893 628.590 659.063 606.614
637.564 651.890 682.360 626.169 658.690
AGW3 468.756 472.824 495.185 487.866 501.897 510.253 534.587
514.729 533.696 544.173 571.167 539.927 563.019 574.888 603.801
563.727 590.108 603.009 633.027 585.940 614.893 628.590 659.063
606.614 637.564 651.890 682.360 626.169
EXRATE1 95.355 96.731 97.699 97.896 99.930 98.453 100.147
100.333 102.699 99.963 102.047 102.288 104.805 100.975 103.308
103.594 106.160 101.724 104.226 104.544 107.100 102.267 104.880
105.218 107.726 102.671 105.361 105.714
EXRATE2 94.242 95.355 96.731 97.699 97.896 99.930 98.453
100.147 100.333 102.699 99.963 102.047 102.288 104.805 100.975
103.308 103.594 106.160 101.724 104.226 104.544 107.100 102.267
104.880 105.218 107.726 102.671 105.361
EXRATE3 93.667 94.242 95.355 96.731 97.699 97.896 99.930
98.453 100.147 100.333 102.699 99.963 102.047 102.288 104.805
100.975 103.308 103.594 106.160 101.724 104.226 104.544 107.100
102.267 104.880 105.218 107.726 102.671
CR1 252.421 251.264 256.125 260.042 262.835 258.493 264.567
269.532 272.905 266.111 273.268 279.121 282.640 274.082 282.189
288.829 292.143 282.344 291.279 298.624 301.464 290.861 300.512
308.489 310.659 299.583 309.859 318.408
CR2 250.645 252.421 251.264 256.125 260.042 262.835 258.493
264.567 269.532 272.905 266.111 273.268 279.121 282.640 274.082
282.189 288.829 292.143 282.344 291.279 298.624 301.464 290.861
300.512 308.489 310.659 299.583 309.859
CR3 248.282 250.645 252.421 251.264 256.125 260.042 262.835
258.493 264.567 269.532 272.905 266.111 273.268 279.121 282.640
274.082 282.189 288.829 292.143 282.344 291.279 298.624 301.464
290.861 300.512 308.489 310.659 299.583
DEMAND1 765.635 697.149 736.961 758.638 808.134 728.926
770.431 791.955 837.998 759.280 801.771 823.532 866.408 788.651
831.770 853.825 894.032 816.991 860.571 882.944 920.975 844.331
888.279 911.000 947.278 872.378 916.845 940.073

DEMAND2 717.535 765.635 697.149 736.961 758.638 808.134
728.926 770.431 791.955 837.998 759.280 801.771 823.532 866.408
788.651 831.770 853.825 894.032 816.991 860.571 882.944 920.975
844.331 888.279 911.000 947.278 872.378 916.845
DEMAND3 704.455 717.535 765.635 697.149 736.961 758.638
808.134 728.926 770.431 791.955 837.998 759.280 801.771 823.532
866.408 788.651 831.770 853.825 894.032 816.991 860.571 882.944
920.975 844.331 888.279 911.000 947.278 872.378

Optimal value of objective function: 81521.123
Deterministic : 81521.123
_hs: 0.000
_hp: 0.000
_hc: 1421538.110

Deviations of optimal states from targets (optimal - target):

20071 20072 20073 20074 20081 20082 20083 20084
20091 20092 20093 20094 20101 20102 20103 20104
20111 20112 20113 20114 20121 20122 20123 20124
20131 20132 20133 20134

GDPR -4.917 2.925 -6.938 -0.082 -5.733 0.586 -13.487 -
9.046 -9.350 -4.015 -19.739 -18.103 -13.893 -9.442 -26.460 -
27.365 -19.625 -16.024 -34.301 -37.443 -26.708 -23.960 -43.510 -
48.646 -34.065 -32.029 -52.793 -59.585
YDR 317.506 333.035 349.053 359.786 330.880 346.603 359.889
367.907 341.976 357.861 370.876 375.743 353.161 369.056 382.139
384.114 364.200 380.040 393.245 392.666 375.227 390.982 404.315
401.515 386.095 401.827 415.303 410.511
M2R 651.566 677.805 711.924 719.413 693.212 714.624 751.182
757.240 735.559 754.503 792.703 798.585 775.935 793.478 833.169
839.507 814.133 830.844 871.992 879.215 848.558 864.805 907.293
915.668 885.833 901.979 945.951 955.612
UN 131.666 126.506 124.656 124.455 132.046 127.529 125.535
123.211 131.481 127.409 125.589 122.883 130.657 126.886 125.180
122.590 129.780 126.233 124.599 122.229 128.884 125.496 123.897
121.724 127.822 124.538 122.948 120.914
UR 1.111 0.510 0.290 0.258 2.126 1.603 1.370 1.097
3.042 2.572 2.359 2.043 3.931 3.497 3.297 2.995 4.816
4.408 4.216 3.940 5.700 5.310 5.123 4.869 6.565 6.188
6.003 5.766
PROD 59.686 62.589 64.724 68.208 62.180 65.040 66.768
69.858 64.382 67.242 68.927 71.720 66.563 69.429 71.122
73.705 68.709 71.583 73.293 75.724 70.805 73.688 75.419
77.736 72.989 75.900 77.666 79.914
AGWR 272.630 275.286 275.932 279.024 276.631 278.774 280.305
282.980 280.676 282.900 284.642 287.269 284.394 286.772 288.567
291.136 288.047 290.530 292.335 294.807 291.483 294.018 295.815
298.169 294.712 297.262 299.045 301.272

