Department of Economics

AN OPERATIONAL FRAMEWORK FOR INFLATION TARGETING IN EGYPT

Thesis submitted for the degree of Doctor of Philosophy in Economics

at the University of Leicester

by

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September 2011

Abstract

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The thesis focuses on the potential adoption of the inflation targeting (IT) regime in Egypt. Basically, it aimed at answering the following questions. (1) Should the central bank of Egypt shift to IT or continue with the current monetary policy framework, monetary aggregate targeting (MAT). (2) What the optimal policy horizon (OPH) should central bank choose to target inflation, (3) Does modelling inflation using models that allow for time-varying conditional variance, skewness and kurtosis helps in better understanding of inflation uncertainty?

The main results of the thesis show that:

(1) To answer the first question, the stability of velocity of money in circulation and money multiplier has been analysed using variance ratio tests and found unstable. Therefore, we could conclude that the current MAT framework cannot achieve its ultimate goal of price stability and it is believed that shifting to IT framework is highly recommended.

(2) Concerning the OPH, the results show that the OPH is largely dependent on the nature of the shock and on a central bank's preferences over goals. Thus, for different kinds of the shocks, even if they are generally classified of the same type, the concern of the central bank about other policy objectives affects the policy horizon. With respect to shock persistence, the results demonstrate that the horizon increases with the persistence of the shock as persistent shock distributed over many period in comparison with transitory and less persistent shocks.

(3) To answer the third question, the methodology proposed by Leon, Rubio, and Serna (2005) for modelling nonconstant conditional second, third and fourth moments is applied. The results indicate that models with nonconstant second, third and fourth moments are superior to models with time invariant volatility, skewness and kurtosis.

To my dad soul

*To my beloved husband **Mahmoud***

*To my lovely kids **Salma** and **Noureldin***

Acknowledgment

All praise is due to Allah, the Lord of the whole world for everything He granted to me. First, I would like to convey my thankfulness to my supervisor Professor Stephen G. Hall for support and help in reviewing the thesis and providing invaluable guidance during the preparation of the thesis. I am also very grateful for my sister Amira for important discussions and suggestions as well as the continuous encouragement.

I owe my deepest gratitude to my husband Mahmoud for the love, patience and care he provides. I also thank my children, Salma and Noureldin for bringing the joy to my life. I extend my gratitude to my extended family especially my mother, sister Samer, brothers Ahmed and Mahmoud for their constant prayers and encouragement. Also, I am deeply indebted to Professor Hafiz Shaltout at the University of Benha for supporting me since I was undergraduate student and for motivating me throughout the research period. Additionally, I am very grateful to my friend Safiya Chibane for continuous support and the precious help she provides looking after my kids. Last but not least, many thanks for my friend Dina Gaafer for her prayers and my friend Heba El-Sayed for making my viva day.

Leicester, September 2011
Doaa Akl Ahmed

Abbreviation list

ARCH	Autoregressive Conditional Heteroscedasticity
ARDL	Autoregressive Distributed Lag
ARMA	Autoregressive Moving Average
CB	Central Bank
CBE	Central Bank of Egypt
CBI	Central Bank Independence
CHODE	Chow and Denning
CPI	Consumer Price Index
ERSAP	Economic reform and Structural Adjustment Programme
ERT	Exchange Rate Targeting
GARCH	Generalised Autoregressive Conditional Heteroscedasticity
GARCH-M	GARCH in mean
GC	Gram- Charlier
IFS	International Financial Statistics
IMF	International Monetary Fund
IT	Inflation Targeting
LM	Lagrange Multiplier
LOMAC	Lo and MacKinlay
LRS	Leon, Rubio and Serna
MAT	Monetary Aggregate Targeting
MDF	Money demand function
ML	Maximum Likelihood
MPC	Monetary Policy Committee
MM	Money Multiplier
MM2	Money Multiplier of M2
MTM	Monetary Transmission Mechanism
VM	Velocity of Money
VM1	Velocity of M1
VM2	Velocity of M2
NPL	Non-Performing Loans
OPH	Optimal Policy Horizon
RW	Random Walk
RWH	Random Walk Hypothesis
SMM	Studentized Maximum Modulus
TARCH-M	Threshold Autoregressive Conditional Heteroscedasticity-in mean
TARCHSK-M	TARCH Skewness Kurtosis-in mean
TARCHTSK-M	TARCH Threshold Skewness Kurtosis-in mean
TB	Treasury Bill
VAR	Vector Autoregressive
VR	Variance Ratio
WDI	World Development Indicators

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Chapter one

Introduction

It is generally accepted that achieving price stability is the main duty of the monetary authorities. Traditional regimes of monetary policy depended on MAT and ERT. In 1990s, several countries moved to IT framework to conduct their monetary policy. Shifting to this new framework of monetary policy was basically due to the disappointing performance under other regimes. The key motive of IT was to enhance accountability, and transparency of monetary policy, and improve inflation performance (Tutar, 2002; Horska, 2004). Due to its success in many developed and developing countries, the CBE announced its intention to introduce IT as a framework to anchor its monetary policy when the basic prerequisites are satisfied (CBE, 2005).

According to (Mishkin, 2004), developing countries differ from developed ones as the former are characterised by their greater weakness due to the vulnerability of fiscal and financial institutions, low credibility of monetary institutions, currency substitution, as well as fragility to unexpected stops of capital inflows. Thus, it is essential to study this monetary framework in both developed and developing countries. Tables (1.1), and (1.2) briefly summarises some of the research work devoted to IT focusing on the studies that analysed the applicability of IT in developing countries as well as the evaluation of IT performance in inflation targeters.

Table 1.1: Studies that assessed IT performance

Study	Case study	Main result
Masson, Savastano, and Sharma (1998)	Different advanced and emerging countries	They found that the preconditions for adopting IT are not yet satisfied in most developing countries. However, strengthening financial institutions and increasing market powers could make IT an attractive option for a number of countries at a relatively more advanced stage of development.
Mishkin (2000)	Chile	The Chilean example with IT looks quite successful as inflation rates fell from high double-digit number to a low single-digit number. Additionally, output growth rates were very high during the period of his analysis. This would suggest that IT could be successful strategy for gradual disinflation in emerging market countries, even when initial inflation is on the order of 20%. However, the improved performance of IT in Chile was supported by other elements such as the absence of large fiscal deficits and rigorous regulation and supervision of the financial sector as well as the gradual hardening of the targets over time.
Schmidt-Hebbel, and Tapia (2002)	Chile	They found that IT helps to establish monetary credibility, directly decreasing inflation and inflation expectations, and diminishing the inflationary effects of nominal inflation and exchange rate shocks. Their results indicate the feasibility of IT in developing countries that would represent an effective regime to improve monetary credibility and minimize the costs of stabilization.
Dodge (2002)	Canada	IT was successful in tying inflation expectation to the target which helps in establishing a credible anchor for monetary policy. Furthermore, IT proved effectiveness in lowering output volatility.
Amato and Gerlach (2002)	Number of IT countries*	They examined the role of preconditions of IT, the usage of intermediate exchange rate targets, and the specification of inflation targets in the actual implementation of IT. They found two main results: a) however that the preconditions of IT were not satisfied in the countries of interest, IT has been introduced successfully in most cases, b) exchange rate objectives might play a relatively greater role in emerging market and transition countries, mainly due to the financial structure of these economies especially during disinflation where inflation targets are coexisted with exchange rate targets giving the priority to the inflation target if there is conflicts between the two targets.
Hu (2003)	66 countries	The results show that IT plays a positive role in improving the performance of inflation and output. Furthermore, he examined the factors associated with the decision of adoption of IT. These elements are: low GDP growth and high real interest rates are significantly correlated with the decision of adopting IT which support the view that the key reason for adopting IT is to improve the overall economic performance. Additionally, at low inflation rates, the CB is more likely to adopt an IT regime. Other elements include: a sound fiscal position, financial depth, CBI, and flexible exchange

		rate regime although they are not essential prerequisites.
Ball and Sheridan (2004)	OECD countries	They compared the performance of seven OCED inflation targeters to thirteen of nontargeters in terms of the behaviour of inflation, output and interest rates. Their results showed that the performance of both targeters and nontargeters has improved along many dimensions during the 1990s. However the IT countries has improved more in controlling average inflation that fell by a larger amount, these differences are explained by the fact that targeters performed worse than non-targeters before the early nineties. They concluded that there is no evidence that IT improves performance which could be investigated by the fact that both targeters and nontargeters applied similar interest rate policies. Thus, institutional aspects of targeting are not important. However, they claimed that IT has some benefits they have not measured such as it may be desirable for political reasons and its performance may improve in the future
Chohan (2005)	Five IT countries (New Zealand, Canada, Sweden, UK, and Australia) and inflation nontargeters (Germany, Switzerland, and USA)	He examined the impact of IT on the main macroeconomic features particularly inflation and economic growth by comparing the behaviour of the CBs before and after adopting IT. Additionally, he compared IT group of countries with the other group that represents the most credible monetary regimes in the world. It is found that the adoption of IT improved the performance of the targeters in comparison to their own past in terms of low inflation and lowering the volatility of output. In comparison with nontargeters, the monetary policy outcomes under IT are consistent with the performance of most credible non-IT countries.
Gonçalves and Salles (2008)	36 emerging countries	They extended Ball and Sheridan's (2004) analysis for a subset of 36 emerging market economies and found opposite results to those of Ball and Sheridan. Compared to non-targeters, IT in developing countries not only experienced greater drops in inflation, but also in growth volatility.
Gonçalves and Carvalho (2009)	OECD IT countries	They proved that IT countries enjoy smaller output losses during disinflations in comparison with non-IT countries. In addition, they also provided evidence that higher past inflation and lower debt levels increases the likelihood that a country will adopt IT framework.

* These countries are: Australia, Brazil, Canada, Chile, Czech Republic, Israel, Finland, New Zealand Poland, South Africa, Spain, Sweden, Thailand, UK.

Table 1.2: Studies of the applicability of IT to different countries

study	Case study	Main result
Jonsson (1999)	South Africa	He recommended that South Africa should adopt explicit IT as the main prerequisites of this framework are satisfied. However, Reserve Bank of South Africa should take further steps to gain experience with the operational elements of IT and improvement of the inflation forecasting prior to the implementation. This would help in enhancing transparency and reduce the uncertainties of Reserve Bank's objectives.
Gottschalk and Moore (2001)	Poland	They analysed the effects of an exchange rate and interest rate shocks on the price level and found that the exchange rate plays an important role as an instrument of monetary policy. On the other hand, the direct linkages between the interest rate and inflation do not appear to be really strong and are less well understood. Based on these results, adjustment of some details of the strategy, such as widening the target range or lengthening the target horizon would be useful to avoid both overburdening the exchange rate and excessive volatility in the traded goods sector of the economy
Tutar (2002)	Turkey	She examined the extent to which the Turkish economy met the prerequisite of IT framework. The main findings are (1) CBI is not completely satisfied, (2) the law guarantee the existence of sole target of the CB after the shift to a floating exchange rate in 2001, (3) Using VAR model, she found that the relationship between monetary policy instruments and inflation is not stable and predictable which indicates the unpreparedness of the Turkish economy to implement IT yet.
Siklos and Abel (2002)	Hungary	It is found that the National Bank of Hungary pays more attention to the achievement of the inflation objective in recent years. In addition, applying Taylor rule suggests that it may be used to describe some of the policy choices made by it since the early 1990s. However, the relationship between the government and the CB needs explanation and further evaluation.
Youssef (2007)	Egypt	She examined the extent to which IT prerequisites are satisfied in Egypt. She basically focused on fiscal balance, the financial sector and CBI. However the main requirements are not fully met, she suggested that CBE should shift to IT as the move towards them is believed to contribute to the macroeconomic stability of the country. Consequently, she introduced some policy recommendation that CBE should undertake to emphasise a successful transition towards IT*.
Crowe and Meade (2008)	different developed and emerging	They examine the current level of CBI and transparency in a broad sample of countries. They found that the legal CBI has increased clearly since the 1980s, whereas the rise in transparency since the late 1990s has been less remarkable. Their results provide robust evidence that greater CBI is associated with lower inflation, and the enhanced transparency practices are

	countries	associated with the private sector making greater use of information provided by the CB.
Awad (2010)	Egypt	He found that the legal independence granted to the CBE under the latest legislation is not factual. Additionally, by examining the MTM, he found that: CBE is (implicitly) maintaining a target for the foreign exchange rate, (2) The CBE does not apply an independent monetary policy, (3) Foreign economic shocks play a dominant role in explaining the behaviour of real domestic growth, whereas domestic economic shocks play a dominant role in explaining the behaviour of domestic inflation, especially in the short run. (4) The interest rate channel explains the MTMs in the Egyptian economy, where changes in domestic interest rate have significant impact on both the rate of growth of real GDP and inflation. Additionally, analysing the stability of the demand for money function proved its instability which supports the view that CBE cannot achieve price stability under the currently applied MAT. Accordingly, the CBE should take steps toward adopting IT regime.

* These recommendation will be described in detail in section (2.6) when analysing the preconditions of IT in Egypt.

The review of these research papers reveal that the implementation of IT in Egypt has not been adequately explored. Therefore, the thesis is motivated by the following:

1. The emphasis of (Mishkin, 2004) concerning the necessity of investigating IT in both developed and developing countries.
2. The announcement of the CBE that it intends to shift to IT once the preconditions are satisfied.
3. To fill the gap in literature by studying some elements of the operational framework of IT in Egypt.

Consequently, the thesis starts with examining the IT framework focusing on its preconditions and the extent to which these requirements are satisfied in Egypt. Additionally, the elements of the operational framework will be discussed offering some recommendations for the CBE based on the experience of other targeters. Therefore, the thesis addresses the following questions:

1. Is Egypt ready to shift to IT framework to conduct its monetary policy?
2. Should the CBE adopt an IT or continue with MAT as a monetary policy strategy?
3. What is the best horizon for CBE to target inflation?
4. Does modelling inflation using models that allow for time-varying conditional variance, skewness and kurtosis helps in better understanding of inflation uncertainty?

Examining the extent to which the preconditions of IT are met in Egypt is the core of chapter two. Thus, it analyses the prerequisites of IT indicating the extent to which these conditions are met.

The second question concerning the ability of CBE to achieve the goal of price stability under the current MAT framework is of great importance as it determines the rationality to shift from MAT to IT regime or not. Awad (2010) found that neither the MDF nor the velocity of circulation of money is stable in Egypt. Therefore, he recommended that CBE should abandon MAT as it fails in achieving price stability. However, he used conventional methodology to investigate the issue by employing cointegration analysis for the components of velocity and used Chow breakpoint and forecasts tests to examine stability of VM and MDF.

A successful conduct of monetary policy under MAT is hinged on two assumptions: First, a stable MDF which implies the stability and predictability of VM. Second, the targeted monetary aggregate should be controlled directly by the CB, i.e., the predictability of MM (Agenor, 2000; Awad, 2010). Therefore, current study investigates the appropriateness of currently applied monetary policy in terms of examining the stability and predictability of both MM and VM. This is done by testing the RWH of both variables using VR tests. If they are unstable, this would imply the unsuitability of the current MAT regime.

To the best of my knowledge, the most recent paper that tested the RWH of the VM is Karemera, Harper and Oguledo (1998). They applied both LOMAC (1988) and (1989) and CHODE (1993) VR tests to investigate the stochastic structure of VM. Yet, the most recent methodologies that avoid the limitations of the aforementioned methodologies have not been applied to examine velocity. Therefore, the study contributes to the literature by examining the stability of MM and VM using the Kim's (2006) wild bootstrap test. The methodology assumes that these variables are stable if they are mean-reverting over a period of time. Applying the VR tests for RW would result in three cases. First, if the RWH is rejected, then the value of the VR should be examined. If it is less than one, then there is negative serial correlation in the first differences and the series is mean-reverting and hence stable (Liu and He, 1991) and (Karemera, Harper and Oguledo, 1998). In contrast, if the VR is greater than one, then there exist a positive serial correlation and hence the velocity is not stable as mean reversion requires negative serial correlation in changes of velocities. Finally, if the RWH cannot be rejected, then the velocity is also unstable

Based on the recommendation of evaluating the suitability of MAT regime, the thesis investigates some issues involved in the actual implementation of IT. Basically, implementation of IT consists of four components which are the assignment of the target, procedures of accountability, definition of the target, and inflation estimations. Concerning the third element, there are some certain steps to define the target. These steps entail choice of the price index, determination of the time horizon over which the inflation target is specified, the level of the target, and width of the target band. The main focus of the thesis is the OPH and inflation modelling.

Concerning OPH, it is defined as the time at which it is least costly for a given loss function, to bring inflation back to its target after a shock (Batini and

Nelson, 2001). This element of IT implementation is of great importance as the estimation of the OPH is crucial in deriving an interest rate path consistent with the best path to get inflation back towards its target. Furthermore, it would help in anchoring inflation expectations at the target in the medium term and improves the accountability of CBs (Akram, 2008). Previous studies that investigated the OPH used VAR models and system of equations for aggregate demand, aggregate supply and exchange rate (Batini & Nelson, 2001; and Smets, 2000). However, both models have been criticised for their limited ability to derive OPH for a few aggregate shocks. Therefore, a disaggregate model that allows for different kinds of supply and demand shocks is believed to improve policy conduct as it derive different horizons for different shocks even if they are all classified of the same type (Akram, 2008).

Accordingly, the current research employs VAR model consists of 7 variables and is estimated using Egyptian quarterly data. These variables include GDP, nominal exchange rate, CPI inflation, interest rate, real credit demand, and government expenditure. In addition, the model accounts for oil prices as an exogenous variable.

With respect to the final element of IT implementation, modelling inflation, it is the core of chapter five. The analysis explores the relation between inflation and its higher-order moments. The importance of investigating the relationship between mean-inflation, volatility, skewness and kurtosis under IT framework stem from the growing concern of monetary authorities about the risks involved in inflation. Noureldin (2008) employs GARCH-M model to investigate inflation dynamics in Egypt. His main findings support the hypothesis that there is a strong positive association between the level and variability of inflation. Additionally, he found that the distribution of individual price changes is non-normal and exhibits positive skewness, which implies a positive association between relative price adjustments and overall inflation. Accordingly, investigating the higher-order moments for inflation would allow a much richer setting of anti-inflation policy. Therefore, the chapter aims at examining the link between CPI inflation and its higher-order moments. However ARCH family models are used widely in investigating uncertainty, these models assume that the conditional distribution are time-varying only in the first two moments and ignore the information content in higher-order moments (Chaudhuri, Kim, and Shin, 2011). Yet modelling the third and fourth moments become popular in analysing the stock markets, it is still limited in investigating and forecasting inflation. Bryan and Cecchetti (1999) reported fat-tailed properties in inflation data. Additionally, Roger (2000) found evidence towards right skewness. In addition, (Chaudhuri, Kim, and Shin, 2011) found that the mean inflation is positively correlated with variance and skewness.

Thus, the thesis contributes to the literature by modelling the relationship between inflation and its second, third, and fourth moments that represent the full risks involved in inflation. The implemented methodology is attributed to LRS (2005) who jointly model time-varying second, third and fourth moments by applying a G-C series expansion of the normal density function. They allow both conditional skewness and kurtosis equations to follow a GARCH-type process. Moreover, I allowed the conditional skewness and kurtosis equation to have an asymmetry term (i.e., TARCH-type specification for conditional third and fourth moments).

The main conclusions of the thesis are:

1. Based on the analysis of the prerequisites of IT, Egypt could move towards implementing IT conditional on some reforms to the financial and fiscal sectors besides some amendments to the law.

