AN ANALYSIS OF MONETARY POLICY IN IRAN

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Abstract

This thesis provides an analysis of monetary policy, source of inflation and potential adoption of inflation targeting in Iran. In particular, the conduct of current monetary policy and the source of inflation in Iran presented in Chapter 2. Chapter 3 investigates the concept of inflation targeting and its specification as well as the prerequisites that should be met by an economy in order to move to inflation targeting strategy. Since a Taylor-type rule it is not a theory-based rule, a model is derived by optimising the monetary authority’s loss function. In order to express the significant role of the variation of the exchange rate on a monetary policy, Chapter 4 derives a theory based central bank reaction function which explicitly includes the exchange rate gap and is empirically tested. The hypothesis of ignoring the fluctuation of exchange rate is rejected. One of the vital elements in success of inflation targeting framework, is the accuracy of the predicted inflation rate from the central bank. After evaluating the P-star model as a representative instrument for forecasting inflation in chapter 5, different measures of velocity, have been evaluated. After structural break test on data and stationarity tests, a VAR has been constructed and the concluding VECM is estimated. From the results of the exogeniety test, the P-star model can be used as an appropriate tool in forecasting inflation in Iran.

This thesis contributes to the literature in three aspects. Firstly, a micro-based model of the monetary policy reaction function is derived which considers the target of the inflation explicitly. Secondly, it recommends a practical formation of monetary policy to include exchange rate fluctuations in the reaction function of the Central Bank of Iran and finally, investigates the effectiveness of the P-star model in predicting inflation in Iran.
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1.1. Motivation

A high rate of inflation has direct effect in reducing the welfare of the individuals in a society. Price stability has become a general consensus among monetary authorities as the main duty. If the policy makers can implement a strategy that can bring inflation to an optimum level according to the specifications of each economy which will not alter the other objectives in economics such as saving and investment, then a typical monetary policy is able to improve the living standards and welfare of households in that economy. A fairly new framework of monetary policy which was introduced just over two decades ago is known as Inflation Targeting. In 1991, New Zealand was the pioneer in adopting this framework, which has now become a leading monetary strategy that is conducted in many economies.\(^1\) As a result of a very good response of such a policy in the reduction and stabilisation of the inflation rate, inflation targeting has replaced traditional frameworks such as the Monetary Aggregate Targeting (MAT) and Exchange Rate Targeting (ERT), and due to the conflicts between the objectives of these strategies, especially the latter, inflation targeting promptly became the main monetary policy framework for both developed and developing countries where over 32 countries have officially adopted such a strategy.\(^2\)

To provide a straightforward proposition for inflation targeting, one can say that when the monetary authorities in an economy state an inflation rate as their target of inflation for the period ahead, and conduct the necessary arrangements to reach that

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\(^1\) As of now (Feb 2012) there are 32 countries adopted such a framework. (IMF 2012)

\(^2\) A detailed specifications of the date of adoption and their targets in some of the countries have been summarised in Chapter 3.
target, they are following an inflation targeting framework where the objectives of
the inflation have priorities to the other goals in an economy.

There are some compulsory conditions for a central bank as a representative
monetary authority to be able to adopt such a framework, most importantly, the
independence of the central bank and its credibility and accountability. The structure
of the financial system in the economy should meet some standards in order to be
able to adopt such a strategy. The perquisites and condition of this strategy is
discussed in detail in Chapter 3 of the thesis.

The definition of economics can generally be expressed as the optimal allocation of
the limited resources available in the world -or in micro phase in an economy- to the
unlimited desires of individuals. By analysing different countries’ performance by
this point of reference, it can be found that fewer developing economies have
benefited from this valuable part of science. Inflation targeting is an effective
instrument to reduce the gap between developed and developing economies in terms
of individual welfare, however the implication of this strategy vary in different
economies.\(^3\)

In order to analyse the ability of an economy in adopting the inflation targeting
framework, Firstly, we need to evaluate the condition of the economy and the
conduct of its monetary policy. Secondly, the determinants of the inflation in the
country should be thoroughly discussed and the sources of inflation need to be
clearly defined. The target of this thesis is to analyse the condition of the monetary
policy in Iran with respect to the adoption of an inflation targeting frame work. To

\(^3\) Mishkin (2000b) and (2004) have explained this variation in implication of inflation targeting in
developed and developing countries.
do this, after analysing the Iranian conduct of the monetary policy in Chapter 2, the specifications of an inflation targeting are explained and an instrumental rule has been theoretically derived to be used as the tool of monetary policy in the framework.

An increasing amount of literature evaluate inflation targeting from different perspectives. Mishkin (2000a,b), (2001) and (2004), Blejer et al.(1999) and Fry et al.(2002), among others, have expressed the rational of inflation targeting. Dodge (2002) and Mishkin (2000b) have evaluated the performance of this structure in Canada and Chile and they found that inflation targeting was successful in reducing inflation as well as lowering output volatility. In the case of Chile, as will be seen in the Chapter 3, inflation was reduced from over 20% to approximately 5% which indicates quite a successful policy for high-inflation economies.

Hu (2003) and Ball and Sheridan (2004) have assessed the performance of this policy framework in a cross country comparison and concluded that the inflation targeting countries have been more successful in terms of price stabilisations in addition to growth and output improvements. Bernanke et al.(1999) has compared inflation targeting to alternative monetary policy strategies such as monetary aggregate and exchange rate anchors, and the results of his research also supports the adoption of this framework. However, fewer studies have selected emerging economies to evaluate inflation targeting both in adoption and performance aspects. This is because of the limitation and rigidities in the structure of developing economies such as the dominance of fiscal policies which will not allow the central bank to independently follow its objective. Jonsson (1999), Tutar (2002) and Crowe and Meade (2008) among others provide examples of studies carried out in
developing economies where the adoption of such a framework was examined in South Africa and Turkey. They found upon meeting the prerequisites of inflation targeting, mainly the central bank independence, that the adoption of this strategy is highly recommended. In Crowe and Meade’s (2008) research to the level of central bank independence and the transparency in the monetary policy, their main conclusion indicates that the higher the level of independence and transparency a central bank enjoys the better the performance in reducing inflation.

The main motivation of this thesis originates from an attempt to reduce inflation in developing countries and particularly in Iran, which is currently experiencing a high rate of inflation, and the implementations of a range of monetary policies are not able to persistently reduce inflation to a satisfactory level. Figure 1.1 below provides an overview of the inflation rate in Iran in the last four decades. One may argue that due to the special conditions of Iran with regards to the political aspect which is unrelenting economic sanctions since 1979, sanctions have been placed on the Central Bank and the oil trade in Iran, the monetary policy would not be effective in practice. But after having a closer look in the conditions of the economy, it can be argued that the existence of the natural resources of oil and gas which has ranked Iran as the first in the world in with reference to the sum of these reserves, makes Iran an interesting case study for adopting an inflation targeting framework.
Figure 1.1: The rate of inflation in Iran from 1965 to 2007

Figure 1.1 illustrates that all the people in Iran had to persevere with a high rate of inflation of more than 10% in the last 40 years and as it can be seen in the boxplot, the average rate exceeded 15% and in some periods the economy has experienced a high rate of 29% and 49% in 1988 and 1995 respectively.

As it will be discussed in next Chapter in more detail, inflation is a persistent problem in Iran and this is the main motivation for the thesis to firstly, analysis the structure of the monetary policy and the determinants of inflation in Iran and secondly indicate and examine the important issues which affect the inflation rate in Iran. A reliable tool to predict inflation was necessary as a vital aspect of inflation targeting framework and this task is evaluated by and devoted to the P-star model in Chapter 5 of the thesis.

Source: WDI (2010)
In order to reduce the rate of inflation in such an economy, and to evaluate the possibility of the adoption of an inflation targeting strategy, firstly, an analysis of a framework of the monetary policy in Iran should be undertaken. In addition to limitation induced to the economy from the sanctions against Iran, the economy has experienced eight years of war with Iraq\(^4\) which has placed considerable costs and distortions in the Iranian economy on the one hand, and the special features of financial system under the Islamic Banking\(^5\) regulations on the other hand, contribute to the argument that Iran is likely to be a special case that differs from other developing economies.

1.1.1. The cost of inflation in Iran

When the prices level increases continuously, it is quite possible that an inflationary situation is forming. Inflation is a concept that economics as well as common people attempt to avoid it. Inflation is not always a bad phenomenon, however. In a condition in which an economy is in boom, it may be plausible to accept a certain level of inflation that is sufferable. In a monetary economy, when nominal interest rate increases, the cost of maintaining of money shall increase. The increase in inflation leads to an increase in nominal interest rate. As a result, financial institutions (banks) are willing to lend money with higher rate. In such a condition, economic agents prefer to do not maintain cash and this have a negative effect on economic activities. This is the welfare cost of inflation that Friedman (1969) stated

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\(^5\) The specification of this banking system is explained in Chapter 2.
In his study. In other words, in an inflationary condition, people maintain money less than an optimal level and hence they will lose the welfare.

Inflation in Iran is a long standing problem where the power of purchase of people decreases sharply with an increase in inflation. Since inflation makes the situation uncertain and then it has been a significant obstacle to investment and capital accumulation in Iran, the price stability is one the most important objectives of economic authorities in Iran. As Fischer (1996) believes, price stability does not necessarily mean bringing inflation to zero. Fisher argues that an inflation about two or three percent is necessary for the economic growth. The problem in Iran is high inflation rate which makes the central bank of Iran to publish new notes with higher scales (higher number of zeroes on one note). This leads to a fall in the value of national currency which it itself in turn prompts inflation to increase again. The problem of inflation in Iran is a multilateral issue. With a rise in inflation, people value the economic activities and investment in a level lower than the reality. This is mostly psychological which attributes to uncertainties. Therefore, people attempts to keep the purchasing power the same as before and hence the do not think about investment. As a result, the economy falls in to a recession. Moreover, inflation makes economics agents to change their prices which is costly. As inflation is increasing in a continuing manner in Iran, there is no stable pricing strategy for firms and other economic agents and hence in the present of the uncertainty, each agent increases the prices proportionally. This leads to a wrong resource allocation along the economy which is an important problem in an inflationary economy (see Fender, 1990).
The current monetary policy configuration of the Central Bank of Iran, which does not explicitly include the exchange rate as a component in formation of the monetary policy, and a robustness check of this decision by the monetary authorities has been the main motivation of Chapter 4 of the thesis where I evaluate the effect of the exchange rate in Iran on monetary policy components as an important element in constructing an anti-inflationary framework. Assuming implementing an inflation targeting framework, the Iranian monetary authorities do need to utilise an appropriate technique to forecast inflation and adapt their instrument accordingly. I aim to evaluate one of these techniques, and will assess the performance of a P-star model for Iran in Chapter 5 of this thesis, using a combination of econometrics techniques which will be discussed in detail.

1.2. Methodologies, contributions and thesis outline

This thesis consists of one Chapter introducing the monetary policy in Iran and the source of Iranian inflation. Then, Chapter 3, as one theoretical chapter firstly, evaluates the features of an inflation targeting framework and secondly, presents a micro-foundation analysis of an instrumental rule for the monetary policy. Chapter 3 of the thesis involves the rational for maintaining low inflation in general, and explains the prerequisites for the adoption of an inflation targeting framework. In addition, the arguments for and against inflation targeting will be discussed. Then, the Taylor rule will be taken into account as the main point of policy rule under inflation targeting.

Since the Taylor rule originally generated from tracking the behaviour of the data in the United States, and is not a theory based rule, in order to make a strong basis for
the model on the one hand, and make a theory based practical model on the other hand, using the micro-foundation of the monetary authority’s reaction function based on Clarida et al. (2001) and Gali and Monacelli (2005), I derive an optimal monetary policy rule for a small open economy. To do so, I use a Dynamic Stochastic General Equilibrium (DSGE) model with households as the consumers and capital owners who try to maximise their utility functions, firms as the producers who try to maximise their profit by minimising the marginal cost of production, and monetary authorities (central bank) who try to minimise their loss function. Detailed steps of the optimisation process will be revealed in Chapter 3. The concluding optimal monetary policy rule as a central bank reaction function is a Taylor type rule which relates the policy instrument (e.g. short-term interest rate) to the inflation gap which is the deviation of inflation from its target, output gap and two lags of itself. This model contributes to the literature in terms of specification of the New Keynesian Phillips Curve (NKPC), also unique to this model, considering the inflation target in the central bank loss function formation while it has been assumed as zero as a rule of thumb in the literature. This rule addresses questions about how the monetary authority should respond to the deviation of inflation from its target (in a flexible inflation targeting framework, where part of inflation, also considers the fluctuation of the output in the model) and real output from the equilibrium level of output. One of the interesting results of this optimal monetary policy rule is the indirect effect of an exchange rate policy reaction function where the exchange rate affects the short term interest rate via its effect on domestic inflation and output.

Chapter 4, based on the model derived in Chapter 3, investigates the role of the exchange rate in monetary policy. The effect of the exchange rate has been a popular
topic in debates regarding monetary policy formation, and an analysis of this effect has been carried out by a number of studies. For instance, Taylor (2001) and Svensson (2000b), among others, have carried out key analysis of how monetary authorities should respond to exchange rate fluctuations, but they have considered developed economies as their case study. In regards to developing countries, when we discuss the exchange rate, there is always “fear of a floating” exchange rate, due to the structure of the economy, and the non-existence of a sound domestic financial market, the authorities prefer not to have a fully flexible exchange rate or at least they presume the boundaries for exchange rate variation. Ball and Reyes (2004), Bigio (2010), Calvo and Reinhart (2002), Hagen and Zhou (2009), Cavoli (2009) and (2010), Honig (2005) and Schmidt-Hebbel and Tapia (2002) among others have analysed the effects of moving to a floating exchange rate in emerging economies which will be discussed in more details in Chapter 4.

In order to evaluate the effect of exchange rate fluctuations on monetary policy components, precisely interest rate, inflation and output, I shall derive a model of a central bank reaction function where it takes the direct effect of the exchange rate in forming a policy instrument. To do so, following Stevens (1998) and Bofinger and Wollmershauser (2001), I specify a relevant Monetary Condition Index (MCI) as a base of analysis for entering the exchange rate in a Taylor type monetary policy reaction function which will be derived in Chapter 3.

After designing the model in order to evaluate the results empirically, I assess the impulse response function of the components of the relevant Vector Autoregressive (VAR) model on Iranian data. The impulse response function is a commonly used method in macroeconometrics to express how the economy reacts to the shocks of its
different components, and it refers to the response of a dynamic system to a shock. Since this method allows us to analyse the effects of a specific shock on a variable at the shock time and subsequent time steps afterwards while the effect of the shock lasts, it is a practical and useful instrument to track the effect of a fluctuation of a variable on the other variables that exist in the model, which is the target of Chapter 4.6

Moreover, impulse response functions reflect the impact of the correlation between residuals in the model and due to the nature of the VAR, there is simultaneous shock dependence. This impact of the correlation amongst residuals in the model can be controlled by orthogonalizing. Since this approach depends on the order of the variables affected by a shock, the response functions may vary by changing the order of the components. In Chapter 4, in order to overcome this issue, I use the Generalised Impulse Response (GIR) function developed by Koop et al. (1996) which does not depend on the order of the variables in the model. The generalised impulse response function -excluding the shocked variable- allows the other variables to freely fluctuate instead of the other method of controlling the impact of the correlation amongst residuals, it is believed that this method integrates simultaneous and future shocks.

As a result, the resultant response is independent on the ordering of the variables in the VAR. Nevertheless, the results are checked robustly by reporting the response functions of some combination of the variables in different orders, but potential changes in the results are insignificant.

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6 As will be seen in detail in Chapter 4, the main question to address is whether the monetary authorities in Iran should consider explicitly and directly the effect of exchange rate variation in constructing of monetary policy reaction function.
In Chapter 5 of the thesis, as another step in analysing the monetary policy in Iran, I check the relevance of the P-star model to the Iranian economy to be used as an instrument to predict inflation. Following the leading literature on the P-star framework, Hallman et al. (1989) and (1991), and analysis from Svensson (2000c), Todter (2002) and Gerlach and Svensson (2003) among others, the P-star model is used to identify and pinpoint the source of inflation in an economy.

The P-star model signifies that, if all the changes in the stock of money (monetary aggregate) are not accompanied by changes in real output, then the remainder will be the source of changes in the price level and therefore inflation. In the P-star model, the main issue is finding the price gap, which is the deviation of the price level from P-star as will be discussed in detail in Chapter 5, is constructing the velocity of money and the equilibrium value of it.

As suggested by Hallman et al. (1991), this equilibrium assumed as a constant level, the literature tried to argue that this should not be the case. I will summarise some ideas on formation of the velocity of money and its equilibrium in this chapter and in the empirical analysis, I will measure the velocity of money in the Iranian economy using both quarterly and annual data. Next, the cointegration analysis of the data will be performed and relative Vector Error Correction Model (VECM) will be constructed to control the long-run manner of the endogenous variables to gather together the cointegrating relationship while allowing for short or medium term fluctuations. A cointegration object is known as an error correction term since the divergence from the long-run equilibrium is adjusted steadily through a series of partial short run adjustments. Before testing the model empirically, I aim to explain
the intuition behind the concepts to improve and develop the link between the model and the results.

The variables in the VAR consist of aggregate money (measured by M2), the GDP deflator as a measurement of price, real GDP and equilibrium velocity while all the data are in natural logarithm. Due to the nature of the data in Iran, I had to find a way of testing the existence of the unit root in the data while taking care of the structural breaks in the model. The occurrence of a structural break may potentially result of estimation to be biased. Testing of the unit root is carried out by using Gauss 7.0, where I employ Vogelsang and Perron’s (1998) framework to perform a stationarity test while testing for structural break in the model and the test results will also support other stationary tests that will be used in this chapter.

The exogeniety and long run causality test of the components in the P-star model is the next crucial step. The results of the exogeniety tests will reveal that, the annual data are endogenous and in support of the P-star model. Consequently the inflation equation (P-star model) will be estimated on the annual data and as it will be discussed in detail in Chapter 5, the resultant coefficient of the error term will meet our prediction of the model and it will not change significantly when altering the formation of the components, including other endogenous variables.

Overall, to present a brief thesis outline, the remainder of the thesis is organised as follows: A review of the structure of the monetary policy in Iran, the source of inflation and the relation of the Taylor-type rule to the Iranian monetary policy is thoroughly discussed in Chapter 2. Chapter 3 identifies and pinpoints different features of inflation targeting in which more weight is given to specifications of
developing economies. In the final part of Chapter 3, the derivation of optimal monetary policy rules is analysed. Steps in minimising the loss function of the monetary authority are provided in the appendix following the chapter. Chapter 4 investigates the relationship between the exchange rate and monetary policy components through constructing a relevant MCI and aims to answer the question “whether the monetary authority should consider deviations of exchange rate in the construction of monetary policy.” As a result, the fourth Chapter presents a policy recommendation that includes the exchange rate, which is based on the impulse response functions of the components in VAR. Appendix after this chapter plots the impulse response functions of the model and compares the results as well as the residuals in correlation test. Chapter 5 tests the relevance of the P-star model to the Iranian economy while the importance of the structural break in data will be theoretically and empirically expressed and tested as a part of an initial stationarity test. The magnitude and different methods of calculating the velocity of money will be evaluated, then after forming the VAR and VECM, the resultant model will be estimated. Appendix of the chapter also complement this Chapter, tabulates the relevant VAR and VECM tests results in addition to the final model estimation results respectively. Finally, Chapter 6 concludes the thesis and provides concluding remarks and recommends policy implications based on the case study of the Iranian economy.
CHAPTER 2: IRANIAN CONDUCT OF MONETARY POLICY AND INFLATION
2.1. Introduction: A review of the determinants of inflation in Iran

In construction of an inflation targeting framework, defining the determinants of inflation in a country is a vital task especially in emerging economies. When the causes and sources of the inflation are accurately specified, the monetary authorities can choose the suitable policy adjustment and this will be effectively implemented. In this section the structure of inflation in Iran will be reviewed. In this chapter I aim to introduce the determinants of the monetary policy and inflation in Iran. There is not a large number of literature in regards to the structure of inflation and monetary policy in Iran, but this is an important step in order to be able to design a successful anti-inflationary policy in Iran. Consequently before starting the theoretical and empirical analysis I devote this chapter to introduce the determinants of inflation and structure of the monetary policy in Iran.

In regards to the source of inflation in Iran, Kia (2006) has examined the role of internal and external factors\(^7\) which influence the inflation in Iran. To so do, he developed a monetary model which considers both fiscal and monetary policies as well as internal and external factors in construction of inflation. He found that the higher the exchange rate (the lower the value of domestic currency) the higher the

\(^7\) The examples of internal factors are: specific formation of monetary policy, government deficit, debt financing, structural regime changes (such as policy constraints, political regime change and revolutions) and institutional economics (such as economic freedom, risk and shirking opportunism. For external factors Kia (2006) has considered these elements: foreign interest rate, terms of trade and the approach of the rest of the world such as wars, sanctions and risk generating activities.
inflation in Iran. 8 Kia (2006) also concludes that the role of anticipated change of money supply in changing inflation is not significant and this tool only is empirically effective when it is not predicted by the individuals.

His results can be divided into two time horizons. He shows that both internal and external factors are affected inflation in short run while the role of external causes of inflation is not significant and the internal factors are the main issues in Iranian inflation in long run. The external factors in his study include foreign interest rate and sanctions and the main internal issue is fiscal policy. For instance, in long run the foreign interest rate has a deflationary effect on Iranian inflation while imported inflation does not exist in that country.

The remainder of the chapters is as follows. The sources of inflation and the major causes of it, is discussed in next section. The institutional structure of the monetary policy in Iran is presented in section 2.3, section 2.4 summarise the current conduct of the monetary policy and its instruments as well as the role of the money supply in inflation in Iran. Fiscal deficits and oil revenue as the two important components which influence monetary policy in Iran have been discussed in section 2.5. As the analysis of the next two chapters is based on the Taylor rule (which is based on the interest rate) on the one hand, and the Usury-free banking law in Iran which does not allow any interest rate in the economy, on the other hand, this produces some contrasts in analysis. To answer this critique in section 2.6, I introduce the alternative

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8 The effect of exchange rate on Iranian inflation is discussed in detail in chapter four where these effect is captured from modelling the monetary policy on a Taylor rule based instrumental method and analysing the resultant impulse response functions.
to the interest rate in Iran also explain in detail the relevance of the Taylor rule to the Usury-free banking law in Iran, and finally the section 2.7 concludes the chapter.

2.2. Source of inflation in Iran

In the theory of the determinants of inflation, there are three major arguments in the literature. Monetarists believe that atypical increase in money supply is the source of inflation. Friedman (1968) and Schwartz (1973) as the representative monetarists argue that the money supply plays the main role in determination of inflation in an economy. Amongst the against ideas in this regards, Stiglitz and Greenwald (2003) indicate that although for ordinary inflation, the money supply plays the main role but this is not true in the case of hyperinflation, where the structure of the monetary policy is known as the main cause. In contrast to the monetarists, Keynesians e.g. Keynes (1936) and Blinder (2002) declares that money supply is not the main factor in inflation determination and aggregate demand in the economy takes this task.

On the other hand, structuralists dispute that the formation of inflation highly depends on the structure of the economy. Sunkel (1960), Maynard (1961) and Olivera (1964) are the representatives of this group. Some others like Machlup (1960) argue that the major determinant of inflation is the increase in cost which will be explained further below.

Controlling inflation is more achievable when the monetary authorities can find the source of inflation. In general there are four groups of the source of inflation. One group of the causes of inflation which comes from the formation of economic policy is referred to the demand-pull. For example an expansive monetary or fiscal policy
can be the source of inflation which will be categorised in this group. By the same
token, as the Keynesians argue, this type of inflation is caused by an increase in
aggregate demand. On the other hand, cost-push inflation or aggregate and sectoral
inflation involves the inflation that comes from an increase in the wages or interest.
This can be interpreted as the inflation causes by a decrease in aggregate supply that
increase the production costs. The third group can be specified as the temporary
causes which come from the effects of natural disasters and wars. The resulting
inflation from this source can be easily identified. The last source which is known as
import-induced inflation comes from an increase to the foreign capital price in the
form of goods and services imported from abroad. The sanctions against an economy
which will significantly increase the cost of imported capitals can be categorised in
the latter group.

There is not a wide range of literature regarding inflation in Iran. Amongst the
researches about Iran in the literature, Pahlavani and Rahimi (2009) evaluate the
major determinants of inflation in Iran using an Autoregressive Distributed Lag
(ARDL) model and the data from 1971 to 2006. Their results indicate that liquidity,
exchange rate, the rate of expected inflation and imported inflation are the main
elements in constructing the inflation rate over the sample period. They also found
the significant effect of the eight-year war with Iraq on Iranian inflation. On this
research they - using an ARDL method - investigate that the roles of imported
inflation, exchange rate, Gross Domestic Product (GDP) and liquidity are significant
in inflation determination in Iran.

In the case of developing economies in which the economy is significantly related to
the imported capital, as the price if the foreign capital goods increase, the domestic
economy is subject to the higher price level from the cost-push inflation or the supply effect. If such an economy has to face an upward slope supply function of foreign loans, the amount of the debt will be raised by the amount of the debt and the cost of servicing the debt. This can be interpreted as; if for any reason, like an unexpected change in terms of trade, the economy faces an increase in the cost of the imported capital, this will restrain the aggregate supply and will cause inflation.

Bahmani Oskooee (1996) has examined this term for Iran and argues that consumer price index in Iran is affected over the long run by changing the world price. This effect can be analysed by tracking the exchange rate volatility on another way. To do so Bahmani Oskooee (1995) developed a monetarist model of inflation combined with the exchange rate and import prices to be able to find the determinants of Iranian inflation. He concludes that there exist two cointegration vectors among the macro variables in his sample size of 1959-1990. In another study, Arize et al. (2004) have evaluated the manner of inflation to the nominal and real exchange rate and concluded that inflation is positively related to the fluctuations of exchange rate on 82 economies including Iran.

In order to see the role of external factors such as war and sanctions on inflation, one can mention the obvious effect of the sanctions and war on the supply side of the economy and it can be concluded that these factors will generate the higher inflation rate through the supply effect. Berument and Kilinc (2004), for example, evaluate this effect in Turkey and indicate that domestic inflation rate is positively affected by the shocks to the industrial production of the Germany and United States. The current sanction against Iran can also be considered as an important cause of the current inflation rate in Iran. The sanctions started from 1979 after the revolution and
in recent years the domain of it is increasing. The sanctions simply increase the cost of obtaining necessary goods from abroad which cannot be produced in the country. Iran also experienced the eight years war just after the revolution with Iraq and during that period and in the period after that as well while the country was restructuring the damages to the whole economy, the lack of enough domestic products will cause some inflation in consumer price index. So in analysing the source of inflation in Iran generating from the external factors, we can find the evidence from both war and sanctions in the last three decades.

The Iranian economy has experienced a high rate of inflation since the revolution in 1979 with the average of 19.8 and 23.7 during the 1980s and 1990s respectively. From the first year of the Third Development Plan (2000-2005) of the long run government plan, although the authorities pronounced that they follow a managed floating exchange rate, but the Iranian government has applied a comprehensive stable exchange rate framework to improve economic growth and investment. As a consequence of this policy the average inflation rate reduces to 15.1 percent between 2000 and 2006. Some economists e.g. Sadeghi et al. (2007) believe that the main cause of inflation in Iran is because of the current structure of monetary policy and the main reason of the higher inflation after 2005 was the policy that the authorities were implementing in the first five years of 20th Century. The current evidence in increasing the inflation rate also supports their conclusion.

As Iran is one of the resource rich countries and benefits from the largest resource of the combination of gas and oil in the world, the country is in the risk of “Dutch

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9 It has the world’s third largest proven reserves of crude oil and the second largest proven reserves of natural gas and the first in the combination of these two. (Qfinance, 2011).
Disease”. In the case of Iran this problem has been exacerbated by exchange rate stabilisation policy as well as the high inflation and interest rate. Under the current monetary policy in Iran, the price of foreign goods and services imported to the country is fixed but the domestic price is increasing by inflation rate. This will increase the import of the consumer commodities which will lead to weaken the competitiveness of the manufacturing sector. This process will increase the capital out flow in the long run and the capital owners will choose Foreign Direct Investment (FDI) instead of investing in domestic projects. This fact was emphasised in UNCTAD\textsuperscript{11} report at New York and Geneva in 2003, the FDI inflow of Iran was $161 million while the outflow reached the number of $4.99 billion during 1999 and 2002.

As the cost of maintaining a stable exchange rate is increasing according the recent global sanctions against Iranian economy, the monetary authorities have no way to move from this policy in order to be able to control inflation. To do so, the main question is which monetary strategy suits the Iranian condition and will help in reducing inflation, and evade the depreciation of the domestic currency resultant from an inflation reducing frameworks, however.

\textsuperscript{10} This term has been devised by the Economist (1977) to express the decrease in manufacturing sector in the Netherlands when a large gas field had been discovered in 1959. The phenomenon indicates that an increase in the revenue from natural resource will improve the given country’s currency value, resulting increase in the price of the other exports of the country for others to buy which this will make the manufacturing sector less competitive in the market.

\textsuperscript{11} United Nations Conference on Trade and Development
2.3. Current conduct of monetary policy strategy of the Central Bank of Iran

In general, the major three monetary policy strategies available to the monetary authorities are categorised as exchange rate targeting (the current policy of the Central Bank of Iran), monetary aggregate targeting and inflation targeting. As will be discussed in more details in chapter three the first two strategies were not as successful as the inflation targeting. As argue by Sadeghi et al. (2007), the current monetary policy in Iran is based on stabilisation of the exchange rate and they argue that this conduct of the monetary policy is the main source of persistence high inflation in Iran. They try to establish a model determining the stabilisation of the exchange rate while taking into account the inflation targeting specifications. To do so they developed a model based on the structural conditions and the constraints in Iran where they define a “Reference Exchange Rate” as the rate that abolishes the inflationary pressures of a foreign exchange rate in to the domestic economy.

In conduct of the monetary policy in Iran we cannot ignore the role of the money supply. Money supply plays a crucial role in determination the aggregate demand in any economy albeit in Iran. The change in the income from the foreign exchange will affect the money supply in Iran via the effect on the foreign reserve of the central bank and it will vary by change in the amount of the revenue from foreign exchange earnings.\footnote{For instance in the oil boom of 1974 (doubling the oil price), the net foreign asset of the central bank increased by more than 100 percent.}
Iran has had relatively high inflation for the last four decades. The average rate of inflation has been just less than 20% p.a. since the revolution in 1979. As it can be seen from the Figure 2.1, there has been a large shift in mean and variation of inflation, especially from the 1970s to 1990s. In this period, Iran experienced two events, the Islamic revolution and an eight-year war with Iraq. In the 2000s, it seems that inflation shows a more stable manner although it is still relatively high.