ANWR 171.757 173.430 173.837 175.785 174.277 175.628 176.592
178.277 176.826 178.227 179.325 180.979 179.168 180.667 181.798
183.416 181.470 183.034 184.171 185.729 183.634 185.231 186.364
187.847 185.669 187.275 188.398 189.801
ANWN 307.355 316.195 321.459 336.790 324.279 336.228 342.829
359.835 340.154 354.702 362.179 380.395 355.148 371.768 379.896
398.807 369.142 387.383 396.011 415.210 382.167 401.665 410.691
429.887 394.486 414.975 424.335 443.362
UTIL 82.999 86.731 88.920 92.581 82.686 86.076 87.601
90.820 81.919 85.091 86.452 89.204 81.080 84.078 85.362
87.735 80.167 83.018 84.251 86.331 79.188 81.913 83.109
84.962 78.325 80.957 82.135 83.828
LTIRLR 8.347 9.172 8.042 6.331 7.735 6.812 6.471
7.051 7.651 7.236 6.782 7.507 7.378 7.264 6.845 7.583
7.326 7.398 7.021 7.728 7.326 7.544 7.206 7.866 7.272
7.556 7.233 7.838
EXRATER 58.893 58.439 58.405 57.576 58.224 57.618 57.588
56.729 57.754 57.042 56.998 56.149 57.465 56.688 56.629
55.804 57.258 56.440 56.371 55.577 57.109 56.264 56.189
55.429 57.002 56.142 56.063 55.337
CAPR 4472.447 4507.667 4553.827 4626.481 4655.288 4697.192
4748.729 4821.255 4853.468 4898.230 4951.778 5021.591 5055.420
5100.822 5154.292 5220.182 5253.977 5298.236 5349.945 5411.028
5443.499 5485.298 5534.021 5589.746 5620.428 5659.439 5704.968
5755.728
DEMAND 697.149 736.961 758.638 808.134 728.926 770.431
791.955 837.998 759.280 801.771 823.532 866.408 788.651 831.770
853.825 894.032 816.991 860.571 882.944 920.975 844.331 888.279
911.000 947.278 872.378 916.845 940.073 975.173
PRATIO 1.642 1.672 1.676 1.736 1.691 1.738 1.742
1.810 1.731 1.789 1.795 1.867 1.757 1.822 1.829 1.902
1.777 1.847 1.855 1.927 1.791 1.864 1.873 1.944 1.801
1.877 1.886 1.954
INTDIFF 9.072 10.007 9.601 10.769 9.371 9.472 9.098
10.068 8.665 8.827 8.442 9.289 8.036 8.282 7.922 8.661
7.550 7.861 7.522 8.163 7.229 7.606 7.289 7.845 6.951
7.340 7.030 7.513
CR -4.529 -3.329 -1.882 -0.945 -8.810 -6.563 -4.179 -2.745
-13.220 -10.063 -6.907 -5.414 -17.820 -13.892 -10.070 -8.873 -
22.694 -18.125 -13.726 -13.098 -27.903 -22.816 -17.916 -18.059 -
33.526 -28.018 -22.685 -23.750
IMPR -9.474 -2.119 15.752 8.127 -8.900 0.562 21.875
10.951 -8.389 1.887 24.445 10.794 -9.441 1.136 24.611 8.363
-11.909 -1.284 23.066 4.297 -15.669 -5.144 20.093 -1.132 -
20.166 -9.792 16.400 -7.165
INVR 3.087 3.885 5.780 3.023 7.988 8.792 9.074 -0.440
10.190 9.933 8.967 -6.649 10.482 8.677 6.527 -14.419 8.849
5.303 2.011 -23.567 5.522 0.152 -4.239 -33.867 1.226 -5.871
-11.270 -44.425

EMP 739.637 745.361 747.664 748.434 740.958 745.750 748.055
750.820 742.600 746.911 749.040 752.177 744.394 748.384 750.387
753.393 746.170 749.926 751.852 754.623 747.907 751.490 753.369
755.924 749.744 753.210 755.069 757.465
CPI 178.948 182.318 184.920 191.592 186.071 191.444 194.136
201.840 192.367 199.017 201.969 210.187 198.221 205.776 208.966
217.433 203.418 211.646 215.024 223.557 208.113 216.846 220.370
228.850 212.468 221.586 225.233 233.593
AGWN 487.866 501.897 510.253 534.587 514.729 533.696 544.173
571.167 539.927 563.019 574.888 603.801 563.727 590.108 603.009
633.027 585.940 614.893 628.590 659.063 606.614 637.564 651.890
682.360 626.169 658.690 673.548 703.750
LFORCE 871.303 871.867 872.319 872.889 873.004 873.279 873.591
874.032 874.080 874.320 874.629 875.060 875.052 875.269 875.567
875.984 875.950 876.159 876.451 876.852 876.791 876.986 877.267
877.648 877.566 877.747 878.017 878.378
STIRLN 3.782 4.227 4.201 5.369 4.971 5.072 4.698
5.668 5.265 5.427 5.042 5.889 5.636 5.882 5.522 6.261
6.150 6.461 6.122 6.763 6.829 7.206 6.889 7.445 6.551
6.940 6.630 7.113
LTIRLN 13.577 13.999 13.953 15.070 13.716 13.817 13.454
14.400 13.034 13.191 12.817 13.642 12.421 12.661 12.310
13.030 11.948 12.250 11.920 12.545 11.634 12.001 11.692
12.234 11.364 11.742 11.440 11.911
EXRATE 96.731 97.699 97.896 99.930 98.453 100.147 100.333
102.699 99.963 102.047 102.288 104.805 100.975 103.308 103.594
106.160 101.724 104.226 104.544 107.100 102.267 104.880 105.218
107.726 102.671 105.361 105.714 108.154
YPOT 531.879 537.890 544.215 551.401 557.198 563.499 570.152
577.524 583.623 590.236 597.196 604.748 611.113 617.990 625.207
632.911 639.519 646.627 654.064 661.905 668.726 676.033 683.662
691.629 698.660 706.164 713.986 722.097
NETTAXN 221.807 243.362 249.394 288.743 241.606 265.026
270.954 316.078 261.860 287.335 293.687 344.107 282.132 309.770
316.687 372.186 302.041 331.811 339.328 399.634 321.174 352.976
361.124 425.911 342.358 376.386 385.436 455.053
NETTAXR 123.950 133.482 134.866 150.707 129.846 138.435
139.569 156.598 136.125 144.377 145.412 163.715 142.332 150.537
151.549 171.173 148.483 156.777 157.809 178.761 154.327 162.778
163.871 186.109 161.134 169.860 171.127 194.806
GN 160.641 177.798 182.638 213.254 176.370 195.025 199.742
235.222 192.526 212.855 217.932 257.807 208.748 230.850 236.417
280.473 224.723 248.579 254.664 302.655 240.112 265.642 272.274
323.918 257.179 284.542 291.954 347.519
GR 87.681 95.252 96.468 108.717 92.581 99.501 100.494
113.828 97.755 104.465 105.394 119.803 102.861 109.576 110.504
125.992 107.904 114.718 115.680 132.232 112.692 119.653 120.679
138.249 118.228 125.425 126.607 145.310
GDPDEF 183.210 186.661 189.324 196.155 190.502 196.003 198.760
206.647 196.948 203.757 206.779 215.193 202.942 210.677 213.943