2. Examining the stability of VM and MM show that both variables are unstable and hence, the current MAT framework cannot achieve its ultimate goal of price stability and it is believed that shifting to IT framework is highly recommended.

3. Results obtained from chapter four shows that the OPH is largely dependent on the nature of the shock and on a central bank's preferences over goals. Thus, for different kinds of the shocks, even if they are generally classified of the same type, the concern about other policy objectives rather than inflation affects the policy horizon. With respect to shock persistence, the results demonstrate that the horizon increases with the persistence of the shock as persistent shock distributed over many period in comparison with transitory shocks.

4. Finally, using GARCHSK models, the results show that specifications that allow skewness and kurtosis to vary with time outperform specifications that keep them constant. However, allowing both conditional skewness and kurtosis to follow a TARCH structure is inferior to allowing them to have a GARCH-type process

Thus, the remaining of the thesis is organised as follows. Chapter two outlines IT focusing on its preconditions, and elements of implementation.

Additionally, it summarises Egypt's monetary policy starting from the establishment of the CBE up to 2009. Chapter three evaluates the appropriateness of current monetary policy framework in Egypt. Then, chapter four focuses on determining the OPH to target inflation while chapter five employs GARCHSK models to estimate inflation. Finally, chapter 6 concludes.

Chapter Two

Inflation Targeting: An Overview with Special Reference to Egypt

2.1. Introduction

The CBE announced its intention to shift to IT as a framework to conduct monetary policy when the prerequisite are satisfied. This was motivated by the good performance of IT in emerging economies. Accordingly, studying this monetary policy framework is necessity for the Egyptian economy. As stated in chapter one, the thesis is interested in investigating the preparedness of Egypt to shift to IT regime besides examining the operational framework of IT focusing on two elements, OPH and modelling inflation. Therefore, this chapter is devoted for exploring IT as a framework of monetary policy. Thus, this chapter consists of six sections. Section two is devoted for examining the advantages and disadvantages of IT while section three compares IT with other monetary policy regimes. This is followed by examining the basic preconditions required for adopting an IT regime with special reference to the extent to which these prerequisites are met in Egypt. Then, section five studies the elements of the operational framework of IT regime. Finally, section six introduces a brief evaluation of Egypt's monetary policy starting from the establishment of CBE up to now.

2.2. Advantages and Disadvantages of IT

2.2.1. The Advantages of IT

The key advantage of adopting an IT framework is that it allows achieving and maintaining a low and stable inflation rate which have positive effects on the rate of economic growth (Jonsson, 1999). Another benefit is that it facilitates enhancing credibility of the CB given its commitment to low inflation. Thus, by announcing a numerical inflation target and given the CB obligation to attain this target, the inflationary expectations of market participants will be tied around this target. Moreover, an IT regime does not require frequent adjustments because it directly concentrates on the ultimate objective of monetary policy (Tutar, 2002). Proponents of this policy also claim that it gives the CB more flexibility in responding to demand and supply shocks as it leaves a considerable scope for using discretion in conducting monetary policy (Jonsson, 1999). Furthermore, IT is highly transparent due to its simplicity to understand by the public (Mishkin, 2000). Additionally, under a flexible IT framework, it reduces inflation variability and can stabilize output as well (Ball and Sheridan, 2004)

2.2.2. The disadvantages of IT

However IT has the aforementioned benefits, the opponents of IT state that it suffers many shortcomings. These disadvantages are listed below:

1. There is no assurance that the CB will successfully use its discretion to properly conduct monetary policy. This is due to the complexity of IT in comparison with other monetary policy frameworks (Jonsson, 1999).
2. Since the forward-looking nature of an IT framework includes some uncertainty for the policy objective function, it gives the CB the ability to use more discretion than an ERT or MAT frameworks. As a result, this discretion may permit monetary authorities to excessively usage of expansionary policies (Tutar, 2002).
3. Due to the long and inconsistent lags of the policy instruments to have their impacts on inflation, developing countries have some difficulties to control inflation especially when inflation rates are reduced from high levels. In such cases, large forecast errors will be unavoidable and the inflation targets are

not likely to be met. Accordingly, monetary authorities will face some problems in justifying the deviations from the target and will not be able to achieve credibility, which is critical to the success of IT regime (Tutar, 2002; Mishkin 2000).

4. Another cause of lack of inflation controllability in the developing countries is that the government administrated prices are used to calculate the headline inflation. Therefore, a successful IT regime requires the existence of high levels of coordination between monetary and fiscal policies regarding the time and the level of future adjustments in administrated prices or excluding these prices from the targeted price index (Mishkin 2000).
5. Introducing IT causes a disinflation may lead in turn to short-run output costs if private agents do not trust the credibility of policy framework (Jonsson, 1999). In addition, IT does not guarantee the absence of fiscal dominance which may lead to a failure of the regime. Thus, ensuring the absence of fiscal dominance is vital to the success of this strategy (Masson, Savastano, & Sharma, 1998).

2.3. IT versus other monetary policy frameworks

Achieving the goal of price stability can be made through focusing directly on it, or by targeting either a fixed exchange rate, or monetary aggregates as intermediary goals. This subsection compares these two alternative strategies for monetary policy against IT.

2.3.1. MAT versus IT

The key advantage of MAT is the ability to conduct an independent monetary policy and hence, to respond to shocks to the local economy. Additionally, announcing the attainment of the inflation target by the CB is almost immediately because the values of monetary aggregates are reported regularly with very short time lags. Consequently, MAT gives instant indicators to the public and markets about the attitudes of the monetary authorities to maintain inflation under control. These indicators may be useful to decrease the inflationary expectations and lead to reduce actual inflation (Tutar, 2002). Furthermore, MAT could protect the economy from facing the problem of inflation bias as it is able to promote direct accountability for CB to maintain inflation at low rates (Mishkin, 1999). To gain these benefits of MAT, it requires the fulfilment of two conditions: a) the MDF must be stable; b) the targeted monetary aggregate should be controlled directly by the CB which implies the stability of MM (Agenor, 2000; Mishkin, 1999; Tutar, 2002).

Under that policy framework, CB targets the rate of growth of monetary aggregate to be consistent with low rate of inflation. However, in a country that experience rapid financial liberalization, the parameters of MDF, especially the interest rate elasticity of money demand could be highly unstable. Therefore, money cannot be used to forecast future inflation due to the instability of the relation between the intermediary and the final goal. Consequently, using this function to predict future inflation implies potential risk. Moreover, assuming that monetary targeting goal is to minimise money growth volatility around the targeted rate of money growth, this goal may contradict with the objective of minimising inflation variability.

Due to the instability of MDF, many developed countries abandoned the MAT as a framework to its monetary policy by the end of 1980's. However, despite the argument that MDF is unstable in developing countries as well, some researchers found this instability in emerging countries could be attributed to omitted variable, namely financial innovation (Agenor, 2000).

2.3.2. ERT versus IT

ERT is a monetary policy strategy that allows central bankers to modify interest rate and intervene directly in the foreign exchange market to maintain the stability of exchange rate with the anchor country so as to benefit from the credibility of the foreign country's monetary policy. This requires the existence of a suitable macroeconomic policy mix to guarantee a low inflation differential in relation to the anchor currency, the existence of an adequate level of international reserves, and protecting the country's competitiveness and overall credibility concerning its institutional and governmental framework and political stability. In addition, the anchor economy must have a considerable share in the anchored country's trade (Tutar, 2002).

The key advantage of an ERT is its simplicity to be understood and its ability to reduce the inflation rate by tying inflation expectations to the rate of inflation in the anchor economy (Mishkin, 1999).

On the other hand, an ERT has many shortcomings. These limitations are summarized below:

1. It prevents the monetary authorities from responding to domestic shocks. The main reason behind that is under liberalised capital flows, domestic interest rates must be close to those of the anchor economy. As a result, the targeting country cannot use monetary policy to respond to local shocks and hence cannot have an independent monetary policy. Moreover, the shocks that occur in the anchor economy are directly transferred to the targeting economy as domestic interest rates must be changed by the same proportion as those of the anchor economy (Tutar, 2002; Mishkin, 1999).
2. It implies financial vulnerability in developing countries if the exchange rate target fails. For example, devaluation of the domestic currency increases the debt burden of home firms as their assets are denominated in terms of the local currency however the debts are mostly issued in foreign currency which results in worsening the firms' balance sheets, and hence decreases economic growth (Mishkin, 1999).
3. ERT may decrease accountability of monetary authorities, in particular in developing countries, because it eliminates important indications that can help to restrict monetary policy from being too expansionary. These indications come from the daily fluctuations of the exchange rate in case of excessively expansionary monetary policy (Mishkin, 1999).
4. Under a fixed exchange rate regime, the monetary policy cannot be independent and the country may be exposed to speculative attacks against its currency.

2.4. Preconditions of IT

Economists consent that a country must meet some preconditions before adopting an IT regime. These requirements are related to CBI and accountability, safe and sound financial system, having a single target, fiscal consolidation, and stability and predictability of inflation rates. This section is devoted to examine the prerequisite of IT and the extent to which these preconditions are satisfied in Egypt.

2.4.1. CBI and accountability

According to Hayo and Hefeker (2002), the theoretical argument of CBI is based mainly on the seminal paper of Barro and Gordon (1983). According to them, the CB is responsible to maximize the social welfare function with full control over the inflation rate. This objective function is defined over both inflation and output. Additionally, they assume that: 1) the loss function is quadratic in variances of output and inflation from their target values, 2) rigidity of nominal wages over a certain time period, and thus inflation causes a decline in real wages and increase in output and employment. Based on these assumptions, monetary authorities will have the incentive to raise the inflation rate above the expected rate, according to which the nominal wage demands are determined, to surprise wage setters. According to rational expectations, wage setters anticipate this incentive and include the expected inflation rate into their nominal wage demands. Assuming that the objective function of the policymakers is publicly known, a monetary expansion will raise the rate of inflation without any decrease in the rate of unemployment. The reason behind this is that welfare maximizing government is not credible as it can break its promises not to inflate once wage contracts have been signed (Hayo and Hefeker, 2002). To avoid this increase in inflation rate, CBs is required to commit to conservative monetary policy or as stated by Rogoff (1985), CBI could solve the problem of inflation bias.

CBI means at least instrumental self-determination which mainly necessitates that the CB is not required to finance the government budget deficit, to lower interest rates on government debt or to maintain a particular nominal exchange rate. That is to say, to maintain effective monetary policy, monetary authorities must be protected against any political pressure to achieve other objectives that contradict with the attainment of the inflation target. Thus, an independent CB will be able to achieve price stability even though other policy goals appear to be more attractive in the short term (Masson, Savastano, and Sharma, 1998; Tutar, 2002; Youssef, 2007).

As a consequence, the main characteristics for an independent CB are: a clear primary objective that dominates any other objectives, absence of any political pressure in designing of monetary policy, economic independence for the implementation of monetary policy, financial independence, and an obvious accountability procedures. An additional requirement for the CBI is that the design of the board and management of a CB must guarantee that the decision making process is not affected by any political influences. It is worth noting that accountability enhances credibility and efficiency of monetary policy and give the CB the opportunity to defend its policy (Mishkin, 2000; Youssef, 2007).

According to Roger and Stone (2005), most of inflation targeters monetary policy decisions are made by MPCs within the CB. These MPCs are the institutionalization of instrument independence that decrease the dependence of decision making on a single personality and increase the scope for information-based decision making.

Concerning the independence of CBE, Awad (2007) found that however Law No. 88/2003 determined the legal independence of the CBE, the actual practice is different. While achieving price stability is the main goal of monetary authorities, the CBE failed to implement its monetary aggregate target and achieve price stability due to high political pressure to finance public deficit. Additionally, Farrag and Kamaly (2007) measure the degree of independence of CBE from both a legal and behavioural perspective, since its establishment in 1961 until 2004. Their results indicate that the CBE enjoys a moderately low degree of independence.

On the other hand, Al-mashat (2008) claims that after the establishment of the MPC, the CBE has full operational independence to achieve the inflation target. That is emphasised by the procedure that the interest rate decisions of the MPC are not known to the government and the market except on the following business day through the officially published press release (MPC statement).

However, the independence of the CBE is still wavering due to official representation of the government in the composition of the MPC as well as eliminating the article of prohibiting dismissal of the governor before the end of his mandate. Additionally, there is no clear procedure to solve any conflict may arise between the CBE and the government. Therefore, to increase the independence of CBE, the following recommendations are suggested by (Youssef, 2007)

1. Revision of MPC membership and/or limits the right of government members to vote.
2. The deleted article concerning the dismissal of the governor before the end of its mandate should be reintroduced.
3. Amendment of the law to ensure that monetary financing of fiscal deficits is prohibited.
4. Communication with the public should be increased via regular publications (inflation reports, annual reports, press releases…) with a full explanation of the reasons underlying the CBE's actions.

2.4.2. Safe and sound financial system

Financial systems in developing countries are always dominated by the state, particularly the banking sector which lowers banking operations efficiency and reduces market competition. In addition, these countries are characterised by financial weakness that may lead to reversal capital outflows resulting in a huge depreciation of the exchange rate, and ultimately result in increasing pressures on the inflation rate. Consequently, it is essential to undertake a financial reform programme prior to implementing a new monetary policy. Moreover, it is vital to reinforce the financial system by closing insolvent financial institutions and adopting strong supervisory practices as the financial vulnerability can challenge any efforts to control inflation. Furthermore, other problems such as NPL, liability dollarization must be solved. These procedures along with developing financial markets would help enabling implementation of IT using market-based instruments (Mishkin, 2004; Youssef, 2007).

Concerning the financial sector in Egypt, as prevailed in many developing countries, it is dominated by the state where the banking sector represents about 80%-90% of it. Accordingly, the CBE launched its banking reform plan in September 2004. These reforms include a programme to privatise state-owned banks as well as the introduction of a new minimum capital requirement in July 2005. These improvements resulted in a decline in the number of operating banks from 57 in 2004 to 39 in 2007. As the problem of NPL reduces the efficiency of the banking sector, a "NPL Management Unit" was established in the CBE to deal with this problem, in addition to similar units in public and private sector banks (Yossef, 2007). The NPL management unit succeeded to settle more than 90% of NPLs excluding debts of the public business sector (CBE Economic Review, 2010).

The second stage of the plan (2009-2011) aims at raising the efficiency and soundness of the Egyptian banking system, and enhancing its competitiveness and the ability for risk management. This stage is based on number of pillars as follows:

- Prepare and implement a comprehensive programme for the financial and administrative restructuring of specialized state-owned banks[1] and follow up the results of the first stage of the restructuring programme of

[1] This includes the following banks: the Principal Bank for Development and Agricultural Credit, Egyptian Arab Land Bank, and Industrial Development and Workers Bank of Egypt.

other banks[2], and finalize the required steps requirements to improve their efficiency in financial intermediation and risk management.

- Appling Basel II standards[3] in Egyptian banks to enhance their risk management practices. Actually, a protocol was signed with the European Central Bank and seven European CBs to provide a three-year technical assistance programme started on 1st of January 2009, to implement Basel II requirements in the Egyptian banking sector. The strategy of the CBE in implementing Basel II framework is based on two main principles; simplicity and consultation with banks, to ensure that all banking units will apply this framework (CBE Economic Review, 2010)

To sum up, this requirement is reasonably fulfilled due to the accelerating reforms undertaken by the government to support the soundness of the financial sector. These reforms need to be taken further steps by supporting the private sector participation in the banking system. In addition, the government is required to maintain disclosure and transparency as well as developing the bond market and introducing new products (Youssef, 2007).

2.4.3. Having a single Target

To implement a successful IT framework, there must be only one target in the system. For instance, a country that adopts a fixed exchange rate regime will not be able to attain both its inflation target and exchange rate target simultaneously.

[2] These banks are: The National Bank of Egypt (NBE), Banque Misr (BM) and Banque du Caire (BdC).

[3] Basel II standards are recommendations on banking laws and regulations issued by the Basel Committee on Banking Supervision in June 2004 and aims at creating an international standard that banking regulators can use to make rules about how much capital reserves banks need to put aside to guard against the types of financial and operational risks banks face through its lending and investment practices.

This is due to that achieving the exchange rate target will lower the effectiveness of monetary policy especially in the presence of capital mobility, leading the inflation rate to deviate from its targeted level.

Moreover, the existence of more multiple targets could create conflicts between them and consequently, destroy the credibility of all these anchors. However, other economic objectives can be achieved if they are consistent with the inflation target. Accordingly, under a non-fixed exchange rate regime, there might be coexistence of attaining both a nominal exchange rate target and an inflation target as long as the priority is given to the inflation target in the case of a contradiction between objectives. In practice, this synchronicity is difficult as it is unfeasible for policymakers to give explanation about the priorities to the public in a credible way before a conflict occurs. Therefore, the public will construct its own conclusions about the policy actions without any guarantee that the policy stance will give the suitable signs to draw proper conclusion. Therefore, having the inflation rate as the single target in the system will avoid all these problems (Tutar, 2002).

This requirement seems to be achieved in Egypt as stated in CBE's (2005) statement: "*Law no. 88 of 2003 of the "Central Bank, Banking Sector and Monetary System" entrusts the CBE with the formulation and implementation of monetary policy, with price stability being the primary and overriding objective. The CBE is committed to achieving, over the medium term, low rates of inflation which it believes are essential for maintaining confidence and for sustaining high rates of investment and economic growth. The Government's endorsement of the objective of* *price stability and its commitment to fiscal consolidation is quite important for achieving this objective".*

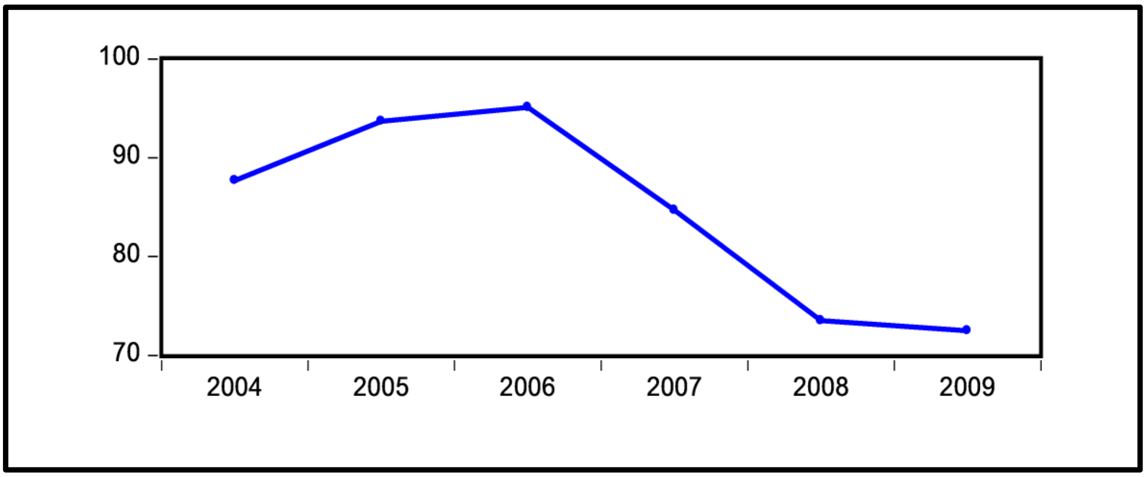
2.4.4. Fiscal consolidation

A sound fiscal position is crucial to the success of IT framework. This is due to the existence of different ways through which monetary policy is affected by fiscal policy. First, a large budget deficit that requires CB finance through monetization leads to induce higher inflation. Second, monetary authorities may hesitate to raise interest rates to control high inflation if the short-term public debt is huge because such a rise in interest rate increases both debt level and its services payments. In addition, high level of debt leads to capital outflows resulting in a depreciation of the exchange rate which in turn cause an increase in the value of the debt if it is denominated in foreign currency. This depreciation creates an increase in prices through the imported inflation. All the aforementioned effects generate an increase in the inflation expectations and finally in actual inflation. Moreover, reducing taxes leads not only to a decrease in government revenues but also raises the real wealth causing a rise in both aggregate demand and the price level.