*Figure 2.1: Inflation and real GDP growth in Iran*

![Inflation rate and real GDP growth in Iran](image)

*Source: IFS (2009)*

After the revolution in 1979 and during the war with Iraq, the government of Iran started the heavy control over economic sections and hence, most industries and services were owned by the government. This contributed to increases in the government’s expenditure (along with the state subsides), and as a result inflation rate jumped. This is clear from the Figure 2.1, that during the post-war period, the

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13 From 1980 to 1987
rate of inflation has increased to its peak (from approximately 7% in 1990 to more than 40% in 1995). In the same period, real growth of GDP dropped from 24% in 1990 to -5% in 1995 (except 1993 where GDP growth is positive).

Iran is a country enriched with natural resources (oil and gas). Most part of the country’s income is from the oil revenue. After the war, oil revenues started to decline in 1993 and then foreign debt started to increase. This event was the beginning of the balance of payment crisis (Salehi Esfahani and Pesaran 2009). Moreover, the government unified the exchange rate. Quick devaluation of the Rial (Iran’s national currency) followed the event, and this caused weakening of the financial strength of domestic firms to repay their foreign debts. Then, the government decided to cover most of their losses derived for the Rial (Iranian currency) devaluation, and this led to expansion of the monetary base (Salehi Esfahani and Pesaran, 2009). The consequence was the recession in 1995, and this was reflected as a sharp rise in the rate of inflation.

2.3.1. Money supply in Iran and the inflationary costs of it

In order to assess the economic policy in Iran, we have to consider the largest incident in the country, which was the revolution in 1979, which affected the whole country and its economy. The Iranian economy was not by some means, easily reached by its authorities over its history. Before the revolution, since Iran is an oil exporting economy where the majority of its income for the economy comes from this source, many countries found Iran a good place to have an investment and a high rate of return from this resource. The economic authorities, especially the monetary authorities were not able to plan and follow a specific monetary policy because of
the high level of dominance of the oil in the income basket of the country on the one hand, and the fluctuation in the reserves amount due to the presence of the foreign powers, at the time of revenue, on the other hand.

After the revolution, and the eight years of forced war with Iraq (which ended 20\textsuperscript{th} August 1988), in such unstable conditions, and the shortage of income from oil because of the distortion of refinery constructions during the war, the dominance of the government’s budget deficit which had been increasing each year, changed the governing power of the economy to consistent budget deficit. In such an economy, monetary policy is not practical in implementation. Another point that is worth noting is the banking system in Iran and the limitation of their activities in terms of borrowing money from the central bank and setting their trading rules.

The government still has the ability to change monetary policy and has a direct effect on supply of money. By the same token, there are no signs of independency in the central bank. For example, in one of the most recent welfare policy in the housing system, the government has established a bank and ordered the central bank to print a considerable amount of money at a lower interest rate than the usual interbank rates.

In such an economy, working on plans and following a monetary plan for the economy seems to be a difficult task. But, due to the existence of oil, policy makers were able to construct six socio-economic development plans that each lasted five years (from 1990 to 2020) for the outlook of the economic position of Iran. Four of the plans have been completed so far and they are currently in the fifth plan where
one of the articles has indicated that the Iranian government is not allowed to borrow money from the central bank.

In contrast, the economy is moving from the high inflation period and the steering of the economy is being able to be controlled by central bankers, although, we cannot articulate that there is not any more fiscal and governmental dominance.

2.3.2. Conduct of monetary policy in Iran

The key goals of macroeconomic policies, in general, and monetary policies, in particular, are price stability, economic growth and a favourable employment level. Since it is difficult for policy makers to achieve these ultimate goals, especially in the case of developing countries, determining intermediate objectives and introducing appropriate instrument seems to be useful. In the case of monetary policy, the issue of setting an intermediate objective is often reflected in controlling the rate of return and money supply. With monetary policy aimed at controlling the monetary aggregates, attempts are made to prevent monetary expansion, incompatible with liquidity and inflation targets set in the development plans, and to finance productive and investment sectors. As discussed earlier, the current conduct of the monetary policy in Iran - in practice - is exchange rate targeting. According to the research by Sadeghi et al. (2007), although the current currency regime in Iran officially is announced as “managed float” but by having a look on the behaviour of the exchange rate data over the past 12 years, one can find that the regime in practice is more “fixed” than “managed float”.

2.3.3. Monetary Policy Instruments in Iran

In general, there are five main instruments available to monetary authorities to implement the objectives of a monetary policy. The monetary base is a tool that central bankers can use to achieve their targets via the open market operations. The other instrument for monetary authorities is the amount of reserves that the banking systems need to hold at the central bank. By changing this amount, the central bank will change the available funds to be entered into the economy in the forms of loans and mortgages. The other instrument that affects the money supply is the discount window lending in which the commercial banks borrow from the central bank and the rate of these deposits are usually below the short-term interest rate. Currency board is the other tool which is the main instrument in fixed exchange rate regimes, where the central bank fixes the monetary base of the country to the other country in order to limit the volatility of the exchange rate.

The interest rate is the most popular monetary policy instrument and most developed economies and growing number of developing economies use this tool to steer the economy.

The central bank of Iran as the issuer of money can have an impact on the money market. Overall two types of instruments can describe the monetary policy in Iran: direct instruments and indirect instruments.

In operating a monetary policy, the Central Bank of Iran (CBI) can directly resort to its regulating power or affect money market conditions indirectly as the issuer of money which consists of notes and coins in circulation and deposits held with the central bank. Direct instruments (with no dependence on market conditions) which
are either banking profit rate or credit ceiling and indirect instruments (market oriented) that consist of: reserve requirement ratio, CBI participation papers and Open Deposit Account (ODA) which are explained in more detail below.

2.3.3.1. Direct instrument

Direct instruments refer to the instruments that are able to control the credit expansion in Iran. The first one is *interest rate (deposit rate)* in the banking system.

One important point to clarify here is the clash between this instrument i.e. interest rate and the Islamic banking (Usury-free) law in Iran. Iranian economy is regulating under the Usury-free banking law since about four years after the Islamic revolution in 1979. In section 2.6 of this chapter under a specific topic, I will discuss this phenomenon and clarify the question that how interest rate can play a role in a Usury-free system.

*Banking profit rates*: with the implementation of Usury (interest) free Banking Law and the introduction of contracts with fixed return and partnership contracts, the regulations pertaining to the determination of the profit rate or expected rate of return as is stipulated by the law of the Usury free banking, are determined by the Money and Credit Council (MCC)\(^\text{14}\). Moreover, the CBI can intervene in

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\(^{14}\) The Monetary and Credit Council (MCC) in Iran is composed of: Minister of Economic Affairs and Finance, Governor of the Central Bank, Head of State Management and Planning Organization, Two ministers elected by the Council of Ministers, Minister of Commerce, Two monetary and banking experts to be nominated by the governor of the Central Bank and confirmed by the President, Attorney-general or his/her deputy, President of the Chamber of Commerce, Industries and Mines, President of the Chamber of Cooperative, Representatives of the Economic Affairs and Plan and Budget and Account Commissions of the Islamic Consultative Assembly (one from each) as the overseers, to be chosen by the parliament. (Source: Central Bank of Iran website 2010)
determining these rates both for investment projects or partnership and for other facilities extended by banks. This instrument can be assumed as a short/long term deposit rate.

**Credit ceiling:** according to Article 14 of the Monetary and Banking Law of Iran\(^\text{15}\), CBI can intervene and supervise monetary and banking affairs through specifying the mechanisms for use of funds and determining the ceiling of loans and credits in each sector.

#### 2.3.3.2. Indirect instruments

Another pathway in which Iranian monetary authorities can implement a monetary policy is by using the central bank’s share of affecting the money market conditions as the producer of reserve money via currency in circulation and deposit balances required to be hold in the Central Bank. Indirect tools act throughout the market by adjusting the underlying supply of bank reserves. In Iran, the following three indirect instruments are being used by monetary authorities.

**Reserve Requirement Ratio (RRR):** reserve requirement ratio is one of the (indirect) instruments of monetary policy that the central bank uses to control the quantity of money in the economy. Banks are obligated to deposit part of their liabilities in terms of deposits with the central bank. By increasing or decreasing this ratio, the

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\(^{15}\) Article 14; Central Bank of Iran shall, for the proper implementation of monetary policy, have the authority to intervene in and supervise monetary and banking affairs using different methods such as but not limited to: determining the banking regulations and the maximum and minimum rates of interest and charges receivable or payable by banks in different sectors and controlling the money market by injecting money in the market,... (Source: Central Bank of Iran website 2010)
CBI contracts or expands broad money in circulation or by the same token implementing tightening or expanding monetary policy. According to Article 14 of the Monetary and Banking Law of Iran, the CBI is authorised to determine the RRR between 10% and 30% depending on the composition of the liabilities of the bank and its sector e.g. agricultural, industrial and mining.

**CBI Participation Papers:** with the similar definition (in practice) as bonds in European banking systems, following the implementation of the Usury-free Banking Law, designing appropriate Sharia-based instruments for development of open market operations in the context of liquidity management and affecting money and the capital market became a necessity for policy-makers. Utilisation of bonds, owing to its fixed interest rate nature, is prohibited according to Usury-free Banking (Islamic Banking). However, the use of participation papers and investors’ partnership in economic activities and payment of profit is encouraged. More precisely, the central bank of Iran from time to time issues some participation papers that allow the owner of the paper to behave as an investor in an investment project and hence obtain a share of the project’s profit.

CBI participation papers are issued mostly when an important national project is taking place. This acts like an open market operation where the central bank can implement the monetary policy while the public can invest in projects and hence excess liquidity of people allocated to investment projects. This technique may be useful to control inflation in the economy. Consequently, these participating papers are sold with an estimated profit rate\(^\text{16}\), where the actual interest will be paid in addition at a redemption date. For instance, according to the 3\(^{\text{rd}}\) Five Year

\(^{16}\)The current rate of these papers in third quarter of 2012 is 20% p.a.
Development Plan (FYDP)\textsuperscript{17}, the CBI was authorised to issue participation papers subject to Money and Credit Council (MCC) approval. However, based on the 4\textsuperscript{th} FYDP Law, issuance of participation papers by the CBI is authorised upon approval from the Parliament. By using this instrument, the CBI could affect broad money through monetary aggregate and indirectly control inflation by decreasing the velocity of money in circulation.\textsuperscript{18}

**Open Deposit Account (ODA):** In Usury-free Banking Law, a specific type of indirect tool for monetary policy is to allow banks to open a special deposit account with the central bank. Regulation on ODA had been approved by the MCC in 1999. The main objective of this plan was the adoption of appropriate monetary instrument to control liquidity through the absorption of banks’ excess resources. The central bank pays profit to these deposits on the basis of specific rules.

**2.4. The role of fiscal deficit and oil revenue in structure of monetary policy and inflation rate in Iran.**

Amongst the very few literature in analysing the role of the fiscal variables on inflation in Iran, Kia (2006) argues that the fiscal policy is an important factor in controlling inflation in Iran. He concludes that an anticipated increase in fiscal deficits and government expenditure boost inflation but the results are opposite when the changes are unpredicted. Another interesting result of his paper indicates that

\textsuperscript{17} Covering the period of 2000 to 2005.

\textsuperscript{18} A comprehensive discussion on velocity of money will be followed in the next chapter
when the outstanding governmental debt increases, it is considered a higher asset and demand for real balances increases and consequently the high debt per GDP is deflationary in long run.

Having a look on the balance sheet of the Central Bank of Iran (CBI),\(^\text{19}\) for about forty years starting from 1969, the oil and gas exported from the country make the considerable amount of 86 percent of the total export of the economy. On the other hand, the capital commodities and raw materials make 84 percent of imports. Consequently, imports have gone up as the increase in exchange income.\(^\text{20}\)

The role of the fiscal deficits on the rate of inflation is not a new phenomenon and can be discussed through different channels. One prerequisite of this which is still debatable is the effects of deficits on interest rate. Firstly, if we assume that the higher fiscal deficits will result in higher interest rate, this will decrease domestic investment due to the lack of financing source. This crowding-out effect of government deficit will cause lower aggregate supply resultant of lower formation of capital and eventually an increase in price level. One against argument is Bradley (1986) who evaluates this effect and compared twenty one studies in the relationship between the budget deficits and interest rate. He found that only four studies are in support of this linkage.

Secondly, the inflation rate can be affected by government deficit through the monetisation of the government’s debt. This situation happens when there is fiscal dominance in an economy. In this case when the government faces the deficits or

\(^{19}\) Balance sheet of the CBI, 1969-2006
\(^{20}\) For instance, by the oil price sharp increase by 100 percent in 1974, the imports increased by 70 percent and more recently by 18 percent increase in oil price, we can see about 20 percent increase in imports in 2002.
debt, monetary authorities should act as a filler of this gap by printing money, to ensure that the intertemporal budget of the government is balances. This has been the situation for Iran a number of times during the last forty years. Amongst the very limited literature of this effect on developing economies, Ashra et al. (2004) argue that the relationship between government debt and money is not significant in India. In the case of developed countries Grier and Neiman (1987) found some evidence of fiscal dominance in the United States.

Thirdly, another method of financing the budget deficits which has been more implemented in Iran is the wealth effect of government deficits financing. This case happens when the budget deficit of the government is financed by issuing the bonds and the bondholders do not judge these bonds as future taxes. As a result, the welfare of the individuals in the economy seems to have amplified. This will increase the aggregate demand for goods and services. Consequently, the higher the wealth effect, the higher the demand for goods and services and this results the higher price level. Tekin koru and Ozmen (2003) examined this effect in Turkey and they concluded that there is not any linkage between inflation and deficits through this channel.

In Iran, the main source of financing the governmental expenditure is the income from the oil, gas and taxes. According to the CBI balance sheet (2006) more than 60 percent of the government budget comes from the revenue of oil and gas. By increasing the oil price, this fraction will be larger as we can see that about 75 percent of the government revenue is from oil and gas in 1974 where the oil price

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21 The amount of this bond (in Iran called Participation papers) as well as rate of return of them has been significantly increased in the last two years and the most recent rate in 2012 is 20%.
doubled. Tehranchian et al. (2010) test the relationship between the government size and inflation in Iran by constructing a vector error correction model and testing the direction of causality. They conclude that a decrease of the government size will lead to reduce inflation without any pressure on the economic growth.

In a more recent study by Nademi et al. (2011), the effect of Iranian government debt on inflation in Iran has been evaluated and using a threshold regression model, they conclude that there is a non-linear relationship between inflation and foreign government debt. They divided the foreign debt regime into two groups; low and high. The results indicate that when the foreign government debt is high, then it has a considerably positive impact to inflation.

The revenue from the export of oil and gas pay a vital role in Iranian economy and the whole economy is heavily reliant on the income from this natural resource. The government has a monopoly control on the revenue of these resources which has made the monetary policy less effective in Iran. According the latest figures oil export accounts for 80 percent of the foreign exchange receipt of Iran and the 70 percent of the total revenue of the government comes from the oil and gas export. The amount of the exported oil is defined by the OPEC quota and its price will be defined in the oil market. The nationalism of the oil industry on the other hand will provide government with a fundamental monopoly power to fix the value of the power exchange and control the supply of it. This in fact will supply of these funds inelastic with respect to the exchange rate. Safdari et al. (2011) examine the roots of inflation in Iran using a vector autoregressive model for the period of 1975-2008. They conclude that the oil revenue has a positive significant effect on inflation rate

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22 Source: Qfinance 2012.
in Iran. They also argue that commodities imported and budget deficit of the government has also positive effect on Iranian inflation.

2.5. **Interest rate as instrument in Usury-free banking law, is it applicable?**

Monitoring the fluctuations of macroeconomic variables in an economy such as inflation, unemployment and growth rate has been generally accepted to be the main task of economic authorities. In the theory of monetary policy, monetary authorities are the main responsible for monitoring and controlling the monetary variables such as inflation. The widely used instrument which has been implemented by monetary authorities in different economies is interest rate. However, this role of interest rate is restricted in Islamic banking system where the financial system should operate under Usury–free law. In this section the empirical instrument of the monetary policy in Iran which operates in Usury-free system is discussed and the alternatives to the interest rate as instrument is introduced and the question of “is the interest rate ignored in practice?” is thoroughly addressed.

Iran has switched its banking system to the Islamic banking which is based on the Usury-free banking law, four years after the revolution in 1979 (i.e. in 1983) by defining a three-year conversion period. The process of shifting the banking system into the Islamic banking in Iran started just after revolution in 1979 in practice, however. The Usury-free law was passed in parliament in August 1983 and put into action from March 1984. By this law, the banks were given one year to transfer the

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23 See for more details of the switch to the Islamic banking, Aryan (1990) and Taheri (2004)
form of their deposits in a compatible way to Islamic banking law and adopting their operation system within three year according to the new rules.

The Islamic banking in Iran, allows bank to accept current and savings deposits from individuals without having to pay any interest or profit. Alternatively, it allows the banks to offer encouragements to depositors in terms of different kind of prizes or bonuses.

In this section I do not aim to present the full characteristics of Islamic banking but the role of interest rate need to be defined explicitly as an alternative of this will be used in the next chapter as an instrument for monetary authorities.

Under the Usury–free banking system, the term of interest rate does not exist. An alternative to this has been introduced by this law as the "deposit rate". By this term, banks are permitted to open different time-length accounts ranged from one month to 5 years for the depositors and pay the profit to them accordingly. This at the first view looks like the interest rate, but in practice, the bank makes a contract with the depositors and take the permission from them in order to invest their deposits into a project or production sectors and bank will act as the manager of the project, and its profit will be divided between the bank and investors with different fractions. By this, the bank on the one hand can use this rate as an instrument of monetary policy and on the other hand it has been operated under the Islamic banking framework.

Another important issue to note here is “participating papers” with the similar definition to the bonds in non-Islamic banking. Banking system sometimes acts as a broker for the central bank or government to sell some contracts to the individuals in
order to invest in a specific project of the government for a limited period. For instance, government is interested in expanding the underground network which the project will last 4 years, using a representative bank in the country, the government issues some participating papers in order to finance this project and “estimates” the minimum payable rate of return of the project. The return of these papers usually is paid every quarter and the papers are transferrable to others and for creating more incentive for individuals these papers are tax free. At the end of the project, the “actual” rate of return is calculated and will be paid to the paper holders on top of the estimated rate that they have already received. This actual profit which is calculated at the end of the period will make this tool well-suited with the Usury-free banking law and will make it different from the definition of bonds in non-Islamic banking system.

There are a few literature that examine the merits of the Usury-free banking system in practice. Darrat (2002) for instance examine the role of adopting of this system in Iran and Pakistan on the overall macroeconomic performance of the countries using cointegration and error correction models. He concludes that this switching to the Islamic banking in both countries improved the macro performance of the economy. He also argue that in comparison to the interest based system, the monetary aggregate in interest free system shows evidence of a more stable velocity of money which will prepare for the authorities a better environment in controlling monetary variables.

Khan and Mirakhor (1990) and Abdul Gafoor (1995) also check whether these two countries are really following the interest – free law in practice. They concluded that in Pakistan interest based transaction still were used by banks in practice after the
government decision of banning interest in late 1970s while the evidence were not significant in Iran.

2.5.1. The relevance of the Taylor based rule to the Usury-free banking system in Iran

In the next chapter I use the Taylor rule as the base model of the theoretical analysis. In first instance, as the Taylor rule is based on the interest rate, on the one hand, and the fact that there is no interest rate in Islamic banking system (the law that the banking system is operating in Iran) on the other hand, makes the Taylor rule irrelevant to the analysis. To resolve this problem, we need to adjust the definition of the relevant variable in Taylor rule accordingly. One can argue that “as the Taylor rule is not a micro-founded rule, and is achieved by tracking a time series, if we change the assumption, the rule is not valid anymore?”

I reply to this in two parts. Firstly, as the actual interest (profit) is paid at least one lag later in the Usury-free law, we have benefited from the rule in the current time and the results is known, and the amount that is going to be paid one period later is not affecting our achievements. Secondly, this is the main motivation of the analysis which is presented in the next chapter. I used this weakness in the model to build a Taylor-type rule using the micro-foundation of the welfare maximisation of the producer and consumers in an economy. In the new assumptions, the interest rate variable in Taylor rule is replaced by deposit rate to be applicable to the Iranian economy. In this way, the problem of the relevance of the Taylor type rule to the Islamic banking has been resolved.
In the empirical works some researchers have pointed the role of Usury-free banking system in construction of inflation in Iran, Eslamloueyan (2008) has evaluated the effect of a Usury-free banking system in Iran, his findings indicate that, comparing to the previous banking system in Iran, the Islamic (Usury-free) system as the main framework of financial system in Iran has been able to lessen the volatility of inflation in Iran but it could not attain any perceptible results in reducing the level of inflation.

2.6. Conclusion

As defining the source of inflation is the vital task for monetary authorities to undertake any anti-inflationary policy and this will increase the probability of success of the policy, in this chapter the general determinants and source of inflation has been reviewed and then the relevance of these factors to Iran were analysed and the source of persistent relatively high inflation rate in Iran were discussed. By reviewing not an extensive literature regarding inflation in Iran, the roots of inflation in Iran were divided to two groups of internal and external factors.

The role of money supply in inflation also according to the literature is significant only when it is not predicted by the individuals. In regards to the time horizon effect of the factors affecting inflation, it is also argued that in the long-run the external factors play a minor role in determination of the inflation rate and the internal factors are the main source of inflation, while in the short-run both groups have significant influence on inflation.
The effect of the exchange rate volatility of inflation rate and the imported inflation in Iran were analysed in the literature and it is argued that Iran is vulnerable to the effects of the depreciation in domestic currency and this is another source of inflation in Iran. The empirical analysis of this phenomenon is discussed in chapter four of the thesis, however.

The weight of the two specific external factors namely; war and sanctions, in defining the inflation rate in Iran were analysed and argued that Iran has the experiences of both factors since 1979. Firstly, the eight-year war with Iraq from 1980 and secondly the ongoing sanctions since 1979 which is expanded even more in recent years have been important items in constructing relatively persistent and high rate of inflation in Iran. Some other economists also argue that the structure of the monetary policy which is now giving more weight to minimise the volatility of the exchange rate is the main cause of inflation in Iran. The vulnerability of Iran to the “Dutch disease” as Iran is an oil exporting economy was discussed according to the literature.

The instruments of the monetary policy in Iran, according to the publication of the Central Bank of Iran were reviewed and five direct and indirect instruments in Iran, compatible to the Usury-free banking law which has been implemented since 1983, were introduced. As Iran is an oil exporting economy which the income of the economy is highly dependent to the revenue of oil products, on the one hand, and the size of the government and the budget deficits on the yearly basis, on the other hand, it seems necessary to evaluate the role of these two factors in determinants of inflation in Iran. The relevant literature in this regards were analysed and it is concluded that these factors has also a significant effect on inflation.
Finally, as a prerequisite to the next two chapters, the alternative to the interest rate in Iran (as the economy is regulating under a Usury-free law) i.e. “deposit rate” has been introduced and the possible critiques in using an interest rate-based rule as the instrumental rule in defining the inflation targeting framework for Iran has been thoroughly discussed and the relevant literature in this regards were reviewed. It is concluded that the role of the alternative to the interest rate i.e. deposit rate in Iran is very similar to the definition of the interest rate and it has the same performance in practice, consequently it can be used as an instrument to steer the Iranian economy.
CHAPTER 3: INFLATION TARGETING

AND TAYLOR RULE IN IRAN
3.1. Introduction

In analysis of inflation targeting framework a considerable amount of research have been carried out and published since 1990, when New Zealand was a pioneer in adopting such a policy. In the last two decades, many central banks have implemented an inflation targeting framework as their monetary policy regime. A few of the monetary authorities have used inflation targeting without considering any other variables such as output and the exchange rate, so called “strict inflation targeting” and others took these variables into consideration as well, so called “flexible inflation targeting” where the latter is the case for emerging economies who have adopted inflation targeting.

The Taylor rule\textsuperscript{24} has been credited to be the base model for adoption of this strategy in most economies. All countries which have adopted inflation targeting so far have not followed the same structure in applying the policy especially in developing economies,\textsuperscript{25} however, the goal of reducing (controlling) inflation seems to be their joint objective. In general, as Bernanke \textit{et al.} (1999) argue, the objective of inflation targeting framework is to contain expectations of inflation and augment accountability of monetary policy by announcing a numerical target rate for inflation in the short or medium term policy of the central bank. Inflation targeting has had an affirmative outcome around the world and the number of countries that have adopted this strategy or have expressed their intention of implementation of this policy to the

\textsuperscript{24} Taylor (1993), will be discusses in more detail in section 3.5.

\textsuperscript{25} For a summary of different implementations of inflation targeting see Schaechter \textit{et al.} (2000) where they discuss the institutional and operational framework of inflation targeting in emerging economies.
International Monetary Fund (IMF) is gradually increasing. By observing the inflation rate before and after the adoption of this framework, the success of this strategy can be observed in both developed and developing economies.

This chapter firstly, presents an overview of an inflation targeting strategy. The specifications of a typical inflation targeting framework will be discussed with an analysis of the characteristics of emerging economies. In addition, the rationale behind maintaining low inflation will be summarised. The start rate of inflation and the target rate at the time of the adoption of the policy of inflation targeting countries will be tabulated and the appropriate time for an economy to adopt the policy will be discussed. Secondly, as the main objective of this chapter, a theoretical Dynamic Stochastic General Equilibrium (DSGE)-type model will be derived to track the behaviour of a central bank in an inflation targeting framework. This part is motivated by the lack of micro foundation of the Taylor rule.

Therefore, this chapter is devoted to exploring the specifications of an inflation targeting framework and designing a micro-based optimal monetary policy rule for monetary authorities. Consequently, the remainder of this chapter is as follows: Section 3.2 evaluates the rationale of maintaining low inflation and outlays of inflation. Section 3.3 presents the structure of inflation targeting and issues on adoption of this framework and gives a summary of the countries that have used this strategy in their monetary policy. In section 3.4 the two main alternative policies of inflation targeting will be discussed and analysed. Section 3.5 illustrates the Taylor rule as the most common instrumental rule in practice. The optimal monetary policy rule will be generated through the micro foundation of the model which will be presented in section 3.6, followed by section 3.7 which concludes the chapter.
3.2. Maintaining low inflation, rationale and reality

Inflation targeting has raised much attention in recent years among both developed and emerging countries, even if some of them have not adopted inflation targets but are keen in maintaining inflation at a low level in their economic policies. For example, Federal Reserve has not announced any inflation targeting policy so far, but in practice, especially in the recent years, in economic policy and more precisely in the monetary policy structure, the Federal Reserve has established keeping inflation at a low level as their medium and long run monetary policy. Another example is Japan in which the monetary authority has indicated that maintaining stable prices is their primary objective of monetary policy, although Japan is not an inflation targeting country.

On the other hand, there are twenty-seven (as of January 2009) countries which officially have adopted an inflation targeting framework in their monetary policy. New Zealand adopted the framework for the first time in the early 1990s and some countries for instance, Canada, the United Kingdom, Sweden, Thailand, Romania, Mexico and Turkey among others have followed.

3.2.1. Cost of inflation

Nowadays in many countries (especially in emerging economies) even those which have not adopted inflation targeting in their monetary policy, having a stable price has become priority over unemployment, development and growth targets. The logic behind this phenomenon is motivating. In general the central bank is in charge of the
monetary policy and have (should have)\textsuperscript{26} the full power as policy maker to maintain price stability. A stable price level and low inflation can set the foundations for other objectives of an economy to grow. For example, maintaining low inflation has a direct effect on, and acts as a good perquisite of, employment and growth objectives.

The literature on the cost of inflation tends to focus on ongoing increases in the price level. There are four potential consequences of a rise in the price level which will be discussed in this subsection. The assumption of these results is obviously when inflation is not predicted or by the same token unanticipated inflation. The disadvantages of inflation can be summarised in four groups. Firstly, reducing the value of money; the most obvious result of inflation which does not require any rationale behind it, is a reduction of the value of money in the inflation process and consequently amounts to a tax on money balances.\textsuperscript{27} As a result, individuals are led to hold lower amounts of money than they would in the absence of inflation, in order to guarantee a sub-optimal outcome. To measure the loss of welfare generated by this type of inflation we can compute the area under the demand curve which is erased by price increases. On the other hand, a reasonably rapid drop in the value of money will be a cost to money users. In struggling to keep up with rising prices, money users may have to make additional visits to the bank to stock-up their considered necessary nominal money balances. We might more generally name these

\textsuperscript{26}In fact a central bank should have a high level of independence to able to adopt inflation targeting and have dominance over fiscal policy when the objectives of monetary and fiscal authorities conflicts.

as banking transaction costs. These trips to the bank are not necessary in the absence of inflation, and thus represent a cost imposed by it.

Secondly, the redistribution of wealth from creditors to debtors; assuming unpredictable inflation, debtors will pay back their debts in real amount which is worth progressively less. Inflation reduces the burden on debtors and troubles creditors. One might argue that this is not a cost of inflation because it amounts to a transfer, not a net loss. However, the existence of inflation may cause lenders to reduce the amount of credit they bring into the money market, which would represent a real loss in contrast to an economy in monetary equilibrium.

Thirdly, menu costs; the existence of inflation even if it is well-predicted, will force the sellers to devote some resources to frequent change in prices, so-called menu cost.\textsuperscript{28} The more volatile is inflation, the more often sellers should adjust prices. The time spent in remarking catalogues, or reprogramming computers, reflects a cost which is imposed by inflation.

Fourthly, effect on relative prices; so far, the discussion regarding the cost of inflation had been due to change in the general price level. However, sometimes changes in the price level might change the division of relative prices in an economy. If inflation only affects nominal prices, not touching relative prices, it would still maintain the first three costs. However, if inflation affects relative prices as well, then, resources will not be allocated fairly because some relative prices will no longer be at their equilibrium values.