222.612 208.263 216.686 220.145 228.882 213.070 222.010 225.619
234.300 217.528 226.863 230.598 239.156
GDPN 808.791 870.803 916.175 1001.357 877.695 950.691 992.721
1083.876 941.612 1023.344 1067.575 1160.874 1005.561 1094.662
1141.792 1236.134 1067.728 1163.209 1213.118 1307.892 1128.320
1229.402 1281.936 1376.805 1190.377 1296.948 1352.294 1447.653
DEFICITN -0.701 -0.858 -0.817 -2.699 -0.916 -1.058 -1.106 -
2.424 -0.986 -1.059 -1.059 -2.012 -0.942 -0.913 -0.829 -1.507
-0.801 -0.660 -0.485 -0.954 -0.582 -0.328 -0.057 -0.365 -0.274
0.101 0.504 0.333
DEF% -0.087 -0.099 -0.089 -0.270 -0.104 -0.111 -0.111 -
0.224 -0.105 -0.104 -0.099 -0.173 -0.094 -0.083 -0.073 -0.122
-0.075 -0.057 -0.040 -0.073 -0.052 -0.027 -0.004 -0.027 -0.023
0.008 0.037 0.023
CAR -9.043 -9.529 -8.905 -24.790 -11.683 -14.039 -16.049 -
29.728 -14.404 -17.327 -19.739 -31.834 -15.711 -18.682 -21.132 -
31.825 -15.763 -18.519 -20.924 -30.350 -14.690 -17.075 -19.410 -
27.689 -13.060 -15.016 -17.303 -24.612
CA% -2.048 -2.043 -1.840 -4.856 -2.536 -2.894 -3.213 -
5.668 -3.013 -3.450 -3.823 -5.901 -3.171 -3.595 -3.960 -5.731
-3.075 -3.450 -3.797 -5.311 -2.774 -3.083 -3.416 -4.712 -2.387
-2.627 -2.951 -4.066
GRGDPR -1.151 0.659 -1.477 -0.017 -0.135 -0.530 -1.289 -
1.755 -0.729 -0.954 -1.130 -1.649 -0.862 -1.044 -1.130 -1.566
-1.031 -1.185 -1.246 -1.593 -1.209 -1.344 -1.391 -1.666 -1.162
-1.262 -1.289 -1.489
GRCPI -3.771 -4.172 -3.089 -0.261 -2.020 -0.995 -1.016 -
0.651 -1.616 -1.044 -0.965 -0.865 -0.957 -0.604 -0.535 -0.552
-0.378 -0.148 -0.101 -0.184 0.308 0.457 0.487 0.368 0.092
0.186 0.207 0.072
GDPR1 488.589 441.456 466.516 483.918 510.493 460.727 485.039
499.458 524.505 478.101 502.238 516.288 539.458 495.493 519.593
533.689 555.286 512.683 536.817 551.054 571.427 529.554 553.759
568.186 587.624 547.229 571.687 586.430
GDPR2 469.719 488.589 441.456 466.516 483.918 510.493 460.727
485.039 499.458 524.505 478.101 502.238 516.288 539.458 495.493
519.593 533.689 555.286 512.683 536.817 551.054 571.427 529.554
553.759 568.186 587.624 547.229 571.687
GDPR3 443.628 469.719 488.589 441.456 466.516 483.918 510.493
460.727 485.039 499.458 524.505 478.101 502.238 516.288 539.458
495.493 519.593 533.689 555.286 512.683 536.817 551.054 571.427
529.554 553.759 568.186 587.624 547.229
CPI1 179.496 178.948 182.318 184.920 191.592 186.071 191.444
194.136 201.840 192.367 199.017 201.969 210.187 198.221 205.776
208.966 217.433 203.418 211.646 215.024 223.557 208.113 216.846
220.370 228.850 212.468 221.586 225.233
CPI2 177.960 179.496 178.948 182.318 184.920 191.592 186.071
191.444 194.136 201.840 192.367 199.017 201.969 210.187 198.221
205.776 208.966 217.433 203.418 211.646 215.024 223.557 208.113
216.846 220.370 228.850 212.468 221.586

CPI3 177.305 177.960 179.496 178.948 182.318 184.920 191.592
186.071 191.444 194.136 201.840 192.367 199.017 201.969 210.187
198.221 205.776 208.966 217.433 203.418 211.646 215.024 223.557
208.113 216.846 220.370 228.850 212.468
LTIRLN1 13.777 13.577 13.999 13.953 15.070 13.716 13.817
13.454 14.400 13.034 13.191 12.817 13.642 12.421 12.661
12.310 13.030 11.948 12.250 11.920 12.545 11.634 12.001
11.692 12.234 11.364 11.742 11.440
LTIRLN2 15.887 13.777 13.577 13.999 13.953 15.070 13.716
13.817 13.454 14.400 13.034 13.191 12.817 13.642 12.421
12.661 12.310 13.030 11.948 12.250 11.920 12.545 11.634
12.001 11.692 12.234 11.364 11.742
LTIRLN3 19.140 15.887 13.777 13.577 13.999 13.953 15.070
13.716 13.817 13.454 14.400 13.034 13.191 12.817 13.642
12.421 12.661 12.310 13.030 11.948 12.250 11.920 12.545
11.634 12.001 11.692 12.234 11.364
IMP1 277.046 255.693 270.445 274.720 297.641 268.199 285.392
292.496 313.493 281.180 299.534 307.244 326.950 293.158 312.177
320.137 338.746 304.308 323.754 331.890 349.547 314.777 334.520
342.814 359.654 325.150 345.158 353.643
IMP2 247.816 277.046 255.693 270.445 274.720 297.641 268.199
285.392 292.496 313.493 281.180 299.534 307.244 326.950 293.158
312.177 320.137 338.746 304.308 323.754 331.890 349.547 314.777
334.520 342.814 359.654 325.150 345.158
IMP3 260.827 247.816 277.046 255.693 270.445 274.720 297.641
268.199 285.392 292.496 313.493 281.180 299.534 307.244 326.950
293.158 312.177 320.137 338.746 304.308 323.754 331.890 349.547
314.777 334.520 342.814 359.654 325.150
INV1 153.788 111.554 124.668 136.313 163.731 121.336 135.010
145.481 167.500 128.638 141.832 151.512 168.849 134.261 146.510
155.487 168.976 138.198 149.339 157.674 168.081 140.691 150.670
158.428 166.405 142.478 151.420 158.718
INV2 124.912 153.788 111.554 124.668 136.313 163.731 121.336
135.010 145.481 167.500 128.638 141.832 151.512 168.849 134.261
146.510 155.487 168.976 138.198 149.339 157.674 168.081 140.691
150.670 158.428 166.405 142.478 151.420
INV3 115.582 124.912 153.788 111.554 124.668 136.313 163.731
121.336 135.010 145.481 167.500 128.638 141.832 151.512 168.849
134.261 146.510 155.487 168.976 138.198 149.339 157.674 168.081
140.691 150.670 158.428 166.405 142.478
EMP1 743.136 739.637 745.361 747.664 748.434 740.958 745.750
748.055 750.820 742.600 746.911 749.040 752.177 744.394 748.384
750.387 753.393 746.170 749.926 751.852 754.623 747.907 751.490
753.369 755.924 749.744 753.210 755.069
EMP2 748.578 743.136 739.637 745.361 747.664 748.434 740.958
745.750 748.055 750.820 742.600 746.911 749.040 752.177 744.394
748.384 750.387 753.393 746.170 749.926 751.852 754.623 747.907
751.490 753.369 755.924 749.744 753.210
EMP3 748.603 748.578 743.136 739.637 745.361 747.664 748.434
740.958 745.750 748.055 750.820 742.600 746.911 749.040 752.177