Concisely, for a country that suffers from structural fiscal imbalance, implementation of an IT regime requires: (a) the budget deficit must be in a margin that could be financed through capital market operations particularly if the financial markets cannot finance the fiscal deficit sufficiently, (b) extensive fiscal reforms to raise the transparency of the government budget and budget rules. (c) government budget should be rebalanced with reducing public debt and default probability (Youssef, 2007).

In 2004, Egypt started the fiscal reforms to raise tax revenues and to increase the transparency of the tax administration making it fairer. Reforms included tax cuts, extending of the tax base, improvement of tax collection as well as the announcement of establishing the appropriate tax policies and administrative structures for a modern and efficient tax system. These reforms are important progress but they need to be balanced by discreet government spending. To ensure credibility of fiscal consolidation strategy in the medium-term, public debt as a percentage of GDP must be put on a decreasing path. Figure 2.1 show the development of public debt as a percentage of GDP. Starting from 2006, there is a clear decline in the percentage from 95.1% to 72.5% at 2009. However, there must be a reform in the budgetary institutions including all the rules and regulations related to budgets preparation, approval and implementation. Besides, the fiscal transparency and accountability must be emphasized (Youssef, 2007).

Figure 2.1: Development of the public debt as a percentage of GDP



Source: CBE.

2.5. Implementation of IT

There are some practical issues regarding the operational framework of inflation targets. These issues include four components which are the assignment of the target, procedures of accountability, definition of the target, and the existence of proper inflation forecasting models which requires understanding the dynamics of inflation and the included uncertainty. Thus, this section presents an investigation of the elements of the operational framework of IT.

2.5.1. Assignment of the Target

Assignment of the inflation target depends on the CBI and the announcement of the inflation target. Thus, it differs across countries. In some countries including Australia, Finland and Sweden, the CB announced it without any explicit approval from the government. On the other hand, it determined by a joint agreement between fiscal and monetary authorities in Canada, and New Zealand. Even though the CB announces the inflation target first, fiscal authorities have to consequently approve it since this raises the efficiency and the credibility of this regime and improves the coordination between fiscal and monetary policies (Tutar, 2002).

As indicated by (Al-Mashat, 2008) that it has not been decided which entity will be responsible for ultimately setting the target, the CBE or the government. Though, experience from other countries has shown that it works better if the target is set by the government not by the CB. This suggested that, it would be better for CBE to have the instrument independence that enable it to isolate short-run political pressures that may lead it to pursue time inconsistent, expansionary policy that produces bad long-run outcomes while the goal is set by the government.

2.5.2. Definition of the Target

To define the target of inflation, there are some certain steps. These steps entail choosing the optimal time horizon to target inflation, selection of the price index, choice of the target level, and the width of the target band.

2.5.2.1. Optimal Time Horizon of the Target

The inflation target horizon is the period over which the CB is committed to achieve the targeted rate and the time period during which the target should prevail. This time horizon relies on the original level of inflation rate when IT has been adopted. In case of deviations of the current inflation rate from the targeted rate, the CB assigns approximately two-year time period including lag periods of monetary policy to achieve inflation rate (Tutar, 2002).

For an inflation target to be significant, it requires that the horizon takes into account the lags between policy actions and their effects on inflation outcomes. Therefore, a policy horizon shorter than the lags associated with monetary policy transmission implies that inflation over that horizon is largely outside the control of the CB. Additionally, a longer horizon can give the CB more flexibility for taking other policy objectives into account without subordinating the inflation objective (Roger and Stone, 2005).

According to Batini and Nelson (2001), IT should be designed such that the target is attained over the medium term. Thus, CBs should not aim at neutralizing inflationary shocks immediately but they should respond gradually to these shocks. Additionally, Akram (2008) asserts that this horizon should depend on the nature of shocks and their properties such as its size and persistence as well as the extent to which the CB cares about other policy objectives rather than inflation, i.e., a strict of flexible IT. Therefore, due to differences in preferences for output stabilisation and interest rate volatility, the optimal horizon in response to a shock may vary across countries even if they become exposed to the same shock. Chapter four will be devoted to empirically choosing the best horizon to target inflation in Egypt in response to different types shocks.

2.5.2.2. Choice of the Price Index

Choosing the price index that is used to compute the targeted rate of inflation varies across countries due to the different methods of calculating price indexes. According to Roger and Stone (2005), all inflation targeters used CPI as the target measure of inflation. This is because public are most familiar with the CPI rather than GDP deflator which is an important factor for the transparency of an IT regime. Additionally, CPI does not require too much revision.

Recently, some countries have constructed a measure for core inflation which is based on the CPI with the exception of the volatile food and energy sector as well as mortgage interest payments. The reason behind this is that the core inflation eliminates the first outcomes of the shocks that have been accommodated by monetary policy. Nevertheless, it does not rule out the effects of the innovations to wages and prices. However, most countries define the target in terms of the official “headline” inflation rate, while the core rate has been targeted only by three countries, Korea, Norway, and Thailand (Roger and Stone, 2005; Tutar, 2002).

(Al-Shawarby, 2008) examines the accuracy of measuring headline CPI inflation in Egypt. Generally, Egypt's CPI structure follows procedures and techniques that are increasingly consistent with international standards, guidelines and agreed practices. However, there is still a wide gap between the public observation of inflation developments and the announced official rates. Thus, she recommended that the calculations and approach adopted in the construction of the CPI to be available to the public for independent verification which would improve credibility in official measures of inflation. Additionally, she proposed improving some issues to raise the accuracy of CPI calculation. These issues include the way the outlet sample is selected, housing pricing, and the biases arises from quality adjustment and introduction of new goods.

Recently, CBE started constructing and publishing a core inflation measure that excludes food and energy prices. However, as stated by Noureldin (2008), it would be risky to define an inflation target based on this measure of inflation. The reason is that food represents around half of the CPI basket (in expenditure terms). Consequently, this will make it an irrelevant index for consumers as it becomes significantly detached from being a cost-of-living index. However, in the long-run, as the weight of food items in the CPI basket gradually decreases with the planned price liberalization, it would be feasible to define the inflation target in terms of Core inflation. In the meantime, it would be more appropriate to target the headline CPI given that the CBE will have a successful communication strategy with the public to underline what monetary policy could and could not do to affect inflation outcomes.

2.5.2.3. Level of the Target

Theoretically, the price stability is equivalent to a zero inflation rate. However, in practice many countries interpret the operational definition of price stability as to be the centre point of the inflation target. In fact, IT countries set their targets to be greater than zero as a result of the upward biases in computing CPI. These biases can be attributed to introducing new goods, the modification of consumers to relative price changes by shifting to substitutes with lower prices and quality bias (Agenor,2000).

Setting the inflation target to be too low or equal to zero, may lead to a deflation in the economy which cause in turn contraction and destruction of the financial system. On the other hand, an inflation target above zero reduces the likelihood of periods of deflation. What's more, it does not increase inflationary expectations or lower the CB credibility. Thus, assigning an inflation target to be around 2% annually is convenient for advanced economies. In contrast, there is no empirical evidence for the best inflation rate in developing countries. In this regard, it may suitable for these countries to set the inflation target between 4 and

8 % per year and allowing it to fluctuate within a broader range to accommodate larger supply shocks (Tutar, 2002).

2.5.2.4. Width of the Target Band

The choice of bandwidth reveals the trade-off between announcing a tight band and breaks it occasionally, and announcing a wide band. The main reason behind the choice of a broader band is the possibility that monetary authorities may not have complete control over the inflation rate. This could be attributed to the long and changeable lags of monetary policy and its incomplete ability to predict future inflation accurately which cause the inflation rate to exhibit some variability. Therefore, the adoption of broader range will give more scope to stabilise output. In addition, a broader range provides more flexibility in responding to short-term shocks. In contrast, the broader band causes economic agents to tie the inflation expectation to the ceiling of the band which induce the inflationary pressures (Tutar, 2002).

However a narrower band is a sign of a stronger commitment to the attainment of the inflation target, it is riskier than the broader band as frequent breaks may weaken the credibility of the regime. Additionally, it reduces the CB flexibility to respond to short-term shocks. Moreover, the narrow range causes monetary policy instruments to be unstable which may raise volatility in the financial markets although the inflation target is satisfied. Nevertheless, a narrower band simplifies observing the performance of CBs since it emphasize its accountability in the short run to achieve the inflation target as it has to explain the reasons for any break of the band (Agenor, 2000).

The adoption of the point target involves credibility to the implementation but it is risky due to the unexpected shocks and the nature of inflation. To conclude, adopting a band raises flexibility of the regime but decreases credibility (Agenor, 2000; Tutar 2002).

2.5.3. Accountability

The accountability of IT raises the ability of the CB to monitor and improve the understanding of expectations as well as decreases the possibility of time inconsistency trap that causes deviations from monetary authority's long-term objective. Furthermore, it provides a good reference point which could simply be observed by the economic agents in the economy (Tutar, 2002)

As stated by (Roger and Stone, 2005), there are two ways of the assessment of CB performance. First, it could be evaluated according to the deviations of actual inflation from the target rate, which is typically used. Second, in a forward-looking method at which the CB is required to explain how it is managing policy in order to keep future inflation consistent with the target.

The procedures of accountability depend heavily on the target ranges. Thus, it typically distinguishes between two cases depending on if inflation is inside or outside of the target zone. When inflation is within the target range, CB reports a regular accounting for inflation effects and predictions in addition to any required policy actions to maintain inflation within the range. On the other hand, if inflation departs from the target range, or is likely to do so, CB has to explain reasons for the deviation from target and measures to remain consistent with target and the required procedures to bring inflation back inside the target zone.

In the latter case, accountability can be either formal or informal[4]. According to Roger and Stone (2005), most of inflation targeters use informal methods of accountability with exception of eight countries out of 22 economies of interest in their study.

2.5.4. Inflation estimations

IT dynamically uses predictions because of its forward-looking nature. Thus, monetary authorities must adjust the instruments of monetary policy prior to the actual increase in the inflation rate. When there is a deviation between the expected and the targeted rate, CBs take preventive actions to remove the difference. This requires that policymakers fully understand inflation uncertainty. Accordingly, Chapter five is devoted to build models that allows for a better understanding of risks involved in inflation. This is done by simultaneously estimating the relation between the first fourth moments of inflation which allows a much richer setting for anti-inflation policy.

2.6. Egypt's monetary policy

This section starts by a brief description of monetary policy adopted by Egypt prior to applying ERSAP in 1991. In addition, it presents the reforms that have been applied to both financial and foreign exchange markets. This is done through presenting the general framework, objectives and the tools of monetary policy as well as the evaluation of the success of that policy.

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[4] The formal accountability means that the CB should formally give an explanation of the reasons of breaching the target. This formal announcement could be in terms of reports to the government or president, or an explanation to the parliament or to the public through policy statement or report. In the informal case, CBs are still need to explain significant deviations of inflation from the announced targets (Roger and Stone, 2005).

2.6.1. Monetary policy prior to ERSAP

The banks law issued in 1957, and its adjustment according to the law no.120 issued at 1975 concerning the CB and banking system, states that CBE responsibility is to organise and supervise the implementation of monetary and credit policies according to the general plan of the state to achieve price stability and support the development of the economy. According to this law, CBE applied discretionary policy to control the volume and the type of the credit, as well as to limit economic imbalances. Additionally, its role included managing the international reserves and management of public debt on behalf of the government (Abu-Elayoun, 2003).

Prior to implementing ERSAP, CBE depended absolutely on the direct instruments to achieve its goals which limited the role of market mechanisms and leaded to increase the distortion of the market. These instruments included high reserve ratio, discount rate, restriction of credit expansion, determination of interest rates. Table (2.2) summarises the objectives, instruments and effectiveness of monetary policy before applying ERSAP. Analysis of Egyptian monetary policy during this period reveals that all interest rates were not effectively used by the CBE. Furthermore, the behaviour of these rates is not consistent with the primary objective of monetary policy.

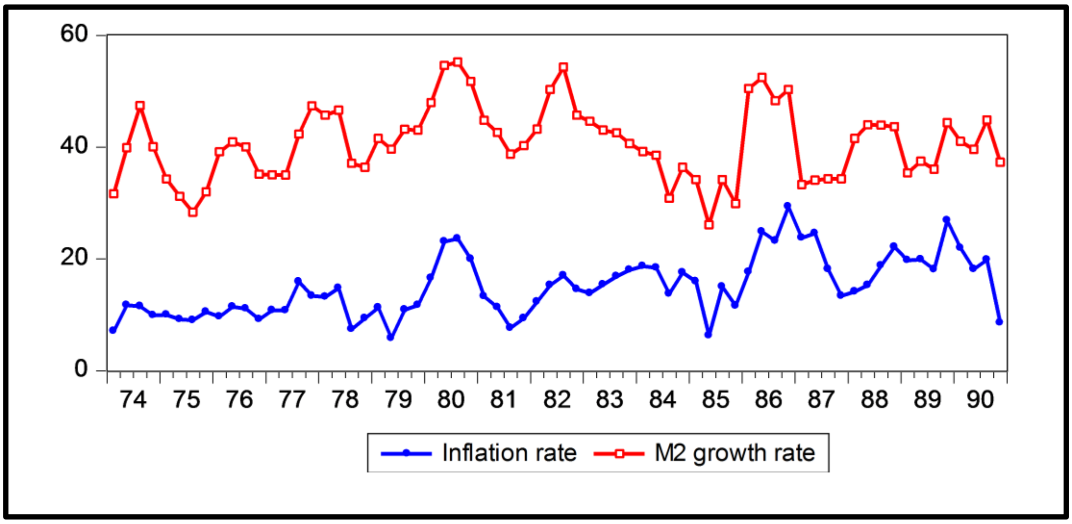
Table 2.1: The consistency of the goals and instruments of monetary policy since the establishment of CBE prior to ERSAP

Period	Objective	Reserve ratio	Liquidity ratio	Lending and discount rates	Deposit rate	Credit ceilings to some sectors	Open market operations
1957-1974	economic development	Constant at 20%.	30% for both domestic and foreign currencies.	Discount rate was not ever used while lending rate was not instituted yet.	Was not created yet.	Has not been used before 1974.	It has not been used up to June 1990 as CBE mainly used direct tools.
1974-1982	economic development which requires expansionary monetary policy	CBE raises the ratio to reach 25% at 1979. This was accompanied by amending its calculation to exclude 2-years deposits to encourage banks to attract long-term deposits. Additionally, it was subject to seasonal adjustments to finance the cotton companies*. (Consistent with the objective of economic development).	30% for both domestic and foreign currencies.	Discount rate was largely determined seasonally according to the requirements of financing cotton harvest (decrease discount rate in harvesting and marketing seasons). For lending rate, it increases gradually to reach 15% at 1981 and 1982. (this behaviour is not consistent with monetary policy goal that require decreasing both rates which indicates that both tools were not basic tools of CBE to conduct its policy).	Gradual increase from 3% to 11% during the period 1976 to 1982. The purpose was to encourage savings and to help depositors get positive real interest rates.	To control the total credit in the economy, and to reallocate it to certain sectors, CBE mainly applied this tool. Starting from June 1988, CBE developed the Ceilings to be in the form of the relationship between the ratios of loans to deposits. According to that development, banks loans to certain sector should not exceed 60% of their deposits in the banks.	
1983- 1990	Reduction of structural deficiency and increase savings (contractionary policy)	Increase reserve ratio in the beginning (consistent) then it continued to be constant to the end of the period (indicates that CBE did not used it as key tool).	30% for both domestic and foreign currencies.	Discount rate settled on 13% until 1988, then increased to 14% from May 1989 to December 1990. However, this tool was not really active. Related to lending rate, it freezes at 15% until 1987 then increases regularly to the end of the period. (indicates this tool has not been used effectively)	Constant at 11% up to 1988, then increased to 11.7% and 12% in 1989 and 1990 respectively. (not consistent with the CB objective, which implies that it was not effective).		

* Cotton represented the main crop for the agricultural sector in this period.

Source: Abo-ElAyoun (2003); and table A1.

Figure 2.2: Inflation rate and M2 growth prior to ERSAP



Source: IFS.

Figure (2.2) shows the relation between inflation and M2 growth rates during the period 1974-1990 using quarterly data. Clearly, the period witnessed sharp fluctuations in M2 growth rates from year to year. Additionally, there is apparent association between inflation rate and the rate of growth of domestic liquidity. The movements of inflation rate were largely explained by the changes of M2 growth rate. As a result, monetary policy in that period did not achieve the desired monetary or price stability as the CBE used its policy instruments basically for financing public deficit which resulted in high double-digit inflation rate throughout the period. This high rate of inflation decreases the purchasing power of the pound leading depositors to shift their savings to foreign currencies mainly the dollar. Consequently, the CBE's monetary policy lost a great part of its control and effectiveness.

2.6.2. Reforms of financial and foreign exchange markets

Due to the failure of achieving price stability along with the existence of multiple structural imbalances in the Egyptian economy, Egypt launched its ERSAP with agreement with World Bank and IMF to facilitate the shift from command economy to market-based economy. The ERSAP includes an extensive implementation of privatisation programme, improving the public finance sources, liberalisation of money, exchange and financial markets. Additionally, CBE contributed in reforming the banking sector and shifts its policy to indirect instruments and abandoned the direct tools. The reforms that has undertaken could be summarised as follows (Abo-ElAyoun, 2003):

1. Allowing banks to determine their own lending and deposit interest rates according to market mechanism.
2. Removal of credit ceilings.
3. Adjustments of the rules of calculating the reserves ratio and CBE lending and discount rates.
4. Introducing TB to finance the budget deficit through real savings.
5. Allow for establishment of exchange offices to expand the exchange market.
6. Development of money market through increasing interbank transactions and creation of second TB market, in which it uses open market operations.
7. Liberalisation of exchange rate to be determined according to market mechanisms.
8. Link the discount rate to rates of TB to reduce its degree of rigidity that was experienced before ERSAP.

2.6.3. Monetary policy after ERSAP to exchange rate floating

From 1991 onwards, CBE's conduct of monetary policy has witnessed frequent changes which were a part of reform activities that was followed to promote the short-term growth of the real economy. These changes incorporated reforms in both operational and intermediate targets of the CBE along with the adoption of the monetary instruments. However, the primary objectives of monetary policy were generally unchanged focusing on price stability and on the stabilization of the exchange rate. To achieve the ultimate goals of monetary policy during the period (1991-2002), the intermediate target of monetary policy was controlling the rate of growth of M2. The daily operational targets were managements of nominal interest rates and the bank's excess reserve which had to be determined in such way that would achieve the intermediate target. Concerning tools, CBE tended to use the indirect tools to conduct its policy. These tools included reserve ratio, and open market operations along with various interest rates including the discount rate, TB rate, and 3-month deposit rate. Additionally, CBE continued using some of the direct tools such as the credit ceiling policy that is removed at the end of 1993 (Awad, 2010; Moursi, El Mossallamy and Zakareya, 2007). Table (2.3) summarises the goals and tools of monetary policy starting from the launch of ERSAP to the end of 2002.