To summarise these costs of inflation, we can argue that the first three problems will define a new equilibrium position comparing the previous price levels and clearly with lower overall welfare, while the fourth dilemma can cause the economy to be out of equilibrium in addition to any reduction of welfare. The literature offer a number of discussions for how inflation will affect relative prices. (See for example Dowd (1996) for a comprehensive discussion on relative price effect)

Since the influential work of Bailey (1956), economists have tried to measure the welfare cost of inflation in a fair numbers of articles. Bailey’s method has been derived in a partial-equilibrium setting. It assumes real money balances as a consuming good and inflation as a tax on balance. The welfare cost is calculated by measuring the area underneath the inverse money demand function. One of the most cited papers is Lucas (2000). He presents estimates of the cost of inflation based on U.S. (United States) time series from 1900 to 1994. To do so, he classifies the money supply as M1, assuming an interest elasticity of -0.5, and estimates the cost of inflation by using Bailey’s (1956) and Friedman (1969), consumer surplus approach as well as the reimbursing variation approach.

3.2.2. Political aspect of inflation

By monitoring the reaction of individuals in (developed) economies, some interesting results can be obtained regarding the political aspect of inflation. It can be concluded that people tend to bear inflation as long as it was steady, low and

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predictable. When labour markets were drooping, they were even eager to accept higher inflation rate in order to stimulate additional economic activity. Only when economic activity was at a good level and inflation moved “well-above” the existing trend did inflation rank top of the list of public concerns.

It is easy to recognise why inflation does not greatly concern by the public when it is steady and expected. Individuals are inconvenienced only to some extent by steady inflation. As long as earnings, prices and asset values move up in tandem, the financial costs are inconspicuous, especially when inflation is low. Also, a short-term and modest rise in inflation around a low trend need not instantly stimulate concerns.

However, a persistent increase of inflation above its trend causes apprehensions because people then doubt whether a new trend may be established. Depositors are anxious about how much of an inflation premium to claim in interest rates. Businesses are concerned about how insistently charge the output in order to cover rising costs and finally workers are worried about maintaining the purchasing power of their income.31

3.2.3. Credibility of low inflation

One of the most important lessons learned from the countries in which a low level of inflation is maintained over a continuous period of time is that credibility of low inflation is the basis of a successful monetary policy. For example, the Federal Reserve has obtained credibility since the early 1980s (excluding the recent crisis) by constantly taking policy actions to keep inflation at a rationale level. In consequence, the Federal Reserve had set up a mutual appreciative between itself and the markets.

31 See for more discussion: Romer and Romer (1989) and Taylor (2000)
From this perception, wage and price-setters maintained their part of an implied bargain by not increasing prices excessively as long as the Federal Reserve expressed its vow to low inflation. As a result, the Federal Reserve and the public sustained low inflation.

Considering the Federal Reserve, to a large level the precise monetary policy to control (reduce) inflation would follow the approach to monetary policy developed by Volcker and Greenspan, two of the former Federal Reserve Chairmen. On the other hand, it seems worthwhile to think about whether more explicit inflation reducing policies could help the Federal Reserve to prolong a credible monetary policy in the future. Different kinds of inflation targeting actions have been implemented by several central banks in conducting monetary policy to construct credibility for low inflation.\(^{32}\)

### 3.3. Inflation targeting framework

#### 3.3.1. A brief overview

A growing number of research has been carried out on inflation targeting since the early 1990s. A range of aspects of inflation targeting from rationale of inflation targeting to implementation issues and alternatives to this policy, have been assessed in the literature.\(^{33}\) However, in case of emerging economies, there are fewer studies.

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Bogdanski et al. (2000) and Masson et al. (1997) among others\textsuperscript{34}, summarise the particulars of inflation targeting in emerging economies, however, the implication of this framework is restricted in practice in such economies compared to developed ones.

In contrast, some studies do not agree with the success of inflation targeting. Lee (1999) argues that the reduction of inflation in the countries which had adopted this policy was because of the global disinflationary environment and not the performance of this strategy, to do so he compared the inflation manner of three inflation targeting countries with three who had not adopted the framework and concluded that these two groups had the same results from their monetary policy over a same period.\textsuperscript{35} A conventional definition of inflation targeting is a monetary policy strategy that involves five main elements. Mishkin (2000b), summarises these factors as:

\begin{enumerate}
\item \textit{A public announcement of medium-term numerical targets for inflation;}
\item \textit{An institutional commitment to price stability as the primary goal of monetary policy, to which other goals are subordinated;}
\item \textit{An information inclusive strategy in which many variables, and not just monetary aggregates or the exchange rate, are used for deciding the setting of policy instruments; (this is the matter of “flexible inflation targeting” discussion).}
\end{enumerate}

\textsuperscript{34} For more studies on emerging economies see: Schaechter et al. (2000), Jonsson (1999), Reyes (2004) and Fraga et al. (2003).

\textsuperscript{35} For more evidence of the against arguments see: Groeneveld et al. (1998) Laubach and Posen (1997)
d) Increased transparency of the monetary policy strategy through communication with the public and the markets about the plans, objectives, and decisions of the monetary authorities; and

e) Increased accountability of the central bank for attaining its inflation objectives.

Inflation targeting is not only a pronouncement of a number as the goal of inflation to the public, if that was the case, almost all countries would be inflation targeting economies due to a long-run target of reducing inflation which is usually one part of the governments’ economic objectives.

3.3.2. Advantages and disadvantages of inflation targeting

3.3.2.1. Advantages of Inflation Targeting

Inflation targeting has several advantages both in implementation of short run and long run strategies for monetary policy relative to other frameworks. An inflation targeting regime enables monetary authorities to focus on domestic economic fluctuations and to respond to shocks arising from internal sources, which are distinguishable from other policies, for example, exchange rate targeting. In contrast to monetary targeting, inflation targeting has such advantage that a stable relationship between money and inflation is not critical to its success. The strategy does not depend on such a relationship, but instead uses all available information to determine the best settings for the instruments of a monetary policy. As Jonsson (1999) and Mishkin (2000b) argue, inflation targeting also has the key advantage that it is easily understood by the public and it is therefore highly transparent. It

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36 Monetary aggregate targeting and exchange rate targeting as two alternatives of inflation targeting will be discussed in section 2.4.
consents to obtaining and maintaining a lower level of inflation which has a positive effect on economic growth. Because of an explicit numerical target for inflation augments the accountability of the central bank, inflation targeting also has the potential to reduce the likelihood that the central bank will fall into time-inconsistency problem.

Moreover, since the source of time-inconsistency is often found in (hidden or open) political pressures on the central bank to undertake exceedingly expansionary monetary policy, inflation targeting has the advantage of focusing the political debate on what a central bank can do in the long run i.e. controlling inflation rather than other economic objectives such as increase economic growth, lower unemployment, increase external competitiveness through monetary policy which it cannot implement directly. For an inflation targeting strategy to deliver this objective, a strong institutional commitment to make price stability the primary goal of the central bank (as the main monetary authority) ought to be present. This is particularly important in emerging economies which have often had a history of monetary misconduct. The institutional commitment involves parliamentary support for an independent central bank whose charter is supposed to contain two key features:

a) Sufficient insulation of the policymaking board of the central bank from the politicians with members of the government excluded and the members of the board appointed to long terms and protected from arbitrary dismissal;

b) Authorising the central bank full and exclusive control over the setting of monetary policy instruments. The institutional commitment to price stability also requires that the central bank to be given a mandate to have price
stability as its primary goal, making it clear that when there is a conflict with other goals, such as exchange rate stability or promotion of high employment, price stability must be accorded the higher priority.

An inflation targeting regime also puts great stress on the need to make monetary policy transparent and to maintain regular channels of communication with the public. In fact, these features have been central to the strategy's success in industrialised countries. Inflation targeting central banks have frequent interactions with governments, and their officials take every opportunity to communicate their monetary policy strategy to the public.

As originated by Bank of England, inflation targeting central banks have taken public outreach a step further and publish inflation report documents to clearly present their views and analysis about the past and future performance of inflation and monetary policy. Another key feature of inflation targeting regimes is that the transparency of policy associated with inflation targeting has tended to make the central bank highly accountable to the public. Sustained success in the conduct of monetary policy as measured against a preannounced and well defined inflation target can be an instrumental objective in building public support for an independent central bank.

### 3.3.2.2. Disadvantages of Inflation Targeting

Detractors of inflation targeting have noted some disadvantages of this monetary policy strategy.\(^3^7\) These factors can be summarised in the following seven points:

a) Inflation targeting is too rigid

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37 See for example: Bernanke, et al. (1999) and Mishkin (2000b) amongst others.
b) It allows too much discretion  
c) It has the potential to increase output instability  
d) It will cause lower economic growth  
e) Inflation targeting can only produce weak central bank accountability because inflation is difficult to control (in emerging economies)  
f) Inflation targeting cannot prevent fiscal dominance  
g) Exchange rate flexibility required by inflation targeting might cause financial instability\textsuperscript{38}

The last two disadvantages expressed above, are also very relevant in the emerging market countries which are concerned about the fluctuation of the exchange rate and the effect of imported inflation on their price index.

As Mishkin (2000a,b) indicates, in contrast to exchange rates and monetary aggregates, the inflation rate cannot be easily controlled by the central bank. In addition, inflation outcomes that incorporate the effects of changes in instruments settings are publicised only after a significant lag. The difficulty of controlling inflation creates a particularly severe problem for emerging market countries when inflation is being brought down from relatively high levels. In such circumstances, inflation forecast errors are expected to be large, inflation targets will tend to be missed, and it will be difficult both for the central bank to gain credibility from an inflation targeting strategy and for the public to determine the reasons for the departures. This suggests that, inflation targeting is likely to be a more efficient approach if it is phased in only after some successful disinflation period.

\textsuperscript{38} Next chapter will evaluate the effect of exchange rate in monetary policy reaction function in inflation targeting framework.
One other factor affecting inflation controllability which is especially relevant to the emerging market situation is the (at times large) incidence of government controlled prices on the index that are used to compute headline inflation. As a result inflation targeting may demand a high degree of synchronization between monetary and fiscal authorities on the timing and the extent of future changes in controlled prices or, alternatively, the exclusion of controlled prices from the targeted price index, as in the experience in Czech Republic.  

3.3.3. Issues on adoption of an inflation targeting framework

3.3.3.1. Perquisites of inflation targeting

Firstly, absence of absolute fiscal dominance is a key prerequisite for inflation targeting, and the setting up of organisations that help to keep fiscal policy in check are critical to the accomplishment of the strategy.  

As Mishkin (2000b) argues in his paper,

“A sound financial system is another prerequisite for successful inflation targeting because, when financial systems blow up, there is typically a surge in inflation in emerging-market countries.”

However, as argued by Mishkin and Savastano (2000), a sound financial system is also a key factor to the success of any other monetary policy strategies such as exchange rate targeting.

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39 See the study by Fisher (1999).

40 See Masson et al. (1997) for more discussion.
In this association, it is generally agreed that once an economy has experienced high inflation rates (e.g. more than 20%) for a number of years, it will be incapable of relying on monetary policy alone to target any permanent reduction in the rate of inflation. At high rates of inflation, fiscal and monetary policies are likely to become practically indissoluble. Inflation targeting in moderately dollarized economies may not be feasible unless there are strict prudential rules on, and strict control of, financial institutions that ensure the system is capable of withstanding exchange rate shocks.

Another condition for adopting inflation targeting is that the authorities should desist from targeting any other nominal variable (e.g. wages or exchange rate). An economy which has a fixed exchange rate system subordinates its monetary policy to exchange rate targets and manage the money and financial markets in order to keep the exchange rate constant and is not in actual fact able to target directly any other macroeconomic variable, such as inflation. Nevertheless, if these restrictions are relaxed through such variants of a fixed exchange rate system as target region, then in theory, an exchange rate objective could coexist with an inflation target as long as it is comprehensible, and central bank behaviours show that the latter has priority if a clash arises.

An economy that convince these basic requirements is able (in theory) to perform its monetary policy in a way that is consistent with inflation targeting. To do so, nonetheless, the authorities would need to set up a monetary policy structure with the following four vital elements:

a) Explicit inflation goals for some period ahead
b) Clear and unequivocal warnings that achieving those inflation targets is the dominant objective of monetary policy
c) A model for predicting inflation that uses related variables and information indicators, and
d) A forward looking operational method in which the setting of policy instruments depends on considering inflationary pressures and where inflation forecasts are used as the main target of monetary policy.

3.3.3.2. Instrument independence

Inflation targets can be set by either the central bank, the government, or jointly by both divisions. To clarify this, the announcement of the inflation rate to the public must be carried out by the government rather than central bank. Most inflation targeting countries in practice officially involve the government in the setting of the inflation targets (Table 3.1). This reinforces the sincerity of the inflation targeting policy by in some way committing the government to drive fiscal policy in a way that supports the inflation objective. The independence of the instrument i.e. the central bank’s freedom in implementing the inflation targeting objectives should be maintained. Government association in designing the targets is particularly beneficial when the central bank does not have an apparent authorisation to track an inflation target as the primary objective of monetary policy. However, the credibility of given independence will be reduced if the government changes more often. This is the problem of giving the fiscal authorities control of inflation steering because when a new party wins the election, it will not usually follow the previous party’s rules in practice. Central banks typically announce inflation targets in countries where price stability consent is clearly packed in their governing legislation as the primary object
for the monetary policy. In this case, the announcement of the target by the central bank reflects the designation by the government of the authority for setting monetary policy objectives to the central bank. Table 2.1, summarises key inflation targeting countries and the source of announcement of this framework.

**Table 3.1: Authority of announcement in inflation targeters**

<table>
<thead>
<tr>
<th>Government</th>
<th>Central Bank</th>
<th>Joint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norway</td>
<td>Sweden</td>
<td>New Zealand</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>Colombia</td>
<td>Canada</td>
</tr>
<tr>
<td>Israel</td>
<td>Mexico</td>
<td>Australia</td>
</tr>
<tr>
<td>Brazil</td>
<td>Poland</td>
<td>Czech Republic</td>
</tr>
<tr>
<td>Egypt</td>
<td>Chile</td>
<td>South Korea</td>
</tr>
<tr>
<td>Iceland</td>
<td>Thailand</td>
<td>South Africa</td>
</tr>
<tr>
<td></td>
<td>Romania</td>
<td>Hungary</td>
</tr>
<tr>
<td></td>
<td>Philippines</td>
<td>Peru</td>
</tr>
<tr>
<td></td>
<td>Switzerland</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ukraine</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Turkey</td>
<td></td>
</tr>
</tbody>
</table>

*Source: Central banks’ websites and IMF (2009)*

**3.3.3. Level of inflation at adoption of inflation targeting**

At the start of designing an inflation targeting framework, inflation should be low enough to guarantee a practical degree of monetary control. However, it does not mean that this phenomenon is an absolute term because there are some countries which adopted the framework when they were experiencing high level of inflation. Table 2.2 summarises the date, level of inflation in the date of adoption, and the long term inflation target for twenty-seven countries. As can be seen, most industrial countries adopted an inflation targeting framework, when inflation was at a relatively low level. Countries that started with higher rates of inflation and crawling peg
exchange rate regimes disinflated over long-time periods to limit disruptions to the real economy. Poland and Chile for example, gradually shifted from a crawling exchange rate regime to an inflation targeting policy.

Responses to violations of inflation targets mainly depend on whether or not inflation is at or above the long term target. When the inflation target is at the long term rate policy, responses to breaches of the bottom and upper limit of the target range (if a range is defined rather than a target point) are likely to be symmetric in order to limit output variability.

As can be seen in Table 3.2, there are some countries which adopted inflation targeting in higher levels of inflation e.g. Turkey, Chile and Mexico.

As explained in the table notes, some countries had not officially announced that they had the intention to target inflation, but in practice they were following the fundamentals of the policy. In the case of Turkey, the central bank could manage to reduce inflation from 68% in 2002 to about 8% in 2006 which is an average reduction of 15% per year when in this period, Turkey was not on the inflation targeters’ list. The instrument that they used, like most other countries, had been the nominal interest rate which will be discussed in more detail in the next section.
Table 3.2: Inflation targeting countries at a glance

<table>
<thead>
<tr>
<th>Country</th>
<th>Start date</th>
<th>Starting inflation rate</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>Mar 1993</td>
<td>2%</td>
<td>2-3%</td>
</tr>
<tr>
<td>Brazil</td>
<td>Jun 1999</td>
<td>3.3%</td>
<td>4.5% (±2%)</td>
</tr>
<tr>
<td>Canada</td>
<td>Feb 1991</td>
<td>6.2%</td>
<td>2% (±1%)</td>
</tr>
<tr>
<td>Chile*</td>
<td>Sep 1990 (1999)</td>
<td>24% (2.9%)</td>
<td>2-4%</td>
</tr>
<tr>
<td>Columbia</td>
<td>Sep 1999</td>
<td>9.3%</td>
<td>5% (±0.5%)</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>Jan 1998</td>
<td>13.1%</td>
<td>2-4%</td>
</tr>
<tr>
<td>Hungary</td>
<td>Apr 2001</td>
<td>10.5%</td>
<td>3.5% (±1%)</td>
</tr>
<tr>
<td>Iceland</td>
<td>Mar 2001</td>
<td>3.9%</td>
<td>2.5%</td>
</tr>
<tr>
<td>Israel*</td>
<td>Jan 1992 (1997)</td>
<td>17% (8.5%)</td>
<td>1-3%</td>
</tr>
<tr>
<td>Korea*</td>
<td>Apr 1998 (2001)</td>
<td>6% (3.2%)</td>
<td>2.5-3.5%</td>
</tr>
<tr>
<td>Mexico*</td>
<td>Jan 1999 (2001)</td>
<td>18% (8.1%)</td>
<td>3% (±1%)</td>
</tr>
<tr>
<td>New Zealand</td>
<td>Mar 1990</td>
<td>7%</td>
<td>1-3%</td>
</tr>
<tr>
<td>Norway</td>
<td>Mar 2001</td>
<td>3.7%</td>
<td>2.5% (±1%)</td>
</tr>
<tr>
<td>Peru</td>
<td>Jan 2002</td>
<td>-0.8%</td>
<td>2.5% (±1%)</td>
</tr>
<tr>
<td>Philippines</td>
<td>Jan 2002</td>
<td>3.8%</td>
<td>4-5%</td>
</tr>
<tr>
<td>Poland</td>
<td>Oct 1998</td>
<td>9.9%</td>
<td>2.5% (±1%)</td>
</tr>
<tr>
<td>South Africa</td>
<td>Feb 2000</td>
<td>2.3%</td>
<td>3-6%</td>
</tr>
<tr>
<td>Sweden</td>
<td>Jan 1993</td>
<td>4.8%</td>
<td>2% (±1%)</td>
</tr>
<tr>
<td>Switzerland</td>
<td>Jan 2000</td>
<td>1.9%</td>
<td>0-2%</td>
</tr>
<tr>
<td>Thailand</td>
<td>May 2000</td>
<td>1.7%</td>
<td>0-3.5%</td>
</tr>
<tr>
<td>Turkey*</td>
<td>Jan 2002 (2006)</td>
<td>68% (8.2%)</td>
<td>3-5%</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>Oct 1992</td>
<td>3.6%</td>
<td>2% (±1%)</td>
</tr>
<tr>
<td>Slovakia</td>
<td>Mar 2005</td>
<td>3.2%</td>
<td>3.5% (±1%)</td>
</tr>
<tr>
<td>Indonesia</td>
<td>Sep 2005</td>
<td>7.8%</td>
<td>5.5% (±1%)</td>
</tr>
<tr>
<td>Romania</td>
<td>Sep 2005</td>
<td>8.8%</td>
<td>7.5% (±1%)</td>
</tr>
<tr>
<td>Ukraine</td>
<td>Oct 2007</td>
<td>11.6%</td>
<td>7% (±1%)</td>
</tr>
<tr>
<td>Egypt**</td>
<td>Apr 2009</td>
<td>17.8%</td>
<td>5%</td>
</tr>
</tbody>
</table>

Source: Batini et al. (2006), IMF and central banks’ websites (2009)

* These countries although, were following an implicit inflation targeting plans at given dates, but official date in which has been announced by IMF is given in brackets

** The Central Bank of Egypt is giving the reports and analysis of inflation but not officially announced by IMF yet, due to the recent global crisis

All the inflation targeting countries have a unique numeric target range. In countries mentioned in Table 3.2, monetary authorities are using the forecast process to predict the inflationary pressure and define the appropriate econometric forecasting tools for
it. These forecast reports are published to inform the public regularly except the case of Mexico which does not publish the inflation forecast.

3.4. Alternative policy strategies

In the discussion of monetary policy, there are some other methods of attaining price stability and to hold the value of money. However, the effects of these methods are indirect. Exchange rate targeting and monetary aggregate targeting are the most applicable alternatives to inflation targeting. As Mishkin (1999) specifies, rather than inflation targeting, these two strategies of monetary policy can also help to reduce inflation. In the following subsections the alternatives to inflation targeting will be briefly discussed in terms of advantages and disadvantages of them in practice.

3.4.1. Exchange rate targeting

Targeting the exchange rate can be performed in different ways. It can take the form of fixing the value of the domestic currency to that of a foreign (large and low inflation) country, fixing it to a valuable commodity such as gold, or setting a crawling rate in which the currency (domestic) is allowed to depreciate at a constant rate.

In the first case, the country can benefit from the credibility of the foreign country’s monetary policy. However, this requires the existence of a reasonable amount of international reserves, and protecting the domestic country’s competitiveness in the international market. It also requires a stable political and governmental framework as well as an independent central bank. The choice of the anchor economy also plays an important role in this strategy and should be the main element in the domestic
country’s trade partners. As Mishkin (1999) argues, the key advantage of such a policy is that it is simple to understand by the public and it has the ability to decrease inflation by tying it to the anchor’s economy. This strategy has the following weaknesses.

Firstly, the monetary authorities have to ignore the domestic shocks to the components of the monetary policy. The rationale behind this is that the monetary policy instrument (i.e. interest rate) should be chosen in a way that keeps the exchange rate constant and consequently, it will fluctuate by the deviations of the foreign interest rate, not the domestic shocks. There is not an independent monetary policy. As a result, the domestic policy will respond to the shocks of the foreign country that may not be relevant to the domestic economy. More importantly, the monetary policy might be out of control in case of unpredictable speculative attacks against domestic currency.

Secondly, exchange rate targeting will decrease the accountability of a central bank especially in the case of developing economies because it removes and ignores important indications that help to control the economic policy from being too expansionary. As Mishkin (1999) suggests, these indications originate from fluctuations of the exchange rate in case of an excessively expansionary policy.

Thirdly, assuming a developing country, if the authorities cannot meet the target, it will result in becoming financially vulnerable. Depreciation of the home currency increases the producers’ debt to the foreign firms which has a direct effect on decreasing economic growth in the country. The experience of the Asian financial crisis of 1997 is a clear example where the approach was followed.

For more discussion in the perquisites of exchange rate targeting see Tutar (2002) and Krugman (1979) among others.
crises in July 1997 in Thailand is against the stabilisation of exchange rate where it makes the countries and domestic currencies prone more prone to the speculative attacks.

### 3.4.2. Monetary aggregate targeting

In many economies, it is not possible to adopt exchange rate targeting because they cannot meet its prerequisites such as finding an anchor country because the country is so large that considerable trade with foreign countries does not exist. Monetary aggregate targeting is another alternative of inflation targeting which aims to maintain a low level of inflation (indirectly) by controlling the aggregate money in the economy (or growth of the monetary aggregate). The independence of the central bank plays a more crucial role in this strategy.

The main advantage of this strategy over exchange rate targeting is that the central bank is able to adjust its instrument in response to the domestic shocks. Moreover, as Mishkin (1998) indicates, both public and financial markets will be notified immediately\(^42\) about the intention of the central bank to decrease inflation, resulting in the avoidance of time inconsistency problems which have a direct effect on the accountability of the central bank. However, in a country where rapid financial liberalisation exists, the elasticity of the interest rate of money demand is highly volatile. Consequently, money cannot act as a good prediction of future inflation and this can be one disadvantage of this policy. Furthermore, assuming that the target of monetary aggregate is to restrict money growth volatility around the targeted rate, this will contradict with the target of minimising inflation variation. Moreover, the

\(^{42}\) This is because of the values of monetary aggregates are effected almost with very short lags.
monetary aggregate targeting is not an adequate strategy during the development and innovation periods of financial markets as it produces an unstable demand for money which will result in weakening the linkage between the economy and monetary policy.

These doubts in performance of the monetary aggregate strategy on the one hand and disillusionment with the exchange rate targeting regimes on the other hand, has convinced a growing number of economies to adopt inflation targeting framework. As explained in previous section, Brazil, Poland, South Africa, Thailand, Czech Republic and Chile among others are the representative developing countries which have adopted inflation targeting strategy.

3.5. **Taylor rule as the most popular instrument**

3.5.1. **A brief history of Taylor Rule**

During the last two decades, interest among macroeconomists in estimating monetary policy reaction functions has increased markedly. In the context of a macroeconomic model, an appropriately specified reaction function can be used to evaluate the actions and policy stance of a central bank, and by estimating such rules empirically, researchers have aimed to gain insight into how central bank behaviour has varied both over time and across institutions.

Taylor (1993) made an important contribution to this, by a simple characterisation of the Federal Reserve’s monetary policy. His claim was that expressing the Federal funds rate as a linear function of current inflation deviation from an inflation target and the output gap is not only a good description of monetary policy in the US but
also a reasonable policy recommendation. Since its introduction, Taylor’s rule has become highly popular, and versions of it are frequently employed in both empirical and theoretical studies of monetary policy.\footnote{For example see; Clarida et al. (1998), (2000), Taylor (1999), Levin et al. (1999), Gerlach and Schnabel (2000), Huang et al. (2001), Orphanides (2001), Rudebusch (2002a,b), Leitemo and Soderstrom (2004) and Benigno and Benigno (2008).}

Taylor’s (1993) original formulation is shown in the following equation:

\begin{equation}
    i_t = r^* + \pi_t + \rho_1(\pi_t - \pi^*) + \rho_2(y_t)
\end{equation}

where \( i_t \) represents the central bank policy rate (nominal interest rate), \( r^* \) the equilibrium real interest rate, \( \pi_t \) inflation rate, \( \pi^* \) the target of inflation of the central bank and \( y_t \) the output gap. Taylor (1993) found that a rule with parameters set subjectively to: \( r^* = 2, \pi^* = 2, \rho_1 = 0.5 \) and \( \rho_2 = 0.5 \), supported the actual federal funds rate reasonably well from 1987 to 1992.

Rewriting equation (3.1.1) and falling any restrictions on the coefficients, this can be expressed as:

\begin{equation}
    i_t = \rho_0 + \rho_{\pi}(\pi_t - \pi^*) + \rho_y(y_t)
\end{equation}

Where \( \rho_0 = r + \pi^* \), \( \rho_{\pi} = 1 + \rho_1 \) and \( \rho_y = \rho_2 \). The policy rate of the central bank is decomposed to respond to deviations of current inflation from its target rate, response to deviations of the output (GDP) gap from zero, and a constant including the equilibrium real interest rate and the inflation target.

A number of studies have evaluated or estimated Taylor-type rules for various time periods, countries and specifications,\footnote{For example see; Clarida et al. (1998), (2000), Taylor (1999), Levin et al. (1999), Gerlach and Schnabel (2000), Huang et al. (2001), Orphanides (2001), Rudebusch (2002a,b), Leitemo and Soderstrom (2004) and Benigno and Benigno (2008).} beginning with Taylor’s (1993) paper. In his
initial work, no formal econometric study was performed, and the rule in equation (3.1.1) was found simply to visually track the Federal Reserve funds rate fairly well between 1987 and 1992. Subsequently, Taylor (1999) estimated a modified version of equation (3.1.2), shown in (3.1.3), for the U.S over several different sample periods using OLS (Ordinary Least Squares).

\[ i_t = \delta + \rho_\pi (\pi_t) + \rho_y (y_t) + \varepsilon_t \]  

(3.1.3)

Where \( \delta = r - \pi^* (\rho_\pi - 1) \) is assumed as a given term which is the sum of target rate and real interest rate minus the estimated coefficient of inflation times target number.

### 3.6. Optimal monetary policy

#### 3.6.1. Preface of the model

In order to evaluate the monetary policy, the first task is trying to identify is an optimal monetary policy rule based on micro foundation of an economy in order to see how monetary authorities should respond to the fluctuations of the components of the monetary policy. To do so, a Dynamic Stochastic General Equilibrium (DSGE) type model of a small open economy is used based on Divino (2009), Gali and Monacelli (2005) and Clarida et al. (2001) studies. They examine the effect of exchange rate fluctuations on the dynamics of aggregate supply and demand where the coefficients of New Keynesian Philips curve and aggregate demand function are

---

influenced by the openness of the economy. Then they use a simple monetary authority’s policy rule to evaluate the effects of shocks to the economy.

From this section onward in this chapter, the main intention is to design an optimal monetary policy rule for a small open economy by constructing a DSGE model and working out the optimisation queries of the agents in the model (i.e. households and firms) while taking into account the possibility of inflation targeting adoption into the model. The role of the exchange rate in monetary policy and its effect on constructing the monetary authority’s reaction function is also considered, but its empirical application will be discussed in the next chapter via the derivation of the relevant Monetary Condition Index (MCI). The agents in the model involve the following: a central bank as the monetary authority, households who try to maximise their utilities subject to the budget constraints that they are facing, and the firms whose objective is to minimise their costs of production and hence maximise their profit function by using the Calvo (1983) price setting. The other assumption in this model is that the firms borrow only from households in order to finance their production. Moreover, there is not any other financial intermediary between the households and firms to play the role of trader.

In the operational framework of this section, the monetary policy influences economic activities via an interest rate rule designed by monetary authorities. The transmission channel of the model implies that the marginal cost of the firms is affected by the fluctuations in the exchange rate and consequently, the model presents a trade-off between inflation versus output gap stabilisation caused by real exchange rate. With reference to relevant literature, unlike some studies regarding
the role of the exchange rate and its channel in monetary policy transmission. Svensson (2000b) recommends that the monetary authorities should target the Consumer Price Index (CPI) because these models produce less fluctuations in the exchange rate, output and domestic inflation. His findings, however, are concluded by a specific structure of his model where he considered a range of loss functions. The model in this chapter in contrast to the previous studies, the welfare loss function is a utility based function and the domestic inflation rate has been targeted by the optimal monetary policy rule. The empirical analysis of the resulting model is assessed in the next chapter and here the only task is to theoretically derive the optimal monetary policy rule.