744.394 748.384 750.387 753.393 746.170 749.926 751.852 754.623
747.907 751.490 753.369 755.924 749.744
AGW1 495.185 487.866 501.897 510.253 534.587 514.729 533.696
544.173 571.167 539.927 563.019 574.888 603.801 563.727 590.108
603.009 633.027 585.940 614.893 628.590 659.063 606.614 637.564
651.890 682.360 626.169 658.690 673.548
AGW2 472.824 495.185 487.866 501.897 510.253 534.587 514.729
533.696 544.173 571.167 539.927 563.019 574.888 603.801 563.727
590.108 603.009 633.027 585.940 614.893 628.590 659.063 606.614
637.564 651.890 682.360 626.169 658.690
AGW3 468.756 472.824 495.185 487.866 501.897 510.253 534.587
514.729 533.696 544.173 571.167 539.927 563.019 574.888 603.801
563.727 590.108 603.009 633.027 585.940 614.893 628.590 659.063
606.614 637.564 651.890 682.360 626.169
EXRATE1 95.355 96.731 97.699 97.896 99.930 98.453 100.147
100.333 102.699 99.963 102.047 102.288 104.805 100.975 103.308
103.594 106.160 101.724 104.226 104.544 107.100 102.267 104.880
105.218 107.726 102.671 105.361 105.714
EXRATE2 94.242 95.355 96.731 97.699 97.896 99.930 98.453
100.147 100.333 102.699 99.963 102.047 102.288 104.805 100.975
103.308 103.594 106.160 101.724 104.226 104.544 107.100 102.267
104.880 105.218 107.726 102.671 105.361
EXRATE3 93.667 94.242 95.355 96.731 97.699 97.896 99.930
98.453 100.147 100.333 102.699 99.963 102.047 102.288 104.805
100.975 103.308 103.594 106.160 101.724 104.226 104.544 107.100
102.267 104.880 105.218 107.726 102.671
CR1 252.421 251.264 256.125 260.042 262.835 258.493 264.567
269.532 272.905 266.111 273.268 279.121 282.640 274.082 282.189
288.829 292.143 282.344 291.279 298.624 301.464 290.861 300.512
308.489 310.659 299.583 309.859 318.408
CR2 250.645 252.421 251.264 256.125 260.042 262.835 258.493
264.567 269.532 272.905 266.111 273.268 279.121 282.640 274.082
282.189 288.829 292.143 282.344 291.279 298.624 301.464 290.861
300.512 308.489 310.659 299.583 309.859
CR3 248.282 250.645 252.421 251.264 256.125 260.042 262.835
258.493 264.567 269.532 272.905 266.111 273.268 279.121 282.640
274.082 282.189 288.829 292.143 282.344 291.279 298.624 301.464
290.861 300.512 308.489 310.659 299.583
DEMAND1 765.635 697.149 736.961 758.638 808.134 728.926
770.431 791.955 837.998 759.280 801.771 823.532 866.408 788.651
831.770 853.825 894.032 816.991 860.571 882.944 920.975 844.331
888.279 911.000 947.278 872.378 916.845 940.073
DEMAND2 717.535 765.635 697.149 736.961 758.638 808.134
728.926 770.431 791.955 837.998 759.280 801.771 823.532 866.408
788.651 831.770 853.825 894.032 816.991 860.571 882.944 920.975
844.331 888.279 911.000 947.278 872.378 916.845
DEMAND3 704.455 717.535 765.635 697.149 736.961 758.638
808.134 728.926 770.431 791.955 837.998 759.280 801.771 823.532
866.408 788.651 831.770 853.825 894.032 816.991 860.571 882.944
920.975 844.331 888.279 911.000 947.278 872.378

Deviations of optimal controls from targets (optimal - target):
20071 20072 20073 20074 20081 20082 20083 20084
20091 20092 20093 20094 20101 20102 20103 20104
20111 20112 20113 20114 20121 20122 20123 20124
20131 20132 20133 20134

M2N -9.428 -12.413 -13.963 -15.541 -8.945 -11.134 -11.838 -
11.821 -7.223 -8.675 -8.803 -8.038 -5.019 -5.850 -5.607 -4.544
-2.719 -3.089 -2.659 -1.610 -0.674 -0.742 -0.290 0.483 0.645
0.681 0.921 1.040
TGEN -0.025 -3.802 -5.974 -14.298 -2.597 -7.457 -11.280 -
16.754 -4.194 -9.739 -14.124 -17.806 -4.874 -10.786 -15.414 -
17.621 -4.519 -10.659 -15.405 -16.355 -3.048 -9.309 -14.020 -
13.830 0.048 -6.228 -10.460 -8.982
TGRN -1.619 1.615 4.936 -3.582 -4.216 -1.361 0.979 -
5.470 -5.984 -3.163 -0.853 -6.093 -6.944 -3.888 -1.335 -5.590
-6.956 -3.565 -0.676 -4.087 -5.915 -2.128 1.207 -1.415 -3.351
0.970 5.192 3.517

End of OPTCON output.