Table 2.2: The consistency of the goals and instruments of monetary policy after ERSAP

Period	Objective	Reserve ratio	Liquidity ratio	Lending and discount rates	Deposit rate	Credit ceilings to some sectors	Open market operations
1991-2002	The key objective was price stability and the stabilization of the exchange rate. Some other goals include increasing the level of output, controlling liquidity growth, raising foreign competitiveness, stimulating exports and creating confidence in the national currency. These goals were inconsistent with the main objective especially during the period 92/93-96/97*.	Decreased the ratio to 15% of total deposits in Egyptian pound which conflicts with contraction policy. From 2001, reserve ratio kept unchanged with adjustment in the components of ratio to encourage savings in national currency.	20% for local currency, 25% of foreign currency. It has not been used for monetary purposes, so it has been used only for control purpose which indicates that it has not been used as an effective tool for monetary policy. (actual ratios were higher than the required ratios)	After ERSAP, CBE relied on the discount rate as a monetary policy instrument. It was connected with 91 days TB rate to reduce the rigidity in discount rate**. Thus, change in TB interest rate was an indicator for the discount rate. However, starting from 1995, the linkage has been broken as there was a reduction in interest rate while discount rate kept frozen. At 2001, CBE decreased the discount rate which led banks to decrease loans interest rate.	Banks were free to set their rate subject to the restriction that 3-month interest rate on deposits should not fall below 12% per year. This constraint had been removed in 93/94. Due to the decrease in discount and lending rates, banks lowered deposit rate gradually to the end of the period.	CBE abandoned using this tool in 1993.	CBE started using this instrument gradually after ERSAP by issuing TB with different maturity (91, 182 and 364 days). Additionally, CBE started intervention in the secondary (trading) market in 1993, then more effectively and extensively from 1997 onwards. CBE depended on a number of tools including repurchasing of Treasury bonds, final purchase of TB and government bonds, foreign exchange swaps and debt certificates. This attitude was consistent with the liberalization of the interest rates. In 97/98, CBE increased its dependence on an alternative instrument, the *repurchasing operations of TB* (repos), to provide liquidity and to stimulate economic growth. Starting from 2000/01, CBE decreased its reliance on it.

* In 92/93, however the CBE aimed at contractionary policy, it is also intended to decrease interest rate on the domestic currency to boost investment and economic activity. During the period 93/94- 95/96, monetary policy objectives were swung between the two objectives of both economic growth and price stability. In 96/97, the CBE changed back to the objective of economic growth through monetary stabilization (Moursi, El Mossallamy and Zakareya, 2007).

** This rigidity is due to the strong administrative control of CBE which led discount rate to be a poor operational instrument of monetary policy.

Source: Abo-ElAyoun (2003); Awad (2010); Moursi, El Mossallamy and Zakareya (2007), table A1.

In addition to the adjustments in the structure of the indirect monetary policy instruments, the CBE started performing numerous reforms in the exchange rate system. At the beginning of the 1990s, Egypt officially implemented a managed float regime, with the exchange rate acting as a nominal anchor for monetary policy. However, the actual implemented policy was a fixed exchange rate regime as CBE was determining the official exchange rate without accounting for market forces. As a result, the exchange rate for the Egyptian pound against the US dollar was highly stable until the series of devaluations starting from 2000 (Moursi, El Mossallamy and Zakareya, 2007). However, the appreciation of the real exchange rate during the nighties decade deeply contributed to the liquidity shortage. This appreciated exchange rate along with high real interest rates generated speculative attacks on the pound, worsened the economy's foreign competiveness and increases in importation bills financed through banking loans. The growth rate of nominal imports accelerated from 2.87% to 16.34%[5] between 1994 and 1995 resulted in a surge in inflation rate that reached 15.74% in 1995.

The Egyptian economy was exposed to several external and domestic shocks in the second half of the 1990s that led to a shortage of liquidity[6]. The main reason behind that was that the CBE was reluctant to have a market-based exchange rate because of some fears of the pass-through effect. Accordingly, as

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[5] Calculated from IFS.

[6] The domestic shocks were attributed to a large increase in bank lending, particularly to the private sector which was accompanied by the large fiscal debt led to a liquidity crisis. The large fiscal debt was generated by the government's launch of several huge projects simultaneously. These projects included Toshka Project, Al-Salam Canal, North West of Suez Development Project and East of Port Said Project. External shocks included: (a) the East Asian crisis in June 1997; (b) the Luxor terrorist attack in November 1997; and (c) the fall in oil prices in 1998. These external shocks along with the decrease of workers' remittances from abroad at the end of 1990s worsened the liquidity crisis (Moursi, El Mossallamy and Zakareya, 2007).

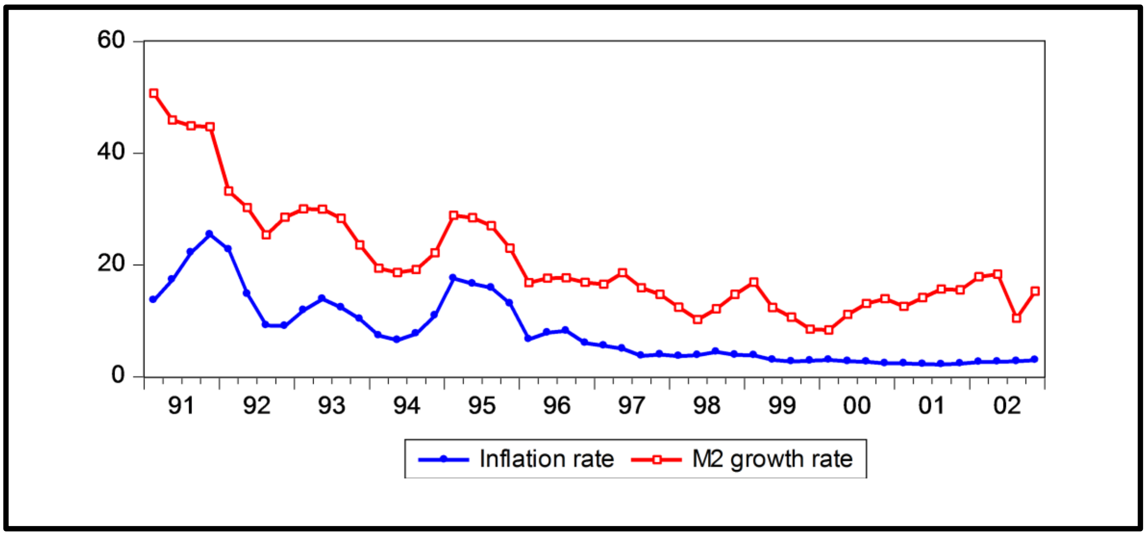
CBE continued maintaining an unrealistic value of the Egyptian pound during this period, there was a big shortage in the foreign exchange in the economy and thus the CBE lost a great amount of its international reserves[7]. As a result, the CBE started moving towards a more flexible exchange rate through gradual devaluations from 2000 to 2002 until the announcement of the Egyptian pound floating in January 2003 (Awad, 2010; Moursi, El Mossallamy and Zakareya, 2007).

According to (El-Refaie, 2001), The 3-month TB rate could be relatively regarded as a short-term policy rate given that the securities were issued in coordination with the CBE to sterilize capital inflows, substantially exceeding the financing needs of the government. Additionally, The CBE's discount rate is also a key policy rate, even though the limited changes that took place between 1996 and 2005 (Al-Mashat, 2008).

Figure (2.3) shows the relation between M2 growth rate and inflation rate during the period (1991-2002). It shows the existence visual co-movements of the monetary aggregate with inflation over the investigated period excluding the period (1998-2002). However the M2 growth rate had accelerated starting from 1998 due to changes in the exchange rate that affected some elements of the components of domestic liquidity, these instabilities has not been reflected in the inflation rate which remained at low single-digit of 2.7% to the end of 2002.

[7] During 1998–2000 the international reserves decreased from $18 billion to $14 billion (Awad, 2010).

Figure 2.3: Inflation rate and M2 growth after ERSAP to exchange rate floating



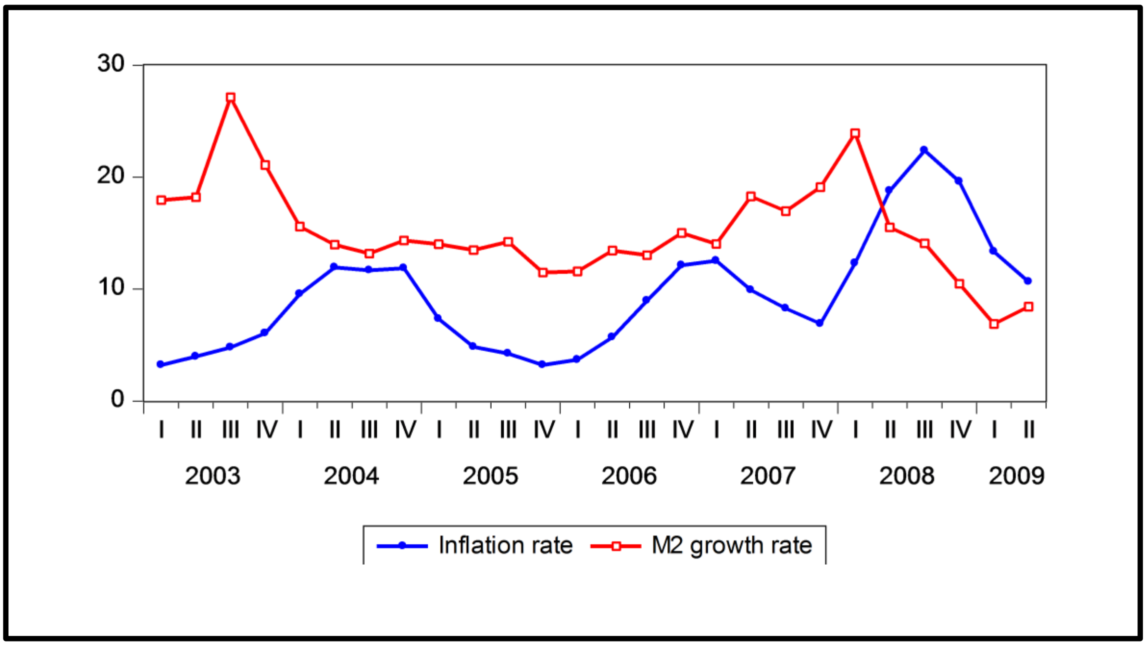
Source: IFS

2.6.3. Monetary policy following exchange rate floating in 2003:

Following the floatation of the Egyptian pound at January 2003, the inflation rate has increased to reach a double-digit number in 2004. This increase in inflation rate could be attributed to two elements. First, the gradual passing-through of higher prices resulting from the gradual devaluation of the Egyptian pound starting from April 1999 until the floatation at January 2003. This was accompanied with an expansionary monetary policy as the growth of M2 has increased from 5.36% to 21.1% between 2000:q1 and 2003:q4. This acceleration in monetary aggregates was not accommodated by equivalent high real GDP growth, leading to double digit inflation. Second element is the increase of energy prices. This surge in inflation rate led CBE to adopt price stability and low inflation as the overriding policy objective. This attitude was strongly underscored by the structural reforms that included the establishment of the Coordinating Council, under the leadership of the Prime Minister, in January 2005 and the MPC affiliated to the CBE Board of Directors in mid-2005 (Al-Mashat, 2008; Moursi, El Mossallamy and Zakareya, 2007).

Introduction of interbank foreign exchange market launched in December 2004 led to an appreciation of the Egyptian pound reflected in the downward direct of CPI inflation till mid-2006. In 2007, the economy was exposed to some internal shocks including supply shocks related to oil subsidy cuts and the second round-effects of the avian flu. Furthermore, the rise in the international food prices along with rising prices of some oil products in 2008 raised inflation rate gradually to peak at 22% in the third quarter of 2008. Another factor that contributed to the surge in inflation rate was the acceleration of economic growth rates; especially in the sectors of construction and manufacturing that anchored inflation expectations into high levels (See figure 2.3). In 2009, however M2 growth rate had increased slightly, the inflation rate has decreased due to decline in the group of food and non-alcoholic beverages as a result of the sharp fall in their domestic prices following the severe drop in the world prices of several foodstuffs (CBE, 2010). Table (2.4) presents the goals and instruments of monetary policy after the floating of the pound.

Figure 2.4: Inflation rate and M2 growth after the flotation of exchange rate



Source: IFS

To achieve price stability as the ultimate objective of monetary policy, the CBE restructured its policy by adopting the overnight interest rate on interbank transactions instead of the excess bank reserves as the main operational target[8]. Accordingly, CBE created the corridor system as a new operational framework. Within this system, the ceiling is the overnight interest rate on lending from the Bank, and the floor is the overnight deposit interest rate at the Bank[9]. Figure (2.4) displays the movements of the policy interest rates and rate of operational target, overnight interbank rate. It is clearly shown that the interbank rate has fluctuated close to the lower bound of the corridor.

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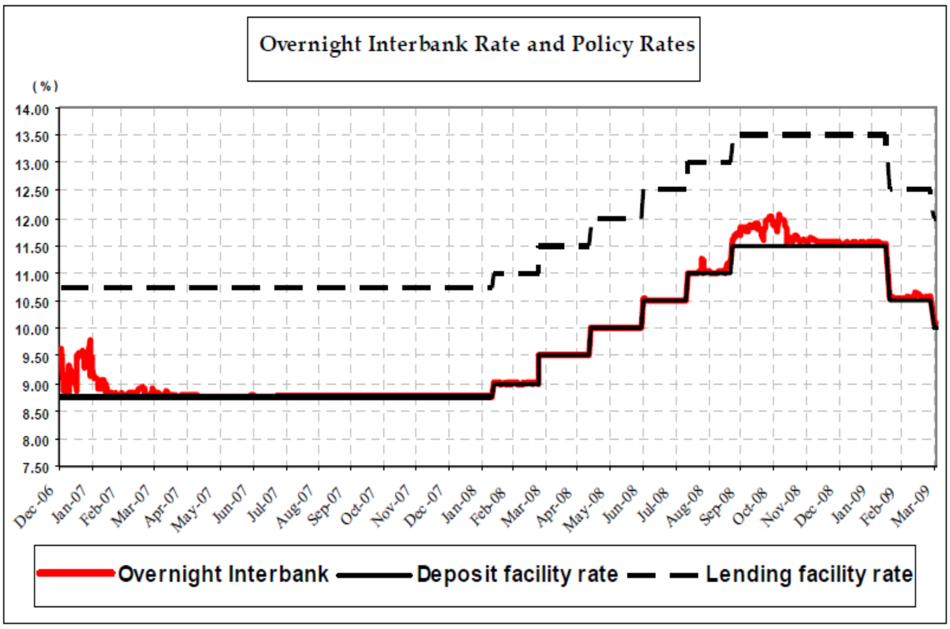
8 This system started on 5th of June 2005.

9 This system is based on conventional macroeconomic theory, which states that monetary tightening policy could stabilize prices and control inflationary pressures. However, there is no guarantee that the actual implementation of monetary contraction would achieve the expected outcome from the theory (Moursi, El Mossallamy and Zakareya, 2007).

The period 2005-2009 was largely characterised by the existence of excess liquidity in the banking system. The CBE had regularly intervened using the open market operations, to absorb this excess liquidity. In doing so, the CBE used many different traditional instruments and created new instruments like the CB notes (CBE, 2010). Summary of CBE objectives along with the implemented instruments are displayed in table (2.4)

Figure 2.5: Movements in the outer bounds of the corridor and the operational target overnight interbank rate



Source: CBE, Economic Review (2009), Vol. 49 No. 3, p12.

Table 2.3: The goals and instruments of monetary policy after the floatation of the pound

Period	**Objective**	Reserve ratio	**Liquidity ratio**	**Lending and discount rates**	**Open market operations**
2003-2009	Price stability and low inflation rates along with banking system soundness. After the CBE statement on the intention to shift to IT in June 2005, price stability was emphasised as the key goal of monetary policy.	Changing the components in Feb 2003 aiming at raising interest rate however banks did not greatly respond as they had excess liquidity that covers the change in reserve ratio.	No change to the ratio.	CBE lowers the lending rate gradually to the end of the period. Concerning discount rate, it has been gradually decreased except of the year 2008.	CBE continued to use this tool up to the end of 2003, and then it ended using it due to the existence of excess liquidity in the banking system. In 2003/2004, the CBE introduced the reverse repos of TB and permitted outright sales of TB between the CBE and banks through the market mechanism. In August 2005, the CBE notes were introduced instead of the TB reverse repos as an instrument for the management of the monetary policy.

Source: Abo-ElAyoun (2003); Awad (2010); Moursi, El Mossallamy and Zakareya (2007), table A1.

Appendix A

Table A1. Policy interest rates during the period (1976-2010)

	Discount rate	Treasury bill rate	3-months deposit rate	Lending rate
1976	6	-	3	8
1977	7	-	4.66667	8.83333
1978	8	-	5.875	10.1667
1979	9	-	7	12
1980	11	-	8.33333	13.3333
1981	12	-	10	15
1982	13	-	11	15
1983	13	-	11	15
1984	13	-	11	15
1985	13	-	11	15
1986	13	-	11	15
1987	13	-	11	16.3333
1988	13	-	11	17
1989	14	-	11.6667	18.3333
1990	14	-	12	19
1991	20	19	12	...
1992	18.4	17.8	12	20.3283
1993	16.5	14.9	12	18.2975
1994	14	12.4	11.8333	16.5125
1995	13.5	10.9	10.9167	16.4708
1996	13	10.3	10.5417	15.5833
1997	12.25	8.9	9.83542	13.7917
1998	12	8.8	9.3625	13.0167
1999	12	9	9.2175	12.965
2000	12	9.1	9.45667	13.2158
2001	11	7.2	9.45833	13.2917
2002	10	5.5	9.33333	13.7917
2003	10	6.9	8.225	13.5333
2004	10	9.9	7.725	13.375
2005	10	8.572	7.225	13.1417
2006	9	9.534	6.01667	12.6
2007	9	6.852	6.1	12.5083
2008	11.5	11.369	6.58333	12.325
2009	8.5	9.842	6.49167	11.975

Source: IFS and CBE.

Table A2. Main economic indicators during the period (1976-2009)

	Inflation rate	GDP growth rate	M2 growth rate
1974	10.02432	2.485499	30.21742
1975	9.669695	8.939173	21.46571
1976	10.31742	14.62725	25.97745
1977	12.73216	12.83696	34.03463
1978	11.0781	5.77971	27.02788
1979	9.904361	6.038857	31.32567
1980	20.81922	10.01134	51.41943
1981	10.31728	3.756081	30.89756
1982	14.82301	9.907171	31.1521
1983	16.07987	7.401139	22.62572
1984	17.03637	6.091515	18.84797
1985	12.10676	6.60205	18.30439
1986	23.86429	2.646576	20.9506
1987	19.69359	2.519422	20.95886
1988	17.66349	5.300719	21.54756
1989	21.26187	4.972379	17.49797
1990	16.75637	5.701753	28.73037
1991	19.74854	1.078838	19.3389
1992	13.63742	4.431996	19.42824
1993	12.08979	2.900791	13.24901
1994	8.154231	3.973172	11.21468
1995	15.74223	4.642459	9.896515
1996	7.187104	4.988731	10.8359
1997	4.625606	5.491131	10.77196
1998	3.872575	4.036367	10.77641
1999	3.079499	6.10546	5.663642
2000	2.683805	5.368006	11.58132
2001	2.269757	3.535226	14.07257
2002	2.737239	2.370489	12.30873
2003	4.507776	3.193518	21.0906
2004	11.27062	4.092072	15.82178
2005	4.869397	4.471744	11.49323
2006	7.644526	6.843838	15.00441
2007	9.318969	7.087827	19.11931
2008	18.31683	7.156284	10.48521
2009	11.7635	4.64854	9.474081

Source: WDI

Chapter Three

Should the CBE Shift to IT Framework: Evidence Using VM and MM

3.1. Introduction

The VM and MM are significant variables from theoretical in conjunction with policy perspective due to their vital role in the economy. The VM is defined as the ratio of nominal output to a given money stock, whereas the MM is defined as the ratio of the money supply to the monetary base. In a MAT framework, the choice of monetary aggregate for policy purposes depends on the predictability of the relationship between that aggregate and nominal GDP where the velocity is the link. Additionally, MAT requires that monetary aggregate must be under the control of the CB which implies that the MM must be predictable. That is to say that the CB could control the money supply by altering the monetary base conditional on the prediction of MM. Thus, by determining the desired level of money supply in the next period, and given the projection of MM, the CB changes the monetary base to achieve the desired level of money supply (Agenor, 2000; Awad, 2010; Mishkin, 1999, Moosa and Kim, 2004).