3.6.2. Use of DSGE model

Dynamic Stochastic General Equilibrium (DSGE) methodology is used to build a microfoundation of our model to be used in the empirical section of the thesis. This methodology is employed to explain aggregate economic phenomena and the effect of the economic policies on the basis of macroeconomic models derived from microeconomic principles. Microfoundations are based on the preferences of decision makers e.g. households and firms in the economic models. As Woodford (2003b) argues, DSGE models characterise a benchmark to analysis the dynamic of welfare effect of the policy changes in the general equilibrium theory framework.

45 Some other studies that evaluate this stabilisation trade-off are; Aoki (2001) who did not find this trade-off under optimal policy of domestic inflation stabilisation, Kollmann (2002) who argues that the Taylor type of policy rule is an optimal rule by assuming domestic inflation, however, it causes a volatile exchange rate, Devereux and Engel (2003) and Devereux (2004) indicate that if the prices are set in a producer’s currency, this will lead to a fully flexible exchange rate.
In other words, by using a DSGE model, I aim to illustrate the behaviour of the economy as a whole by evaluating the interaction of many micro-decision makers. These decision makers in my example include, household as the consumers, firm as the producers of goods and services and central bank which tries to minimise its loss function. As the name of the DSGE models indicates, these models are appropriate to analysis the simultaneous welfare effect of consumers and producers, as they are dynamic and by this term we mean they illustrate how the economy evolves over time and its does not consider any specific time lag or ignoring the time preference in the case of static models. Also it is stochastic meaning that covers the fact that the economy can be affected by some random shocks such as change in the combination of the policy makers and economic regimes as well as oil price fluctuations.

To present a consistent depiction of a DSGE model, it should include three main features. Firstly, the objective of the agents existing in the economy must be clarified. This can be assumed as the utility maximisation of the households and cost minimisation of the firms. Secondly, the formation of the production function of the firms should be specified, indicating the amount of goods and services they produced which depends on the amount of capital and labour they employed. This can be interpreted as technology. And finally, the institutional constraints administrating economic interaction should be explained. This can be an exogenously defined budget constraint, or in more details, the specifications of the monetary and fiscal policies.

In the following sections of this chapter, I will employ a DSGE methodology in order to create a micro foundation of the Taylor type model which the latter is the benchmark model of the empirical analysis of the remainder chapters. As explained
in the previous chapter under the use of Taylor rule in a Usury-free financial system, this derivation will resolve the problem of using the profit rate instead of interest rate which the Taylor rule is based on. By the same token, I assume that the Taylor rule does not exist, and using a DSGE model I derive the loss function of the monetary authority and its operational monetary policy rule accordingly.

### 3.6.3. Household side

The model consists of a small open economy and a foreign country which represents the rest of the world economy. The home economy is populated by households who are assumed to live for infinity on the one hand, and firms as the production sector on the other hand, which forms the consumer-producer agents. Households supply labour to the firms and consume both domestic and foreign produced goods. This ratio of consumption is determined by the degree of openness of the economy. Firms use labour (individuals) and capital (borrowed from households) to produce domestic goods. A typical representative household try to maximise the utility function of:

$$U(C_t, L_t) = \frac{c_t^{1-\sigma}}{1-\sigma} \frac{L_t^{1+\phi}}{1+\phi}$$  \hspace{1cm} (3.1)

Where $C_t$ is the consumption of the household and $L_t$ is the hours of labour. As assumed before, the consumption of the household consists of domestic and foreign goods consumption which can be shown as:

$$C_t = \left\{ (1-\beta)^{\frac{1}{\theta}} (C_{D,t})^{\frac{\theta-1}{\theta}} + \beta^{\frac{1}{\theta}} (C_{F,t})^{\frac{\theta-1}{\theta}} \right\}^{\frac{1}{\theta}}$$  \hspace{1cm} (3.2)

Where $C_{D,t}$ and $C_{F,t}$ is consumption of domestic and foreign goods respectively and $\theta$ is positive and defined as elasticity of substitution between the goods produced by
domestic and foreign agents and $\beta$ represent the degree of openness of the economy. Using Dixit and Stiglitz (1997) definition of Constant Elasticity of Substitutions (CES) aggregators, the domestic and foreign consumption can be written as:

$$c_{D,t} = \left\{ \int_0^1 c_{D,t}(j) \frac{\varepsilon - 1}{\varepsilon} \, dj \right\}^{\frac{1}{\varepsilon - 1}}$$  \hspace{1cm} (3.3)

$$c_{F,t} = \left\{ \int_0^1 c_{F,t}(j) \frac{\varepsilon - 1}{\varepsilon} \, dj \right\}^{\frac{1}{\varepsilon - 1}}$$  \hspace{1cm} (3.4)

Where $\varepsilon > 1$ is the elasticity of substitution between varieties (produced good within the country) and $j \in (0,1)$ denotes the good variety. The prices of home and foreign produced good in a similar way can be expressed as:

$$p_{D,t} = \left\{ \int_0^1 p_{D,t}(j)^{1-\varepsilon} \, dj \right\}^{\frac{1}{1-\varepsilon}}$$  \hspace{1cm} (3.5)

$$p_{F,t} = \left\{ \int_0^1 p_{F,t}(j)^{1-\varepsilon} \, dj \right\}^{\frac{1}{1-\varepsilon}}$$  \hspace{1cm} (3.6)

Where $p_{D,t}$ is the Producer Price Index (PPI) and $p_{F,t}$ is the home price of the foreign produced good. Now, we can form the Consumer Price Index (CPI) as the weighted average of these two prices in the form of total consumption in equation (3.2) as:

$$p_t = \left\{ (1 - \beta)(p_{D,t})^{1-\theta} + \beta (p_{F,t})^{1-\theta} \right\}^{\frac{1}{1-\theta}}$$  \hspace{1cm} (3.7)

Therefore, the total consumption expenditure by domestic household is given by:

$$p_t c_t = p_{D,t} c_{D,t} + p_{F,t} c_{F,t}$$  \hspace{1cm} (3.8)
As a result, the corresponding budget constraint for the household in this economy can be written as:

\[ P_t C_t + D_t B_t \leq W_t L_t + \Pi_t + B_{t-1} + TR_t \] (3.9)

Where \( D_t \) is the price of a one period domestic bond, \( B_t \) is the domestic bond, \( W_t L_t \) is the total wages of labour, \( \Pi_t \) is the ownership profit of the firm and \( TR_t \) is the total lump-sum transfers from the government. In order to form the value function for the optimising problem we need to consider the one-period ahead budget constraint, to be able to calculate intertemporal effect of the value function. Consequently, the one period ahead budget constraint is simply written as:

\[ P_{t+1} C_{t+1} = W_{t+1} L_{t+1} + \Pi_{t+1} + B_t + TR_{t+1} - D_{t+1} B_{t+1} \] (3.10)

The value function is in the form of \( V_t(C_t) = \max \{ \sum_{i=t}^{T-1} U(C_i) \} \) and the corresponding Bellman Equation can be written as:

\[ V_t(C_t) = \max \{ U(C_t) + \beta E[V_{t+1}(C_{t+1})] \} \] (3.11)

Using equations (3.1) and (3.11) and considering intertemporal effect of expected term in equation (3.11), the new Bellman equation can be shown as:

\[ V_t(C_t) = \frac{e_1^{1-\sigma}}{1-\sigma} - \frac{\delta_t^{1+\phi}}{1+\phi} + \beta E[V_{t+1}(C_{t+1})] + V_t(C_t) \] (3.12)

---

46 Assuming the bonds last only for one period and the individuals only invest on domestic bonds.

47 It is useful to note that the value function originally take the form of: \( V(x_0) = \max \sum_{t=0}^{\infty} \beta^t U(x_t, a_t) \) subject to the constraint of: \( a_t \in \Lambda(x_t), x_{t+1} = T(x_t, a_t), \forall t \in \{0, ..., \infty\} \), which represent the optimal value that obtained from maximising the objective function subject to the proposed constraint.
By substituting the values of $C_t$ and $C_{t+1}$ from the equations (3.9) and (3.10) respectively the following first order conditions will be concluded:

\[
\frac{\partial v_t}{\partial b_t} = V_t'(C_t) * \left( -\frac{B_t}{P_t} \right) = (C_t^{-\sigma}) * \left( -\frac{B_t}{P_t} \right) = 0
\]

\[taking \ ln(\cdot) \Rightarrow -\sigma c_t - b_t + p_t = 0\] (3.13)

\[
\frac{\partial v_t}{\partial w_t} = -w_t^{\sigma} + V_t'(C_t) * \left( \frac{w_t}{P_t} \right) : w_t - p_t - \sigma c_t = \varphi l_t \quad \text{(Optimal labour supply)} (3.14)
\]

\[
\frac{\partial v_t}{\partial c_t} = V_t'(C_t) = C_t^{-\sigma} : = -\sigma c_t, \quad (3.15)
\]

\[
\frac{\partial v_{t+1}}{\partial c_{t+1}} = V_{t+1}'(C_{t+1}) = C_{t+1}^{-\sigma} : = -\sigma c_{t+1} \quad (3.16)
\]

\[
\frac{\partial v_t}{\partial \beta_t} = \frac{\beta}{P_{t+1}} V_{t+1}'(C_{t+1}) - \frac{d_t}{P_t} V_t'(C_t) : \frac{\beta}{P_{t+1}} C_{t+1}^{-\sigma} - \frac{d_t}{P_t} C_t^{-\sigma}
\]

\[\therefore D_t = \frac{\beta C_{t+1}^{-\sigma} p_{t+1}}{C_t^{-\sigma} p_t} \quad C_t^{-\sigma} = \frac{\beta C_{t+1}^{-\sigma} p_{t+1}}{D_t p_{t+1}} \quad (3.17)
\]

By taking the natural logarithm of the latter part of equation (3.17) the consumption Euler equation can be written as (the lower letters denote natural logarithms of variables):

\[c_t = -\sigma^{-1} (ln\beta - \sigma c_{t+1} + p_t - d_t - p_{t+1}) \quad (3.18)
\]

The foreign country is assumed to have the same specification of the home country, consequently its consumption Euler equation can be written as:

\[C_{t+1}^{t+\sigma} = \frac{\beta C_{t+1}^{-\sigma} p_{t+1}}{D_t p_{t+1}} \quad \therefore c_t^{t+\sigma} = -\sigma^{-1} (ln\beta - \sigma c_{t+1} + p_t^{t+\sigma} - d_t - p_{t+1}^{t+\sigma}) \quad (3.19)\]
After some manipulation and assuming that there is no arbitrage in financial markets, the nominal exchange rate can be written as:

\[ e_t - E_{t+1}e_{t+1} = i_t^* - i_t + \xi_t \quad (3.20) \]

Where \( e_t \) is the log of nominal exchange rate, \( i_t \) is nominal interest rate (domestic) and \( i_t^* \) is the foreign country nominal interest rate and \( \xi_t \) shows any deviation from Uncovered Interest Parity (UIP) and can be expressed as the risk premia. The real exchange rate varies over time as a result of different combinations of the domestic and foreign country consumption basket\(^{48} \), therefore we can consider the log linear version of real exchange rate as:

\[ e_t = q_t + p_t - p_t^* \quad (3.21) \]

Where \( q_t \) is the real exchange rate \( p_t \) and \( p_t^* \) are the domestic and foreign CPI respectively. If we assume the complete international financial market and no arbitrage opportunity, from Euler equation, and equation (3.21) the resulting equation indicating the relationship between consumption and real exchange rate can be shown in log linear version as:

\[ c_t = c_t^* + \frac{1}{\sigma} q_t \quad (3.22) \]

Equation (3.22) indicates that assuming the real exchange rate is constant, if the elasticity of intertemporal substitution in consumption \((\frac{1}{\sigma})\) is high/low, the consumption differential will be high/low.

\(^{48}\) For empirical evidence see Chari et al. (1997) and (2002) and for more theoretical discussion see Divino (2009).
3.6.4. Producer side

A typical firm in a home economy produces differentiated goods with a linear technology model which is characterised by the following production function:

\[ Y_t(j) = A_t L_t(j) \] (3.23)

Where \( A_t \) is a technological shock assume to follow AR(1) process i.e. \( a_t = \rho a_{t-1} + \varepsilon_t \) where \( a_t = \ln A_t \). Hence, the real marginal cost (in terms of home country price) will be in the form of:

\[ mc_t = -\varrho + w_t - p_t - a_t \] (3.24)

Where the new term \( \varrho \) is logarithm of employment subsidy which will be neutral in derivations of the policy rule and will be explained in due time.

Let the aggregate output and aggregate labour demand, similar to the consumption index format, be defined as:

\[ Y_t = \left\{ \int_0^1 Y_t(j) \frac{e-1}{\pi} dj \right\}^{\frac{e}{e-1}} \] (3.25)

\[ L_t = \int_0^1 L_t(j) dj \] (3.26)

From equations (3.23), (3.25) and (3.26), and following Gali and Monacelli (2005), the aggregate relationship can be written in log linear form as:

\[ y_t = a_t + l_t \] (3.27)

Where \( a_t \) is the total factor productivity and \( l_t \) is employment rate. In order to have the condition of the clearing market met, the total supply or output of good \( j \) should
be equal to aggregate demand of the good which involves both domestic and foreign consumption of domestic goods as:

\[ Y_t(j) = C_{D,t}(j) + C_{D_t}^*(j) \]  \hfill (3.28)

It is also assumed that the home economy does not have any effect on the foreign country and the foreign country can be assumed as a closed economy where its equilibriums are exogenous to the home economy, consequently we can write:

\[ P_t^* = P_{F,t}^* \quad \text{and} \quad C_t^* = C_{F,t}^*. \]

Then from equation (3.3) and (3.22) also the corresponding definition for foreign country one can write the relationships between the domestic and foreign outputs (in logarithm form) as:

\[ y_t = y_t^* + \eta s_t \]  \hfill (3.29)

Where \( s_t \) is the logarithm of terms of trade as the ratio of foreign price to the domestic price, \( y_t \) and \( y_t^* \) are domestic and foreign output respectively and \( \eta \) is a positive coefficient. From equations (3.29) and (3.22) and considering the equilibrium condition for the foreign country i.e. \( c_t^* = y_t^* \) the following relationship between consumption and outputs can be concluded:

\[ c_t = \mu y_t + (1 - \mu) y_t^* \]  \hfill (3.30)

Where \( \mu \) is a positive coefficient not greater than one, clearly and \( c_t \) is logarithm of domestic consumption.

Recalling Euler equation as express in equation (3.18), and rewriting it by considering the expected value of the future term, the Euler equation can be shown as:
\[ c_t = E_t c_{t+1} - \frac{1}{\sigma} (-\gamma - E_t \pi_{t+1} + i_t) \quad \text{Where } -\gamma = \ln \beta \] (3.31)

By equalising equations (3.30) and (3.31) we have:

\[ \mu y_t + (1 - \mu) y^*_t = E_t c_{t+1} - \frac{1}{\sigma} (-\gamma - E_t \pi_{t+1} + i_t) \] (3.32)

And solving equation (3.32) for \( y_t \) while considering the lag of equation (3.30) as:

\[ c_{t+1} = \mu y_{t+1} + (1 - \mu) y^*_t \] (3.33)

one can write:

\[ y_t = \frac{1}{\mu} \left[ E_t (c_{t+1}) - \frac{1}{\sigma} (-\gamma - E_t \pi_{t+1} + i_t) - (1 - \mu) y^*_t \right] \] (3.34)

And by substituting the equivalent of \( E_t (c_{t+1}) \) from equation (3.33), we have:

\[ y_t = E_t (y_{t+1}) - \frac{1}{\mu \sigma} (-\gamma - E_t \pi_{t+1} + i_t) - \frac{1-\mu}{\mu} E_t \Delta y^*_t \] (3.35)

The equation (3.35) indicates that domestic output depends on fluctuation of the exchange rate and degree of openness of the economy and the variation of the exchange rate can affect imports, price level and then the interest rate.\(^\text{49}\) According to this, if the gap (deviation from current level in this case) of the foreign output is positive, then we expect the domestic and foreign aggregate demand to be positively correlated.

In order to find the output gap we need to add an identical term of \((-\bar{y}_t - E_t \bar{y}_{t+1})\) to the both sides of equation (3.35), we have:

\(^\text{49}\) Chapter 4 summarises this empirical analysis comprehensively via analysing the shocks to the model and evaluating the corresponding impulse response functions.
Where $x_t$ is the deviation of output from its equilibrium level stated as the output gap.

### 3.6.5. Marginal cost

Recalling equation (3.24) as the firm’s initial marginal cost and using equation (3.14) as the optimal labour supply in household optimisation section, and substituting equation (3.14) into (3.24) one can write the marginal cost equation as:

$$mc_t = -\varphi + \varphi l_t + \sigma c_t - a_t$$ (3.38)

Where $\varphi$ is the wage elasticity of labour supply (derived from the F.O.C in equation 3.14). By substituting the equivalents of $c_t$ and $l_t$ from equations (3.30) and (3.27) respectively the marginal cost of the firm can be shown as:

$$mc_t = -\varphi + \varphi(y_t - a_t) + \sigma[\mu y_t + (1 - \mu)y_t^*] - a_t$$ (3.39)

After some simple manipulation, the real marginal cost of the firm in terms of both domestic and foreign output and productivity can be expressed as:

$$mc_t = -\varphi + (\varphi + \sigma\mu)y_t - (1 + \varphi)a_t + \sigma(1 - \mu)y_t^*$$ (3.40)

When the marginal cost of a firm is zero the equilibrium level of output can be yielded, consequently by considering the equation (3.40) equal to zero it is easy to show that:
\[ \ddot{y}_t = \left( \frac{1}{\varphi + \sigma \mu} \right) [\varrho + (1 + \varphi) a_t - \sigma (1 - \mu) y^*_t] \] (3.41)

By substituting equation (3.41) and its lag into equation (3.37) we have:

\[ x_t = \left( \frac{1}{\varphi + \sigma \mu} \right) [\varrho + (1 + \varphi) E_t a_{t+1} - \sigma (1 - \mu) E_t y^*_{t+1}] + E_t x_{t+1} - \left( \frac{1}{\varphi + \sigma \mu} \right) [\varrho + 1 + \varphi \sigma t - \sigma 1 - \mu y_t^* - 1 \mu \sigma - \gamma - E_t \pi t + 1 + i t - 1 - \mu E_t \Delta y t + 1^*] \] (3.42)

After some simple manipulation we have:

\[ x_t = \left( \frac{1}{\varphi + \sigma \mu} \right) [(1 + \varphi) E_t \Delta a_{t+1} + \left[ \sigma (1 - \mu) \left( \frac{1 - \mu}{\mu} \right) \right] E_t \Delta y^*_{t+1}] + E_t x_{t+1} - \frac{1}{\mu \sigma} (-\gamma - E_t \pi_{t+1} + i_t) \] (3.43)

One can write the equation of the output gap in the following form of aggregate demand (IS curve) as:

\[ x_t = E_t x_{t+1} - \frac{1}{\mu \sigma} (-\bar{r}_t - E_t \pi_{t+1} + i_t) \] (3.44)

Where \( \bar{r}_t = \gamma - \mu \sigma \left[ \left( \frac{1}{\varphi + \sigma \mu} \right) [(1 + \varphi) E_t \Delta a_{t+1} + \left[ \sigma (1 - \mu) \left( \frac{1 - \mu}{\mu} \right) \right] E_t \Delta y^*_{t+1}] \right] \)

### 3.6.6. Aggregate Supply and Calvo\(^{50}\) price setting

In a small open economy as discussed by Gali and Monacelli (2005), domestic inflation can be interpreted in terms of real marginal cost as:

\[ \pi_t = \beta E_t (\pi_{t+1}) + \lambda m\bar{c}_t \] (3.45)

\(^{50}\) Firm assumed to set the prices according to the Calvo (1983) framework.
Where $\bar{m}c_t$ is the deviation of real marginal cost from the marginal cost under the fully flexible price setting i.e.

$$\bar{m}c_t = mc_t - \bar{m}c_t \quad (3.46)$$

From equation (3.40) we can write the expression of the marginal cost under the flexible prices as:

$$\bar{m}c_t = -\varphi + (\varphi + \sigma\mu)\bar{y}_t - (1 + \varphi)a_t + \sigma(1 - \mu)y_t^* \quad (3.47)$$

From equation (3.40) and (3.47), $\bar{m}c_t$ can be written as:

$$\bar{m}c_t = (\varphi + \sigma\mu)x_t \quad (3.48)$$

Now in order to derive a version of the New Keynesian Philips Curve (NKPC) we can combine equations (3.45) and (3.48) as following to find the expression of inflation in a small open economy in terms of the output gap:

$$\pi_t = \beta E_t(\pi_{t+1}) + \theta x_t \quad \text{where } \theta = \lambda(\varphi + \sigma\mu) \quad (3.49)$$

The final part after conducting the equation of inflation is to minimise the loss function in order to find the optimal monetary policy rule.

**3.6.7. The loss function of central bank and optimal policy rule**

In order to obtain policy targets, a representative monetary authority (Central Bank) minimises the effective social loss function taking the small open economy rational expectation as well as equilibrium conditions. Following Woodford (2003) a modified quadratic loss function of the monetary authority under inflation targeting can be written as:
Where \( \pi_t \) is inflation target, \( x_t \) is the output gap and \( i \) is the target interest rate (equilibrium interest rate). The objective is to minimise equation (3.50) subject to equations (3.44) and (3.49) in order to find the policy rule defined as the short term interest rate. The solution uses the Lagrangian method\(^{51}\) to find the following equation of interest rate:

\[
i_t = \zeta_0 i + \sum_{j=1}^{2} \zeta_{ij} i_{t-j} + \zeta_{i} (\pi_t - \pi_e^t) + \zeta_{x} x_t - \beta \zeta_{x} x_{t-1}
\]  

(3.51)

Where the coefficients are \( \zeta_0 = -\frac{\theta}{\mu \sigma} \), \( \zeta_i = \beta \), \( \zeta_{\pi} = \frac{\theta}{\mu \sigma \omega_i} \), \( \zeta_{x} = \frac{\omega_x}{\mu \sigma \omega_i} \). Equation (3.51) implies that the degree of openness of the economy effect the policy rule coefficient, as it can be seen the term of exchange rate does not exist in this equation indicating the limitation of the implication of such a policy rule under a fully floating exchange rate, due to the resulting model (equation 3.51), interest rate will take the effect of fluctuation of the exchange rate indirectly through the domestic inflation and output. Consequently, the resultant rule of the monetary policy is a Taylor type rule which has taken into account the effect of an inflation target.

### 3.7. Conclusion

To sum up, I can divide this chapter into two main divisions. Firstly, I tried to present an overview of the rationale behind maintaining low inflation, cost of inflation and inflation targeting framework and its perquisites. The advantages and

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\(^{51}\) For details of the solution see appendix.
disadvantages of inflation targeting, the alternative strategies for it and why inflation targeting has priorities over them are also explained.

Secondly, after expressing the Taylor rule briefly, Due to the lack of micro-foundation of the Taylor rule, a small open economy model based on a DSGE-type model were constructed in order to find an optimal monetary policy rule for the economy. The model benefited from the base model of Gali and Monacelli (2005) and derived the monetary authority’s reaction function to the macroeconomic variables in the model. The role of the exchange rate has been evaluated and it does have a direct effect on domestic inflation and aggregate supply and consequently, the producer’s marginal cost but it has an indirect consequence on aggregate demand.

The important point and novelty of this model, is where the inflation target has been consider by the monetary authorities and the reaction function is in response to the inflation gap and not inflation rate. This will prepare a good foundation of the model in (future) empirical analysis to adopt an inflation targeting framework in small open economies.

The resulting monetary policy rule indicates that the central bank should react to the output gap and its first lag, inflation gap, and two lags of interest rate, and also indirectly respond to the deviation of exchange rate via its effect on aggregate supply and output.
Appendix

- Optimal monetary policy rule

This appendix shows the steps of derivation of the optimal monetary policy rule by minimising the loss function of the central bank for domestic inflation targeting in a case of small open economy. From the main text we have the loss function in the form of:

\[ L = (\pi_t - \pi_t^*)^2 + \omega_x x_t^2 + \omega_i (i_t - \bar{i})^2 \]  

(1)

We are going to minimise this function subject to the following constraint equations for inflation and output derived in the main text:

\[ \pi_t - \beta E_t (\pi_{t+1}) - \theta x_t = 0 \]  

(2)

\[ x_t - E_t x_{t+1} + \frac{1}{\mu} (-\bar{r}_t - E_t \pi_{t+1} + i_t) = 0 \]  

(3)

To do so, I apply the widely used Lagrange method as follows. First I form the Lagrange equation which combines the main function and constraints as well as one lag of the resulting equation:

\[ \mathbb{L} = (\pi_t - \pi_t^*)^2 + \omega_x x_t^2 + \omega_i (i_t - \bar{i})^2 - \lambda_{1,t} \left[ x_t - E_t x_{t+1} + \frac{1}{\mu} (-\bar{r}_t - E_t \pi_{t+1} + i_t) \right] - \lambda_{2,t} \left[ \pi_t - \beta E_t (\pi_{t+1}) - \theta x_t \right] + (\pi_{t-1} - \pi_{t-1}^*)^2 + \omega_x x_{t-1}^2 + \omega_i (i_{t-1} - \bar{i})^2 - \lambda_{1,t-1} \left[ x_{t-1} - x_t + \frac{1}{\mu} (-\bar{r}_{t-1} - \pi_t + i_{t-1}) \right] - \lambda_{2,t-1} [\pi_{t-1} - \beta \pi_t - \theta x_{t-1}] \]  

(4)

The first order conditions for \( \mathbb{L} \) with respect to \( \pi_t, x_t \) and \( i_t \) can be shown as:

\[ \frac{\partial \mathbb{L}}{\partial \pi_t} = 2(\pi_t - \pi_t^*) - \lambda_{2,t} + \frac{\lambda_{1,t-1}}{\mu} + \beta \lambda_{2,t-1} = 0 \]  

(5)
By substituting (7) and (8) into (6) we have:

\[
\frac{\partial L}{\partial x_t} = 2\omega_x x_t - \lambda_{1,t} + \theta \lambda_{2,t} + \lambda_{1,t-1} = 0
\]  
\[\begin{align*}
\frac{\partial L}{\partial i_t} &= 2\omega_i (i_t - \bar{i}) - \frac{\lambda_{1,t}}{\mu \sigma} \\
\therefore \quad \lambda_{1,t} &= 2\mu \sigma \omega_i (i_t - \bar{i}) \\
\therefore \quad \lambda_{1,t-1} &= 2\mu \sigma \omega_i (i_{t-1} - \bar{i})
\end{align*}
\]  

(6)  
(7)  
(8)

By substituting (7) and (8) into (6) we have:

\[
2\omega_x x_t - 2\mu \sigma \omega_i (i_t - \bar{i}) + 2\mu \sigma \omega_i (i_{t-1} - \bar{i}) = \theta \lambda_{2,t}
\]  
\[
\therefore \quad \lambda_{2,t} = \frac{2}{\theta} [\mu \sigma \omega_i (i_t - i_{t-1}) - \omega_x x_t]
\]  
\[
\therefore \quad \lambda_{2,t-1} = \frac{2}{\theta} [\mu \sigma \omega_i (i_{t-1} - i_{t-2}) - \omega_x x_{t-1}]
\]

(9)  
(10)  
(11)

And by substituting the equivalents of (8), (10) and (11) into (5), one can write:

\[
2(\pi_t - \pi^*) - \frac{2}{\theta} [\mu \sigma \omega_i (i_t - i_{t-1}) - \omega_x x_t] + \frac{2\mu \sigma \omega_i (i_{t-1} - \bar{i})}{\mu \sigma} + \beta \frac{2}{\theta} [\mu \sigma \omega_i (i_{t-1} - i_{t-2}) - \omega_x x_{t-1}]
\]  
\[
i_t \quad = 0
\]

(12)

With some simple manipulation on equation (12) one can derive the dependent variable \(i_t\) as:

\[
i_t = \zeta_0 \bar{i} + \sum_{j=1}^{2} \zeta_{ij} i_{t-j} + \zeta_\pi (\pi_t - \pi^*) + \zeta_x x_t - \beta \zeta_x x_{t-1}
\]

(13)

Where:

\[
\zeta_0 = -\frac{\theta}{\mu \sigma}, \quad \zeta_i = \beta, \quad \zeta_\pi = \frac{\theta}{\mu \sigma \omega_i}, \quad \zeta_x = \frac{\omega_x}{\mu \sigma \omega_i}
\]
Chapter 4: INFLATION AND EXCHANGE RATE IN IRAN
4.1. Introduction

By introducing the open economy phenomenon, and the fact that each country does need the products of other countries (considering the distribution of the resources in the World) in order to satisfy the preferences of the individuals living in domestic economy, the role of the exchange rate has secured a place in most of the macroeconomic debates. In this chapter we are interested in evaluating the effect of exchange rate on inflation both theoretically and empirically using the real data of Iran. The literature which addresses this issue is increasing and the monetary economists are trying to find a remedy for the shocks to inflation from fluctuations in the exchange rate. The fact that inflation targeting has a positive effect on reducing inflation or at least reducing the volatility of inflation is shown by the experience of the countries adopted such a framework and discussed in more details in chapter three.

The rising number of both developing and developed countries that adopted such a policy and their successes in decreasing inflation and controlling the price levels is supporting this fact.\textsuperscript{52} Cordero (2008) has compared the performance of a monetary policy under inflation targeting with one with real exchange rate targeting. He argues that the inflation targeting strategy is very effective at price stabilisation, but it has a negative effect on the growth rate and employment. He also concludes (in the case of a small open economy) if a country wants to embark on inflation targeting regimes, \textsuperscript{52}See the work of Lin and Ye (2009) for evaluating the treatment effect of inflation targeting in thirteen developing countries, they conclude that this effect is largely significant, but the performance of this rule can be affected by a country characteristics of economic policy such as dominance of the government fiscal policies, the exchange rate peg in central bank desires and the time length since the policy espousal.
it should abide by higher inflation goals to avoid excessive appreciations on the real exchange rate. The logic behind this phenomenon can be illustrated in the case of high-inflation developing economies (such as Iran) where the authorities should abide the target of inflation over ten percent and try to reduce it further in the other long-term plans after success of this first step. Iran is a good example of a case vulnerable to the appreciation of the real exchange rate as the inertia of the sanctions on the economy and the Central Bank and the limitation of transferring the foreign currencies into and out of Iran by banking system.