(gauss)

APPENDIX C DATA SET

DATA SET

X state variables

CONS x[10]

Years	Q1	Q2	Q3	Q4
1987	10793	11492	14644	14088
1988	11429	11888	15028	13292
1989	10592	11559	15246	13707
1990	12098	13335	16940	15429
1991	12374	13325	17635	15579
1992	13027	13727	18082	16027
1993	13698	15430	17379	17379
1994	14498	13856	18041	16099
1995	14009	15528	19678	16797
1996	15552	16998	20903	18161
1997	16832	18662	22767	19360
1998	18276	18555	23055	18227
1999	17318	18387	22376	17996
2000	18013	19234	24531	18996
2001	17474	16928	22112	16841
2002	17150	17464	22699	17581
2003	18493	17964	24016	19389
2004	20793	21263	25758	20083
2005	21637	22092	28435	23429
2006	23452	24394	29090	23455

INVR x[12]

Years				
1987	3377.8	4423.3	5147.6	5542.4
1988	3676.3	4578.7	5188.3	4855.3
1989	4192.4	4443.4	5193.5	4871.5
1990	4271.2	5304.7	6075.9	6018.1
1991	4411.7	5265.9	6217.8	6039.5
1992	4815.8	5738.9	6169.3	6158.2
1993	5320.3	7173.7	7958.3	8121.4
1994	5754.9	5734	6471.5	6066.4
1995	4955.1	6596.2	7337.7	7933.9
1996	5970.2	7779.9	8817.3	8030.4
1997	6474.3	8943.4	9953.4	9766.1
1998	7093.6	8810.8	9210.9	8652.9
1999	5729.7	7406.8	7929.9	7406.4
2000	6280.8	8725.9	9563.3	8711.2
2001	5472.9	5943.8	6019.2	5346.8
2002	3910.9	5824.3	6356.4	6440.3
2003	4368.4	6194	6545.6	7673.8
2004	6885.1	9129.8	8251.9	8535.5
2005	7593.2	10954.5	10780.7	11353.1
2006	9929	12213.2	11794.4	10245.8

EXRATE x[18]

Years

1987	764.7	812.6	891.62	968.91
1988	1149.31	1301.86	1508.7	1751.6
1989	1916.81	2085.5	2193.7	2303.5
1990	2391	2565.37	2691.12	2799.15
1991	3225.2	3995.4	4511.2	4952
1992	5699.8	6678.3	7109.3	8027.5
1993	9049.4	10007.2	11570.6	13352.2
1994	17856.2	32567.6	32266.6	36273.7
1995	41069.9	42967	46404.8	53114.6
1996	64366	76583.1	85614.6	99224.9
1997	118868	137902.6	162478.9	188816
1998	224538	253812.8	273061.2	294385.8
1999	342669	396863	439443	499080
2000	564884.5	611913.2	647711.7	682136.8
2001	785492.6	1186797	1398185	1531641
2002	1362588	1411373	1650668	1620250
2003	1654777	1519518	1395551	1445151
2004	1333971	1453930	1478474	1445844
2005	1326820	1364625	1340980	1356580
2006	1332080	1456460	1501740	1457410

IMPORTS	x[11]			
Years				
1987	2740.4	3037.6	3516.7	4763.1
1988	3493.7	3781.47	3265.1	3795.2
1989	3319	3897.3	3994.4	4671.4
1990	4706.7	4875.2	5434.7	7285.6
1991	4915.9	4745.7	5243.9	6141.6
1992	4815	5375	6150	6451
1993	5872	7705	7860	7989
1994	5602	4637	5314	6720
1995	6533	8291	9245	10719
1996	9398	10555	10714	11664
1997	10140	11368	12452	13198
1998	10912	11621	11510	10671
1999	7736	9948	10070	11273
2000	11070	13577	13838	14195
2001	9939	9104	9533	9530
2002	9575	11489	12443	13900
2003	13516	15495	17344	18861
2004	19436	22579	23370	25540
2005	24197	27609	28431	29638
2006	28149	34495	34007	22658

DEMAND	x[8]			
Years				
1987	16906.6	19378.2	27253.4	24146.6
1988	18684.1	20452.4	27250.3	22446.3
1989	17709.4	19935.4	28497	23765.5
1990	20800.3	23628.3	30210.3	26828.3
1991	20457.7	22913.7	31384.2	26359.6
1992	22162.5	24573.1	32934.3	27541.6
1993	24087.5	28611	36472.3	31571.6

1994	25290	24272.2	32421.8	28696.8
1995	25223.3	28920.8	36726.7	32891.2
1996	28780.7	32519.2	39980.1	35036.1
1997	31294.5	36336.3	44582.3	39095.5
1998	34815	38267.2	45025.6	37746.7
1999	31155.2	37476.9	42816.4	37510.2
2000	35246	41949	47697	41751
2001	33428.2	35060.8	41847.2	35630.8
2002	34203.1	39205.6	46189.4	40674.9
2003	38291	42983	51091	45953.6
2004	45075.2	51642.6	55222.7	50684.8
2005	48670.4	55144	60004.8	56446.8
2006	52116.6	59769.7	61761.7	62786

GOVR	x[13]			
Years				
1987	1113.2	1310	1473.6	1948.6
1988	1158.2	1363.2	1428.8	1832.7
1989	1179.8	1370.7	1400.1	1880
1990	1210.2	1473.3	1486.8	2126.7
1991	1313.9	1521.8	1579.3	2164.3
1992	1237.5	1502.8	1723.9	2364.3
1993	1388.4	1623.9	1767.7	2419.2
1994	1400.1	1551.1	1760.1	2236
1995	1499.2	1700.5	1800	2411
1996	1520.7	1831.6	2080.1	2614.5
1997	1461.2	1842.7	2202.6	2873.2
1998	1586.9	2117.8	2158.8	3172.7
1999	1751.6	2163.3	2354.9	3353.1
2000	1739.7	2436.7	2585.8	3548.1
2001	1718.8	2277.5	2200.7	3233.3
2002	1756.8	2337.7	2465.7	3379.4
2003	1716.4	2291.8	2449.3	3239.1
2004	1760.2	2112.9	2277.2	3597.7
2005	1838.2	2197.8	2350	3598.8
2006	1987.8	2594.4	2697.83	3622.99