Concerning VM, as it provides the linkage between the monetary aggregate and GDP, providing that the CB can achieve the desired level of money supply, the attainment of achieving a nominal GDP target is dependent on the accuracy of VM forecast. Furthermore, the stability of VM is vital for the monetarist model of inflation as deducted from the quantity theory of money. Precisely, stability of VM indicates the existence of a stable relationship between the general price level and the money supply per unit of real output (Moosa and Kim, 2004).

Given the announcement that the CBE intended to shift to IT once the preconditions are met, the paper aims at answering the following question: Should the CBE adopt an IT or continue with MAT as a monetary policy framework? A prerequisite for MAT framework is a stable MDF, which in turn requires stability in velocity. In other words, instability of velocity indicates instability of MDF which violates with the core of MAT. Additionally, instability of the MM also contradicts with the essence of MAT regime. Thus, if VM or MM is unpredictable, this would imply the inappropriateness of the current monetary policy based on monetary aggregates. This is done by testing if the VM and MM follows a RW process.

The implications of testing the RWH of VM and MM originate from the statistical decisions to accept or reject the RWH. Acceptance of the null hypothesis indicates that current-period VM and MM involves all the required information in predicting future VM and MM respectively. In other words, changes in VM and MM are unpredictable random events and cannot be used to predict future changes for the related variable. Alternatively, rejection of the RWH implies the need to structural modelling for the prediction of future values (Kim, 1985; and Karemera, Harper, and Oguledo, 1998).

According to (Gould and Nelson, 1974), if the VM follows a RW process, this does not mean that there is no meaningful relationship between the money supply and national income. Nevertheless, it indicates the need to be more careful in drawing inferences about that relationship based on historical behaviour of velocity only. In other words, that would suggest that there are several factors that affect the VM. Furthermore, for short-run forecasting and policy evaluation, it is futile to try identifying apparent “deviations” from trend. The reason behind this is that if velocity follows RW, we should not expect that any such deviations will be corrected in the future.

As stated by Kim (2006), VR tests are now the methodology that applied mostly for testing the RWH. Consequently, the employed methodology assumes that both variables are stable if they are mean-reverting over a period of time. Thus, the procedure is as follows: first, testing for the RWH using the VR tests. Then, if the RWH is rejected, the value of the VR should be examined. Checking the value of VR would result into two cases: first, when the VR is less than unity, this suggests a negative serial correlation in the first differences and hence the series is mean-reverting, i.e., stable. Second, if the VR is greater than one, then there exist positive serial correlation and hence the series is not stable. Finally, non-rejection of the null hypothesis also indicates instability of both variables (Liu and He, 1991; Karemera, Harper, and Oguledo, 1998).

The VR tests were initially created by the pioneer work of LOMAC (1988) and (1989). However, CHODE (1993) criticises LOMAC (1988) and (1989) that the latter fails to control the joint-test size and is associated with a large probability of Type-I error. However the multiple VR test of CHODE (1993) is quite powerful testing for homoscedastic or heteroscedastic nulls, it is limited as well as LOMAC (1988) and (1989) test as both tests are asymptotic in their sampling distributions which are approximated by their limiting distributions. Recently, Kim (2006) developed a wild bootstrap[10] version of CHODE (1993) test to improve small sample properties of VR tests. This procedure has desirable size properties and superior testing power than its alternatives. To the best of my knowledge, Kim's (2006) wild bootstrap test has never been used in the evaluation of the RWH of

[10] A wild bootstrap is a computer intensive resampling method which is used to approximate the sampling distribution of the test statistic and from which critical values are obtained (Smith and Rogers, 2006).

VM and MM. Accordingly, this paper applies the aforementioned different VR tests to VM and MM as its empirical methodology.

The remainder of the chapter is organised as follows. Section two is devoted to review the existing literature. Section three presents the underlying methodology while the empirical results are displayed in section four. Finally, section five concludes.

3.2. Literature review

As indicated in the introduction, the behaviour of the VM and MM has implications for both monetary theory and implementation of monetary policy. From theoretical perspective, the classical quantity theory of money assumes that the VM is constant. However, modern quantity theory suggests that the VM is a stable function of various macroeconomic variables includes interest rates, inflation rate, and gross national product (GNP). Under this analysis, researchers aimed to show that changes in money stock leads to reasonably predictable changes in national income (Gould, Miller, Nelson, and Upton, 1978). On the other hand, Fisher treated VM as a black-box. According to him, it is not constant but instead it drifts over time in response to structural changes in the economy. Based on this view of velocity, financial economists assume that VM follows a RW process (Karemera, Harper, and Oguledo, 1998; Gould, Miller, Nelson, and Upton, 1978).

From a policy perspective, a stable VM would be consistent with targeting to achieve low inflation through a gradual change in monetary aggregates over a period of years (Omer and Saqip, 2009).

Many studies have applied different methodologies to examine the structural change and determinants of VM and MM. Table (3.1) shows a summary of these studies. The following are the most important points:

1. Most of previous studies applied in the 1960s, 1970s and 1980s used the available methodologies to test the RWH of velocity. These conventional RW tests include unit root tests of Dickey and Fuller (1979, 1981) and the "white noise" tests of Box-Pierce and Ljung-Box.
2. Studies that tested the RWH of VM obtained different and often contradictory results. These results varied with model assumptions and techniques used. For example, Ahking (1982) found that the VM of the five European community countries followed a RW. He showed that the hypothesis was neither sensitive to the period of data sample or the definition and measure of VM. On the other hand, Kim (1985) used quarterly VM series for different industrialised countries and found mixed results, with more evidence suggesting that the behaviour of the VM significantly deviates from RW.
3. Most of these studies has been applied to USA and developed economies.
4. Two studies only have been applied using VM Egyptian data whereas the behaviour of Egypt's MM has not been ever investigated.

Thus, the studies of VM in Egypt are quite low. Baliamoune-Lutzand and Haughton (2004) tested Friedman's velocity hypothesis that increased volatility in the growth of money supply decreases VM. Using cointegration tests, they proved a statistically significant long-run relationship between the variability in monetary growth and VM, for both M1 and M2 aggregates. However, they found that

Friedman's hypothesis is only supported for M2, while increased variance of the growth of M1 has no effect on VM which could be attributed to the continuous change of the definition of M1 over time. Additionally, they found that anticipated movements in M2 volatility are not neutral as they affect velocity. Based on their results, they suggested that the scope for discretionary monetary policy in Egypt is moderately limited in the short run. Accordingly, they recommend that CBE should make its decisions more transparent and pre-announce its policies to improve the predictability of VM. In addition, Awad (2010) applied cointegration and Chow breakpoint and forecasts tests on VM and found that the VM is not stable in Egypt. Therefore, he recommended that CBE should abandon MAT and adopt IT regime.

Based on the above analysis, the behaviour of MM and VM in Egypt needs to be adequately explored especially under the current applied MAT regime.

Table 3.1 Summary of VM and MM studies

Study	Case study	Variables studied	Methodology	Sample	Main results
Gould and Nelson (1974)	USA	VM	autocorrelation test for first differences	1869-1960	The results indicate the uncorrelatedness of first differences, and implying that VM is RW without drift
Bomhoff (1977)	USA and Netherland	MM	Box-Jenkins model	1962:Jan-l971:Dec	The results suggest that if the Dutch CB invested more resources in the collection of data from the banks, then predictions could be made sufficiently precise for use in the control of the money stock.
Gould, Miller, Nelson, and Upton (1978)	USA	VM	autocorrelation test for first differences	1869 to 1972	VM follows RW process.
				1947:1 to 1973:4, 1955:1 to 1973:4, and 1961:1 to 1973:4	Mixed results as the RWH is sensitive to both time interval and definition of velocity.
Stokes and Neubuger 1979	USA	VM	autocorrelation test for first differences	1869 to 1940	They found that Gould and Nelson's (1974) results are sensitive to the choice of sample and may be affected by heteroscedasticity. They conclude that VM is not RW but it drifts over time.
Johannes and Rasche (1979)	USA	MM	ARIMA model	1955:Jan-1978-March	They developed a component approach to forecasting the MM. Their results suggest that the forecasting power of the component approach is superior to forecasting the MM itself.
Ahking 1982	EEC countries*	VM	autocorrelation test for "white noise"	1960:1-1978:4	RWH cannot be rejected. Results are not sensitive to the selected sample, definition of velocity or data frequency
Hafer and Hein (1984)	USA	MM	OLS	1959:1-1979:12	They compared the relative abilities of two forecasting procedures for MM. The. They presented evidence that the aggregate model forecasts the MM as well as the component procedure does.
Kim 1985	UK	VM	Ljung-Box autocorrelation test for "white	1871-1975	RW hypothesis cannot be rejected.
	8 industrial countries**	VM		1955:1 -1976:4 for all countries	RWH is sensitive to the definition of money used. Results are contradicted with Ahking (1982) while it

			noise"	1949:1-1979:1 for USA	is consistent with Gould, Miller, Nelson, and Upton (1978).
Hall and Noble (1987)	USA	VM	Granger Causality	1960:1 1984:4	Variability of money growth helps predict VM providing empirical verification for Friedman's velocity hypothesis that the decline in velocity was partly due to the increase of the volatility of money growth.
Chowdhuty (1988)	Canada, Germany, Italy and Japan	VM	Granger causality	1964:1 1986:4	The results indicate that the variability of money growth rates help predicting VM supporting Friedman's velocity hypothesis.
Brocato and Smith 1989	USA	VM	Granger causality	1962:Feb-1985:Sep	In contrast to Hall and Noble (1987), their results suggest that the increased volatility of money growth following the late 1979 contributed to a breakdown in the money growth/velocity relationship which contradicts with Friedman's hypothesis which would suggest that the causality results should be even stronger after late 1979. Furthermore, the Friedman hypothesis is not met over the relatively stable period prior to 1979.
Mehra (1989)	USA	VM	Granger Causality	1963:1-1984:2	They showed that Hall and Noble's (1987) results are not robust to some changes in specification as the VM declined in the absence of any further increase in volatility. Hence, it may be necessary to re-examine the role of monetary variance in a more general framework that controls the influence of other factors on VM. Thus, the results of Hall and Noble (1987) must be viewed with caution.
Siklos (1989)	USA	VM	Dickey-Fuller Unit root test	1870-1986 and 1947:1-1984:4	The existence of unit root is sensitive to the choice of the sample. In addition, results may be sensitive to the choice of the money stock and income measures and the sources of the data.
	Canada			1870-1986	
	UK			1870-1985	
Bordes (1990)	France	VM	Granger Causality	1974:2 1988:2	They provide evidence supporting Friedman's velocity hypothesis that money volatility leads VM to

					change.
Serletis (1990)	USA	VM	Granger causality	1973:2 1988:1	He tested the relation between VM changes and anticipated and unanticipated monetary growth and its volatility. The results indicate that a multivariate model including anticipated and unanticipated monetary growth and its volatility improved the predictability of VM.
McMillin (1991)	USA	VM	VAR model	1961:1-1981:4 1982:1-1988:4	He concludes that the misbehaviour of the velocity of M1 in the 1980s originates from a shift in the process generating VM and is not attributed to unusual volatility in the determinants of VM.
Payne (1992)	USA, UK, Japan, West Germany	VM	Granger causality	1965:1-1979:3 1979:4-1988:4	He tested Friedman's velocity hypothesis regarding the relationship between the volatility of money growth and VM and found mixed results. That is, the results are sensitive to the choice of the lag structure used as well as proxies for money growth variability.
Karemera, Harper, and Oguledo (1998)	G7 countries***	VM	VR: LOMAC and CHODE	1955:1-1976:4 and 1970:1- 1991:4	The results suggests that VM do not follow RW process for most of G7 excluding US M1 and M2 velocities. Additionally, results are sensitive to the chosen sample and monetary aggregate.
Karfakis (2002)	Greece	VM	ARDL model	1948-1997	The VM is stationary process. There is a proportional relation between nominal income and money suggests that shocks which affect the money supply are reflected in the nominal income. Thus, VM will not fluctuate widely and its movements will be predictable.
Baliamoune-Lutzand and Haughton (2004)	Egypt	VM	Cointegration	1960-1999	There exist a significant long-run relationship between the volatility of money growth and VM providing evidence for supporting Friedman's velocity hypothesis.
Moosa and Kim (2004)	Japan	VM	AR model and Harvey's structural time series model****	1970:1-1999:1	They compared the direct and indirect methods***** of predicting the VM. The results indicate the superiority of the direct method.

Moosa and Kim (2006)	UK	MM and VM	AR model and Harvey's structural time series model	1970:1–1999:3	They compared direct and indirect methods of forecasting. Results are mixed but the overall evidence seems to be supportive of the direct method.
Omer and Saqib (2009)	Pakistan	VM	ADF unit root test	1975- 2006	The results showed that VM are not stable as it is integrated of order one.
Omer (2010)	Pakistan	VM	ARDL model	1975- 2006	The results proved the existence of a stable relationship between VM and its determinants.
Rami (2011)	India	VM	OLS	1972-2004	The results support the monetarist model as the velocity of M3 is predictable.
Awad (2010)	Egypt	VM	Cointegration	1995:1 to 2007:4	The results implied instability of VM.

*These countries are France, Germany, Netherland, Italy, and UK.
**Include the five countries in Akhing (1982) paper. Other countries are USA, Canada, and Japan.
***G7 countries are France, Germany, Netherland, Italy, UK, Japan and USA.
**** It is a methodology used to decompose an observed time series into unobserved components. These components are the trend component that represents the long-run changes, the cyclical, the seasonal and the random component. These components can be predicted individually and combined to produce a forecast for the total series.
***** As VM and MM are defined variables, i.e., constructed of other variables, it could be forecasted directly or indirectly. The direct method is simply done by estimating a model from historical data for the whole series whereas the indirect method is based on estimating separate models for the components and generating forecasts for the components, then using the definition to generate forecasts of the defined variable.

3.3. Methodology

Conventional RW tests such as the unit root tests of Dickey and Fuller (1979, 1981) and the “white noise” tests of Box-Pierce and Ljung-Box has been applied by previous studies. However, the accuracy of these tests is suspected when applying the new tests which are more sensitive to RW. LOMAC (1988 and 1989) developed VR tests for RWs that explore the stochastic behaviour of macroeconomic aggregates such as GNP, stock prices, equity returns, and exchange rate series. Subsequently, CHODE (1993) extended and generalized the methodology to allow for testing a set of multiple VRs over a number of periods to determine whether the multiple VRs are jointly equal to one. However, both LOMAC (1988 and 1989) and CHODE (1993) are criticised as they are asymptotic tests. To cover this limitation, Kim (2006) proposed a wild bootstrap version of the CHODE (1993) test to improve small sample properties of VR tests. This procedure has desirable size properties and superior testing power in comparison to previous tests. The derivation of the abovementioned tests is sequentially discussed below.

3.3.1. LOMAC’s (1988) and (1989) single VR test

Let X_t denote the log of the series under consideration at time t. The hypothesis of the pure RW is given by the recursive equation:

$$X_t = \mu + X_{t-1} + \varepsilon_t \qquad 3.1$$

where μ is a drift parameter and ε_t is a random error term. The usual stochastic assumptions about ε_t apply, i.e. E(ε_t) = 0, E(ε_t^2) $= \sigma^2$, and E($\varepsilon_t \varepsilon_{\acute{t}}$) $= 0$, for $\acute{t} \neq t$. LOMAC (1988 and 1989) developed tests of RW under alternative assumptions of homoscedasticity and heteroscedasticity on ε_t .

As stated by LOMAC (1988 and 1989), the core of the test is that under the RWH, the increments of X_t series are uncorrelated and the variance of the increments is linear in the sampling intervals. Suppose that we obtain *nq + 1* observations $X_0, X_1, X_2, \ldots\ldots, X_{nq}$ of X_t at equally spaced intervals. If the series follows a RW, then the variance of the q^{th} difference would be equal to q times the variance of the first difference. Thus, if the data generating process of X_t is correctly specified by equation (3.1), then the variance of the first difference is defined by equation (3.2). Additionally, that variance increases linearly so that the variance of the q^{th} difference is expressed in equation (3.3)

$$\sigma_1^2 = var(X_t - X_{t-1}) \qquad 3.2$$

$$\sigma_q^2 = var(X_t - X_{t-q}) = q\ var(X_t - X_{t-1}) \qquad 3.3$$

where var is the variance operator

LOMAC (1988 and 1989) provides a single test of the RWH by testing the null hypothesis that the ratio of variances is given by

$$VR(q) = \frac{1}{q}\frac{\sigma_q^2}{\sigma_1^2} = 1 \qquad 3.4$$

Where *VR(q)* is the VR of the q^{th} difference, σ_q^2 is an unbiased estimator of $1/q$ times the variance of the q^{th} differences of X_t , and σ_1^2 is an unbiased estimator of the variance of the first difference of X_t. The RW hypothesis is tested under both the homoscedastic and heteroscedastic specifications of the variances. For the heteroscedastic case, LOMAC (1988 and 1989) weaken the *iid* assumption and allow for fairly general forms of conditional heteroscedasticity and dependence which is sometimes termed as the martingale null. The standard normal test statistic under homoscedasticity, $Z(q)$ is computed as

$$Z(q) = \frac{VR(q)-1}{\left(\emptyset(q)\right)^{0.5}} \sim^{a} N(0,1) \qquad 3.5$$

Where $\emptyset(q) = \frac{2(2q-1)(q-1)}{3q(nq)}$ is the asymptotic variance of the VR.

While the test statistic under heteroscedasticity is calculated as

$$Z^{*}(q) = \frac{VR(q)-1}{\left(\emptyset^{*}(q)\right)^{0.5}} \sim^{a} N(0,1) \qquad 3.6$$

Where $\emptyset^{*}(q) = \sum_{j=1}^{q-1}\left[\frac{2(q-j)}{q}\right]^{2}\delta_j$ and $\delta_j = \frac{\sum_{t=j+1}^{nq}(X_t - X_{t-1} - \hat{\mu})^2\left(X_{t-j} - X_{t-j-1} - \hat{\mu}\right)^2}{\left[\sum_{t=1}^{nq}(X_t - X_{t-1} - \hat{\mu})^2\right]^2}$

However the LOMAC (1988 and 1989) test is simple to implement as it depends on comparing the test statistics $Z(q)$ and $Z^*(q)$ with the critical values of the standard normal tables, they are essentially asymptotic tests which can have low power and result in misleading inferences in finite samples (Smith and Rogers, 2006). Additionally, LOMAC VR test is a single hypothesis unit test of each VR at alternative intervals q, which is not consistent with the VR approach to RWH that requires that all VRs to be jointly equal to unity (Karemera, Harper and Oguledo, 1998). Thus, as pointed by Hung (2009) that although LOMAC test proves that heteroscedasticity-robusted VR is more powerful and efficient than the Box–Pierce or Dickey-Fuller test (1979), it fails to control the joint-test size and is associated with a large probability of Type-I error.