There is still a long standing question of how the monetary authorities should respond to the exchange rate movements, however, it is widely recognised that the exchange rate plays a significant role in the transmission of monetary policy in an open economy. Some key studies on this issue are presented by Gali and Monacelli (2005), Taylor (2001), Svensson (2000b), among others. Some notable authors believe that developing countries have a kind of fear of floating about the exchange rate and hence they should implement fixed exchange rate regimes. For instance, Ball and Reyes (2004), Bigio (2010), Calvo and Reinhart (2002), Hagen and Zhou (2009), Cavoli (2009), Honig (2005) and Schmidt-Hebbel and Tapia (2002) have analysed the effect of the floating exchange rate in developing economies. After the financial crisis in the 1990s (such as the Asian financial crisis that began from the currency crisis of Thailand in 1997), many countries moved to flexible exchange rate regimes along with inflation targeting. More precisely, after the 90th decade when the currency was easing off following the global crash (which continued until the early 20th century), a growing number of economies moved away from a fixed exchange rate and allowed the exchange rate to be more flexible (float) when adopting
inflation targeting in their monetary policy.\textsuperscript{53} It does not mean that the exchange rate should be ignored in designing a monetary policy in an open economy.

Some researchers and monetary authorities argue that the exchange rate should not be considered directly in conducting a monetary policy rule because as long as the exchange rate movement is significant in such a way that affects demand and supply sides of the economy, the central bank would be better off to follow solely an inflation targeting regime.\textsuperscript{54} By this assumption, if inflation is brought close to the desired target, the central bank would also respond indirectly to the exchange rate. However, some inflation targeting central banks consider that the exchange rate directly influences the policy rule and as a result, has its own role in designing the monetary policy framework.\textsuperscript{55} It seems exploring the role of the exchange rate in constructing a monetary policy framework where it implicitly or explicitly has inflation targeting, is a country specific matter that should be investigated empirically based on country specific conditions.

Granville and Mallick (2006) have evaluated the role of the exchange rate in the monetary policy in Russia during the post-communist period and concluded that the monetary authority should consider a flexible targeting model for controlling inflation. Garcia et al. (2011) have examined whether including the exchange rate in conducting monetary policy under inflation targeting framework, will influence the economic performance and changes the results comparing to the case when exchange

\textsuperscript{53} As discussed in the previous chapter, one of the perquisites of inflation targeting was that the monetary authorities does not target any other objective such as exchange rate.

\textsuperscript{54} See for example Divino (2009) and Gali and Monacelli (2005) for more discussion.

rate fluctuations were ignored in construction of inflation targeting regimes. They conclude that when an economy is vulnerable it is likely to benefit if the monetary authorities can have a smooth exchange rate path through while the economy experiences demand shocks.

Svensson (2002) compares the advantages and disadvantages of considering inflation targeting as an instrumental rule and argues that it would be enhanced if the monetary authorities consider inflation targeting as a goal-directed optimising policy rule rather than following a mechanical instrumental rule. However, in practice most of the central bankers implement it as a consequence of the instrumental rule.

In this chapter, the main question to address is;

**Whether or not the monetary authorities in Iran should consider the fluctuation of the exchange rate in designing the inflation targeting framework and the conduct of monetary policy for the economy of Iran.**

This fact that the relationship between the exchange rate and inflation is a country specific phenomenon, become the main motivation of the analysis of this chapter that how exchange rate volatility will affect inflation and other components of the monetary policy in Iran. This is an important question for the authorities in Iran since Iran is a country that has been suffering from high level of inflation over the past thirty years. Therefore, this chapter will be an examination of the extent to which the exchange rate is significant in construction of the monetary policy.

To do this, based on the findings from chapter three, a model is constructed for a small open economy where a Monetary Condition Index (MCI) is derived from
minimising a loss function of the monetary authority. Unlike some literature that use an *ad-hoc* interest rate rule as the operating target of monetary policy, in this chapter, in the theoretical part which follows this introduction, an interest rate equation is derived using the relevant MCI for Iran.\(^56\)

Many central banks have used MCIs in order to include the exchange rate in construction and implementation of monetary policy. The definition of the MCI is almost the same in different countries and can be defined as a combination of short-term interest rate and the real or nominal exchange rate. However, countries follow their own interpretation of it in practice. For instance, monetary authorities in New Zealand and Canada, use MCI as an operating target while in contrast, Norway, Finland, Sweden and Iceland use it as an indicator amongst the other indices.\(^57\)

The resulting monetary policy reaction function is a Taylor type rule in which the term of the exchange rate exists in the function.

To create a link between this chapter and the previous chapter where a Taylor type rule were derived using the microeconomic principles of a DSGE model, I can divide the target of these two chapters into two parts; in the previous chapter the main target was to answer this question that “*how Taylor rule can be used in a Usury-free system?*”. While in this chapter I aim to answer “*whether exchange rate has significant effect on inflation in Iran to be included in the construction of the inflation targeting monetary policy framework*”. My analysis in this chapter is based

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\(^56\) This derivation is based on Civcir and Akcaglayan (2010), and I tried to emphasise the role of the exchange rate in the central bank reaction function.

\(^57\) For more evidence of the different use of MCI see for instance, Gerlach and Smets (2000), Grande (1997), Ball (1998) and Svensson (2000a).
on the findings of the previous chapter i.e. the relationship between the interest rate (deposit rate), inflation and output. The new term which is added here using MCI is the exchange rate as well as two country specific variables which the details follow.

In order to test this model empirically, a Vector Autoregressive (VAR) model has been constructed. Then, the effects of exchange rate shocks on the components of the monetary policy (specifically inflation) are inspected based on impulse response functions. The results indicate that, both inflation and monetary policy instrument (in this case deposit rate in Iran, as the replacement of interest rate) do respond significantly to the positive shocks of the exchange rate. The reason that I have used VAR technique to evaluate the effects of the variables on each other is because of the difficulties in constructing the specific model for Iran. Another way is to estimate the resultant model on Iranian data but the results are not helping us to answer the main question of this chapter.

It should be specify that I have not estimated the Taylor rule or the resultant Taylor type rule, but I have used it as the base of theoretical part of this chapter to be able to include exchange rate volatility via MCI.

One may ask that why a VAR has been used in estimation while the derivations is based on the Taylor rule? To answer this critique, I will use the application of the VAR technique. In modelling the macroeconomic variables, where there does not exist a straightforward and clear relationship of how the variables affecting each other and the dependent variable, or it is too difficult to manipulate such a relationship, we use VAR to see the possible relationship between variables.
Although we have derived the resultant MCI in this chapter using a Taylor type rule in theory but the real data in Iran cannot be modelled using this relationship and as explained before will not yield appropriate results. To overcome this problem, I used the general VAR technique which is a highly used technique in the literature.

The remainder of this chapter consists of section 4.2 in which an applicable version of the Taylor type model for monetary policy rule based on the relative MCI is constructed. Section 4.3 provides information of empirical analysis of the monetary policy in Iran using the impulse response functions, and section 4.4 concludes the chapter.

4.2. The model

The main question to address in this chapter is whether or not the Central Bank of Iran (CBI) should consider the exchange rate in forming an inflation targeting monetary policy. As the current policy of the CBI is to exclude the effects of fluctuations of the exchange rate on the central bank reaction function, an attempt is made here to develop a reaction function for the central bank which takes into account the volatility of the exchange rate. This is important to the Iranian economy as the other attempts were not successful in reducing inflation rate and increasing the welfare of the individual in Iran. The modified version of the Taylor-based reaction function derived in chapter two is taken as the base of theoretical analysis. With the purpose of evaluating this effect, a study of the impulse response function to a variety of shocks in the model has been carried out which will follow in the next section.
In order to include the exchange rate in the model theoretically, a version of the monetary condition index (MCI) from aggregate demand equation in a small open economy framework is derived by constructing a typical monetary policy model responsive to an inflation targeting framework under the flexible exchange rate in an open small economy. The starting point for the analysis is the same as the Taylor (1993) type rule reaction function, followed by Civcir and Akcaglayan’s (2010) assumptions in the small open economy, I derive the monetary policy rule where it demonstrates that the exchange rate has a direct effect on the policy rule. In fact, the concluding model is a Taylor type rule augmented by the effects of exchange rate movements and the other country specific variables.

4.2.1. Flexible inflation targeting with exchange rate pass-through

Although some researchers assume specific conditions for an economy such as the limitation of the fluctuation of the exchange rate (or by the same token assuming a closed economy by its definition) in order to adopt inflation targeting, but in the real world there is not a closed economy which uses this framework in its monetary policy in practice. Consequently, the effect of the exchange rate cannot be ignored in constructing such a policy framework. Svensson (2000b) argues that the exchange rate and the shocks from the rest of the world should be considered and are important for conducting an inflation targeting monetary policy.

He concludes that including the exchange rate in inflation targeting has several important consequences which cannot be dismissed. In an open economy model, the

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58 See for example Svensson (1997a) (1997b), where he discusses the implication of inflation targeting excluding the effect of exchange rate volatility.
exchange rate will influence relative prices between foreign and domestic goods which will cause these changes to both foreign and domestic demand for domestic goods and therefore it affects supply to the aggregate demand channel in transmission of the monetary policy. In regards to the effect of the exchange rate on the consumer price index (CPI) and the percentage changes in it (known as CPI inflation), there is a direct influence, in which the exchange rate affects the domestic currency prices for imported final goods, which will directly enter the CPI. As a result, by the same token, by taking into account the exchange rate volatility, monetary policy can have an effect on CPI inflation with a shorter lag. And ultimately, the movements on the exchange rate will affect the domestic currency prices of imported intermediate inputs, and in the long run nominal wages will be influenced by the effects of CPI on wage setting.\(^{59}\)

In order to embrace the exchange rate in the monetary policy framework, following most of the inflation targeting literature, the fundamental reaction function of the central bank as a Taylor (1993) type rule can be considered as:

\[
i_t = r_t^* + \pi_t + \alpha_\pi (\pi_t - \pi_t^*) + \alpha_y (y_t - y_t^*)
\]

(4.1)

where \(i_t\) is the short-term nominal interest rate, \(r_t^*\) is equilibrium real interest rate, \(\pi_t\) is inflation rate, \(\pi_t^*\) is desired rate of inflation, \(y_t\) is the logarithm of real GDP, \(y_t^*\) is logarithm of potential GDP as determined by a linear trend (e.g. Hodrick-Prescott (HP) filter of real GDP) and \(\alpha_\pi\) and \(\alpha_y\) are positive coefficients.\(^{60}\)

\(^{59}\) See for more discussion Divino (2009).

\(^{60}\) In Taylor (1993) these two coefficients both generated equals to 0.5 and the target rate of inflation equals to 2 for US data he has found this manner of the data over a time series analysis.
4.2.2. Monetary Condition Index

A Monetary Condition Index (MCI) is an indicator that merges the movements in different financial variables with the principle that is a reference to the financial markets and the public at a point in time comparative to some point in the past. This index can be used as a short-term operating target in the conduct of the monetary policy. In other words, a monetary condition index is an index that is used to present a monetary policy based on the components of aggregate demand in an open economy and allows more flexibility to the policy makers to include some variables which is important to be observed.

The Bank of Canada is credited with pioneering the use of this concept in the early 1990s. The objective of the MCI is to present an estimation of influences that the components of a monetary policy is having on the economy. The model, which is stimulated from a standard open economy framework, characterises the aggregate demand side of the economy as a function of the exchange rate and the interest rate in real term amongst other variables.

In regards to interpretation of MCI and to see if this can be used as an instrument or operational target of central bank, the arguments differ in developed and developing economies. As Stevens (1998) states; “in most of developed economies short-term interest rate is the only genuine instrumental tool for monetary policy in practice.” But, when the case changes to developing countries, where there are not well-

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62 The other variables here are the country specific variables in which in Iran, I consider two variables namely; budget deficit and oil exporting revenue.
working financial systems, the authorities need to consider other variables in designing operational target.

To start with, a very simple form of aggregate demand in an open economy can be written as:

\[ y_t = \alpha_1 r_t + \alpha_2 q_t + \vartheta_t \]  

(4.2)

where \( r_t \) is the real interest rate, \( q_t \) is the real exchange rate, \( \vartheta_t \) is the other factors that affect the aggregate demand and \( \alpha_1 \) and \( \alpha_2 \) are the coefficients which reflect the relative effect of real interest rate and exchange rate on aggregate demand. These two coefficients determine the weight of the exchange rate in the MCI in equation (4.3) below. Following Stevens (1998) and Bofinger and Wollmershauser (2001) the MCI can be expressed as a combination of the real interest rate and exchange rate in the form of the following equation with the added country specific term (unique to the model):

\[ MCI_t = \alpha_1 (r_t - r_0) + \alpha_2 (q_t - q_0) + \alpha_\kappa \kappa_t + 100 \]  

(4.3)

in equation (4.3), \( MCI_t \) is the monetary condition index at time \( t \), the interest rate \( r_t \) is calculated in percentage and \( r_0 \) is the based interest rate which can be the longrun target of real interest rate. The exchange rate is calculated as the gap between current real exchange rate \( q_t \) and \( q_0 \) the based (some favourable rate in the past or its target) exchange rate. \( \kappa_t \) is the relevant variable from the other factors (\( \vartheta_t \)) in equation (4.2) which is country specific variables. In our case study as discussed in chapter 2 and 3, I will consider two important variables namely government Budget Deficit (BD) and Oil Export Revenue (OER) in construction of the specific MCI for
Iran. And finally, as $MCI_t$ is an index it is assumed to be equal to 100 at its base date.

For simplicity and to establish a starting point of calculation in order to derive the optimal MCI, by setting $r_0 = 0$ and the base of the index (100) equal to zero and expanding $\kappa_t$ to $BD_t$ and $OER_t$, we can write equation (4.3) as:

$$MCI_t = \alpha_1 r_t + \alpha_2 \Delta q_t + \alpha_3 BD_t + \alpha_4 OER_t$$

(4.4)

where $\Delta q_t$ is the change of the real exchange rate and $r_t$ is the real short-term interest rate, $BD_t$ is the government budget deficit and $OER_t$ is the revenue from exporting oil in Iran. More precisely, MCI presented in equation (4.4), illustrates the demand side of the economy where exchange rate and interest rate channels are determined plus two other important country specific factors. Consequently, two important operating targets (i.e. real interest rate (deposit rate in Iran) and real exchange rate) of central bank are determined by equation 4.4. Under the sticky price assumption, the real interest rate and the real exchange rate are perfectly correlated with their nominal values. $\alpha_1$ and $\alpha_2$ capture the estimated effects of the nominal interest rate and exchange rate on aggregate demand and as a result, on inflation. (This complete and direct effect will be in the case of the vertical supply curve, however)

Bofinger and Wollmershauser (2001) and Gerlach and Smets (2000) present a simple model for a small open economy. Following them, the optimal MCI is derived by minimising the central bank loss function.
The supply and demand sides of the economy are determined by the following equations:

\[ x_t = \beta(\rho_t - E_{t-1}p_t) + \varepsilon_t \] (4.5)

\[ x_t = -\alpha_1 r_t - \alpha_2 \Delta q_t + \varepsilon_t \] (4.6)

where \( x_t \) denotes output gap, \( \varepsilon_t \) and \( \varepsilon_t \) are random white noise (supply and demand shocks respectively). Equation (4.5) is a Philips curve and equation (4.6) indicates aggregate demand for the economy. If the change of real exchange rate is positive, it would increase the output gap and will affect inflation. By equating the RHS of the equations (4.5) and (4.6) and deriving expressions of \( r_t \) and \( q_t \) from them, we can write the following equation for real MCI that had been introduced in equation (4.4) as and assuming:

\[ MCI_t = (\varepsilon_t - \varepsilon_t) - \beta(p_t - E_{t-1}p_t) + \alpha_\kappa \kappa_t \] (4.7)

Equation (4.7) shows that:

\[ \alpha_1 r_t + \alpha_2 \Delta q_t + \alpha_\kappa \kappa_t = MCI_t = (\varepsilon_t - \varepsilon_t) - \beta(p_t - E_{t-1}p_t) + \alpha_\kappa \kappa_t \] (4.8)

After dividing (4.8) by \( \alpha_1 \) we can write:

\[ r_t + \alpha \Delta q_t + \frac{\alpha_\kappa}{\alpha_1} \kappa_t = \frac{MCI_t}{\alpha_1} = \frac{1}{\alpha_1} (\varepsilon_t - \varepsilon_t) - \frac{\beta}{\alpha_1} (p_t - E_{t-1}p_t) + \frac{\alpha_\kappa}{\alpha_1} \kappa_t \] (4.9)

where \( \alpha = \frac{\alpha_2}{\alpha_1} \) and the rest of variables already defined.

The optimal MCI (to be shown by \( MCI^*_t \)) can be derived through minimising the monetary authority loss function.
The loss function of the central bank in a simple form can be expressed as:

\[ l_t = \gamma_1(x_t - \varepsilon_t)^2 + \gamma_2(\pi_t - \bar{\pi})^2 \]  \hspace{1cm} (4.10)

where \( \pi_t \) is the current inflation rate, \( \bar{\pi} \) the inflation target of the central bank and \( \gamma_1 \) and \( \gamma_2 \) are the relative coefficients assigned to deviations of output and inflation to their target level respectively. From equation (4.5) we have \( x_t - \varepsilon_t = \beta(p_t - E_{t-1}p_t) \).

By replacing the latter term in equation (4.10) the new loss function to be minimised can be written as: \( l_t = \beta^2 \gamma_1(p_t - E_{t-1}p_t)^2 + \gamma_2(\pi_t - \bar{\pi})^2 \). In the full information case, both individuals and the central bank are able to observe the endogenous variables and as a result, are able to identify the source of the shocks in the economy. Consequently, when an individual is able to predict the price in the next period, and assuming that s/he does have access to the full information pack at any time, also the expectations are rational, we can replace the price term by its change i.e. inflation.

Under the full information conditions the monetary authority’s loss function can be written as:

\[ l_t = \beta^2 \gamma_1(\pi_t - E_{t-1}\pi_t)^2 + \gamma_2(\pi_t - \bar{\pi})^2 \]  \hspace{1cm} (4.11)

In order to minimise the loss function in equation (4.12) I will take the first order conditions. One of the first-order conditions of this optimization is:

\[ \beta^2 \gamma_1(\pi_t - E_{t-1}\pi_t) + \gamma_2(\pi_t - \bar{\pi}) = 0 \]  \hspace{1cm} (4.12)

with a simple algebra on equation (4.12), the first order condition can be rewritten as:
From equation (13), we obtain:

\[ \pi_t = (1 - \delta)E_{t-1}\pi_t + \delta\bar{\pi} \]  

(4.14)

where \( \delta = \frac{\gamma_2}{\beta^2\gamma_1 + \gamma_2} \).

Equation (4.14) represents the optimal rate of inflation under rational expectations and full information, if we assume that there is no gap between current inflation and its target values that have been expected in the last period (i.e. \( E_{t-1}\pi_t = E_{t-1}\bar{\pi} \)) then optimal inflation rate can be shown as:

\[ \pi_t = E_{t-1}\bar{\pi} + \delta(\bar{\pi} - E_{t-1}\bar{\pi}) \]  

(4.15)

By considering the price forecast error\(^{63}\) as \( p_t - E_{t-1}p_t = \delta(\bar{\pi} - E_{t-1}\bar{\pi}) \) and replacing this term in equation (4.9) optimal MCI can be written as:

\[ MCI_t^* = \frac{1}{a_1} (\varepsilon_t - \varepsilon_t) - \frac{\beta \delta}{a_1} (\bar{\pi} - E_{t-1}\bar{\pi}) + \frac{\alpha \kappa}{a_1} \kappa_t \]  

(4.16)

Central bank reaction function has a common feature where the interest rate rule reacts to the output gap and deviation of inflation from its target. Therefore, using the Taylor definition of the relationship between interest rate, inflation and output gap, a general interest rate rule in its simple form can be expressed as: \( i_t = i^* + \varphi(\pi_t - \bar{\pi}) + \omega x_t \) where the coefficients \( \varphi \) and \( \omega \) consist of parameters of the economy.

\(^{63}\) Gerlach and Smets (2000) have presented this form of price forecast error in their interpretation of the MCI.
As the MCI is the combination of interest rate, exchange rate and important factors in the economy, one can assume it as an operating target such as short-term interest rate in Taylor rule. Transforming the rule of the form in equation (4.16) to a form similar to the Taylor rule allows one to write the equation of optimal MCI (i.e. $MCI_t^*$) as:

$$MCI_t^* = \overline{MCI} + \varphi(\pi_t - \overline{\pi}) + \omega x_t$$  \hspace{1cm} (4.17)

where $\overline{MCI}$ is the neutral level of $MCI_t$ and can be set equal to zero, as $MCI_t$ is an index. Note here that $i_t$ is been replaced by $MCI_t^*$ and $i^*$ is replaced by $\overline{MCI}$ without any changes in the principles of Taylor rule. The difference between the natural level of MCI and the optimal MCI as can be seen in equation (4.17) can be explained. The optimal level of MCI is the natural level with the inflation gap and output gap term added to the natural level.

The nominal interest rate $i_t$ is determined by equalising the equation (4.3) with equation (4.17) and setting the $\overline{MCI}$ and its base term equal to zero we have:

$$\alpha_1(r_t - r_0) + \alpha_2(q_t - q_0) + \alpha_\kappa \kappa_t = \varphi(\pi_t - \overline{\pi}) + \omega x_t$$ \hspace{1cm} (4.18)

Now in order to derive the reaction function of the central bank by using the Fisher equation ($r_t = i_t - \pi_t$), and expanding $\kappa_t$ we can write the equation (4.18) as:

$$i_t = i_t^* + \frac{\varphi}{\alpha_1}(\pi_t - \overline{\pi}) + \frac{\omega}{\alpha_1} x_t - \frac{\alpha_2}{\alpha_1}(q_t - q_0) - \frac{\alpha_3}{\alpha_1} BD_t - \frac{\alpha_4}{\alpha_1} OER_t$$ \hspace{1cm} (4.19)

where $i_t^* = \pi_t + r_0$ and $x_t$ is the output gap as before. As we can see, equation (4.19) considers the exchange rate gap in addition to the inflation and output gap. The country specific terms (i.e. $\frac{\alpha_3}{\alpha_1} BD_t$ and $\frac{\alpha_4}{\alpha_1} OER_t$) which in our case are the...
government budget deficit and oil export revenue is also added in the operating target of the monetary authority. As a consequence, this can be assumed as an extension to the initial reaction function of the Taylor rule (equation (4.1)) by three added items (unique to the model) which is localised for Iranian economy.

4.3. Empirical Analysis

Before starting the empirical analysis, two points should be clarified. Firstly, the method of estimation of the resultant equation which I have not estimated the equation (4.19) as it appears here, using simple estimation techniques such as OLS, TSLS or GMM\(^64\). As discussed in details in the introduction of this chapter, it is not possible to adopt the theoretical relationship obtained from equation (4.19) on real data and estimate the coefficients and evaluate the significance of them in order to present the exact operating target for Iran. In this study, I only aim to show that the role of the exchange rate volatility is so important that need to be secured a place for in the conduct of monetary policy.

One may argue that, if this was the goal of this chapter, “Why did you include the above theoretical parts?” to answer this, one solution would be without any background analysis start straight the VAR analysis, and then the components included in VAR and the rationale behind choosing them would be questioned. Thus, I presented the above theoretical framework just to illustrate which variables should be chosen for VAR analysis.

\(^{64}\)OLS (Ordinary Least Squares), TSLS (Two–Stage Least Squares) or GMM (Generalized method of moments).
In order to analyse whether the monetary authorities should consider the exchange rate volatility in construction of the operating target of the central bank, a vector autoregressive (VAR) estimation of the variables is used and the behaviour of the Impulse Response Functions (IRFs) of the shocks have been evaluated. The advantage of the VAR model is that it yields a dynamic model that all variables of the system are treated as endogenous, so a mutual relationship between variables can be constructed. Since the interaction between variables expressed in equation (4.19) cannot be applicable as shown in the equation, VAR seems to be a plausible method to empirically analyse the relationship between them. Thus, as Sims (1980) argues, VARs can be widely used to describe the complex interactions that exist between variables in macroeconomics and finance. In addition, a VAR model is also used to describe the resulting impacts of unexpected shocks or innovations to a specified variable on other variables in the model. Consequently, in the econometric analysis of this chapter, a VAR model is employed to assess the function of a monetary instrument and targets in transmission mechanism of the monetary policy. Therefore the final configuration of the model in the Iranian economy should involve all variables characterising the structure of the economy to be estimated in an unrestricted VAR model. Before moving to the empirical model estimations, as the econometric results steer this fact that by including the budget deficit and oil revenue to the VAR, the results are altered and the impulse response functions are not significant anymore. Even so, I report the econometric results of the model including all the variables in the appendix of this chapter. In the next section I report the results of the VAR excluding the budget deficit and oil revenue which is compatible with our prediction of the behaviour of the data in Iran. One may argue that the results are
not reliable as they do not cover all the important variables to the Iranian economy. To answer to this critique, I can say, although, Iran is an oil exporting country and the oil revenue makes the majority of the overall budget of the country but, as the oil price changes over time by many reasons mainly exogenous to the Iranian economy on the one hand, and the sanctions and the inertia of these limitations over the past three decades in the economy, on the other hand, can permit us to ignore these two elements. The first variable i.e. oil revenue, is directly affected by the world oil price changes and the second one i.e. budget deficit is also mainly produced by the sanctions over Iran, and the augmented costs of purchasing essential goods for the economy by the authorities, by the same token, it is generated by imported inflation and not only the domestic inflation. This change in prices and depreciation of the domestic currency has been considered by the exchange rate element in the model and including this element in some way would be double counting of the exchange rate. Consequently, this will be reported in the appendix of this chapter only for anyone interested and here only the main four elements namely; Deposit rate (as the indicator of the interest rate in the Islamic banking system), inflation, exchange rate, gross domestic product, and one exogenous factor -as the analysis is based on the open economy environment- namely U.S. gross domestic product, as the indicator of the foreign country conditions.

4.3.1. Data and VAR components

The sample involves quarterly data from 1988 q1 to 2007 q4, and the variables in VAR model are: short-term deposit rate\textsuperscript{65} (I), inflation measured by change in

\textsuperscript{65} This is the closest measure of short-term interest rate in Iran as a banking system which regulates under Usury-free banking law.
Consumer Price Index (CPIP), exchange rate (NEER)\textsuperscript{66}, Gross Domestic Product (GDP)\textsuperscript{67}, as a measure of output, and finally United States’ GDP (GDPU) as the foreign output and the country where exchange rate has been calculated by its currency ratio. All data is taken from IFS except the deposit rate, where data from the Central Bank of Iran is utilised. The natural logarithm of all the variables except interest rate is used and the potential output, equilibrium rate of inflation and exchange rate is obtained by the widely used Hodrick-Prescott (HP) filter.

4.3.2. Descriptive statistics of data

Before starting the econometric analysis of the data, in this section the plots of the time series of the variables used as the components of the VAR are illustrated in Figure 4.1 and the summary statistics of the data is reported in table 4.1. All the variables (apart from U.S. GDP-gap) including the two country specific variables i.e. oil export revenue and budget deficit of Iran are shown in the figure. The gap of the variables (apart from deposit rate and budget deficit) are used in the VAR instead of the level mainly for two reasons; firstly, in the model derived in the previous section (equation 4.19), the policy instrument are affected by the gap of the output, inflation and exchange rate on the one hand and secondly, this fact that if the gap of a variables with its trend (potential level) is altered then the variable itself is changed as well (especially this is useful when analysing the long-run behaviour of the data), on the other hand, were the reasons behind the use of gaps of the variables.

\textsuperscript{66} Net Effective Exchange Rate (NEER), this measure of the exchange rate is the rate published by IFS for Iran and the plot of the data follows.

\textsuperscript{67} Described in the previous section by $x_2$
In all the variables (except deposit rate) firstly the natural logarithm is taken and then the gap between the variables (except deposit rate and budget deficit, where in the latter its ratio to the GDP is reported) and their potential levels (HP-filtered) are obtained and illustrated here.
Table 4.1 Descriptive statistics of the variables

<table>
<thead>
<tr>
<th></th>
<th>GDP-GAP</th>
<th>DEPR</th>
<th>Inflation-gap</th>
<th>Ex-gap</th>
<th>Oil-Rev</th>
<th>BD_PGDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>2.94E-13</td>
<td>15.95</td>
<td>2.11E-13</td>
<td>3.89E-13</td>
<td>5.18E-13</td>
<td>-0.01921</td>
</tr>
<tr>
<td>Median</td>
<td>1.46E-05</td>
<td>16.98437</td>
<td>2.005729</td>
<td>1.29E-02</td>
<td>1.07E-01</td>
<td>-0.01134</td>
</tr>
<tr>
<td>Maximum</td>
<td>0.150532</td>
<td>18.89063</td>
<td>0.639221</td>
<td>0.489129</td>
<td>0.950594</td>
<td>0.058975</td>
</tr>
<tr>
<td>Minimum</td>
<td>-0.09458</td>
<td>7.796875</td>
<td>-1.170393</td>
<td>-0.42399</td>
<td>-2.93744</td>
<td>-0.12534</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>0.036214</td>
<td>2.942231</td>
<td>0.282527</td>
<td>0.157033</td>
<td>0.52806</td>
<td>0.036441</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.924065</td>
<td>-1.55747</td>
<td>-0.874326</td>
<td>-0.16745</td>
<td>-2.79324</td>
<td>-0.83912</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>6.891783</td>
<td>4.669228</td>
<td>6.168537</td>
<td>4.35745</td>
<td>15.52524</td>
<td>3.782392</td>
</tr>
<tr>
<td>Jarque-Bera</td>
<td>61.87187</td>
<td>41.63061</td>
<td>43.65803</td>
<td>6.516111</td>
<td>556.4341</td>
<td>10.14309</td>
</tr>
<tr>
<td>Probability</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.038463</td>
<td>0</td>
<td>0.006273</td>
</tr>
</tbody>
</table>

As illustrated in the top left part of Figure 4.1 and the descriptive statistics tabulated in Table 4.1, the deposit rate in Iran is not changing significantly over some periods of our sample size and it is constant in some years over 80 observations. One may argue that, as this is the instrument of the monetary policy and is not fluctuating like it appears in Figure 4.1, this may not be an appropriate instrument to use in Iran. To answer this critique, we need to consider two points. Firstly, although it is not fluctuating significantly but as it has been shown in the Figure 4.1. as well as according to the test results it meets the requirements to be able to act as an instrument. even though it is constant over the period of 1995 to 2000 but it changes over the other intervals of the data. Secondly, one may argue that why I did not used the alternative such as monetary aggregate instead which has two advantages over deposit rate in Iran, on the one hand it does meet the specification of the Usury free banking law and does have nothing to do with interest rate and on the other hand ot is fluctuating over time. To

69 The variables are GDP-gap, deposit rate, inflation-gap, exchange rate-gap, oil revenue-gap abd budget deficit ratio (the ratio of budget deficit to the GDP)
answer the latter critique, I should express that, this instrument is analysed in the next chapter of the thesis with a comprehensive argument regarding the velocity of money and the role of the monetary aggregate in predicting inflation under the P-star model.