RGDP	x[1]			
Years				
1987	14108.1	16463	23950.1	19894.9
1988	15531.2	17168.3	24313.2	19130.6
1989	14982.4	16810	24818.9	19752.9
1990	16804.6	19200.3	25651	21784.3
1991	16650.9	19064	26840.4	21485.5
1992	17852	19957.4	27980.3	22483.7
1993	18853.1	22064	29445	24664.2
1994	19663.1	19951.7	27638.2	23338
1995	19742.4	22971.3	29998.9	25016.2
1996	21499.4	24694.1	31678.8	27067.5
1997	22957.1	26776.4	34317.6	28840.9
1998	25115	27713	35160	28552.5

1999	23067.5	27020.5	27838.7	24336.5
2000	24336.5	28851.7	35769.1	30189.4
2001	24097.7	26023.6	33076.5	27069
2002	24640.2	28328	35731.7	30222.9
2003	26623.8	29420	37679.1	32055.1
2004	29752.2	33641.9	39657.2	34058.5
2005	31721.3	35506.9	42694.6	37277.3
2006	33772.3	38260.5	44165.2	38514

REXRATE	x[7]			
Years				
1987	94.9	92.3	89.2	93.3
1988	92.5	92.7	90.5	85.3
1989	91.8	99.6	104.5	106.5
1990	111	113	111.9	117
1991	113.8	115.5	112.2	112.9
1992	116.4	103	104.3	114.9
1993	123.1	121.8	122.2	125.7
1994	98.1	85.3	85	95.7
1995	93.9	99.5	107.3	103.1
1996	102.8	101.8	102.4	101.7
1997	107.1	106.1	111.3	115.9
1998	116.2	115.5	121.1	120.9
1999	121.8	121.5	124.1	127.3
2000	132.4	132.3	139	147.6
2001	113.5	111.8	98.5	116.3
2002	138.4	118.9	115.2	125.4
2003	123.5	140.6	151.5	140.6
2004	154.3	137.5	138.1	143.2
2005	154.7	159.5	162.2	171.4
2006	173	142.1	155.5	160.2

UR	x[3]			
Years				
1987	8.3	8.3	8.5	8.5
1988	8.4	8.4	8.8	8.8
1989	8.4	8.4	8.7	8.7
1990	8.6	8.6	7.4	7.4
1991	7.8	7.8	8.5	8.5
1992	8.6	8.6	8.4	8.4
1993	8.7	8.7	9.2	9.2
1994	8.8	8.8	8.3	8.3
1995	7.8	7.8	7.2	7.2
1996	6.9	6.9	6.3	6.3
1997	6.3	6.3	7.1	7.1
1998	6.9	6.9	6.7	6.7
1999	7.9	7.9	7.4	7.4
2000	8.3	6.1	5.5	6.2
2001	8.5	6.7	7.8	10.4
2002	11.5	9.3	9.6	11
2003	12.3	10	9.4	10.3
2004	12.4	9.3	9.5	10

2005	11.7	9.2	9.4	10.6
2006	11.9	8.8	9.1	9.2

WAGE x[4]

Years				
1987	56.1	56.1	59	58.8
1988	58.2	55.1	60.8	67.9
1989	66.6	72	80.3	89.4
1990	85.6	89.9	102.7	95
1991	115.7	120.2	134.7	142.5
1992	126.5	139.3	139	135.2
1993	142.2	143.5	135.8	141.8
1994	141.9	108.8	101.3	102.4
1995	99.9	98.9	94.3	96.2
1996	95	93.7	100	97
1997	99.9	102	101.6	96
1998	99.8	101.4	100.7	97.4
1999	112	110.2	115.4	106.1
2000	111.6	109.4	113.2	111.1
2001	107	93.4	95.3	88.3
2002	90	89.5	92.7	87.9
2003	89.2	84.8	89.2	90
2004	89.4	89.1	92.2	91.4
2005	92.3	91	93.7	92
2006	92	91.4	93.4	92.3

NINTRATELT x[17]

Years				
1987	52	52	52	52
1988	65	65	64	83.9
1989	70.49	63.42	63.88	58.83
1990	56.66	56.83	56.94	59.35
1991	64.39	61.91	71.09	72.7
1992	71.71	74.74	73.89	74.24
1993	74.02	73.89	74.52	74.76
1994	96.9	125.29	98.07	95.56
1995	95.97	91.09	86.48	92.32
1996	92.67	91.57	93.24	93.77
1997	90.11	90.53	96.22	96.56
1998	96.9	92.85	91.53	95.5
1999	90.72	91.72	88.06	46.73
2000	37.4	36.89	40.23	45.64
2001	77.69	60.69	66.6	62.5
2002	58.32	52.04	53.34	48.19
2003	48.89	42.73	34.3	28.59
2004	22.81	23.87	23.4	22.06
2005	19.45	20.31	19.92	20.38
2006	19.07	21.74	23.72	

x[16]

NINTRATEST

Years				
1987	35	35	35	35
1988	45	45	42	66
1989	57.37	50.51	51.61	49.08
1990	46.47	46.89	47.11	50.65
1991	59.31	61.4	68.5	69.6
1992	67.98	67.69	68.11	69.05
1993	63.66	63.97	63.99	64.01
1994	87.05	121.68	67.29	77.31
1995	78.68	73.13	69.11	83.92
1996	82.71	79.11	79.63	79.68
1997	76.54	77.41	82.18	83.2
1998	82.73	77.6	81.68	82.56
1999	81.11	85.3	76.44	59.48
2000	39.95	40.98	50.47	105.56
2001	120.26	67.99	67.61	61.15
2002	54.12	49.16	49.31	44.79
2003	46.87	39.17	31.74	28
2004	23.19	24.61	24.02	22.81
2005	19.99	20.67	20.44	20.42
2006	19.3	21.74	23.81	23.55

EMP	x[14]			
Years				
1987	17345	17345	17650	17650
1988	17453	17453	17755	17755
1989	18220	18220	18223	18223
1990	18047	18047	19030	19030
1991	19336	19336	19209	19209
1992	19357	19357	19561	19561
1993	18320	18320	18679	18679
1994	19986	19986	20026	20026
1995	20260	20260	20912	20912
1996	20840	20840	21548	21548
1997	21326	21326	21082	21082
1998	21223	21223	22334	22334
1999	22589	22589	21507	21507
2000	19856	22347	22796	21153
2001	20149	22231	23038	20714
2002	19387	21975	22833	21658
2003	20244	21696	22411	20811
2004	19902	22188	22874	21870
2005	21190	23058	22566	21332
2006	21272	23200	23128	23150