3.3.2. CHODE's (1993) multiple VR test

To correct the second limitation of LOMAC (1988 and 1989) test, CHODE (1993) designed a corrective expansion to allow for multiple hypothesis tests. Thus, they provide a multiple hypothesis test of unity of all VRs, with control for the test size

(Karemera, Harper and Oguledo, 1998). The test is briefly illustrated below. Recall, from equation (3.4), that the VR minus one, $Mr(q)$, can be rewritten as

$$M_r(q) = \frac{\sigma^2(q)}{q\sigma^2(1)} - 1 \qquad 3.6$$

Consider a set of m VR estimates, $M_r(q_i)$ where i=1, 2, ..., m corresponding to selected values of the aggregation intervals, q_i . Under the RW model, multiple hypotheses are given as:

$$H_{0i}: M_r(q_i) = 0 \quad \text{for } i = 1, 2, \ldots, m \qquad 3.7$$

$$H_{1i}: M_r(q_i) \neq 0 \quad \text{for } i = 1, 2, \ldots, m \qquad 3.8$$

The RWH is rejected if any one of the estimated VR is significantly different from unity. Under CHODE (1993) test, the maximum Z or Z^* statistics (in absolute value) is compared with the asymptotic α-point critical value of the SMM(α, m, N) distribution instead of the critical values of the standard normal distribution, where N represents degrees of freedom (the sample size).

3.3.3. Kim's (2006) wild bootstrap test

Kim (2006) introduced the wild bootstrap procedure as a development based on CHODE joint test. He uses the wild bootstrap to approximate the unknown sampling distribution. Thus, this is a finite sample test which does not rely on any asymptotic approximations. The test consists of three steps are briefly explained below:

1. Generate a bootstrap sample $X_t^* = \eta_t X_t$ where η_t is a random sequence of zero mean and unit variance[11].

[11] The wild bootstrap results are not sensitive to the choice of η_t, Kim (2006).

2. Using X_t^* , We calculate the test statistic JZ^* by calculating $Z^*(q)$ and choosing the maximum absolute value from a set of m test statistics.

$$JZ^* = max|Z^*(q)| \qquad 3.9$$

3. Repeat (1) and (2) a large number of times, to create, say, 10,000 values for the test statistic, which is its bootstrap distribution.

3.4. Empirical results

3.4.1. Data and preliminary examination

The VM is defined as the ratio of nominal GDP to money supply while the MM is defined as the ratio of the money supply to the reserve money. The data consists of quarterly data covers the period 1991:1 to 2009:2 obtained from the CBE's monetary reporting to the IMF's International Financial Statistics (Standardized Reporting Forms, or SRFs). These include four variables, M0, M1 and M2 as measures for reserve, narrow and broad money, and nominal GDP. The MM2 variable represents the MM for broad money while the velocity variables VM1 and VM2 are the velocities of M1 and M2 respectively. As quarterly data of GDP for the sample periods is not available for Egypt, a quarterly series for GDP is extrapolated from annual data.

Figures (3.1) to (3.3) display the graphs of VM using its two definitions as well as MM2 series. However, figure (3.3) shows the MM2 over the period (2001:4-2009:2) only. The reason is that the denominator of the reserve ratio has been modified in March 2001 to exclude balances of savings systems for 3 years or more[12]. This modification resulted in a structural break in MM2 at the third quarter of 2001. Therefore, the stability of MM2 will be examined using the sample that includes the data after the break.

Figure 3.1: VM1 during the period (1991:1 2009:2)

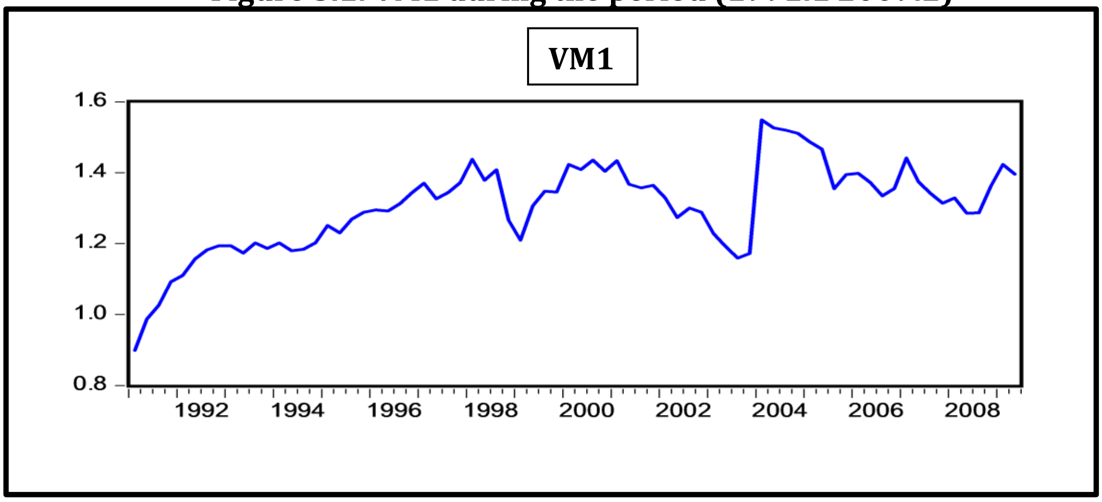
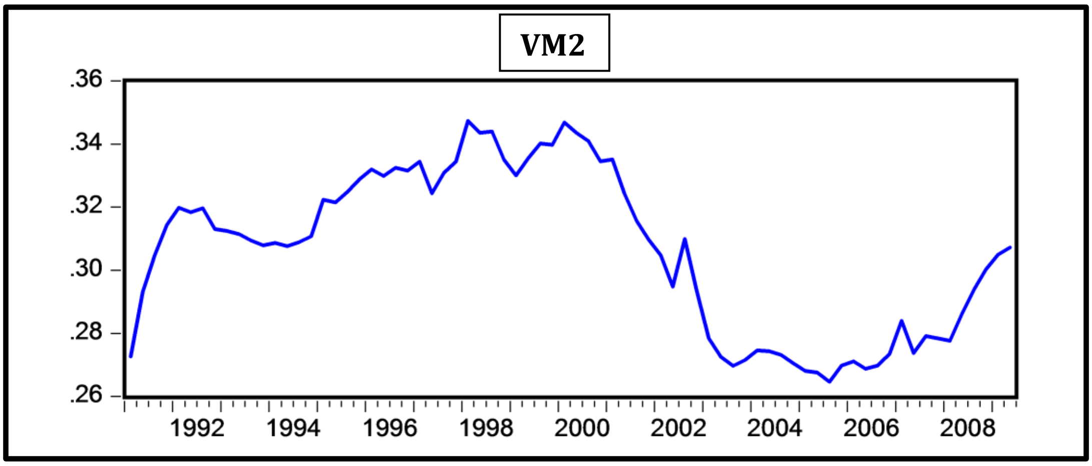
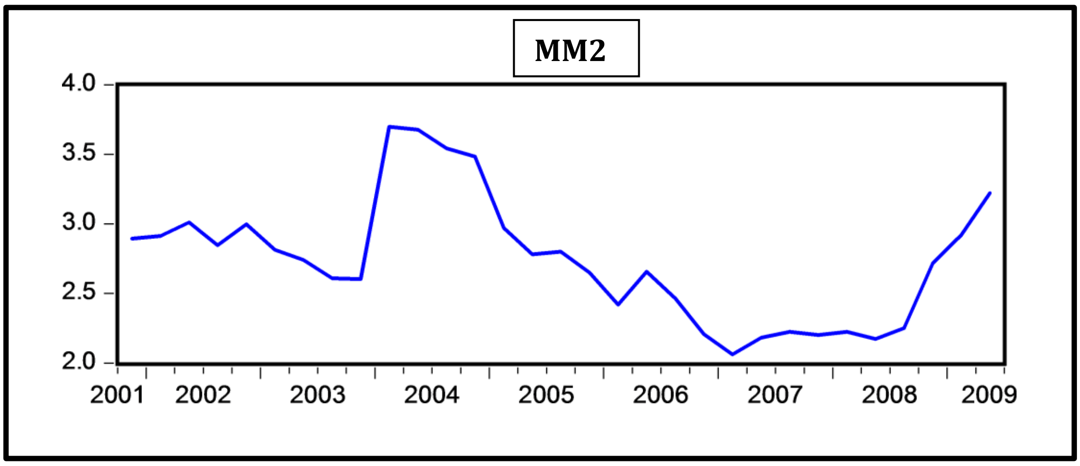


Figure 3.1: VM2 during the period (1991:1 2009:2)



[12] The CBE aimed at providing greater long-term sources of funds freed up from the proportion of reserve and to encourage savings in the national currency.

Figure 3.1: MM2 during the period (2001:4 2009:2)



3.4.2. Results

The results provide the estimates of the VRs, the asymptotic *Z* and *Z** statistics and their corresponding probabilities under homoscedasticity and heteroscedasticity assumptions, respectively. The Z and Z* statistics are calculated for horizons 2-quarter, 4-quarter, 8-quarter, 16-quarter as computations of higher VRs would be inappropriate and may result on over-rejection the null hypothesis. As shown in the upper panel of table (3.2), the p-values of Z and Z* suggests that there is sufficient evidence to non-rejection of the RWH for both velocity definitions with exception of the 16 horizon of VM2 under heteroscedasticity. To control the size of multiple tests, CHODE (1993) methodology is applied by comparing test statistic with the critical value of 2.491 from the SMM distribution. Thus, however the VR of VM2 at quarter 16 is significantly differ from unity when comparing with the critical value of the standard normal distribution; it is jointly insignificant when compared with the SMM critical value at 5%. Consequently, applying CHODE (1993) indicates inferential errors arisen from using the LOMAC (1988 and 1989) single test alone and ignoring the joint nature of the VR approach to test the RWH.

This result is consistent with CHODE (1993) that more caution must be paid in investigating the results of VR using LOMAC (1988 and 1989) tests only.

As the abovementioned methodologies are asymptotic tests, the lower panel of table (3.2) presents the results of the VR test based on the wild bootstrap of Kim's (2006) to avoid that limitation. The results show that the RWH of both velocities cannot be rejected and therefore, both VM1 and VM2 follow RW process. Consequently, it could be conducted that velocity of money in Egypt is an unpredictable phenomenon indicating that the current MAT regime is inappropriate for achieving price stability. This result is consistent with the findings of Awad (2010) who reports the instability of VM in Egypt.

Concerning MM2, the displayed results in table (3.4) indicate that, under LOMAC (1988 and 1989), the null hypothesis of RW cannot be rejected excluding q=2 and 4 assuming heteroscedasticity. As before, comparing the Z* statistics with the critical value of 2.491 of SMM distribution lead to acceptance of the RWH. This result is then confirmed by the application of Kim's (2006) wild bootstrap test. Consequently, the failure to reject the RWH indicates the unpredictability of MM2 which support the earlier finding concerning the unsuitability of MAT framework in Egypt.

Table 3.2: Estimates of VR tests of LOMAC, CHODE and Kim for VM

	q = 2	q = 4	q = 8	q = 16	Joint test
			LOMAC		
VM1					
VR(q)	1.007692	0.923094	0.647712	0.400497	
Z	0.065720	-0.351228	-1.017550	-1.163675	1.163675
p-value	0.9476	0.7254	0.3089	0.2446	0.6743
Z*	0.104750	-0.514915	-1.333293	-1.393843	1.393843
p-value	0.9166	0.6066	0.1824	0.1634	0.5101
VM2					
VR(q)	1.123409	1.296749	1.363333	1.860006	
Z	1.054404	1.355240	1.049452	1.669330	1.669330
p-value	0.2917	0.1753	0.2940	0.0951	0.3294
Z*	0.740680	1.029343	0.904398	1.660034	1.660034
p-value	0.4589	0.3033	0.3658	[0.0969]*	0.3348
			Kim		
VM1					
VR(q)	1.007692	0.923094	0.647712	0.400497	
Z	0.065720	-0.351228	-1.017550	-1.163675	2.130899
p-value	0.9202	0.6299	0.2242	0.1813	0.3537
Z*	0.104750	-0.514915	-1.333293	-1.393843	1.393843
p-value	0.9257	0.6428	0.2114	0.1899	0.4320
VM2					
VR(q)	1.123409	1.296749	1.363333	1.860006	
Z	1.054404	1.355240	1.049452	1.669330	1.669330
p-value	0.4802	0.3343	0.4125	0.0771	0.3771
Z*	0.740680	1.029343	0.904398	1.660034	1.660034
p-value	0.5561	0.3831	0.4470	0.1094	0.2795

* indicate significance at 10% when compared with critical value of 1.64 of the standard normal distribution. The symbol [×] indicates an inferential error in which the VR are separately statistically different from unity according to the standard normal distribution critical values, however; they are insignificant compared with the SMM distribution critical values. For the joint test, probability approximation using SMM with parameter value 4 and infinite degrees of freedom is applied.

Table 3.3: Estimates of VR tests of LOMAC, CHODE and Kim for MM2

MM	q = 2	q = 4	q = 8	q = 16	Joint test
			LOMAC		
VR(q)	0.988092	0.924288	0.866927	0.756502	
Z	-0.066302	-0.225325	-0.250476	-0.308003	0.308003
p-value	0.9471	0.8217	0.8022	0.7581	0.9966
Z*	-1.205404	-2.291373	-1.678416	-1.037823	2.291373
p-value	0.2280	[0.0219]*[x]	[0.0933]**[x]	0.2994	0.0849
			Kim		
VR(q)	0.988092	0.924288	0.866927	0.756502	
Z	-0.066302	-0.225325	-0.250476	-0.308003	0.308003
p-value	0.6499	0.3367	0.3844	0.4498	0.5907
Z*	-1.205404	-2.291373	-1.678416	-1.037823	2.291373
p-value	0.5242	0.1570	0.2093	0.4069	0.3618

*, ** indicate significance at 5% and 10% when compared with critical values of 1.96 and 1.64 of the standard normal distribution. The symbol [×] indicates an inferential error in which the VR are separately statistically different from unity according to the standard normal distribution critical values, however; they are insignificant compared with the SMM distribution critical values. For the joint test, probability approximation using SMM with parameter value 4 and infinite degrees of freedom is applied.

3.5. Conclusion

As the CBE intends to shift to IT when the prerequisites are met, the chapter aimed at investigating the appropriateness of MAT regime in Egypt by addressing the following question: Should the CBE move to IT framework or continue with the current applied MAT regime. Under MAT, the choice of monetary aggregate for policy purposes depends on the predictability of the relationship between that aggregate and nominal GDP where the velocity is the link. Moreover, monetary aggregate must be under the control of the CB which implies that the MM must be predictable. If both MM and VM are predictable, then the CB could control the money supply through modifying the reserve ratio conditional on the forecast of MM. On the other hand, if one or both variables is unpredictable, this implies that the CBE is unable to achieve the price stability using the underlying regime and therefore, it is recommended to move towards IT framework.

Using quarterly data for the period (1991:1-2009:2) for velocity variables and the period (2001:4-2009:2) for the MM, their structure behaviour is investigated using the VR tests of LOMAC (1988 and 1989), CHODE (1993) and wild bootstrap of Kim (2006). The results indicate that the three variables are generated by RW process. Thus, these variables are unpredictable random sequences and the CBE cannot achieve price stability under the currently MAT framework. Accordingly, the CBE should take steps towards adopting IT.

Chapter Four

The Optimal Policy horizon for IT

4.1. Introduction

The choice of the best horizon to target inflation is considered one of the main elements towards the actual implementation of IT framework. This is defined as the required time period to attain the targeted rate and the time period during which the target should prevail. As stated by Batini and Nelson (2001), there are two ways of looking at the optimal horizon for IT, depending on how IT is modelled. That is, if the policy is represented by a simple feedback rule on expected inflation, then the best horizon is the time for which CBs should form a forecast for inflation to use in this rule. On the other hand, if the policy is represented by an optimal rule for the instrument, then it could be thought as the time at which inflation should be on target when the central bankers aim at minimising their loss function, and a shock occurs today. They refer to the first kind as optimal feedback horizon, and to the latter by OPH. Thus, the horizon determines the monetary policy response to shocks. Additionally, estimating the optimal horizon is essential in deriving an interest rate path consistent with the preferred inflation path towards its target. Furthermore, this will help for anchoring inflation expectations at the target in the medium term and improves the accountability of CBs (Akram, 2008).

The choice of the horizon should depend on the nature of shocks and their properties such as its size and persistence as well as the extent to which the CB cares about other policy objectives rather than inflation. Therefore, due to differences in weights assigned to other policy objectives by different CBs, the OPH in response to a shock may vary across countries even if they become exposed to the same shock (Sevensson, 1997). Thus, if the CB loss function accounts for output volatility or interest rate fluctuations beside inflation, the horizon is expected to be longer (Akram, 2008).

To investigate the best horizons in response to different shocks, Batini and Nelson (2001) have employed VAR model to calculate the best horizon to target inflation. For the same purpose, Smets (2000) applied a system of equations for aggregate demand, aggregate supply and exchange rate. However, the main shortcoming of both small VAR models and this system of equations is its limited ability to derive optimal horizons for a few aggregate shocks (Akram, 2008). To avoid this drawback, Akram (2008) argues that disaggregate model that allows for different kinds of supply and demand shocks will help in exploring the corresponding optimal horizon, since the trade-off between inflation and output volatility may differ across shocks. Thus, if the OPH depends on the shock, it may be costly to derive the optimal horizons corresponding to various types of demand and supply shocks from those shocks of the aggregate demand and supply shocks variables[13].

In the presence of transmission lags, returning inflation to target immediately after a shock may involve considerable costs. This is because offsetting immediately the inflationary pressures after a shock may require large movements in the policy instrument, which may raise volatility in the financial markets and excessively causes output losses. To avoid this, CBs should anticipate inflation events and react to them pre-emptively in a more gradual fashion. Acting before it is too late permits CBs to minimise those losses by reducing the extent to

[13] This could be attributed to large costs associated with deviation from the optimal horizon (Smets, 2000).

which the instrument has to be moved in the short run in order to control inflation (Batini and Nelson, 2001).

The employed methodology presupposes that CB will attempt to minimise its loss function under an optimal rule for the interest rate. Therefore, it uses the second way of modelling IT and calculates the OPH corresponding to different kinds of shocks. In addition, the CB is assumed to work under a flexible IT framework. The employed VAR model consists of 7 variables and is estimated using Egyptian quarterly data over the period 1993:1 2005:2. Following Akram (2008), monetary authorities should form an interest rate path that minimises volatility of deviations of goal variables from target. The chapter is organised as follows. In section two, the policymakers' loss function is described. Then the employed model is estimated and investigated in section three. Section four computes the parameters of interest rate smoothing and interest rate paths in responses to various shocks for different policy horizon, loss function with different degrees of concerns about output stabilisation and interest rate volatility, and OPH for different kind of shocks and finally, section 5 concludes.