4.3.3. Unit root tests

Prior to estimating the VAR model of the variables, the order of integration of the series should be determined as non-stationary data may produce spurious results in estimation. Therefore, unit root tests are the first step of the econometric analysis. For the unit root tests, the Augmented Dickey-fuller (ADF), the Philips-Perron (PP), the Dickey-Fuller–GLS and the Kwiatkowski-Phillips-Schmidt-Shin are used as the main four stationary tests. From Table 4.1, the variables in level (natural logarithm) have unit roots except the deposit rate and inflation (only with two tests) which are stationary. The right section of Table 4.1, reports the same four stationary tests for the gap of the variables, and as it indicates all the gap variables are stationary in one percent level of significance.

\[ \text{Table 4.2: Unit root test}\]

<table>
<thead>
<tr>
<th>Test</th>
<th>I</th>
<th>CPID</th>
<th>NEER</th>
<th>GDP</th>
<th>GDPU</th>
<th>GCPID</th>
<th>GNEER</th>
<th>GGDP</th>
<th>GGDPU</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADF</td>
<td>-5.59*</td>
<td>-2.55</td>
<td>-2.01</td>
<td>-0.54</td>
<td>-0.29</td>
<td>-4.46*</td>
<td>-4.24*</td>
<td>-4.56*</td>
<td>-3.83*</td>
</tr>
<tr>
<td>DF-GLS</td>
<td>-0.61*</td>
<td>-2.38**</td>
<td>0.62</td>
<td>1.83</td>
<td>0.95</td>
<td>-4.43*</td>
<td>-2.66*</td>
<td>-4.59*</td>
<td>-1.98**</td>
</tr>
<tr>
<td>PP</td>
<td>-2.25</td>
<td>-2.41</td>
<td>-2.1</td>
<td>-0.33</td>
<td>-0.32</td>
<td>-3.48*</td>
<td>-4.33*</td>
<td>-4.5*</td>
<td>-3.13**</td>
</tr>
<tr>
<td>KPSS</td>
<td>0.63**</td>
<td>0.21*</td>
<td>1.04</td>
<td>1.21</td>
<td>1.24</td>
<td>0.03*</td>
<td>0.05*</td>
<td>0.04*</td>
<td>0.05*</td>
</tr>
</tbody>
</table>

‘*’, ‘**’ and ‘***’ denote stationary at 1%, 5% and 10% significance level, respectively.

\[ ^{70} \text{The lag length for ADF and DF-GLS tests were chosen based on Schwarz information criterion. Variables with prefix ‘G’ are the gap between the variable and its HP filters.} \]
Once more I should indicate that the estimation results of the VAR model containing the two other country-specific variables (budget deficit and oil export revenue in Iran) are also analysed and reported in the appendix of this chapter. From the information in Table 4.2, the gaps of the variables were used to estimate the VAR model. As a result, a VAR model consists of: I, GCPID, GNEER, GGDP and GGDPU is constructed and estimated. The objective is to show how the exchange rate affects inflation in Iran and whether or not the monetary authorities should consider its fluctuations in the central bank reaction function. Besides the effect of the exchange rate on inflation, the effects of changes in interest rate and output on inflation are also studied based on impulse response functions to the shocks of a specific variable at a time.

4.3.4. Generalized Impulse responses

In general, before estimating the impulse response functions, we need to test for the cointegration of the components in a VAR. As the Table 4.2 shows the variables in our VAR model (the gap of the variables except interest rate) are all stationary and integrated of order zero, the condition of performing a co-integration test is not met and we can start our analysis of responses of the variables to a shock from one specific variable.

Orthogonalising the innovations using the residual or the Cholesky decomposition method in impulse definition is the base of constructing impulse response functions in a standard VAR model. In this manner, impulse response of the system is the response of the target variable to a particular shock given that all other shocks are zero. This approach depends on the ordering of variables (in case of Cholesky decomposition). It means that the impulse responses may vary with changing the
order of the variables. Determining the order of variables must be carried out based on a prior economic theory. In most cases, there is not a clear idea for the ordering of variables. Therefore, the Generalized Impulse Response Functions (GIRF) developed by Koop et al. (1996) and Pesaran and Shin (1998) can solve the ordering problem by making the responses unique, which are not affected by ordering the variable. More precisely, GIRF averages and integrates all shocks and hence allows for the varying of other variables when one variable is shocked. Thus, since there is not a clear idea for the ordering of variables in our data set, we apply a generalised one S.D. innovations impulse response for dynamic structure analysis of the system. However, the other response functions i.e. responses to non-factorized one S.D. innovations in residual decomposition method and responses to Cholesky one S.D. innovations in Cholesky decomposition method also have been reported for robustness check of the results.

Impulse responses are the result of estimating the VAR system with the lag order of six. The order of lag has been chosen based on the autocorrelation characteristics of the VAR residuals. This lag length (six lags) makes the residuals serially uncorrelated. Figures 4.2 to 4.4 below illustrate the responses to an exchange rate shock.

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71 The order of the variables in this sample will not change the results significantly, consequently the order of I, GCPID, GNEER, GGDP and GGDPU as in the unit root table test is chosen arbitrary.

72 The full variables impulse response functions are reported in the Appendix.

73 See for example Hall (1989) and Johansen (1992).
Figure 4.2: Responses of variables to an exchange rate shock – Generalised

Figure 4.3: Responses of variables to an exchange rate shock – Non-factorized

\[^74\] Decomposition method is residuals-one standard deviation.
Comparing Figures 4.2 to 4.4, responses of the inflation gap to the exchange rate shock is negative in all methods. In other words, with an increase to the exchange rate (a positive shock from exchange rate gap) or by the same token, an increase to the national currency value\textsuperscript{76}, inflation decreases (has a negative effect on the inflation gap). The graphs clearly illustrate that there is also a significant reduction in inflation after the positive shocks from the exchange rate. To recall, the main investigation of this chapter has been to discover the effect of the exchange rate on inflation in Iran, and whether the monetary authorities should consider this effect directly in their reaction function. One may interpret this as the effect of a floating exchange rate on domestic prices and hence on the deviation of inflation from its target (or trend). The interest rate tends to respond positively to a positive shock.

\textsuperscript{75} Decomposition method is Cholesky- dof adjusted and the order of the variables is: interest rate, inflation gap, exchange rate gap, output gap and United States’ output gap.

\textsuperscript{76} According to the definition of the Net Effective Exchange Rate (NEER), when there is an increase in NEER, the value of the domestic currency will be higher.
from the exchange rate. This shows that the nominal interest rate would increase after the impact of the exchange rate, and hence tightening monetary policy will take place where this may contribute to decrease inflation. The manner of the output gap to a positive shock of the exchange rate is also tabulated in the above figures. As can be observed, the output gap responds positively to a positive shock of the exchange rate, ensuring a better growth rate in the economy. In addition, lower velocity of money circulation results in a decrease in inflation (indirectly).

Figures 4.5 to 4.7 below analysis responses to a positive shock to the change of the nominal interest rate.

*Figure 4.5: Responses of variables to an interest rate shock – Generalised*
Figure 4.6: Responses of variables to an interest rate shock – Non-factorized

Figure 4.7: Responses of variables to an interest rate shock – Cholesky
It can be concluded from Figures 4.5 to 4.7, responses of inflation to a positive shock to the interest rate is negative and significant in all methods. However, the figures illustrate that the response will be significant after half period (i.e. two months) which is acceptable with the specifics of the Iranian economy. These results are also compatible with our expectations. For instance, as the monetary authorities increase the interest rate\textsuperscript{77}, we would expect that individuals to deposit their cash in circulation, resulting in a decrease in the rate of inflation. Interest rates are used as the rate of return on investment either for deposits or for project investments. In this chapter the rate of return on deposits were used as a proxy of interest rate. Lending interest rate is not available in Iran due to prohibition of interest in the banking system and Usury-free law.

In the final empirical part of this chapter, the response of the variables to a positive shock to output is summarised in Figures 4.8 to 4.10 below.

\textsuperscript{77} Once more I should indicate that by the Usury-free banking law there is no interest rate in Iran and it has been replaced by the deposit rate, and wherever the term of “interest rate” is used for Iran in this chapter, I mean, the “deposit rate”.
Figure 4.8: Responses of variables to an output shock – Generalised

Figure 4.9: Responses of variables to an output shock – Non-factorized
Figures 4.8 to 4.10 illustrate the impulse responses of the interest rate, inflation and the exchange rate gap to a positive shock to the output gap. In Iran as can be concluded from these figures, inflation changes with output cycles. As Figures 4.8 to 4.10 point out, with a positive shock to the output gap, the gap between inflation and its trend increases and responds positively to this shock (however, this response lasts only for a short period, especially in a generalised model, and it is also not significant). This may show a type of trade-off between economic activity and inflation. In other words, when the economy is in an over-trend situation, inflation starts to deviate positively from its trend. Other variables i.e. the exchange rate and interest rate in Figures 4.9 and 4.10 have almost the same reactions to the shock and respond negatively. But, in the generalised model illustrated in Figure 4.8, the response of the exchange rate gap to the positive shock of output is positive and
significant though with a very short lag. The reaction of the exchange rate and interest rate is also compatible with our expectation and both respond negatively (if we overlook the one month positive response in the generalised model). One can interpret this as an advantage of the existence of inflation in an economy which has the side effect of increasing production in an economy as the higher profit incentive, signalled from the market to the producers.

4.4. Concluding remarks and policy recommendation

This chapter has constructed a monetary policy model considering a direct channel effect of the exchange rate, in order to show how the exchange rate affects the monetary policy rule as a reaction function of the central bank. As the monetary authorities in Iran do not consider the exchange rate volatility in policy response reaction function, the main aim of this chapter has been to demonstrate that this important element should be considered in the construction of the monetary policy. In order to do this, a reaction function in which inflation, the exchange rate and output gaps determine the policy rate has been generated through conducting a monetary policy model, which started with a Taylor rule and the use of a Monetary condition Index (MCI). Then, the rule was estimated with a Vector Autoregressive (VAR) model for Iran to investigate firstly, the effects of the exchange rate, and then interest rate and output gap volatility on the inflation. The generalised reaction function in this chapter shows that the policy rate (nominal interest rate) is a function of the inflation gap (the deviation of inflation from its trend or from the inflation target), the output gap and the exchange rate gap where these gaps of variables have a positive effect on the policy rule. The derived policy rule is an augmented Taylor
rule in which the exchange rate gap and the two country specific elements namely; budget deficit and oil export revenue have been added to the model.

The result of the VAR estimation of the gaps of the variables in this chapter has been expanded using impulse response functions. The impulse responses suggest that inflation is significantly affected by shocks from the exchange rate in Iran and the hypothesis of not considering it will be rejected. Focusing on the responses of inflation to different shocks from other variables; it seems that the exchange rate and interest rate are the most influential variables which have significant effects on inflation.

One policy implication from these results is that monetary authorities in Iran should consider output stabilisation (along with controlling monetary items) and managing the exchange rate to control inflation. In other words, it seems that the exchange rate should be viewed as a financial asset price where its movement is determined by the demand and supply in the foreign exchange market. Hence, stabilising the exchange rate should be carried out, not only because of its pass-through effect on inflation but for stabilising financial markets. Consequently, policy makers should consider its fluctuations in designing the monetary policy reaction function.

Another conclusion indicates that with a positive shock to the gap of the exchange rate, the change of policy rate (nominal interest rate) is likely to be positive. This can have a negative impact on inflation and decrease it although the channel of effect is not direct and hence the effect on inflation is weak. The results also suggest that the increase in the exchange rate that increases the nominal interest rate may decrease the output gap to some extent.
## Appendix: VAR estimation results (without the two country specific terms)

Vector Autoregression Estimates  
Sample (adjusted): 1989Q3 2007Q4  
Included observations: 74 after adjustments  
Standard errors in ( ) & t-statistics in [ ]

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133
Residuals of the VAR components

Deposit Rate Residuals

Output gap Residuals

U.S. output gap Residuals

Inflation gap Residuals

Exchange rate gap Residuals
IRFs - Generalised

Response of LDEPR to LDEPR

Response of LDEPR to GLGDFS

Response of LDEPR to GLGDP

Response of LDEPR to GLCPD

Response of LDEPR to GLNEER

Response of GLGDFS to LDEPR

Response of GLGDFS to GLGDFS

Response of GLGDFS to GLGDP

Response of GLGDFS to GLCPD

Response of GLGDFS to GLNEER

Response of GLGDP to LDEPR

Response of GLGDP to GLGDFS

Response of GLGDP to GLGDP

Response of GLGDP to GLCPD

Response of GLGDP to GLNEER

Response of GLCPD to LDEPR

Response of GLCPD to GLGDFS

Response of GLCPD to GLGDP

Response of GLCPD to GLCPD

Response of GLCPD to GLNEER
IRFs - Residuals One S.D, Non factorised
The order of the variables is: I, GCPID, GNEER, GGDP and GGDPU, as in the main text.
IRFs- Generalised (including all variables)

In this estimation the two country specific variables (budget deficit and oil export revenue) have been added to the VAR components the number of lags that makes the residuals serially uncorrelated is six. As can be shown from this IRFs, if we include these two variables the responses are not significant any more.
Chapter 5: ANALYSIS OF P-STAR MODEL IN IRAN
5.1. Introduction

After the original study carried out by Hallman et al. (1989) and (1991) regarding the use of money supply as an indicator for inflation and introducing P-star model, a number of studies tried to re-establish a causal relation from money to prices. This study contributes to the literature by investigating whether the P-star model is a good indicator of short run inflation forecasts for a small open economy.

The P-star model stimulates the main quantity theory of money by connecting the determinants of the short term dynamic of prices to the long term equilibrium prices. The basis of this model is that the equilibrium price level can be forecasted by the components of the quantity theory of money equation and consequently the divergence of real to equilibrium prices can be used to foresee future inflation. This research contributes to the literature in three main ways.

Firstly, the velocity of money is calculated using different measures of aggregates. The main issue in the P-star model is the velocity of money and its equilibrium level. Different measures of velocity and the methods in calculating it will be discussed in this chapter. Secondly, before the discussion of the main model, and with respect to the problems with the structural break in the time series, especially for stationary tests – as the main prerequisite of time series analysis – a model of unit root test will be derived which considers the possible structural break in the time series. This will increase the degree of credence of the unit root tests and consequently the final results. And finally two different intervals of the data set (quarterly and annual) will be taken into account in order to check the robustness of the results.
The main findings of the chapter indicate that the model responds positively in the annual data and points out that the P-star model can act as a good indicator for inflation forecasting in Iran.

The remainder of this chapter is as follows. In section 5.2 of this chapter, there will be a review of the relevant literature regarding the P-star. Next, section 5.3, summarises the construction of the P-star model. Then in section 5.4, there will be a discussion of the velocity of money and its equilibrium. The foundation of econometric techniques will be analysed in section 5.5. Then the importance and basis of the special unit root test that considers structural breaks will be discussed in section 5.6. The empirical results which are tabulated in section 5.7 are followed by section 5.8 which concludes the chapter.

5.2. Literature review

Predicting inflation is yet another crucial element in designing an inflation targeting framework. In this chapter, the main question to address is whether the P-star model can be used as a good indicator for short run inflation forecasts in the Iranian economy.

The P-star model is originated by Hallman et al. (1989) and (1991). They found that the P-star could forecast inflation fairly well in the United States in their sample data. Since their research, many economists have addressed and analysed the P-star model over the last two decades. For instance, Czudaj (2011) suggests that the P-star model is still a good indicator in forecasting short run inflation in the Euro zone.
According to Czudaj (2011), a stable money demand function is one of the preconditions for reliable results from the P-star model.

Another study by Ozdemir and Saygili (2009) expresses the role of the P-star model in inflation dynamics and examines the performance of the P-star model in Turkey. They argue that the model selection criteria that contrasts the performance of the P-star model with the New Classical Philips Curve (NCPC) model, favours the P-star model. Their results also indicate that the price gap calculated from the P-star model contains a considerable amount of information regarding inflation dynamics while money is a valuable factor for risk prediction in price stability.

There are not many studies for the P-star model in emerging economies which have empirically analysed the model and its inflationary forecast power. Habibullah and Smith (1998) test the applicability of the P-star model in developing economies. They found that the model is supported by the Philippines data over the period of 1981 to 1994. They also conclude that the broad money (measured as M2) provides an anchor for inflation in their sample size.

Yap (2002) runs the P-star model in Malaysian economies. He also tests the effects of the exchange rate fluctuations on inflation using an extension to the original P-star model. His findings indicate that the original P-star model predicts inflation well, but he also suggests that the result of the extended model including the exchange rate cannot be rejected. Consequently, Yap (2002) recommends that the monetary authorities should consider the monetary aggregate in conducting the monetary policy in Malaysia.
In another study in developing economies, the relationship between the excess money and inflation during the Asian crises in Indonesia is discussed by Anglingkusumo (2005) using the two regimes P-star model. The results indicate that the model in terms of excess narrow money (M1) significantly well represents the long run dynamics of inflation. As a result, he argues that the long run inflation in Indonesia can be expressed as a monetary phenomenon.

A large number of the literatures in analysing the inflation dynamics rely on the New Keynesian framework in which the role of the money in determination of inflation movements has been ignored and devoted to the real demands for goods as proposed by Woodford (2007), in the so called economy without money. On the other hand, the opposition dispenses an important role for money when considering the monetary policy impact on output and price is quite supportive of this famous maxim of Milton Friedman80 where he says: inflation is always and everywhere a monetary phenomenon.

A review of the literature regarding the P-star (of course the literature that is in favour of the P-star model) supports this concept. For instance, in a study by Belke and Polliet (2006) among others, where a P-star model and a structural Vector Error Correction Model (VECM) was used, they found that money has a statistically significant effect on inflation forecasts in Sweden. Thus, their recommendation to the monetary authorities is that they need to devote a more prominent role for money in the monetary policy structure.

In another recent study, Gonzalez et al. (2009), present the estimation of a new version of the P-star model of inflation originated by Gerlach and Svensson (2003), on Colombian data over 25 years starting from 1980. They found that the monetary gap has significant effects on inflation while the effect of the product/output gap is not significant. However, in Gerlach and Svensson (2003), the P-star model, which they express as the real money gap, (i.e. the difference between the present and the long run equilibrium of real money stock) and the output gap, benefits from the empirical support in a study for the Euro zone. Consequently, they argue that the real money gap has substantial prognostic power for inflation in the future. The way of estimation of potential output, which plays a vital role in calculating the output gap, in addition to the real money gap, and the money growth indicator, is the point of stress in their study.

They argue that all the results depend on the potential output as there may be different results if we estimate the potential output using other techniques. In an earlier study, Hoeller and Poret (1991) evaluated the function of a P-star model in 20 countries that were members of the OECD\textsuperscript{81}. They dispute that in nine of the twenty members, and for the OECD in aggregate, the P-star model tracked their past inflation better than the models only based on the output gap. However, the results are less satisfactory in terms of forecasting short term future inflation, while for the United States and Germany, the P-star model dominated the other predictors.

Herrero and Pradhan (1998) used the Spanish data in examining the prediction power of the P-star model in inflation. They used a modified version of the P-star which included the foreign price gap in the model as well, in order to evaluate the effect of

\textsuperscript{81} Organisation for Economic Co-operation and Development.
the German price gap in the Spanish inflation. The results indicate that the domestic price gap plays a more significant role in inflation prediction than the German one.

Another test of the structural time series of the P-star model in three Middle Eastern countries namely: Egypt, Jordan and Morocco is conducted by Tawadros (2007), where the results are vastly in support of the adjustment mechanism intrinsic in the P-star model on the basis of quarterly data using maximum likelihood estimates technique. He also indicates that studies which model the output gap and velocity as a deterministic trend will direct to the failure of the P-star model as an explanatory instrument of determining inflation. On the other hand, the results are supportive of the model when stochastic trends are taken into account.

Qayyum and Bilquees (2005) declare that the P-star model in comparison to a simple autoregressive model and a money growth model can be the leading indicator of inflation in Pakistan. Moosa’s (1998) findings also support the relevance of the P-star model to the U.S. on the basis of the quarterly post-war data, and show that the inflation rate has a large positive coefficient in response to the price gap. In another study by Anglingkusumo (2005), the performance of the P-star model in inflation prediction using an equilibrium correction model in which the long run price movements were determined by excess money, appraised well over 22 years since 1980 in Indonesia. Kool and Tatom (1994) also covered the five European small economies in the analysis of the P-star model which had performed well in predicting inflation.82

82 In this study, they used the generalised P-star model in analysing the domestic prices of Austria, Belgium, Denmark, Netherlands and Switzerland from 1960 to 1990. They have separated the closed
In contrast, Nachane and Lakshmi (2002) recommend that the P-star model cannot be a reliable indicator for future inflation in low developed countries (in the case study of India) due to the lack of reliable series for deriving the potential output, the lags in data availability, and the problems in creating the quarterly estimates of actual and potential output. Svensson’s (2000c) study also does not support the evidence which suggests that the P-star model is a good indicator for monetary targeting in Bundesbank style money growth model or Euro system style. Hall and Milne (1994) test the application of the P-star model to the U.K data and argue that the model does not address the elemental question of causality, and they specify that causality runs from prices to money, especially in the long run and not vice versa. Consequently, they reject the relevance of the P-star model to the U.K data. Among the very few studies for Iran, Tashkini (2006) also did not seem to find any relevance of the inflation in Iran and the specifications of the P-star model.

On the basis on the causality concept of the P-star model following Hall and Milne (1994), Tsionas (2001) empirically evaluated the relevance of the P-star model to the Greek data (using both annual and quarterly data in period 1960-1997), taking into account both domestic and foreign price disequilibria where he gave more weight to the domestic disequilibria (velocity gap and closing output) in establishing inflation. In his paper, Tsionas (2001) argues that the P-star model is a good indicator of inflation after 1989 where there was a systematic effort in reducing inflation in Greece.

and open economy models, also considered the fixed exchange rate regimes, for more similar studies, please see; kool (1994), Mills and Wood (1993) and Frait et al.(1998).
In this chapter, based on the research carried out by Hall and Milne (1994), I will evaluate the relevance of the P-star model to the Iranian economy. To do so, after forming the P-star model and the velocity of money, I use long run causality test in which I test for exogeniety of the elements to observe whether the monetary authorities can use the P-star model as a superior indicator for future inflation.

5.3. The P-star model

In the leading P-star literature Hallman et al. (1989 and 1991), followed by Svensson (1999), Todter (2002) and Gerlach and Svensson (2003) among others, the P-star model was founded from the quantity theory of money. Following Hallman et al.(1991), I pursue the following steps in order to find the price gap. The conventional equation of quantity theory of money or “transaction equation” is the form of:

\[ PY = MV \]  \hspace{2cm} (5.1)

where \( P \) is the price level (as measured by GDP deflator), \( Y \) is the output at constant price or real output, \( M \) is the stock of money (monetary aggregate) and \( V \) is the velocity of money circulation. Equation (5.1) basically expresses that real output valued with its price level equals to the stock of money multiplied by the number of times a unit of money is used in order to finance the nominal output.

The equilibrium price level is given by:

\[ P^* = MV^* / Y^* \]  \hspace{2cm} (5.2)
where $V^*$ is the long run (equilibrium) velocity and $Y^*$ is the long run (equilibrium) output. Now turning to the original P-star model of Hallman et al. (1991) and taking the logarithm of both sides of the equation (5.1) and (5.2) in order to find the long run relationship of the components we have:

$$p + y = m + v$$  \hspace{1cm} (5.3)

$$p^* = m - y^* + v^*$$  \hspace{1cm} (5.4)

where the lower cases indicate the logarithm of the factors. Following this result from transaction equation, Hallman et al. (1991) developed an indicator of the long-run association between the price level and money stock. They presume that the equilibrium values of output and velocity ($y^*$ and $v^*$) are determined independent of the money stock. Consequently, the equilibrium price level $p^*$, moves proportionally with the money stock. By subtracting the equation (5.4) from (5.3) we have:

$$p - p^* = (v - v^*) - (y - y^*)$$  \hspace{1cm} (5.5)

Equation (5.5) specifies that the price gap consists of a velocity (liquidity) gap and the output gap, such that a larger price gap may be the consequence of the increase in the velocity gap or a decrease in the output gap. Hallman et al. (1991) also assume that the equilibrium price gap, theoretically, can take the value of zero, so $p$ adjusts to be equal to $p^*$. On the basis of the P-star model, the change of the size of this price gap is a tool to forecast inflation, when the equilibrium price level is greater than the actual price level, it is expected that the rate of inflation will go up and we have anticipation of a decline in inflation when the sign of the gap is opposite. By the same token, if we assume the price gap as a predicted inflation, under the P-star
mechanism, if the current calculated inflation (e.g. from CPI or GDP deflator) is greater than the forecasted inflation coming from the P-star, the inflation rate in the future tends to fall until it reaches the equilibrium of ($\pi^* = p - p^*$) and vice versa.

As a result, and from the equations (5.3) and (5.4), one can express that the relationship between the actual price gap and equilibrium price gap is negative.

This relationship can be formally expressed by testing the hypothesis that $\varphi_1$ is a negative coefficient in the following equation (5.6). Summarising the micro foundations of an inflation equation derived from minimising the cost function of a firm which yields the price gap equation that affects the dynamics of inflation through an extended Philips curve\textsuperscript{83}, the ensuing inflation relationship can be written as:

$$ p_t - p_{t-1} = \alpha + \sum_{i=2}^{n} \beta_i (p_{t-i} - p_{t-i-1}) + \varphi_1 (p - p^*)_{t-1} + \varepsilon_t $$  \hspace{1cm} (5.6)

The left hand side is inflation and depends on its own lag (to account for short run dynamics), the equilibrium price gap $(p - p^*)_{t-1}$ and an error term $\varepsilon_t$. The coefficient $\varphi_1$, as explained above is the speed of adjustment of prices to the equilibrium price and $\beta_i$ represents the lag of the actual rate of inflation. Equation (5.6) can be written in the form of:

$$ \pi_t = \alpha + \sum_{i=1}^{n} \beta_i (\pi_{t-i}) + \varphi_1 \pi^*_{t-1} + \varepsilon_t $$  \hspace{1cm} (5.7)

Where from equation (5.5), $\pi^* = p - p^* = (v - v^*) - (y - y^*)$

\textsuperscript{83} For micro foundation and derivation of inflation equation please see Todter (2002) and Rotemberg (1982).
Equation (5.7) on the basis of equation (5.4) therefore signifies that, in the long run, if all the changes in stock of money are not accompanied by changes in real output, then the remainder will be the source of changes in the price level.

5.4. Velocity of money

One of the most important aspects of the P-star model of inflation which plays a vital role in the formation of results is the way to define long run velocity equilibrium. As discussed before, the P-star model originated by Hallman et al. (1989) and (1991), can present an anchor for the price level which can be used as an instrument to forecast inflation. The concept is based on the movement of inflation will be in the way to minimise the gap between the price level and its equilibrium (i.e. the price gap). Performance of this structure widely depends on how the velocity equilibrium is defined.

Hallman et al. (1991) applied a version of equation (5.7) to quarterly U.S data. They used M2 as the money stock in their analysis and assumed that the velocity of money is stationary, as a result, equilibrium velocity can be obtained by the mean of the series of velocity and their data sample also supported this assumption.

In another study by Hoeller and Poret (1991), they include the 20 members of OECD countries and they used the Hodrick-Prescott (HP) filter to illustrate the equilibrium values

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84 In fact, they argue that assuming the constant velocity was an adequately true estimate despite the waves in financial innovation in their sample size. However, they stated that: if permanent shifts to velocity are empirically significant, actual prices would diverge from p-star in the long run.

85 Hodrick and Proscort (1980) and (1997). This filtering technique principally employs a long run symmetric moving average or rolling mean as a type of finite impulse response filter to de-trend a time series. Statistically HP filter is a two sided linear filter which minimise the sum of squared deviation of a variable form its trend i.e. \( \sum_{t=1}^{T}(\ln V_t - \ln V_t^*)^2 \) subject to: \( \sum_{t=2}^{T}(\ln V_{t+1} - \ln V_t^*) - (\ln V_t^* - \ln V_{t-1}) \leq e \), then HP filter calculates \( \ln V_t^* \) in order to minimise the: \( \sum_{t=1}^{T}(\ln V_t - \ln V_t^*)^2 \).
for output and velocity. Kool and Tatom (1994) also used HP filter in their analysis on the data of five small European countries and they conclude that the P-star model seems to work better for larger rather than smaller countries.

After the initial discussion by Hallman et al. (1989), the petition started on their assumption of velocity. One of the early works afterwards of Feinman and Porter (1992) questioned the stability of statistical equations containing M2 (the measure of money stock that Hallman et al. (1991) used in their model). Orphanides and Porter (1998) and (2000) and Gerlach and Svensson (2003) among others concluded that assuming constant equilibrium velocity in the P-star model of M2 is no longer reliable and will results in wrong formation of inflation prediction.

It is worth indicating the fact that the long run velocity equilibrium should not be taken as a constant term, was pointed out in earlier studies of the monetary theory. Baumol (1952), Tobin (1956) and Fleetwood (1958) among others, have questioned this in their studies and argue that the velocity of circulation of money is likely to deviate from its “normal” level especially during transition periods. In the first two studies, they determine the velocity of money as an endogenous variable which responses to the fluctuations of the interest rate in a general equilibrium model framework. In the latter study, the velocity of money has been calculated from the ratio of National income at current price on money supply from 1914 to 1953 for Finland, Sweden, United Kingdom and United States and concluded that we have to

\[ \ln V_t^* = \frac{1}{\delta} \sum_{t=1}^{T} \left( \ln V_{t+1} - \ln V_t^* - \left( \ln V_t^* - \ln V_{t-1} \right) \right) \]  

where the coefficient \( \delta \) is the Lagrange multiplier, and works as a penalty parameter that control the smoothness of the variance of the series. By the same token, the larger the value of \( \delta \) the smoother the series under analysis. For example, if instead of velocity we consider the output gap, a smaller \( \delta \) means shorter cycles and shorter gaps.
assume the long run velocity equilibrium as a “variable” rather than a constant term. Ahking (1982) and Kim (1985) examine the random walk hypothesis of the velocity of money, the empirical results of the latter using annual series support the conclusion of random walk of velocity in the former which used quarterly data. Orphanides and Porter (2000) inspected the movement of velocity while tracking the opportunity cost of money suggested from traditional money demand formulation. They used a regression tree approach to endogenously generate the equilibrium velocity based on studies carried out by Clark and Pregiborn (1991) and Hardle (1990). However, there is a matter of discussion of how theory based is this approach in defining the time varying value of equilibrium velocity. In a recent study by Benk et al. (2010), they use a DSGE model calibrated to the U.S data in order to explain the behaviour of the velocity of M1 and concluded that it has exhibited long cycles around a 1.25% per year upward trend between 1919 and 2004.