LABORFORCE		x[15]		
Years				
1987	19550	19550	19420	19420
1988	19678	19678	19391	19391
1989	19897	19897	19964	19964
1990	19748	19748	20552	20552
1991	21015	21015	21005	21005
1992	21172	21172	21355	21355

1993	20060	20060	20568	20568
1994	21922	21922	21831	21831
1995	22005	22005	22567	22567
1996	22390	22390	23003	23003
1997	22786	22786	22724	22724
1998	22820	22820	23940	23940
1999	24533	24533	23332	23332
2000	21642	23803	24131	22562
2001	22018	23836	24992	23108
2002	21917	24233	25247	24347
2003	23089	24115	24739	23206
2004	22732	24457	25265	24297
2005	23784	25363	24989	24043
2006	23883	25445	25444	25444

REALM2Y	x[2]			
Years				
1987	26.66	26.51	28.92	30.63
1988	25.17	24.43	26.57	28.81
1989	26.99	25.71	26.29	28.62
1990	26.23	27.81	27.76	28.69
1991	26.45	27.83	29.46	32.22
1992	28.93	33.36	34.27	34.01
1993	32	31.71	31.55	33.21
1994	32.29	31.88	35.49	34.04
1995	32.68	36.15	37.21	41.79
1996	38.05	40.52	45.18	49.41
1997	47.63	48.18	49.43	53.04
1998	51.18	58.27	66.98	65.5
1999	67.32	71.77	74.99	80.64
2000	76.25	80.97	84.33	85.33
2001	92.88	85.55	89.86	81.53
2002	72.85	79.78	78.86	78.99
2003	70.07	69.61	73.61	78.98
2004	74.83	79.2	83.28	84.24
2005	83.5	87.08	91.68	100.8
2006	101.1	105.45	105.98	106.11

RINTRATE	x[6]			
Years				
1987	27.78	26.78	27.34	23.79
1988	16.17	31.27	38.25	28.44
1989	53.57	41.23	36.43	36.63
1990	41.47	37.42	40.71	37.04
1991	49.11	48.59	56.76	58.24
1992	51.6	52.46	55.83	55.77
1993	54.41	52.99	51.88	50.91
1994	68.16	71.04	54.94	55.9
1995	57.93	61.96	56.81	72.51
1996	66.2	61.48	65.65	66.12
1997	61.93	61.18	64.57	63.84
1998	67.45	65.87	72.71	75.38

1999	73.61	73.64	65.89	46.08
2000	23.67	32.05	43.65	98.81
2001	112.76	42.63	55.69	44.96
2002	43.9	44.89	45.25	38.05
2003	38.33	34.82	29.69	24.13
2004	20.18	21.39	23.92	20.03
2005	19.06	19.08	19.83	18.99
2006	18.14	18.11	21.29	21.07

PI	x[9]			
Years				
1987	14918.8	16146.6	17383.6	19333.9
1988	22975.1	26128.8	27892.4	31674
1989	35611.2	41359	47181.6	54249.1
1990	58377.6	63910.1	67994.8	77248.5
1991	85126.5	96030.7	107306.5	119497.9
1992	139070	160247.3	179929.9	203833.2
1993	222683.1	247149.2	277068.5	313376.5
1994	372587.9	561279.1	630591.4	765598.9
1995	924519.9	1027775	1154159	1285864
1996	1498224	1762288	2008654	2280946
1997	2614263	3038645	3574105	4265881
1998	4917576	5494410	5987218	6417161
1999	6898216	7702322	8514903	9655973
2000	11228294	12231738	13065989	13948144
2001	14995474	18798935	21041482	24447381
2002	26947457	28221441	29371966	31352665
2003	34032242	35515686	36244416	37649423
2004	38783318	40033568	40032875	41148379
2005	41534948	42194304	42450963	43056433
2006	43557803	45136918	46275205	47424895

UTIL	x[5]			
Years				
1987	72.12	74	76	78
1988	73	78	77	73
1989	76	77	71	73
1990	76	74	70	74
1991	75.59	74.28	75.35	76.43
1992	74.58	76.8	78.1	79.79
1993	77.07	81.02	81.59	82.24
1994	78.62	68.51	73.92	75.97
1995	74.86	79.93	83.98	80.88
1996	78.3	80.55	79.67	79.29
1997	79.14	80.42	83.13	80.83
1998	78.13	79.43	80.76	79.5
1999	72.3	77.47	70.89	72.31
2000	73.66	77	75.38	78.45
2001	70.69	70.07	71.89	73.76
2002	73.48	75.3	77.85	78.04
2003	75.14	78.24	80.84	79.77
2004	77.69	82.06	83.19	83.3
2005	78.1	80.84	81.02	81.3

2006	77.89	82.73	81.55	82.5

EXPORT	z[2]			
Years				
1987	2710	2678	2349	2684
1988	2803	2725	2478	3048
1989	2803	2574	2568	3680
1990	2994	2745	2859	4361
1991	3379	2905	3209	4101
1992	3550	3303	3701	4161
1993	3673	3477	3562	4633
1994	3826	3831	4815	5634
1995	4757	5199	5288	6392
1996	7095	7358	8590	9024
1997	7842	7497	7983	9148
1998	7855	7659	7533	7615
1999	6923	6740	7088	8091
2000	7342	7754	7519	8106
2001	8064	8777	8431	9101
2002	8829	9447	10388	11460
2003	11123	12272	13262	14549
2004	14380	16570	16968	19129
2005	17954	19086	18943	20966
2006	19547	22693	23473	16156

RGDPUSA	z[4]			
Years				
1987	6365	6435	6493	6606
1988	6639.1	6723.5	6759.4	6848.6
1989	6918.1	6963.5	7013.1	7030.9
1990	7112.1	7130.3	7130.8	7076.9
1991	7040.8	7086.5	7120.7	7154.1
1992	7228.2	7297.9	7369.5	7450.7
1993	7459.7	7497.5	7536	7637.4
1994	7715.1	7815.7	7859.5	7951.6
1995	7973.7	7988	8053.1	8112
1996	8169.2	8303.1	8372.7	8470.6
1997	8536.1	8665.8	8773.7	8828.4
1998	8936.2	8995.3	9098.9	9237.1
1999	9315.5	9392.6	9502.2	9671.1
2000	9695.6	9847.9	9836.6	9887.7
2001	9875.7	9905.9	9871.1	9910
2002	9977.3	10031.6	10090.7	10095.8
2003	10126	10212.7	10398.7	10467
2004	10566.3	10671.5	10753.3	10822.9
2005	10913.8	11001.8	11115.1	11163.8
2006	11316.4	11388.1	11443.5	11541.6