4.2. The objectives of CB and the interest rate rule[14]

The CB aims at preventing deviations of inflation from target and to minimise the volatility of the output gap. Additionally, the monetary authorities may be interested in minimising the variance of the instrument as well. Accordingly, the monetary authorities that work under commitment try to minimise the following

[14] This section is based mainly on Akram (2008)

loss function with respect to an interest rate path $i_T, i_{T+1}, i_{T+2} \dots i_{T+H-1}, i_{T+H}, i_{T+H+1}, \dots$, in response to an observable shock at time T

$$L_T = (\pi_t - \pi^*)^2 + \lambda(y_t)^2 + \omega(i_t - i_0)^2 \qquad 4.1$$ [15]

Subject to the constraint that the conditional mean of inflation in period *T+H* is close to the constant target rate π^*

$$E(\pi_{T+H}|I_T) = \pi^* \qquad 4.2$$

Where $(\pi_t - \pi^*)$ and $(i_t - i_0)$ are the deviation of inflation from target, and interest rate from the reference value. Additionally, y_t is the output gap and λ and ω is the degree of concern for output stabilisation and interest rate volatility relative to that for inflation respectively, and t is a time indicator. In addition, E is the conditional expectation operator. For simplicity, the quadratic loss function assumes that the discount factor is one (Rudebusch and Svensson, 1998). Additionally H is the policy horizon that is defined as the number of periods of appropriate length, here quarters, during which the policy interest rate will deviate from its neutral value and simulate or cool the economy. Thus, it could take any discrete value starting from zero onwards. Therefore, the precise policy horizon, when measured as the number of periods, would be H+1 as $H \geq 0$.

The OPH is defined as the number of periods it takes for inflation to settle on target after a shock, under the optimal rule for the instrument. The methodology is as follows, in response to a shock, policymakers derive a set of interest rate paths that minimise the inflation gap for different policy horizon.

[15] This representation of the loss function is consistent with Akram (2008) excluding the last term that allows CBs to place some weight on instrument volatility.

Then they choose the path and its corresponding policy horizon that would minimise the loss function represented by (4.1).

To eliminate the effects of a given shock, the CB changes the interest rate when the shock occurs at time T and then allows the interest rate to return gradually towards its reference value, (i_0), (Sack and Wieland,2000). Therefore, given the stability and the linearity of the model, the following interest rate rule could be used to derive an interest rate path corresponding to a specific policy horizon H

$$i_{T+m} = i_0 + (1-\rho_H)\frac{\beta_\varepsilon}{(1-\emptyset)}\varepsilon_T + \rho_H(i_{T+m-1} - i_0) \quad ; m = 0,1,2,\dots,H,H+1,. \quad 4.3$$[16]

Where the initial response coefficient $\beta_{\varepsilon,H} \equiv \frac{(1-\rho_H)\beta_\varepsilon}{(1-\emptyset)}$ determines how much the interest rate must deviate initially from the neutral rate to offset inflationary effects of a shock ε_T. This initial deviation is then reduced gradually, based on the value of an interest rate smoothing parameterρ_H. Both $\beta_{\varepsilon,H}$ and ρ_H depend on the policy horizon, as indicated by the subscript H. Additionally, the degree of the persistence of the shock, denoted $\emptyset$, is assumed to be positive and less than one: 0 ≤ $\emptyset$ ≤ 1. Thus for a given degree of interest rate smoothing ρ_H and β_ε , persistent shock requires a stronger initial response than a transitory shock (for which $\emptyset =$ 0). In addition, β_ε is a derived parameter whose value increases with the inflationary effects of the shock over a specific period, but declines with the effectiveness of interest rate in checking inflation.

[16] For more details about the derivation of the rule, see Akram (2008).

According to this approach, the policy horizon enters the interest rate rule through the interest rate smoothing parameter, ρ_H. It is defined as $\delta^{1/(H+1)}$ and lies between zero and one depending on the corresponding horizon (for a chosen fraction δ). Interest rates are considered converged with the neutral rate when just a fraction δ of the initial interest rate deviation from the neutral rate remains. Additionally, δ determines how close inflation to its target when monetary policy becomes neutral. Moreover, ρ_H increases with the policy horizon in a concave way since $\rho_H = \delta^{1/(H+1)}$. Specifically, if the CB aims at offsetting the shock effects in the same period, i.e., H = 0, there will not be interest rate smoothing ($\rho_H = \delta$) , while large values of H will imply a high degree of interest rate smoothing since $\rho_H = \delta^{1/(H+1)} \rightarrow 1$ when $H \rightarrow \infty$. However, the value of the response coefficient declines (in geometric fashion) with the policy horizon or degree of interest rate smoothing. In particular, when H=0, then $\frac{(1-\rho_H)\beta_\varepsilon}{(1-\emptyset)} \approx \beta_\varepsilon/(1-\emptyset)$, while $\frac{(1-\rho_H)\beta_\varepsilon}{(1-\emptyset)} \rightarrow 0$ when $H \rightarrow \infty$ as$\rho_H \rightarrow 1$. This suggests that if a very long policy horizon is allowed, the interest rate needs to deviate only marginally from its neutral rate, but this deviation has to be quite persistent.

Actually, a long horizon is required to control the necessary initial response to a relatively persistent shock. For example, if persistence in a shock is matched by persistent interest rates, i.e., $\rho_H = \emptyset$, the response coefficient $\beta_{\varepsilon,H}$ becomes equal to β_ε. On the other hand, a short horizon may imply a particularly large deviation from the neutral interest rate in the face of persistent shock. Thus, the included parameters of the interest rate rule depend on the chosen policy horizon (H). Therefore, the interest rate rule and the complete interest rate path as well as the level of the loss L could be changed by altering the corresponding policy horizon.

It follows that once the rule (4.3) is implemented in the model, the OPH to a shock can be found by minimising the loss function (4.1) with respect to H. The optimal value of H will then define the optimal interest rate change β_{ε,H^*}, the optimal degree of smoothing ρ_{H^*}, as well as the optimal loss function, L*, conditional on a given macroeconometric model.

4.3. The empirical model:

4.3.1 Data and preliminary analysis

To explore the optimal horizon, a VAR model for Egypt's quarterly data is implemented. The model is estimated over the period 1993:1 to 2005:2. There are 7 endogenous variables: nominal output[17] (*y*), nominal exchange rate (*e*), CPI inflation (*inf*), nominal interest rate (*r*), domestic equity prices (*s*), and government spending (g), credit demand (l). All variables excluding interest rate are in natural logarithm. The data is obtained from the CBE's monetary reporting to the IMF's International Financial Statistics (Standardized Reporting Forms, or SRFs) excluding *s*. The equity price represents EFGI price index and is sourced from DataStream. Since the data of nominal GDP and government expenditure are available only on annual basis, a quarterly series of them are interpolated. However, the interpolated series is considered to be suggestive rather than providing the true values of the underlying series.

[17] Following Batini and Nelson (2001), when deriving the OPH and associated loss in section 4.4, the estimated *y* equation will serve as the output gap equation.

The short-term interest rate is represented by three-month deposit rate. During the period mid-1980s to 2005, the CBE used at least four different rates of interest as policy instruments including the discount rate, the 3-month deposit rate, the TB rate and the interbank overnight rate. However, the movements of the TB and the interbank overnight rates are captured by the variation in the 3-month deposit rate indicating that the latter is a good proxy for other short-term interest rates (Moursi, and El Mossallamy, 2010). The selected sample is due to the regime change in monetary policy implementation concerning the successful shift to the interest rate target corridor in June 2005 (Al-Mashat and Billmeier, 2008). In addition, the model accounts for the effect of oil prices by including the log of oil price (o) as an exogenous variable. The data on oil prices is obtained from International Energy Agency (IEA). Following Al-Mashat and Billmeier (2008), the crude oil price is calculated as a simple average of the spot prices for dated Brent, West Texas Intermediate, and the Dubai Fateh which is usually regarded as prominent indicator for the CB reflecting pending supply-side driven price pressures.

Finally, as quarterly observations tends to exhibit seasonality patterns, all data excluding r are adjusted using moving average method previous to estimation. This leads to reduce the required number of lags to correct for serial correlation in the residuals to two lags.

To estimate a VAR model, the order of integration of the time series must be determined. Therefore, an ADF test to detect the number of unit roots in each series is conducted. The null hypothesis of ADF implies that the series is nonstationary. Based on results of ADF test reported in table (4.1), it is obvious that all variables are integrated of order 1.

Table 4.1: ADF unit root tests

variable	ADF test statistic	5% critical value	Result
y	-2.297064	-3.502373	I (1)
Δ (y)	-8.220143	-3.502373*	I (0)
e	-2.012304	-3.506374	I (1)
Δ (e)	-3.985142	-3.502373*	I (0)
inf	-2.012255	-2.921175	I (1)
Δ (inf)	-5.020761	-2.921175*	I (0)
r	-0.608016	-2.921175	I (1)
Δ (r)	-6.096610	-2.921175*	I (0)
s	0.974174	-1.947975	I (1)
Δ (s)	-1.951408	-1.947975*	I (0)
g	-2.339872	-3.502373	I (1)
Δ (g)	-5.165395	-3.502373*	I (0)
l	-3.429377	-3.502373	I (1)
Δ (l)	-7.615223	-3.502373*	I (0)

a. All variables are in log except the interest rate, and Δ refers to first difference operator.

b. The ADF equation has been specified to include intercept and trend for all variables excluding inflation and interest rate equations that include an intercept only and equity prices equation that excludes both intercept and trend. The lag length is chosen according to SIC.

c. *indicates rejection of the null hypothesis at 0.05 level of significance.

4.3.2. Model

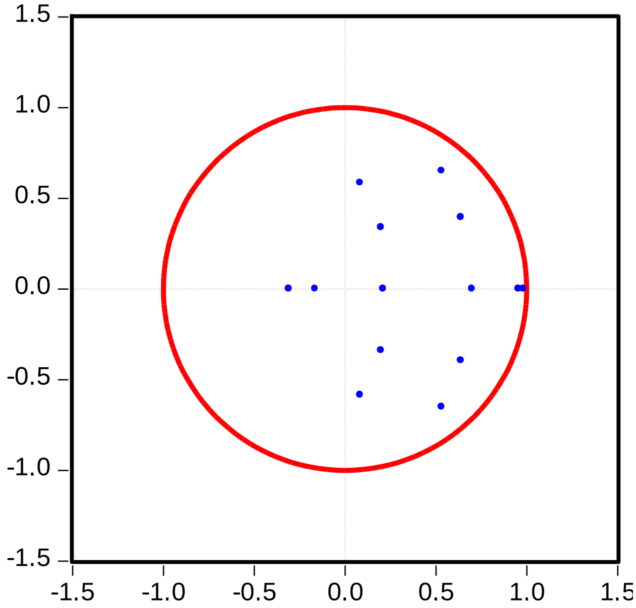
Given that all variables are not stationary but integrated of order one, the cointegration relationship between the variables is explored using Johansen and Juselius (1990) technique. The cointegration results reported in table (4.2) show that both the trace and maximum eigenvalue tests indicate the existence of two cointegrating vectors. Conditional on the cointegration relationship between the variables, the system could be estimated either in levels, with the rank of the system unrestricted, or as a vector error correction model (VECM) with the imposed rank restriction of 2 cointegrating vectors. The first option is selected using lag length of 2 quarters. The lag length is chosen according to LR, HQ and FPE criterions and the results are confirmed by the lag exclusion tests. Diagnostic tests include the LM test for serial correlation show that the null hypothesis of no serial correlation cannot be rejected at 1% level of significance up to the twelfth lag[18]. Moreover, the stability of the system is checked by examining the autoregressive roots, figure (4.1) suggests that no roots lies outside the unit circle suggesting that the VAR is stable.

Table 4.2: Johansen Test for Cointegration between the model variables

Eigenvalues	Trace Test			Maximum Eigenvalue Test		
	No. of coint. vectors	statistic	5% critical value	No. of coint. vectors	statistic	5% critical value
0.680158	0*	167.6921	125.6154	0*	53.57660	46.23142
0.613577	At most 1*	114.1155	95.75366	At most 1*	44.68866	40.07757
0.409476	At most 2	69.42684	69.81889	At most 2	24.75698	33.87687
0.400645	At most 3	44.66986	47.85613	At most 3	24.05932	27.58434
0.259040	At most 4	20.61054	29.79707	At most 4	14.09100	21.13162

* indicates rejection of the null hypothesis at the 0.05 levels.

Figure 4.1: Inverse Roots of AR Characteristic polynomial



[18] The results of lag selection, lag exclusion test and LM test for serial correlation are presented in tables B1, B2 and B3 in the appendix.

Thus, the model considers various channels of interaction between asset prices, exchange rate, output, credit and inflation. Monetary policy is represented by short-term nominal interest rate equation which is consistent with (Rudebusch, 1998) who states that the interest rate equation in the VAR could be interpreted as the monetary policy reaction function.

As indicated by Brooks (2002), the large number of parameters included in the VAR makes the interpretation of the model difficult especially when some lagged variables have coefficients with different signs across the lags. Therefore, to improve the interpretation of the VAR, researchers usually use three sets of statistics: block significance tests, impulse responses and variance decompositions. For the purpose of the paper, the impulse response functions are used to investigate the dynamics of the VAR and to evaluate the transmission mechanism of monetary policy instrument and shock to inflation.

4.3.3. Transmission mechanisms from policy instruments and shocks

The success of the stablisation policy depends on the ability of monetray policy impulses to track the effects of those of shocks synchronously. Therefore, an OPH must ensure as much synchronisation as possible between the effects of monetary policy and the shocks on inflation and output, based on monetary authorities prefrences. Thus, long lags from shocks to inflation and output should lead to long policy horizon and vice versa. Additionally, if policymakers cannot gurantee to get close synchornisation between policy changes effects and those of shocks, it would be better to let the economy adjust on its own over time without policy actions. This could be acheived by keeping the interest rate on its reference value (Akram, 2008). According to the above, impulse responses from both shocks and policy actions to inflation and output is required to understand the emiprical results of the OPH.

The impulse response functions reveal that different shocks lead to different responses and lags of different shocks to output and inflation. However, most of shock lags do not exceed those of a monetary policy shock. First, a transitory shock to short-term interest rates affects both output and inflation nearly instantaneously leading inflation to decline in the first quarter then peak after one year to start converging to its reference value hereafter. The immediate effect on aggregate demand could be attributed to simultaneous effects of interest rate on stock prices and exchange rate that influence output. Second, a shock to exchange rate to inflation has its peak after three quarters particularly because of the pass-through effect from the rise in the imported goods prices. Concerning output, a positive innovation to exchange rate decreases aggregate demand synchronously then it peaks after one and half years followed by fluctuation movement on its way back to its initial value.

Third, a shock to output affects itself simultaneously as output starts to move towards its reference path even though there are slight fluctuations. On the other hand, it has its effect on inflation after a lag of one quarter leading to a decline in inflation to the third quarter followed by a steady increase to the peak by the end of the seventh quarter and then return to its reference value exhibiting small variation. Fourth, a one point rise in inflation has its effect on both output and inflation at once leading inflation to decrease below the reference value up to quarter five then increase to peak at 2-year horizon. On the other hand aggregate demand increases instantly then declines to reach a minimum after 5 quarters followed by some fluctuations on its way to initial value. Finally, a shock to stock prices has its effect on aggregate demand simultaneously leading to a decline within a quarter followed by a peak after one year to start fluctuating towards its initial path. On the other hand, an innovation to stock prices has its effect on inflation with a lag of one quarter to peak in the third quarter then inflation fluctuates while getting back to its original path.

4.4. OPH for different kinds of shocks

This section sheds light on the differences in the policy horizons across different kinds of shocks. In addition, it investigates the possible effects of the persistence of shocks on the choice of the OPH. In the following, these assumptions are held. (1) Monetary policy response is represented by rule (4.3). (2) Values of interest rate smoothing parameter for different policy horizons are obtained from the formula $\rho_H = \delta^{1/(H+1)}$, where δ is set to equal 0.1 to define the convergence of interest rate to the reference value[19]. (3) Estimates of the initial interest rate response for different horizon for a given shock are calculated according to the formula $\beta_{\varepsilon,H} \equiv \frac{(1-\rho_H)\beta_\varepsilon}{(1-\emptyset)}$ for different degree of persistence in the shock and interest rates. As stated before, β_ε is a derived parameter whose value increases with the inflationary effects of the shock over a specific period, but declines with the effectiveness of interest rate in offsetting inflationary pressures. Therefore, it is calculated as the ratio of the accumulated impulse response of inflation to a

[19] According to Akram (2008), the results are not sensitive to the choice of δ.

given shock to the accumulated impulse response of inflation to interest rate change. (4) The shock to an equation is assumed to follow an AR(1) process with a degree of persistence equals $\emptyset$, i.e., $\varepsilon_t = \emptyset\varepsilon_{t-1} + \upsilon_t$. (5) An interest rate path corresponding to a given horizon is calculated and implemented in the model. This will be used to calculate the loss function for different policy horizon across different kinds of shocks and the chosen optimal horizon will be the one that minimise the loss function.

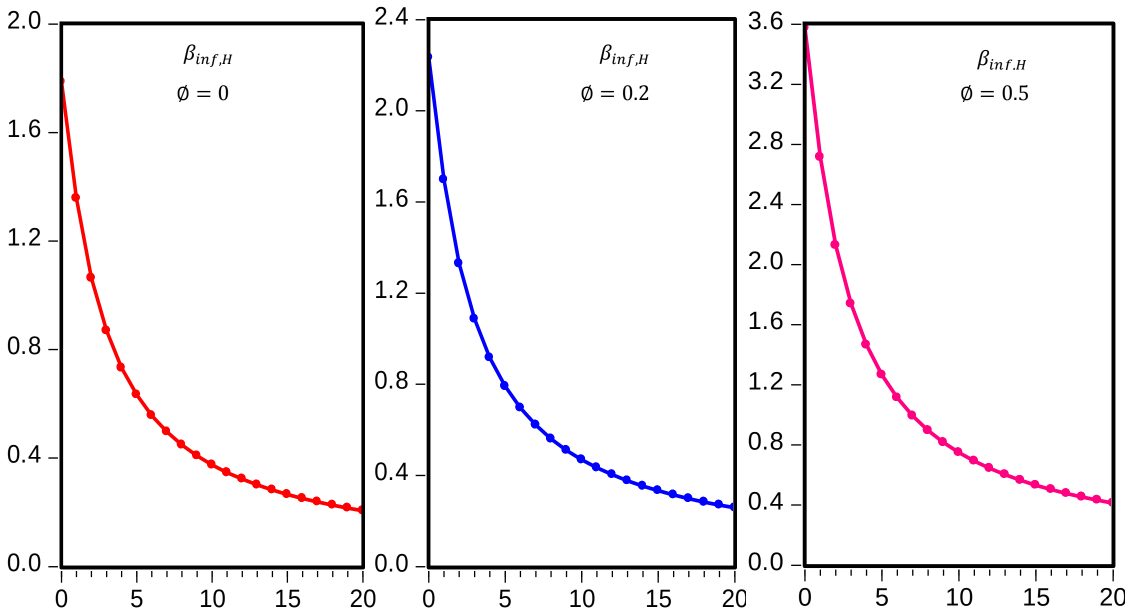
4.4.1. Monetary policy response to transitory and persistent shocks:

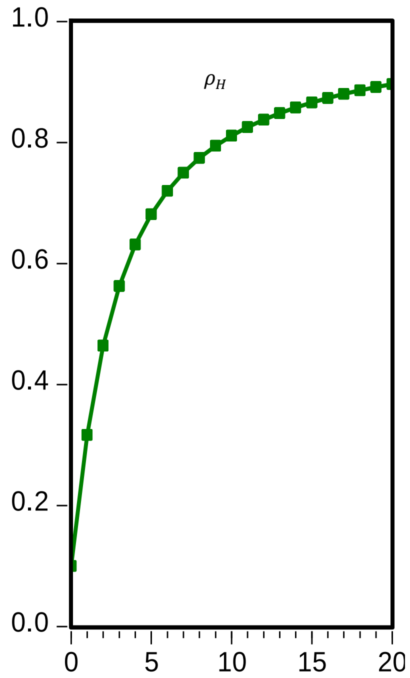
4.4.1.1. Aggregate supply shock:

In this subsection, the estimated values of initial interest rate response and interest rate smoothing are presented in response to transitory and persistent shocks, for different policy horizon of the range 0 – 20. Figure (4.2) displays the initial interest rate response for a transitory shock ($\emptyset$ =0), persistent shocks with different degrees of persistence ($\emptyset = 0.2$ and 0.5), and the degree of interest rate smoothing.