Ireland (1994) formed a model that the velocity of money can raise forever, until the time when money is not use any more. Where this is the basis that Woodford (2003) considers an economy without money to adopt a monetary policy. Elshaghi and Giesen (2010) used the multivariate state space framework that expands the traditional VECM approach. They split the changes in the velocity of money into two parts. One which is due to institutional developments and consequently do not make any contribution in inflationary pressure and the other part reflects the transitory movement of money demand. Kim and Subramanian (2009) show how inflation dynamic is affected by velocity of money via estimating a modified Philips curve derived from a New Keynesian model, while initiating money via transactions
technology. They used GMM\textsuperscript{86} to estimate the resultant velocity augmented Philips Curve on U.S data in the period between 1951 and 2005, and the results are consistent with the model i.e. the changes in velocity of money can lead to inflation volatility. Funke and Hall (1994) calculated the equilibrium velocity by modelling it as set of variables which drive velocity and the equilibrium comes from the forecast of the model.\textsuperscript{87} All in all, as can be seen, there are different methods to calculate the long run equilibrium velocity. In this chapter, we compare three different methods of calculating the velocity of money in both M1 and M2, and in order to define the equilibrium velocity, we de-trend the calculated series of velocity with the widely used HP filter.\textsuperscript{88}

5.4.1. The structure of velocity and stationarity of it

In order to illustrate the velocity of money in our data set, I use three conventions of measuring velocity\textsuperscript{89} as the ratio of: Nominal GNP (GN) and Domestic Absorption\textsuperscript{90} (DA) to contemporaneous money stock of M1 and M2 separately and finally I also calculate the velocity proposed by taking the natural logarithm of quantity theory (LQ) on both M1 and M2. (i.e. $v_t = y_t + p_t - m_t$ where $y_t$ is natural logarithm of

\begin{itemize}
\item\textsuperscript{86} Generalised Method of Moments

\item\textsuperscript{87} They form the velocity model as $v_t = \rho_0 + \rho'Z + e_t$, where $Z$ is the set of the variables that drive $v_t$, $\rho$ is the vector of parameters and $e_t$ is the stationary error term. Then, they defined the equilibrium velocity as a forecast of $v_t$.

\item\textsuperscript{88} Although there are some arguments against the HP filter and the weaknesses of it like trend in start and end of the series, but for simplicity we use this filter in our calculation, further methods such as a Kalman filter can be applied in order to check the robustness of the results.

\item\textsuperscript{89} See the study of Shams (1989), Ewing (1996) Baghestani and Mott (2009), Ahking (1982), Kim (1985) among others for examples of different measurements of velocity.

\item\textsuperscript{90} Domestic absorption is the sum of private consumption, general government consumption and gross domestic investment which usually is shown as a percentage of GDP, constant and current local currency or by the same token GNP less net export.
\end{itemize}
real output, $p_t$ is the natural logarithm of implicit price deflator and $m_t$ will take two numbers of logarithms of M1 and M2.) Consequently there will be six measures of velocity.

The data are obtained from International Financial Statistics (IFS). I have considered both quarterly and annual data. The quarterly ones are over the period of 1988q1 to 2007q4 with 80 observations, while the annual data consists of 43 observations from 1965 to 2007. In order to have a visual inspection, I have illustrated them in Figures 5.1 and 5.2 on the basis of M1 and M2 respectively, the kernel density is also showed to have a diminutive idea regarding the stability point of the series.
Figure 5.1: Velocity of different aggregate on M1

Quarterly

LQ velocity on M1

Annual

LQ velocity on M1

DA velocity on M1

DA velocity on M1

GN velocity on M1

GN velocity on M1
As it is illustrated in Figure 5.1, the velocity has almost the same shape when calculated with different measures. The three level velocities captured in Figure 5.1 both in quarterly and annual intervals are non-stationary and integrated in order one i.e. (I(1)) \(^91\).

Figure 5.2 plots the velocity of the same aggregates on the base of M2. In annual data, the graphs have almost the same shape and this shows that there is not a significant difference in obtaining the velocity from any of aggregates. The stationary tests of the series indicate that the velocities calculated using LQ and GN over M2 are both stationary in level and the velocity generated from DA is I(1). But in the quarterly data, LQ and GN are I(1) and DA is stationary in %5 level of significance.

\(^91\) The ADF, ADF-GLS and PP tests of unit root used for testing stationarity of the series.
Figure 5.2: Velocity of different aggregate on M2

<table>
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<th>Quarterly</th>
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<tbody>
<tr>
<td><strong>LQ velocity on M2</strong></td>
<td><strong>LQ velocity on M2</strong></td>
</tr>
<tr>
<td><strong>DA velocity on M2</strong></td>
<td><strong>DA velocity on M2</strong></td>
</tr>
<tr>
<td><strong>GN velocity on M2</strong></td>
<td><strong>GN velocity on M2</strong></td>
</tr>
</tbody>
</table>
Having a look on the behaviour of the data visually, it would be useful to see how stable the above criteria are, by tabulating the standard deviation of the velocity computed from each aggregate. Table 5.1 summaries the standard deviation of different measures of velocity.

Table 5.1: Standard deviation of velocity

<table>
<thead>
<tr>
<th></th>
<th>Money supply M1</th>
<th></th>
<th>Money supply M2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DA</td>
<td>LQ</td>
<td>GN</td>
<td>DA</td>
</tr>
<tr>
<td>Annual</td>
<td>1.0745</td>
<td>1.4109</td>
<td>1.3474</td>
<td>0.5011</td>
</tr>
<tr>
<td>Quarterly</td>
<td>1.1626</td>
<td>0.3664</td>
<td>1.2338</td>
<td>0.4442</td>
</tr>
</tbody>
</table>

As Table 5.1 shows, there is not a significant difference between the different measures of velocity as a result we can choose one of the resultant velocities (arbitrary) in order to calculate long run equilibrium velocity.

5.4.2. Equilibrium Velocity

In this chapter, I form the equilibrium velocity of money using the HP filter technique, while try to show that it would be an appropriate choice. HP filter increases the quality of the parameter estimates by avoiding possible bias resulting from the misspecification of velocity. On the other hand, the widely used HP filter has made it a natural first approach in calculating the trend of time series in empirical works and this, results a high degree of comparability of this method. One other advantage of HP filter is that it strongly imposes a stationary cyclical
component which allows a computationally efficient search of decomposition if required. However there are some arguments that this method has weaknesses such as calculation of trend in the beginning and end of the period. In Figures 5.3 and 5.4 below, the long run equilibrium velocities of arbitrary chosen series, LQ, is shown over two measure of money stock M1 and M2 and I have renamed them to V1 and V2 respectively.

---

92 This effect has been used by Elshaghi and Giesen (2010) for decomposing the components of velocity in tracking the money and inflation movements.
Figure 5.3: $v^*$ using M1

(Quarterly)

Hodrick-Prescott Filter of V1

(Annual)

Hodrick-Prescott Filter of V1

LQ velocity on M1
Trend
Cycle
Figure 5.4: v* using M2

(Quarterly)
Hodrick-Prescott Filter of V2

(Annual)
Hodrick-Prescott Filter of V2
As illustrated in Figures 5.3 and 5.4, in annual data both equilibrium velocities are almost similar and are both non stationary in level and first difference (i.e. I(2)). In regards to quarterly data, 1st difference of V1 is stationary in 5% level of significance and equilibrium of V2 is stationary. This measure of equilibrium velocity will be used in calculation of the price gap in P-star model.

5.5. Cointegration and Vector Error Correction Model (VECM)

5.5.1. Foundation of cointegration analysis and Johansen test

In general, if a linear combination of two series is taken into account in which each integrated in different order, then the resulting series is integrated in the higher order.

This phenomenon can be easily established as follows:

If: \( x_t \sim I(p) \) and \( y_t \sim I(q) \) where \( p > q \)

If we take a linear combination of \( x_t \) and \( y_t \) as:

\[
z_t = \alpha x_t + \beta y_t
\]

In equation (5.8) if we take the derivative of \( z_t \), \( q \) times, \( d^q z_t = \alpha d^q x_t + \beta d^q y_t \) we would have the second part stationary, and the first part non-stationary. We need to differentiate \( (p - q) \) times more, to have the first part stationary too.

As the difference of a stationary time series is also stationary, so \( y_t \) will remain stationary and therefore we have \( z_t \) stationary in order \( p \). This can be written as:
If: \( x_t \sim I(p), \quad y_t \sim I(q) \quad \text{and} \quad k_t \sim I(r) \) then, \( z_t \), the linear combination is of \( x_t, y_t \) and \( k_t \) is:

\[
z_t \sim I(\max(p, q, r)).
\]

There are however exception in this general rule which is interest of cointegration analysis. Two of the most widely used procedures in the literature of defining cointegration vectors are developed by Engle and Granger (1987) and Johansen (1991). Two variables (both integrated of order \( r \)) are called to be cointegrated if the Ordinary Least Squares (OLS) residuals from a regression of one on the other, are integrated of any order less than \( r \). For instance if \( x_t \) and \( y_t \) are both \( I(1) \), then they called to be cointegrated if the residuals from the regression of \( y_t \) on \( x_t \) are \( I(0) \). Consequently, if there are \( Q \) endogenous variables and they are all \( I(1) \), there can be up to \( Q - 1 \) linearly independent cointegration equations.

The Johansen test will identify the number of cointegration equations explained above. It starts from testing the hypothesis that there is no cointegration equation where the variables have no equilibrium conditions in relation to each other in the long run. The second null hypothesis is that there is one cointegration vector against the alternative hypothesis of more than one. And it will continue the test until the time the null cannot be rejected.

Engle and Granger (1987) argued that the linear combination of two or more non-stationary time series can be stationary. Considering this linear combination, the components of this which are the non-stationary time series is said to be cointegrated. And the equation of the linear combination is the cointegrating equation and can be judged as the long run relationship between the components.
Among the leading literature in cointegration tests in non-panel data, Johansen’s (1991) test stands on the system framework which is the base of cointegration analysis in this chapter, while the residual based test statistics of Engle and Granger (1987) and Philips and Ouliaris (1990) help us to perform the test. In the Johansen cointegration test, we would apply a VAR object. If a cointegrated vector is detected, we will use a Vector Error Correction Model (VECM) to estimate the cointegrating equation.

### 5.5.2. Vector Error Correction

The VECM has cointegration relations in such a way it controls the long run manners of the endogenous variables to gather together the cointegrating relationship while allowing for short term or medium term amendment fluctuations. The cointegration object is known as an error correction term since the divergence from long-run equilibrium is adjusted steadily through a series of partial short run adjustments. VEC models are widely used in the P-star literature\(^9\) in order to find the relationship between the components of the quantity of money equation. In view of the fact that the instantaneous impact of money growth on inflation widely varies, an error correction model seems to be an appropriate tool to be used for empirical analysis of the P-star model. To illustrate a simple error correction model, the following two variable systems with one cointegrating vector and no lags is considered:

\[
x_{2,t} = \alpha x_{1,t}
\]

\(^9\) See for example Lutkepohl and Wolters (2003) and Holtemoller (2004) where they found the evidence of long run relationship in a vector error correction model where money and prices where I(1).
Then, the VECM can be written as:

\[
\Delta x_{1,t} = \beta_1(x_{2,t-1} - \alpha x_{1,t-1}) + \varepsilon_{1,t}
\] (5.10)

\[
\Delta x_{2,t} = \beta_2(x_{2,t-1} - \alpha x_{1,t-1}) + \varepsilon_{2,t}
\] (5.11)

In long term equilibrium, the right hand side (the error correction term) will become zero if \(x_1\) and \(x_2\) are not deviating from the long term equilibrium. The coefficient \(\beta_i\) measures the speed of adjustment of the \(i\)-th endogenous variable.

After defining the order of integration of the series, we are able to go a step further to find the number of cointegrating vectors using Johansen’s (1988) and (1991) procedure. In this paper, I follow the stages of the Johansen’s (1988) procedure and consider the following sequence of random variables:

\[
Y_t = \Pi_1 Y_{t-1} + \Pi_2 Y_{t-2} + \cdots + \Pi_j Y_{t-j} + \varepsilon_t
\] (5.12)

Where \(\varepsilon_t\) is a sequence of \(iid\ (0, \sigma^2)\) random variables for given values of \(Y_{-j+1}, \ldots, Y_0\).\textsuperscript{94} since the process \(Y_t\) is supposed to be non stationary, the following matrix polynomial is assumed:

\[
A(z) = I - \Pi_1 z - \Pi_2 z^2 - \cdots - \Pi_j z^j
\] (5.13)

And the existence of roots of determinants of \(A(z)\) at \(z = 1\) should be concerned, considering the simple case where \(\Delta y_t\) is stationary, as a result \(y_t \equiv I(1)\), (i.e. \(y_t\) is originally non-stationary and we need to take the first difference of it to be stationary) the following long run matrix \(\Pi\) has the rank \(r\) where \(r < p\):

\textsuperscript{94} For more details on statistical steps see Johansen (1988)
We can write this matrix for suitable \( \alpha \) and \( \beta \) with dimensions \( p \times q \) as:

\[
\Pi = \alpha \beta'
\]  

(5.15)

In this procedure we shall assume that although \( \Delta y_t \) is stationary and \( y_t \) is not stationary as a vector process, their linear combinations given by \( \beta' y_t \) are stationary. This implies that the vector \( y_t \) is cointegrated with cointegration vector \( \beta \).\(^{95}\)

The objective of the Johansen (1988) test is estimating the following hypothesis as the space spanned by \( \beta \) from observations \( y_t \), \( t = -j + 1, ..., T \). For any \( q \leq p \) the following null hypothesis is estimated:

\[
H_0: \text{rank } (\Pi) \leq q \quad \text{or} \quad \Pi = \alpha \beta'
\]  

(5.16)

Where \( \alpha \) and \( \beta \) are \( p \times q \) matrices.

By rewriting the equation (5.12) such that the coefficient \( \Pi \) enters explicitly we have the following vector error correction model:

\[
\Delta Y_t = \Gamma_1 Y_{t-1} + \Gamma_2 Y_{t-2} + \cdots + \Gamma_{j-1} Y_{t-j+1} + \Gamma_j Y_{t-j} + \varepsilon_t
\]  

(5.17)

Where \( \Gamma_i = -I + \Pi_1 + \cdots + \Pi_i \quad i = 1,2, ..., j \)

In this equation the long-run matrix \( \Pi \) is the coefficient of the lagged levels in a nonlinear least square regression of \( \Delta Y_t \) on lagged level and lagged differences.

\(^{95}\) See Hall and Milne (1994) and Funke and Hall (1994) for more discussion.
5.6. **Structural break and unit root tests**

To evaluate the relationship between the components of the model we will start with unit root test as the necessary condition for cointegration analysis of the data. Both annual and quarterly data have been taken into account and the results are reported.  

To recall, discovering the long-run causality between price and money, while tracking the behaviour of output, is the main objective of this chapter. Firstly, the order of integration of each time series should be defined.

In this chapter the main four unit root tests have been employed which are: (Augmented) Dickey-Fuller (ADF) (1979) and (1981), Phillips-Perron (PP) (1988), and the GLS-Detrended Dickey-Fuller test introduced by Elliott, Rothenberg and Stock (ERS) (1996) and Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) (1992). The reason for using the four unit tests rather than only one common ADF is due to the result of a study by Liang and Teng (2006) which says the ADF and PP have inferior power in capturing stationarity in time series compared to the other two, and they argue that the KPSS in general has a greater power compared to the other unit root tests.

Before carrying out the unit root test, we have to consider the capability of structural break as pointed out by Perron (1989), Zivot and Andrews (1992) and Vogelsang and Perron(1998) among others. These studies argue that if there is existence of structural break in the series we cannot rely on the results of the unit root tests. In order to carry out the structural break test, I follow the Zivot and Andrews (1992) 

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96 There are 80 observations of quarterly data and 43 observations of annual data both sourced in IFS, the detail results of the empirical analysis will follow in section 5.7.
model as a theoretical background of Vogelsang and Perron (1998) (VP) unit root test with structural breaks. This allows us to test the degree of integration while indicating the break points in series. The simple main null hypotheses regardless the breaks in each series can be expressed as:

\[ y_t = \rho_1 + y_{t-1} + \epsilon_t \]  \hspace{1cm} (5.18)

Following Zivot and Andrews (1992), I add two dummy variables in the above regression in order to be able to consider the breaks. The new null hypotheses are described in three parts as follows:

\[ y_t = \rho_1 + dD(B_T)_t + y_{t-1} + \epsilon_t \]  \hspace{1cm} (5.19)

\[ y_t = \rho_2 + (\rho_1 - \rho_2)DS_t + y_{t-1} + \epsilon_t \]  \hspace{1cm} (5.20)

\[ y_t = \rho_3 + D(B_T)_t + (\rho_1 - \rho_2)DS_t + y_{t-1} + \epsilon_t \]  \hspace{1cm} (5.21)

Where \( D(B_T)_t \) and \( DS_t \) are dummy variables. \( D(B_T)_t \) will take the value of 1 where \( t = T + 1 \) and 0 otherwise. The \( T \) is the time of structural break in the series and \( B_T \) represents the break in time \( T \). \( DS_t \) will take the value of 1 if we have passed the break point in series i.e. \( t > T \) and 0 otherwise. And \( \epsilon_t \) is the identically independent distributed error term with zero mean and variance of \( \sigma^2. \) \( (iid \ (0, \sigma^2)) \)

Equation (5.19) permits the change in the level of the series, equation (5.20) lets changes in slope or growth rate in series and finally equation (5.21) allows these changes simultaneously.

The alternative hypotheses which indicate the trend stationary, considered are:
\[ y_t = \rho_1 + \beta t + (\rho_2 - \rho_1) D S_t + \varepsilon_t \] (5.22)

\[ y_t = \rho_2 + \beta_1 t + (\beta_2 - \beta_1) D T^*_t + \varepsilon_t \] (5.23)

\[ y_t = \rho_3 + \beta_1 t + (\beta_2 - \beta_1) D T^*_t + (\rho_2 - \rho_1) D S_t + \varepsilon_t \] (5.24)

Where in this alternative, \(DT^*_t = t - T\) if \(t > T\) and zero otherwise. In the alternatives same as null hypotheses; equation (5.22) allows for change in the level of the series, the change in \(\rho\) as the coefficient of \(D S_t\) represent the size of the change in intercept. The change in \(\beta\) in equation (5.23) indicates the magnitude of the change in slope of the trend function, these two equations are named crash model and changing growth model respectively by Perron (1989). Equation (5.24) combines these two changes in one model.

Then augmented regression equations for Augmented Dickey-Fuller (ADF) test can be written as\(^9^7\):

\[ y_t = \tilde{\rho}^1 + \tilde{\eta}^1 D S_t + \tilde{\beta}^1 t + \tilde{\alpha}^1 D (B_T)_t + \tilde{\alpha}^1 y_{t-1} + \sum_{i=1}^{n} \tilde{\epsilon}_i^1 \Delta y_{t-i} + \tilde{\varepsilon}_t \] (5.25)

\[ y_t = \tilde{\rho}^2 + \tilde{\gamma}^2 D T^*_t + \tilde{\beta}^2 t + \tilde{\alpha}^2 y_{t-1} + \sum_{i=1}^{n} \tilde{\epsilon}_i^2 \Delta y_{t-i} + \tilde{\varepsilon}_t \] (5.26)

\[ y_t = \tilde{\rho}^3 + \tilde{\eta}^3 D S_t + \tilde{\beta}^3 t + \tilde{\alpha}^3 D (B_T)_t + \tilde{\gamma}^3 D T^*_t + \tilde{\alpha}^3 y_{t-1} + \sum_{i=1}^{n} \tilde{\epsilon}_i^3 \Delta y_{t-i} + \tilde{\varepsilon}_t \] (5.27)

Zivot and Andrews (1992), considered the null that is integrated without the structural break, we can see the selection of the breakpoints for dummy variables in equations (5.25)-(5.27).

\(^{97}\) The numbers in the model are not the powers and just shows the coefficients are different in each equation
By considering equation (5.18) as the main null, there is no longer a need for one of the dummy variables $D(B_T)_t$ in the first and last regressions of equations (5.25) and (5.27). As a result, the final expression of the regression equations to test the unit roots are:

\[ y_t = \hat{\beta}^1 + \hat{\eta}^1 DS_t + \hat{\beta}^1 t + \hat{\alpha}^1 y_{t-1} + \sum_{i=1}^{n} \hat{c}_i^1 \Delta y_{t-i} + \hat{\epsilon}_t \]  
\[ (5.28) \]

\[ y_t = \hat{\beta}^2 + \hat{\gamma}^2 DT^*_t + \hat{\beta}^2 t + \hat{\alpha}^2 y_{t-1} + \sum_{i=1}^{n} \hat{c}_i^2 \Delta y_{t-i} + \hat{\epsilon}_t \]  
\[ (5.29) \]

\[ y_t = \hat{\beta}^3 + \hat{\eta}^3 DS_t + \hat{\beta}^3 t + \hat{\gamma}^3 DT^*_t + \hat{\alpha}^3 y_{t-1} + \sum_{i=1}^{n} \hat{c}_i^3 \Delta y_{t-i} + \hat{\epsilon}_t \]  
\[ (5.30) \]

Where again, $DS_t = 1$ if $t > T$ and 0 otherwise, $DT^*_t = t - T$ if $t > T$ and 0 otherwise. And $n$ is the number of the optimal lags. The estimation process examines the null of existence of a unit root against the alternative of trend stationary, if $y_{t-1}$ is statistically significant, we reject the null hypothesis of a unit root.

As discussed earlier, potential structural breaks in the time series may lead to biased results toward the stationarity of the data. Therefore, for the unit root test, structural breaks should be considered. In this chapter, the empirical analysis use the model of a unit root test with structural breaks from Vogelsang and Perron (1998) (VP) in order to test the simultaneous structural breaks and unit root.

In their study two methods of modelling the shifts were anticipated. The first, called the additive outlier (AO), represent breaks as occurring unexpectedly while the other one called innovational outlier (IO), form the breaks as evolving more slowly over

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98 The detail of the procedure on statistics and the steps of the test explain further in Zivot and Andrews (1992).

time. Assuming that breaks occur suddenly in the series and the constant term in the equation of the model would change after the break, the present study uses the AO model of VP which refers to model 1 in VP:

\[ y_t = \mu + \beta t + \theta DU_t^c + z_t \]  (5.31)

where \( y_t \) is a time series, \( \mu \) is the intercept, \( t \) is the time trend, the indicator function \( DU_t^c = 1 \) when \( (t > T_b^c) \) and 0 otherwise. \( T_b^c \) denotes the date of the breaks and superscript “c” denotes the correct date of break. \( z_t \) is the error term that follows an ARMA (Autoregressive Moving Average) process. When the time series has a unit root, the intercept of \( y_t \) is \( \mu_1 \) (that is a fixed constant), up to time \( T_b^c \) and \( \mu_1 + \theta \) after it. When series is stationary, the intercept is \( \mu_2 \) up to time \( T_b^c \) and \( \mu_2 + \theta \) after that time. The unit root test in the AO model is carried out in two steps: first, estimating the following regression with OLS to de-trend the series as:

\[ y_t = \mu + \beta t + \theta DU_t + \hat{\gamma}_t \]  (5.32)

where \( DU_t = 1 \) when \( (t > T_b) \) and 0 otherwise. Second, the null hypothesis of a unit root is tested using the t-statistic for testing \( \alpha = 1 \) in the regression in equation (5.33):

\[ \hat{\gamma}_t = \sum_{i=0}^{k} \omega_i D(T_b)_{t-i} + \alpha \hat{\gamma}_{t-1} + \sum_{i=1}^{k} c_i \Delta \hat{\gamma}_{t-i} + \xi_t \]  (5.33)

\( k \) denotes the lag length, \( D(T_b)_{t} = 1 \) when \( (t = T_b + 1) \) is the dummy variable and \( \xi_t \) denotes the part that cannot been explained by the regression. Table 1 in VP\(^{100}\)

\(^{100}\) The table is reported in appendix
provides the critical values of the t-statistics for testing $\alpha = 1$ for different sample sizes.

### 5.7. Empirical results

As explained in the previous section, the first step after testing for existence of unit roots is structuring a Vector Autoregressive model (VAR). The VAR consists of four variables namely $m$, $p$, $y$ and $v^*$ which are logarithm of M2, logarithm of GDP deflator, logarithm of real GDP and equilibrium velocity respectively, where the latter will be assumed as an exogenous variable in unrestricted VAR.

As discussed in detail in section 5.5 and 5.6 (the theoretical framework), firstly the stationarity and order of integration of the data will be tested using four conventional unit root tests. The next step is finding the number of appropriate lags to have no serial correlation in residual in order to be able to perform the cointegration test. To do this, I use Breusch–Godfrey serial correlation Lagrange Multiplier test (LM) ran on a basic unrestricted VAR of the variables. Then Johansen cointegration test is employed to find out the number of cointegrating vectors. And finally the VECM is estimated and the exogeniety test results of the data are reported.

#### 5.7.1. Unit root tests

The very first step in analysing the data empirically is to test the stationarity of the data. The series converted to the natural logarithm and then unit root tests has been applied. The result of the test is given in Table 5.2.
Table 5.2: Unit root test

<table>
<thead>
<tr>
<th>Test</th>
<th>Quarterly data</th>
<th>Annual data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Level</td>
<td>1st difference</td>
</tr>
<tr>
<td></td>
<td>Price</td>
<td>Money</td>
</tr>
<tr>
<td>ADF</td>
<td>-1.28</td>
<td>-0.27</td>
</tr>
<tr>
<td>DF-GLS</td>
<td>0.80</td>
<td>0.32</td>
</tr>
<tr>
<td>PP</td>
<td>-1.29</td>
<td>0.28</td>
</tr>
<tr>
<td>KPSS</td>
<td>1.23</td>
<td>1.24</td>
</tr>
</tbody>
</table>

"*", "**", and "***" denote the stationary at 1%, 5% and 10% level of significance.

As can be seen in Table 5.2, if we rely on the KPSS and VP results, in both quarterly and annual data sets, the series are non-stationary and will become stationary in the 1st difference. The VP test result is also reported in Table 1 in order to define the break points, where the first two break points are used as dummy variables while testing the VEC restrictions.

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101 Unit root test results, using the AO framework based on Vogelsang and Perron (1998). Figures imply test statistics. According to VP, critical values of the hypothesis of unit root test are: -5.92, -5.20 and -4.93 for the 1%, 5% and 10% level of significance respectively. (see the full table in appendix)

102 The VP test results been reported using Gauss 7.0 and the Gauss codes is reported in appendix, and the other tests computed by Eview 7.

103 As discussed before, Liang and Teng (2006) and Luintel and Khan (1999) have shown that the KPSS test has greater power in stationary testing comparing to PP and ADF.
5.7.2. Johansen cointegration test

As a VECM only applies on the cointegrated series, and we need to insert the number of cointegrating vectors in VEC specification, we should run the Johansen cointegration test as a prerequisite of VECM in order to determine the number of cointegrating vectors.

Before performing a cointegration test, the number of appropriate lags should be defined. I determine the number of appropriate lags with constructing an unrestricted VAR of the four series explained above. I increased the length of lags until obtained VAR residuals serially uncorrelated. Hence, this yields 4 lag lengths for the annual data, and 7 lags for the quarterly data. Following the Johansen procedure for determining the number of cointegrating vectors, the test results both trace and maximum eigenvalue support the existence of one cointegrating vector in the dataset (see Table 5.3 below). The results of the test (Trace and Maximum eigenvalue test statistics) are given in Table 5.3.

104 The series are logarithm of M2, Real GDP, GDP deflator and equilibrium velocity all in level. The latter is assumed as the exogenous variable in unrestricted VAR.

105 Existence of serial correlation will result of erroneous results in VAR. See Hall (1989) and Johansen (1992) for further discussion. The LM test as explained before is employed for this purpose.

106 The number of observation is 80. As it may be a short span data for testing the cointegration. Reinsel and Ahn (1992) argue that the co-integration tests tend to be biased towards finding evidence for co-integration when the number of observation is limited. To resolve this problem, following Reisel and Ahn (1992), the Trace and maximum eigenvalue statistics were adjusted by factor \((D-KP)/D\), where \(D\) is the number of observations, \(K\) is number of variables and \(P\) is the order of VAR, the results remain the same.
Table 5.3: Johansen cointegration test for annual and quarterly data

<table>
<thead>
<tr>
<th>Number of cointegrating vectors</th>
<th>Trace statistic</th>
<th>5% critical value</th>
<th>Max-Eigen statistic</th>
<th>5% critical value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quarterly</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>45.23</td>
<td>29.79</td>
<td>36.22</td>
<td>21.13</td>
</tr>
<tr>
<td>1*</td>
<td>9.01</td>
<td>15.49</td>
<td>9.003</td>
<td>14.26</td>
</tr>
<tr>
<td>2</td>
<td>0.011</td>
<td>3.84</td>
<td>0.011</td>
<td>3.84</td>
</tr>
<tr>
<td>Annual</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>47.48</td>
<td>29.79</td>
<td>39.05</td>
<td>21.13</td>
</tr>
<tr>
<td>1*</td>
<td>8.42</td>
<td>15.49</td>
<td>8.42</td>
<td>14.26</td>
</tr>
<tr>
<td>2</td>
<td>0.001</td>
<td>3.84</td>
<td>0.001</td>
<td>3.84</td>
</tr>
</tbody>
</table>

“*” indicates the number of cointegrating vector among the variables at 5% significance level.
Both trace and maximum eigenvalue test statistics support the existence of one cointegrating vector in annual and quarterly data.