LIBOR z[1]

Years				
1987	6.49	7.23	7.63	7.86
1988	6.85	7.74	8.42	9.42
1989	10.3	9.4	8.97	8.51
1990	8.49	8.35	8.18	7.92
1991	6.57	6.21	5.62	4.61
1992	7.47	3.99	5.89	3.64
1993	5.33	5.18	4.82	3.37
1994	3.88	4.64	5.13	6.38
1995	6.27	6.01	5.86	5.77
1996	5.39	5.57	5.62	5.55
1997	5.62	5.84	4.36	5.77
1998	5.68	5.69	5.49	5.24
1999	5	5.37	6.08	6
2000	6.29	6.77	6.81	6.4
2001	4.88	3.84	2	1.88
2002	2.03	1.86	1.79	1.38
2003	1.28	1.12	1.16	1.15
2004	1.11	1.61	2.02	2.56
2005	3.12	3.52	4.07	4.54
2006	5	5.48	5.37	5.38

POP	z[3]			
Years				
1987	51245	51245	52389	52389
1988	52458	52458	53284	53284
1989	53645	53645	54448	54448
1990	55008	55008	55580	55580
1991	56119	56119	56694	56694
1992	57243	57243	57798	57798
1993	58199	58199	58756	58756
1994	59174	59174	59736	59736
1995	60305	60305	60864	60864
1996	61429	61429	62019	62019
1997	62587	62587	63154	63154
1998	63725	63725	64290	64290
1999	64856	64856	65422	65422
2000	65767	66041	66323	66603
2001	66883	67153	67431	67707
2002	67983	68250	68525	68800
2003	69074	69340	69613	69884
2004	70154	70417	70685	70949
2005	71294	71558	71287	72085
2006	72323	72567	72803	72879

TAXRECEIPTS

Years	Q1	Q2	Q3	Q4
1987	15.97	21.26	24.48	29.02
1988	26.45	32.35	37.35	46.36
1989	43.35	59.47	67.8	85.1
1990	80.04	106	118.03	150.24
1991	134.24	171.41	216.78	262.99

1992	243.91	322.99	379.2	471.87
1993	446.63	611.57	694.3	891.5
1994	82.77	130.23	176.7	198.04
1995	192.42	261.5	286.8	343.7
1996	333.6	547	628.5	735
1997	690	1080.4	1310.9	1664.3
1998	1641.2	2289.5	2558.4	2739.5
1999	2206.8	3713.7	3978.6	4903.3
2000	5976.3	6338.8	7426.2	6762.4
2001	7067.3	9498.9	10880.84	12297.03
2002	11696	13796.9	16501.2	17684.3
2003	16715.8	20409.6	23056.6	24208.9
2004	18747.9	21090.8	25012.3	25225.3
2005	23045.1	25525.3	29246.3	29112.4
2006	31251.1	34723.9	36030.9	37174.5

TGE	u[3]			
Years				
1987	23.74	26.3	30.19	47.68
1988	37.53	47.01	53.48	76.43
1989	62.52	76.37	106.97	142.85
1990	118.63	157.52	163.35	244.05
1991	204.9	257.18	378.52	468.05
1992	368.13	496.07	613.17	776.61
1993	918.25	95.87	106.56	194.99
1994	162.79	163.11	243.86	332.67
1995	309.7	276.26	398.26	633.66
1996	671.05	878.32	1054.9	1357.02
1997	1264.13	1567.1	1872.1	3347.1
1998	3001.9	3896.3	4386.1	4330.2
1999	5446.8	7020.7	7334.8	8282.5
2000	11380.9	12280.8	11339.8	11703.6
2001	10650.8	20380.8	23775.6	25771.9
2002	27663.3	26032.4	26286.5	35503.5
2003	31252.9	38195.4	32127.5	38478.2
2004	30839.5	33551.8	36466.8	40162.4
2005	31332.9	34046.3	38339	31747.1
2006	39374.9	42223.7	47824.76	45880.7

TGREV	u[2]			
Years				
1987	19.41	24.65	28.04	32.34
1988	34.06	39.25	45.95	56.61
1989	57.39	72.5	81.97	101.83
1990	102.96	126.26	135.7	200.6
1991	176.07	218.24	277.47	319.27
1992	319.47	374.49	508.03	578.7
1993	600.8	824.1	903.6	1270
1994	111.5	173.2	216.9	249.9
1995	255.8	327.2	369.6	456.7
1996	422.6	651.3	748.1	905.9
1997	844.3	1290.8	1540.1	2130.9
1998	2040.5	2971.9	3238.9	3559.7
1999	2994.4	4519.2	5092.8	6326.7

2000	7479.6	8049.1	9441.5	8472.9
2001	10560.6	12367.2	13445.2	15169.9
2002	15027.6	20793.3	19582.6	20996.7
2003	20364.3	24415.1	27061.4	28487.3
2004	23854.4	25951.7	29971.8	30942.9
2005	28336.7	33174.1	34014.3	42455.9
2006	38325.2	45696.1	44017.3	43270.7

NomM2Y	u[1]			
Years				
1987	14738	15828.4	18420.8	23003.9
1988	22957.9	24453.6	29054.4	36706.5
1989	39832.7	43753.8	50484.3	61273.7
1990	65357.4	74082.8	80860	93363
1991	98660.7	114317.3	137079.9	168053.8
1992	187472.8	218835.6	258932.1	293969.7
1993	322040.6	348792	397831.8	473058.7
1994	561735.4	823524.7	1013717	1195353.2
1995	1407375.4	1645662.1	1900178.3	2414597.3
1996	2744470	3335120	41576064	5373708.9
1997	6102709	7035571.4	8382961	10664059
1998	11930219	14858313	18818555	20212649
1999	23203338	27402176	32404614	40562720
2000	43493789	47966921	52582964	56849061
2001	72200477	84668912	101187822	106566525
2002	103060396	116763252	125443967	133664544
2003	132266931	129692516	137689590	151001009
2004	153804903	165060052	176753490	184403561
2005	185316288	197700182	214497271	229536448
2006	237430026	266979938	270165600	272564066

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