5.7.3. VECM and exogeneity test

In P-star models, one of the most important tests is the exogeneity test of the variables that we assume endogenous in VAR. In order to do this, I impose restrictions to the VECM to be able to observe the behaviour of the variables. This test is for determining whether money, price and income are significant for predicting price changes. If such a test shows that money and income have the predictive power to explain the changes of prices (or they are not exogenous), then P-star model for predicting price changes (or inflation) may not be applied. In the present study, following Hall and Milne (1994), in order to perform the exogeneity test, the cointegreted VAR model of the variables (money, price and output) was estimated (as already explained) and then the loading weights were obtained in matrix \( \alpha \) of \( \Pi \) in equation (5.16), I tested the null hypothesis that weights corresponding to money and output are zero. This is for the hypothesis that the series under consideration are exogenous. Table 5.4 below shows the exogeneity test statistics for money and output.
Table 5.4: Exogeneity test*

<table>
<thead>
<tr>
<th>series</th>
<th>Quarterly data</th>
<th>Annual data</th>
<th>5% Critical value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test statistics</td>
<td>P</td>
<td>Y</td>
<td>M</td>
</tr>
<tr>
<td>1.54</td>
<td>6.69</td>
<td>4.71</td>
<td>7.95</td>
</tr>
</tbody>
</table>

*The Table shows exogeneity test within the Johansen cointegrated VAR. The null hypothesis is zero loading weight for price, money and output (or exogenous price, money and output).

As can be seen from Table 5.4, the price is exogenous in the quarterly data while the output and money are endogenous. In contrast, for money and price in annual data, the result shows that we can reject the null hypothesis for money and price at 5% and for real output in 10% level of significance. This means that the variables in annual data have the predictive power to explain the changes in prices. Consequently, the p-star model of inflation explained in equation (5.7) can be estimated using the annual data with appropriate lag. We recall equation (5.7) here as:

\[
\pi_t = \alpha + \sum_{i=1}^{\eta} \beta_i (\pi_{t-i}) + \varphi_1 \pi_{t-1}^* + \epsilon_t
\]

Where \( \pi^* = p - p^* = (v - v^*) - (y - y^*) \)

5.7.4. P-star model estimation\(^{108}\)

This section provides the results of estimating the error correction model in equation (5.7) (the P-star model). Parameter estimates for the P-star model with annual data, are reported below\(^{109}\).

---

\(^{107}\) Asymptotically they have the chi-squared distribution with 1 degree of freedom, whose 5% critical value is 3.841.

\(^{108}\) The results of the extended model estimation (including Money and output) reported in appendix, and the value of the error term is not changing significantly.

\(^{109}\) The full table of results is reported in the appendix (Table 5.5).
\[ \pi_t = \alpha + \beta_1(\pi_{t-1}) + \beta_2(\pi_{t-2}) + \beta_3(\pi_{t-3}) + \beta_4(\pi_{t-4}) + \varphi_1 \pi_{t-1}^* + \varepsilon_t \]

\begin{tabular}{cccc}
0.641068 & 0.225747 & 0.00052 & -0.222947 \\
(0.141837) & (0.136184) & (0.131697) & (0.121957) & (0.208627)
\end{tabular}

The errors are in brackets and the estimated value for the coefficients in reported under each variable. The coefficient of the price gap (highlighted) meet our expectation of the model and is a number close to -1.

5.8. Conclusion

The relevance of the P-star model to the Iranian data was the main question of this chapter to address. First, the arguments in regards to the P-star model have been reviewed. Then, after the steps of relevant econometric tests, the exogeneity test of the model is performed, it can be concluded that in the annual data, money is endogenous in the model. The results support the P-star model for the Iranian data (annual) and indicate that the P-star model can act as a good indicator to forecast future inflation. The different result in the quarterly data is a matter for discussion, however. As it can be seen in exogeneity test, in quarterly data, price is exogenous, indicating that in the long run, the P-star cointegrating vector, has no link with the price, and the direction of the long run causality flows into the real output and money (M2). One reason for this manner of the data can be the different periods under analysis in annual and quarterly data on the one hand, and specific conditions in Iran in the period of quarterly data (1988q1:2007q4), on the other hand. This period represents the era after eight years of war and the revolution. In order to find a remedy for this problem, I tried to run the same analysis for the annual data in a
shorter period same as the quarterly data, but due to the low number of observations (i.e. twenty) some of the tests could not be performed and the results were not reliable.

In order to compute these results first we needed to test the stationarity of the data to avoid spurious results in estimation, so four unit root tests were used, and the results indicate that the data were integrated in order one. Before constructing a VAR we needed to check if there was a structural break in the data. To do this, after explaining the foundation of the structural break test, I used a modified version of Vogelsang and Perron’s (1998) structural break test in Gauss 7.0. The foundations of the P-star model, VAR and VECM have also been briefly discussed. The LM test was used to define the number of lags which make the residuals serially uncorrelated as a prerequisite of a restricted VAR estimation.

A possible extension to this chapter can be to analyse different ways of deriving the output gap and velocity of money. As a policy recommendation, and to build a link between this chapter and the other chapters, monetary authorities in Iran can use the P-star model as a tool for forecasting short run inflation and if this prediction deviates significantly from their target, they can adjust their instrument accordingly. To critically evaluate this chapter, one can use the other aggregate of money such as M0 and M3 to calculate the equilibrium velocity of money. The results may vary if another price index such as Consumer Price Index (CPI) or Producer Price Index (PPI) used instead of GDP deflator. And finally another filtering method for calculating the equilibrium level of the velocity of money such as Kalman filter could be employed.
Appendix

- Gauss procedure for VP test

/*This is a procedure for computing augmented Perron Additive Outlier (Crash)test with the selection of lags similar to Hall (1994) general to specific method. The selection of lags is according to the 'significant' Student-t statistics on augmentations. The break time is assumed to be known

inputs:
  y - a series of data, n x 1;
  b - time index indicating the breakpoint, b < n;
  k - maximum lag length
  crit - critical value for selection
  model - 1, 2 or 3, as in Vogelsang & Perron (1998)

outputs:
  ta - Perron Additive Outlier (AO) statistic
  tth - Student-t statistic for the step(model 1) or slope (model 2,3)
  kvy - vector which identifies particular lags in augmentation in y's
  kvt - vector which identifies particular lags in augmentation in dt's */

proc (4) = per_ao(y, b, k, crit, model);

local k1, kv, i, du, x, c, b1, r, sveta, s, b2, r1, tv, dt, t, t1, koniec;
local sxxy, xx, pocz, l1, dr, cd, td, xmis, cx, n;
local xdt, kvy, kvt, kly, klt, trend, l2;
local sxxy, sxxt, tvy, tvt, ta, tth;
local model12, model3, l3, pocz3, d_t;
local sss, sss3;

model12:
if model ==1 or model ==2;

k1 = k;
kly = k1;
klt = k1;

if k >0;
  kv = seqa(1,1,k);
kvy = kv;
kvt = 0|kv;
else;
kvy=0;
kvt=-1;
k1=-1;
kly=0;
klt=-1;
endif;
n=rows(y);
if b .> n-1-k;
? "Error: breakpoint is too close to the end of the series";
? " or the augmentation length is too long ";
endif;

if b-k+1 .< 0;
? "Error: breakpoint is too close to the beginning of the series, ";
? " or the augmentation length is too long ";
endif;

du = zeros(n,1);
du[b:n,1]=ones(n-b+1,1);
dt = zeros(n,1);
dt[b,1]=1;
d_t=du;
i=b+1;

do until i>n;
   d_t[i] = d_t[i]*(i-b);
   i=i+1;
endo;
trend = seqa(1,1,n);

if model ==1;
   x = ones(rows(y),1)~trend~du;
elseif model ==2;
   x = ones(rows(y),1)~trend~du~d_t;
endif;

c = invpd(x'x);
b1 = c*((x')*y);
r = y-x*b1;

s = stdc(r);
tv= b1./(sqrt(diag(c)).*s);

  t = tv[3]; /* Student-t statistics for the spike DU*/
if model ==2;
   t=tv[4]; /* Student-t statistics for the slope DT*/
endif;

  tth = t;

  dr = r[2:rows(r),] - r[1:(rows(r)-1)];
x = r[1:(rows(r)-1),];
dt =dt[2:rows(dt)];
@ Creating lags on dr and dt @

pocz:

if k1 == -1:
    goto l1;
else:

if k1y == 0:
    kvy = 0; goto l2;
else:

@ Creating augmentations for dr @
sveta = zeros(rows(dr), k1y);

i = 1;
do until i > k1y;
    sveta[., i] = lagn(dr, i);
    i = i + 1;
endo;

dr = trimr(dr, k1, 0);
x = x~sveta;
x = trimr(x, k1, 0);
endif;

l2:

if k1t == -1:
    kvt = -1; goto l1;
else:
    if kvt == 0:
        goto l1;
    else:

@ Creating augmentations for dt @
xdt = zeros(rows(dt), k1t);

i = 1;
do until i > k1t;
    xdt[., i] = lagn(dt, i);
    i = i + 1;
endo;
/*dt = trimr(dt, k1, 0);*/
xdt = trimr(dt~xdt, k1, 0);
x = x~xdt;
endif;
endif;
endif;

cx = cols(x);
l1:
c = invpd(x'x);
b2 = c*{(x')*dr};

r1 = dr-x*b2;

s = stdc(r1);
tv= b2./(sqrt(diag(c)).*s);

ta = tv[1]; /* Perron AO statistic */

if k1 == -1;
    goto koniec;
else;

tv= trimr(tv, 1, 0);

if kly /=0;

tvy=tv[1:rows(kvy)];

if klt /=-1;
tvt=tv[(rows(kvy)+1):rows(tv)];

sxxt = x[.,(rows(kvy)+2):cols(x)]';
endif;

sxxy = x[.,2:(rows(kvy)+1)]';
sxxy = kvy~sxxy;
sxxy = delif(sxxy, abs(tvy).<crit);
xmis = ismiss(sxxy);

if xmis == 1;
    kly = 0;
    kvy=0;
    sxxy = {};
else;
    kvy = sxxy[.,1];
    sxxy=sxxy[.,2:cols(sxxy)];
endif;

if klt /=-1;
    sxxt = kvt~sxxt;
    sxxt = delif(sxxt, abs(tvt).<crit);
    xmis = ismiss(sxxt);
else;
    xmis =1;
endif;

if xmis == 1;
    klt = -1;
    kvt=-1;
    sxxt = {};
else;
    kvt = sxxt[.,1];
    sxxt = sxxt[.,2:cols(sxxt)];
endif;
else;

  sxxy={};
  if kvt/-1;

    tvt=tv[1:rows(tv)];
    sxxt = x[.,2:cols(x)]';

    sxxt = kvt~sxxt;
    sxxt = delif(sxxt, abs(tvt).<crit);

    xmis = ismiss(sxxt);

    if xmis == 1;
      klt = -1;
      kvt-1;
      sxxt = {};
    else;
      kvt = sxxt[.,1];
      sxxt = sxxt[.,2:cols(sxxt)];
    endif;
  else; sxxt={};
  endif;
endif;
endif;

if kly==0 and klt==1;
  kl=-1;
  kv=-1;
  x=x[.,1];
  goto pocz;
else;
  kv = kvy|kvt;
  xx = sxxy|sxxt;
  xx = xx';
  x = x[.,1]~xx;
endif;

if cx == cols(x);
  goto koniec;
else;
  cx=cols(x);

  goto l1;
endif;
endif;

elseif model ==3; /* for model 3*/

model3:

  k1 = k;
  kly = k;
k1t = -1;

if k > 0;
    kv = seqa(1, 1, k);
    kvy = kv;
    kvt = -1;
else;
    kvy = 0;
    kvt = -1;
    kl = 0;
    kl = -1;
endif;

n = rows(y);

if b > n - k;
    ? "Error: breakpoint is too close to the end of the series";
    ? " or the augmentation length is too long ";
endif;

if b-k+1 < 0;
    ? "Error: breakpoint is too close to the beginning of the series, ";
    ? " or the augmentation length is too long ";
endif;

d_t = zeros(n, 1);
d_t[b:n, 1] = ones(n - b + 1, 1);

i = b + 1;
do until i > n;
    d_t[i] = d_t[i]*(i - b);
    i = i + 1;
endo;

trend = seqa(1, 1, n);

x = ones(rows(y), 1)~trend~d_t;

c = invpd(x'x);
b1 = c*((x')*y);
r = y - x*b1;

s = stdc(r);
tv = b1./(sqrt(diag(c)).*s);

t = tv[3];       /* Student-t statistics for the slope DT */
tth = t;

dr = r[2:rows(r),] - r[1:(rows(r)-1)];
x = r[1:(rows(r)-1),];

@ Creating lags on dr @
pocz3:

if kl == -1;
goto l3;
else;
if kly ==0;
  kvy =0; goto l3;
else;

@ Creating augmentations for dr @
sveta= zeros(rows(dr), kly);
i=1;
do until i > kly;
  sveta[.,i]=lagn(dr,i);
i=i+1;
endo;
x= trimr(x~sveta,k1,0);
dr=trimr(dr, k1, 0);
endif;
endif;
endif;
cx = cols(x);

13:
c = invpd(x'x);
b2 = c*((x')*dr);
r1 = dr-x*b2;
s = stdc(r1);
tv= b2./(sqrt(diag(c)).*s);
ta = tv[1]; /* Perron AO statistic */
if k1 == -1;
  goto koniec;
else;
tv= trimr(tv, 1, 0);
if kly /=0;
tvy=tv[1:rows(kvy)];
sxxxy = x[.,2:cols(x)]';
sxxxy = kvy-sxxxy;
sxxxy = delif(sxxxy, abs(tvy).<crit);
xmis = ismiss(sxxxy);
if xmis == 1;
  kly = 0;
kvy=0;
else;
  kvy = sxxxy[.,1];
  sxxxy=sxxxy[.,2:cols(sxxxy)];
endif;
if kly==0 and ktt==-1;
    kl=-1;
    kv=-1;
    x = x[.,1];
    goto pocz3;
else;
    kv = kvy;
    xx = sxxy;
    xx = xx';
    x = x[.,1]-xx;
endif;
if cx == cols(x);
    goto koniec;
else;
    cx=cols(x);
    goto l3;
endif;
endif; /* for model 3 */

koniec:
retp (ta, tth, kvy, kvt);
endp;

/*
This is a procedure for computing an Additive Outlier (Crash)
test in case of an unknown single break. It computes sequentially
the Perron test (procedure per_ao) and chooses the best break
according
to the Zivot and Andrews(1992, JBEA) or Vogelsang and Perron (1998,
IER) criteri
a.
It requires the procedure per_ao to be placed ABOVE this on in the
program.

inputs: y - a series of data, n x 1;
    out - time index indicating the fraction of first and last
        observations
        which have to be discarded while testing;
    kp - maximum lag length
    critp - critical value for selection
    modelp=1,2,3
    d    - selector variable
        if d = 0, the Zivot-Andrews selection is performed
if d = 1, the Vogelsang-Perron selection is performed

d=1,2,3 !!!!!!!!!!!!!!!! SM
1- minimazin ta
2 - maximazin tth
3 - maximazin abs(tth)

(inputs kp and critp are required by the included per_ao procedure)

outputs:
   ta  - final value of the test statistic
   tth - Student-t statistic for the 'crash' dummy variable
         (step for model 1 and slope for models 2 and 3)
   bp  - points of the break in the series
   bn  - number of the break in the series
   rm  - ordered break points

*/

proc (5) = ao_test(y, out, kp, critp, modelp, d);

local low,hig,i,a,b,c,rm, stat, brst, brdt;
local bp, bn, ta, tth;
local dd;

low = round(out.*rows(y));
hig = round(((1-out).*rows(y));
rm = zeros(hig-low+1,3);
rm[,]=seqa(low,1,rows(rm));

i = low;
do until i > hig;
   {a,b,c,dd} = per_ao(y,i,kp,critp, modelp);
   rm[i-low+1,1]=a;
   rm[i-low+1,2]=b;
   i = i + 1;
endo;

if d == 1;
   rm = sortc(rm,1);
elseif d == 2;
   rm = rev(sortc(rm,2));
elseif d==3;
   rm = rev(sortc(abs(rm),2));
endif;

ta = rm[1,1];
tth = rm[1,2];
bp = rm[.,3];
bn = rows(rm);
rm[.,3]=rm[.,3];

retp(ta, tth, bp, bn, rm);
endp;
### Table 1
MODEL (1, AO): DISTRIBUTION OF $t_1(1, AO, T)$

<table>
<thead>
<tr>
<th>Panel (a): Choosing $T_n$ maximizing $t_1, t_2(1, AO, T_n(t_q))$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T = 50$</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>$T = 100$</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>$T = 150$</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>$T = \infty$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Panel (b): Choosing $T_n$ maximizing $t_1, t_2(1, AO, T_n(t_q))$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T = 50$</td>
</tr>
<tr>
<td></td>
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<td>$T = 100$</td>
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<tr>
<td></td>
</tr>
<tr>
<td>$T = \infty$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Panel (c): Choosing $T_n$ maximizing $t_1, t_2(1, AO, T_n(t_q))$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T = 50$</td>
</tr>
<tr>
<td></td>
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<td>$T = 100$</td>
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<tr>
<td>$T = 150$</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>$T = \infty$</td>
</tr>
</tbody>
</table>
### VAR estimation result for annual data

Vector Autoregression Estimates
Sample (adjusted): 1969 2007
Included observations: 39 after adjustments
Standard errors in ( ) & t-statistics in [ ]

<table>
<thead>
<tr>
<th></th>
<th>LOGGDPDF</th>
<th>LOGM2</th>
<th>LOGRGDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOGGDPDF(-1)</td>
<td>0.522929</td>
<td>0.085912</td>
<td>-0.036480</td>
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<tr>
<td></td>
<td>(0.19903)</td>
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<td>(0.14058)</td>
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<tr>
<td></td>
<td>[ 2.62744]</td>
<td>[ 1.07222]</td>
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<tr>
<td>LOGGDPDF(-2)</td>
<td>-0.484225</td>
<td>-0.054926</td>
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<tr>
<td></td>
<td>(0.21757)</td>
<td>(0.08759)</td>
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<tr>
<td></td>
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<tr>
<td></td>
<td>(0.22423)</td>
<td>(0.09027)</td>
<td>(0.15839)</td>
</tr>
<tr>
<td></td>
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<td>[-1.15966]</td>
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<td>-0.887493</td>
</tr>
<tr>
<td></td>
<td>(0.21627)</td>
<td>(0.08706)</td>
<td>(0.15276)</td>
</tr>
<tr>
<td></td>
<td>[ 0.01221]</td>
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<td>[-5.80972]</td>
</tr>
<tr>
<td>LOGM2(-1)</td>
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<tr>
<td></td>
<td>(0.50004)</td>
<td>(0.20131)</td>
<td>(0.35320)</td>
</tr>
<tr>
<td></td>
<td>[ 1.52662]</td>
<td>[ 2.89100]</td>
<td>[-2.04834]</td>
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<tr>
<td>LOGM2(-2)</td>
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<td>0.307815</td>
<td>-0.618504</td>
</tr>
<tr>
<td></td>
<td>(0.56975)</td>
<td>(0.22937)</td>
<td>(0.40245)</td>
</tr>
<tr>
<td></td>
<td>[ 2.51115]</td>
<td>[ 1.34198]</td>
<td>[-1.53686]</td>
</tr>
<tr>
<td>LOGM2(-3)</td>
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<td>0.344907</td>
<td>1.536275</td>
</tr>
<tr>
<td></td>
<td>(0.57092)</td>
<td>(0.22984)</td>
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<td>[ 1.50061]</td>
<td>[ 3.80952]</td>
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<td>0.135257</td>
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<td>(0.29455)</td>
<td>(0.11858)</td>
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- **VAR estimation result for quarterly data**

Vector Autoregression Estimates  
Sample (adjusted): 1989Q4 2007Q4  
Included observations: 73 after adjustments  
Standard errors in ( ) & t-statistics in [ ]

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- P-star model estimation results

Table 5.5: P* model estimation
Dependent Variable: INFLATION
Method: Least Squares
Sample (adjusted): 1970 2007
Included observations: 38 after adjustments

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Adjusted R-squared 0.450043 S.D. dependent var 0.098460
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Sum squared resid 0.170607 Schwarz criterion -1.993747
Log likelihood 48.79395 Hannan-Quinn criter. -2.160317
F-statistic 7.055603 Durbin-Watson stat 2.149713
Prob(F-statistic) 0.000152
# P-star model estimation results (including money and output)

Dependent Variable: DLOGGDPDF  
Method: Least Squares  
Sample (adjusted): 1970 2007  
Included observations: 38 after adjustments

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Chapter 6: CONCLUSION
6.1. Summary of the thesis

The main goal in this research can be summarised in analysing the monetary policy in Iran with respect to adoption of an inflation targeting framework. The major findings drawn from the main four chapters are presented in this chapter. This thesis has attempted to make a contribution to the literature present a detailed definition of the structure and components of the monetary policy in Iran, also introduce a solution for the problems using the Taylor–type rule in Iran. The following six questions have been addressed:

- What are the main structure of the monetary policy and the source of inflation in Iran?
- What prompts emerging economies to shift to inflation targeting?
- What are the prerequisites and condition for an economy to shift to inflation targeting and what are the alternatives to this strategy?
- Due to the lack of micro-foundations of the Taylor rule and the problem of using interest rate in a Usury-free system in Iran, is it possible to derive a theory based instrumental rule in to be used in the potential inflation targeting framework in Iran?
- The monetary authorities in Iran do not explicitly include exchange rate variations in the construction of the monetary policy, are they right?
- Assuming the prerequisites of the inflation targeting carried out in Iran, is the P-star model a good choice in forecasting inflation rate in Iran?

The first question is discussed in Chapter 2. Firstly, a review of the determinants of inflation in Iran and the sources of inflation are presented. The current conduct of
monetary policy which is heavily related to the oil revenue and the direct and indirect instruments of monetary policy are discussed. To provide a solution to the problem of using interest rate in Iran, the alternative of it as “deposit rate” introduced. The function of the deposit rate in practice is evaluated and concluded that it does have the same performance of interest rate but it is compatible with the Usury-free banking system in Iran. Consequently, a modified Taylor rule in which the interest rate is replaced by deposit rate can be used as an instrumental rule in Iran.

The rationale for reducing inflation and the costs of inflation in Iran have been briefly summarised and indicated that although a reasonable rate of inflation act as a promotion to steer the economy, but in Iran due to the persistent high rate of inflation, people are facing the reduction in their purchasing power and as a consequence decreasing the welfare of the individuals in the economy.

In Chapter 3, the prerequisites in a representative developing economy to be able to adopt inflation targeting frameworks have been discussed. Most importantly, the independence of the central bank and then its credibility and accountability as well as the assumptions behind these conditions have been identified and analysed. In addition, the monetary authorities should have periodical communication with the public regarding their strategies and make their actions clear in order to have transparency of the changes in their reaction function. This will also have a direct effect on increasing the credibility of the central bank. The advantages and disadvantages of an inflation targeting framework, in addition to supporting the arguments for and against, have been critically analysed and argued. A summary of
the countries that adopted this strategy has been presented and their performances
has been briefly analysed.

Monetary aggregate targeting and exchange rate targeting as alternatives monetary
strategies and its specifications have been discussed as the other available choices to
monetary authorities. The priorities of inflation targeting in relation to these
alternatives, and the advantages of it in practice, and its relative ability to achieve
price stability, have been presented.

Assuming the prerequisites of inflation targeting have been met, the next step was to
choose a monetary policy reaction function. A Taylor rule and the modified versions
of it were the most popular monetary policy reaction functions and many central
banks in the world have used them. But, since this rule has been generated by
tracking the manner of the data in the United States, it suffers from the lack of
micro-foundation. In the theoretical part of Chapter 3, I derived a theory based
monetary policy rule which is a Taylor-type rule. To do so, I used a Dynamic
Stochastic General Equilibrium (DSGE) type New Keynesian model in a small open
economy modified to be able to consider a target of the inflation rate. This model
contributes to the literature by considering the target of inflation in the reaction
function of the central bank as well as an alternative to the interest rate so called
“deposit rate”. As a result, in Chapter 3, the resulting model is an instrumental rule
for the monetary policy in Iran that can be used in the inflation targeting framework.
Consequently, Chapter 3 provides the answers to the second to fourth questions
above.
This resultant model is the base for analysis of the exchange rate in Chapter 4, where effects of the exchange rate in the structure of the monetary policy were discussed. In the first part of Chapter 4, an outlook of the monetary policy and its current instrument has been explained. As an open small economy in the case of Iran, the monetary policy needs to care of fluctuation of exchange rate. This chapter aimed to stress this effect by designing a Monetary Condition Index (MCI) which takes the effects of exchange rate fluctuations in the monetary policy reaction function. Before constructing a model involving the exchange rate, the necessity of having a floating exchange rate in the economy has been discussed. The effect of the exchange rate on the monetary policy has been assessed using generalised impulse response functions, so this chapter cover the fifth question above.

To reply to the last question, Chapter 5 evaluates the relevance of the P-star model of inflation to the Iranian economy. By taking the assumption that the conditions for adopting inflation targeting framework in Iran is met, in Chapter 5, I examined whether the P-star model can be a good indicator in forecasting inflation in Iran. In order to do this, firstly, the importance of the velocity formation need to be emphasised. Different measures of velocity of money have been calculated by utilising data from Iran. Prior to empirical analysis, using Gauss 7.0, I tried to test for the structural break while testing for the unit root. To do so, I used Zivot and Andrews (1992) and Vogelsang and Perron’s (1998) procedure to perform the test in order to obtain reliable results from the stationarity tests.

In the empirical section of Chapter 5, after finding the order of integration of the variables in the VAR, I used the Johansen test to find the cointegrating vectors. Then, the long run causality between the variables in the VECM has been defined.
using the exogeniety test. On the basis of the findings from the exogeniety test, I estimated the P-star model of inflation in Iran on selected dataset. The relevant estimation results have been presented in the appendices following each chapter.

6.2. Concluding remarks and policy recommendation

In Chapter 3, of this thesis, a micro-based model of interest rate through optimisation of the household utility function, marginal cost of producer and monetary authority loss function, has been derived. This will fill the gap in the lack of theory based of Taylor rule. The resulting monetary policy rule indicates that the central bank should react to the output gap and its first lag, the inflation gap, and two lags of the interest rate (in the case of Iran, deposit rate), and also indirectly respond to the deviation of the exchange rate via its effect on aggregate supply and output. Consequently, the resultant model can be recommended to the monetary authorities in Iran to use as instrumental rule of monetary policy.

Chapter 4 presents a model of the monetary policy reaction function which considers the direct effect of the exchange rate in formation of the model. In the resulting model of Chapter 4, the instrument of the central bank is a function of the inflation gap, output gap and exchange rate gap. Consequently, the derived policy rule is an augmented Taylor-type rule in which the exchange rate gap has been added to the model by deriving the new reaction function using the monetary condition index. The impulse response functions of the results of the VAR estimation in Chapter 4 suggest that inflation is significantly affected by shocks from the exchange rate in Iran and the hypothesis of not considering it will be clearly rejected. Another conclusion from this chapter is the positive response of the deposit rate to a positive
exchange rate shock which can also have a negative impact on inflation and decrease it although the channel of effect is not direct.

Consequently, as the policy recommendation of Chapter 4, the monetary authorities should consider the exchange rate as a key element in constructing the monetary policy reaction function. This will help to appoint a more appropriate instrument in the monetary policy and in achieving better results in controlling inflation.

In Chapter 5, to introduce a reliable tool for predicting the inflation rate in Iran, the P-star model of inflation has been examined on Iranian data. The velocity of money and its equilibrium plays a vital role in calculating the price gap in the model. The results of a structural break test for testing the unit root test will not significantly change the result of the stationarity test. The results of the Johansen cointegration test show the existence of one cointegrating vector in the VAR. Then, an exogeneity test of the price, money and output has been performed, and it can be concluded that (in the annual data) price and money are endogenous in the model. The results support the P-star model for the Iranian data (annual) and indicate that the P-star model can act as a reasonably good indicator to predict future inflation. The different result in the quarterly data is a matter for discussion, however. In the quarterly data, price is exogenous, indicating that in the long run, the P-star cointegrating vector, does not have a link in predicting inflation, and the direction of the long run causality flows into the real output and aggregate money (M2).

To sum up, the thesis concludes:

Since the monetary frameworks have not been successful in reducing inflation in Iran, implementing an inflation targeting monetary strategy is likely to be a
necessary task for monetary authorities in Iran when the prerequisites have been met. The next recommendation of the thesis is that the central bankers in Iran should directly include the exchange rate in construction of the monetary policy reaction function, and maybe the exclusion of this crucial element, have been the main reason that the efforts in reducing inflation have not been successful. Assuming the inflation targeting is in practice in Iran, a P-star model can be used as an appropriate method in predicting inflation, but should be used with some caution due to the slightly different results in exogeniety test achieved by changing the frequency of data.

6.3. Limitations

This thesis is limited by the following points:

- In construction of the monetary policy reaction function in Chapter 3, the role of the financial intermediates has been ignored. For simplicity, this model assumes that households and producers directly trade with each other.

- One may argue that the choice of the deposit rate, which is not an instant effect element, is not appropriate in Chapter 4, in Iran fluctuations in the other instruments is very limited and sometimes it will not change for many years. The selected rate, was my only available choice which met the criteria in the model that also yielded acceptable results. Also, the inclusion of the budget deficit and oil revenue in the estimation will affect the results which are reported in the appendix.

- The analysis in Chapter 4 is based on a floating exchange rate, but considering the sanctions against Iran, implementing a floating exchange rate regime may not be an advisable technique in practice. I have assumed that
these sanctions will not last long and the individuals in Iran are likely to experience a low rate of inflation and a higher welfare level after approximately 40 years.

➢ In Chapter 5, a range of measures for monetary aggregate could be tested in formation of velocity. Moreover, the equilibrium velocity could be calculated using other techniques such as Kalman filter. In regards to the inflation index, Consumer Price Index (CPI) could be used instead of the change in GDP deflator (which the manner of these two significantly differs in Iran). The annual and quarterly data in Chapter 5 are in different time periods, and this can result in different outcomes from the exogeniety test. To answer this, I used the IFS as the source of my data, and there were the only these periods available.


TUTAR, E., 2002. Inflation Targeting in Developing Countries and Its Applicability to the Turkish Economy. MA thesis, Virginia Polytechnic Institute and State University, USA.

WEBSITE: [WWW.CBI.IR](http://WWW.CBI.IR) (2010).


WEBSITE: [WWW.QFINANCE.COM](http://WWW.QFINANCE.COM) (2011) and (2012).