Before proceeding in investigating the estimated monetary response, there are some general remarks must be emphasised. First, the required monetary response decreases by lengthening the policy horizon; however, this longer horizon increases the degree of interest rate smoothing. For example, an increase in the policy horizon from zero to 8 quarters decreases the required initial interest rate response significantly but raises the degree of smoothness of interest rate from 0.1 to 0.77. Second, increasing the policy horizon from a low level would result on a higher decrease in the monetary response coefficient than an increase in the policy horizon from a relatively high level. These two remarks are consistent with those reported in Akram (2008) who investigate the second remark by the concave relationship between the degree of interest rate smoothing and the policy horizon, which leads in turn to a concave relation between the response coefficient and the policy horizon. Third, an increase in the degree of persistence of the shock from transitory to a persistent shock significantly raises the initial response coefficient.

Figure 4.2: The initial interest rate response to a supply shock with different degrees of shock persistence, and the interest rate smoothing

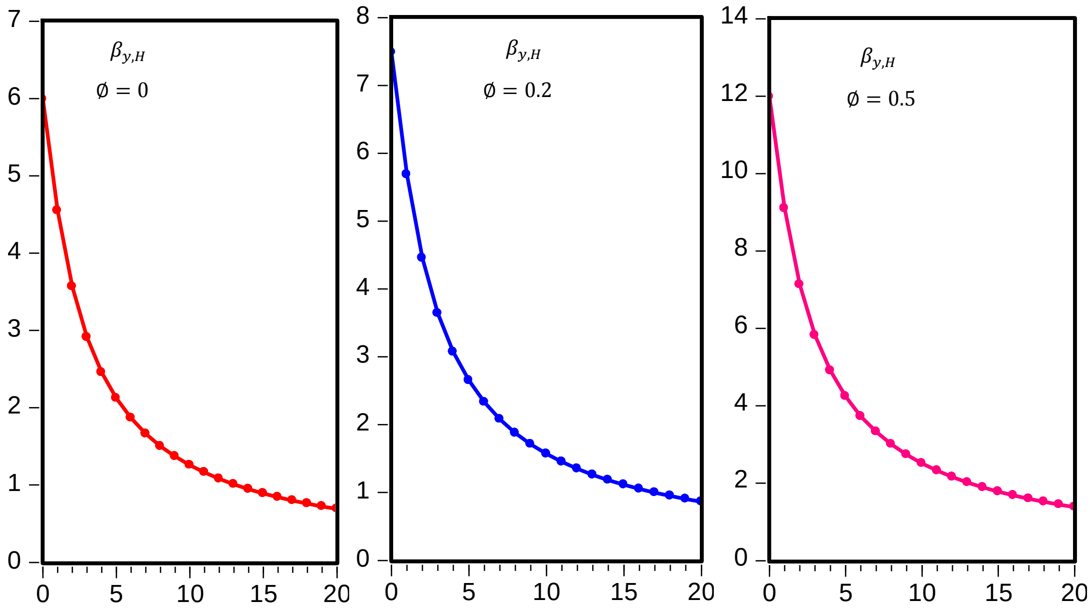




4.4.1.2. Aggregate demand shock:

As in the first case, the estimated values of initial interest rate response are presented in response to transitory and persistent shocks, for different policy horizons of the range 0 – 20. Figure (4.3) displays the initial interest rate response for a transitory shock (∅ =0), persistent shocks with different degrees of persistence (∅ = 0.2 and 0.5).

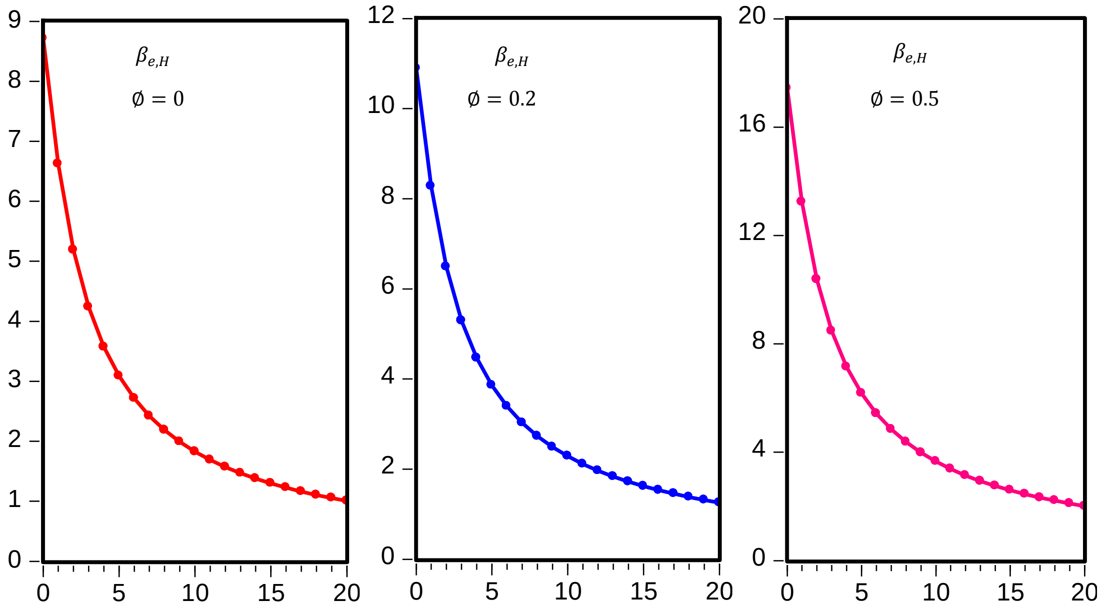
Figure 4.3: The estimated initial interest rate response to a demand shock with different degrees of shock persistence



4.4.1.3. Exchange rate shock:

A shock to exchange rate is considered as a demand shock. In comparison with aggregate demand shock, a shock to exchange rate requires an initial monetary response of about one and half times that required with the aggregated shock. For example, if the CB aims at offsetting the effects of a shock in a horizon of 6 quarters, then the required interest rate response for the aggregated demand shock would be 1.86 while that required for exchange rate shock would be about 2.71.

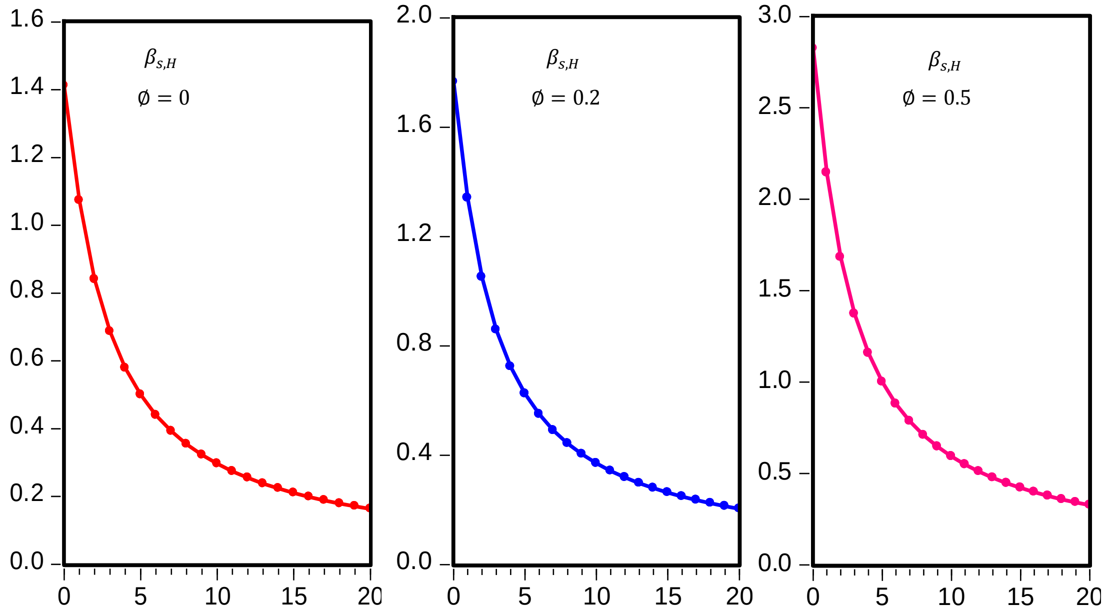
Figure 4.4: The estimated initial interest rate response to an exchange rate shock with different degrees of shock persistence



4.4.1.4. Stock prices shock:

The equity prices shock could be classified as a demand shock as it has wealth effects on aggregate demand. As before, figure (4.5) shows the initial interest rate response coefficient $\beta_{s,H}$ associated with transitory and persistent shocks for different policy horizons. Compared with the effect of aggregate demand shock, there is significant difference between the required monetary responses in both cases. Consider the case that monetary authorities desire to offset the shock effect in a horizon of 3 quarters. In the case of aggregate demand shock this would require a change of 2.91 in the monetary instrument while a shock to stock prices requires only a change of 0.69 in the interest rate. Thus, analysing the effects of different kinds of shocks even if they are generally of the same type is important in deciding the appropriate policy horizon to avoid inefficiency in monetary policy.

Figure 4.5: The estimated initial interest rate response to a stock prices shock with different degrees of shock persistence



4.4.2. OPH in response to transitory and persistent shocks

In this section, OPH corresponding to different kinds of shocks with various degrees of persistence are presented. Additionally, the degree of CB concern regarding other policy objectives is included. The procedure implemented in this section is as follows. First, using the interest rate smoothing parameter and the initial interest rate response in the face of different transitory and persistent shocks, calculated in section 4.4.1., an interest rate paths for different horizons and across different shocks is computed using rule (4.3). Second, these interest rate paths are implemented in the model and the economic performance in terms of the unconditional standard deviation of inflation, interest rate and output is calculated. Finally, the loss function is computed and the chosen optimal horizon is the one that minimises the loss function.

4.4.2.1. OPH for aggregate supply shock

Panel A of table B4 provide results for the OPH calculated for different set of CB preferences over goals. Thus, OPH is calculated for strict IT when the weights on output and interest rate variance are set to zero ($\lambda = \omega = 0$). In addition, the OPH is computed for flexible IT under the assumptions that output and interest rate volatility are equally penalised in two cases ($\lambda = \omega = 0.5$, which is half of the weight placed on inflation variance, and $\lambda = \omega = 1$ where the variance of the three goal variables are penalised equally). Moreover, the OPH is computed assuming that the output volatility is much costly ($\lambda = 2$). The variance of interest rate is costly and included to account for CB concern of financial market fragility (Rudebusch and Svensson, 1998). For a strict IT, the OPH to offset a positive unit innovation to inflation is only a quarter. This result is not so different with the OPH of 3 quarters obtained by Akram (2008) in the face of aggregate supply shock. This horizon of one quarter is sufficient regardless the degree of policymaker's concern regarding output volatility. The reason is that the monetary policy rule implies that a very long horizon can lead to a large reduction in the interest rate response coefficient causing a violation of the so-called Taylor rule principle. This principle implies that, in response to inflation increase, the rise in the nominal interest rate must be higher than that of inflation to avoid the decline in real interest rate that would lead to financial instability (Akram, 2008). The key difference of the OPH is attributed to the inclusion of interest rate volatility in the loss function. That is the OPH increases to 3 and 6 quarters when a penalty of 0.5 and one is included for the deviation of interest rate from neutral.

Concerning shock persistence, the OPH for an aggregate supply shock is the same regardless the degree of shock persistence under a strict IT framework and even with a flexible IT that excludes the volatility of interest rate from the CB loss function. However, accounting for instrument variance significantly changes the OPH. When the persistence of the shock is 0.2, the OPH is two years irrespective of the degree on interest rate concern. Moreover, when the shock is highly persistent ($\phi = 0.5$), the OPH is 10 quarters when the penalty on instrument variation is half of that placed on output and inflation volatility. This best horizon is even lengthened to 5 years when the variability of all goals variables is equally distasteful.

Graph 4.6: Loss functions for an aggregate supply shock

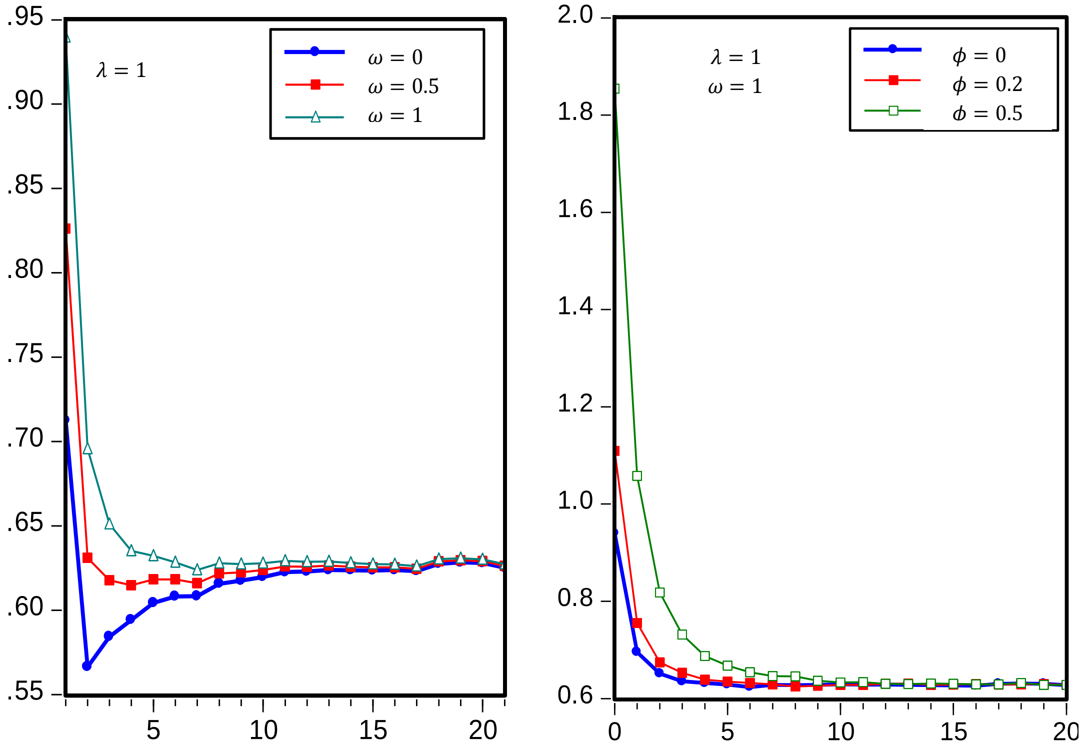


Figure (4.6) shows the loss function for different preferences of monetary authorities over goal variables (left panel) and with different degrees of shock persistence (right panel). The left panel presents the loss function for different weights of interest rate volatility assuming that variability of output and inflation are equally penalised. On the other hand, the right panel provides the loss functions for transitory and persistent shocks to aggregate supply when all goal variables are equally weighted.

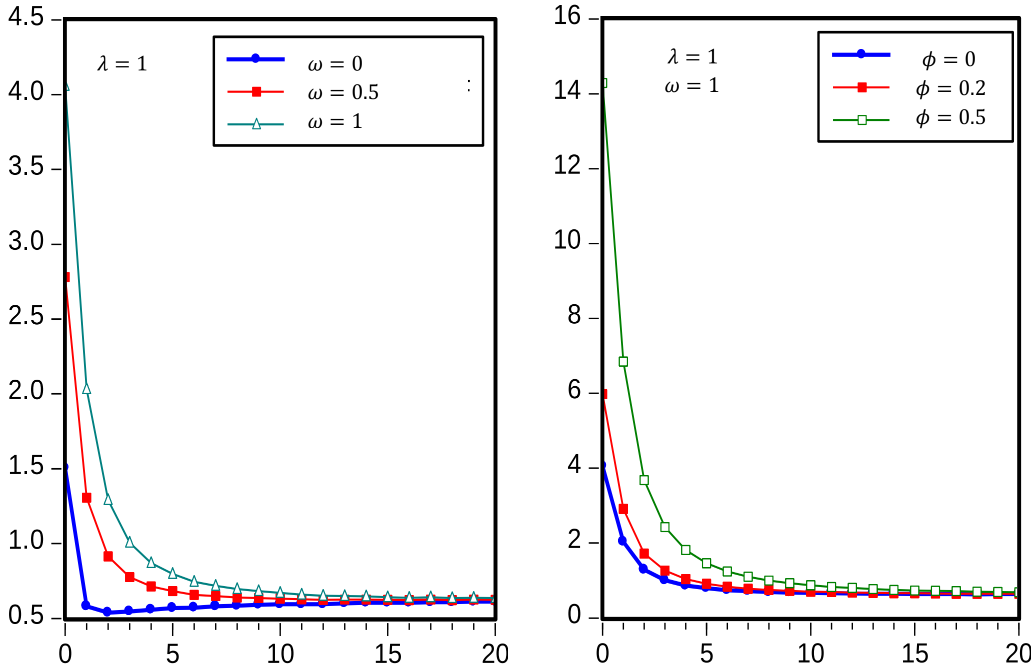
Based upon the graphs, the following remarks are of high interest. First, the OPH increases with the persistence of the shock. Second, as stated before the concern of CB regarding other policy goals (specifically interest rate volatility) lengthens the OPH. Third, however the location of the loss function varies by altering the weights given to other policy objectives rather than inflation and degree of shock persistence, its shape is approximately the same. Fourth, there exists an asymmetry around the OPH. That is, in response to the aggregate supply innovation, choosing a shorter horizon than the optimal one would incur higher losses than choosing a longer horizon. Specially, when the shock is persistent, interest rate rules corresponding to a relatively short horizon will become inefficient causing larger losses in comparison with interest rate rules associated with relatively longer horizon. Thus, choosing a very short horizon would reduce the effectiveness of monetary policy.

4.4.2.2. OPH for aggregate demand shock

As in the aggregate supply shock, Panel B of table B4 presents the OPH calculated for different set of CB preferences over goals and with various degrees of shock persistence. Under either strict IT or flexible IT neglecting interest rate volatility, the OPH is 2, 3 and 5 quarters for transitory and persistent ($\phi = 0.2$ and 0.5) respectively. However, when policymakers' loss function accounts for interest rate variance, the OPH increases to 16, 18, and 20 quarters for transitory and persistent ($\phi = 0.2$ and 0.5) respectively, under the assumption that interest rate volatility receive half of the penalty assigned to output and inflation variability. Moreover, this horizon is even prolonged to 18, 20, and 20 for the aforementioned shocks if all the goals variables are equally penalised ($\lambda = \omega = 1$). In comparison with (Batini and Nelson, 2001), in response to aggregate demand shock, the chosen horizon of 16 quarters is close to their choice of 17 quarters under the assumption that interest rate variance receives a penalty of half of the assigned to output and inflation volatility.

Thus, the OPH is relatively short when the instrument volatility is excluded from the loss function as both output and inflation stabilisation could be achieved jointly in response to aggregate demand shock (Akram, 2008). To explore the OPH for an aggregate demand shock, graph (4.7), displays loss function for transitory and persistent demand shocks (right panel) along with the loss of transitory shock for various degrees of CB preferences (left panel). As in the case of aggregate supply shock, the results show that the OPH increases with the persistence of the shock. Additionally, the left panel shows that the OPH is lengthened when the instrument volatility is included in the CB's loss function. As in the case of aggregate supply shock, the loss function is asymmetric around the OPH indicating that a shorter horizon than the optimal will causes higher losses.

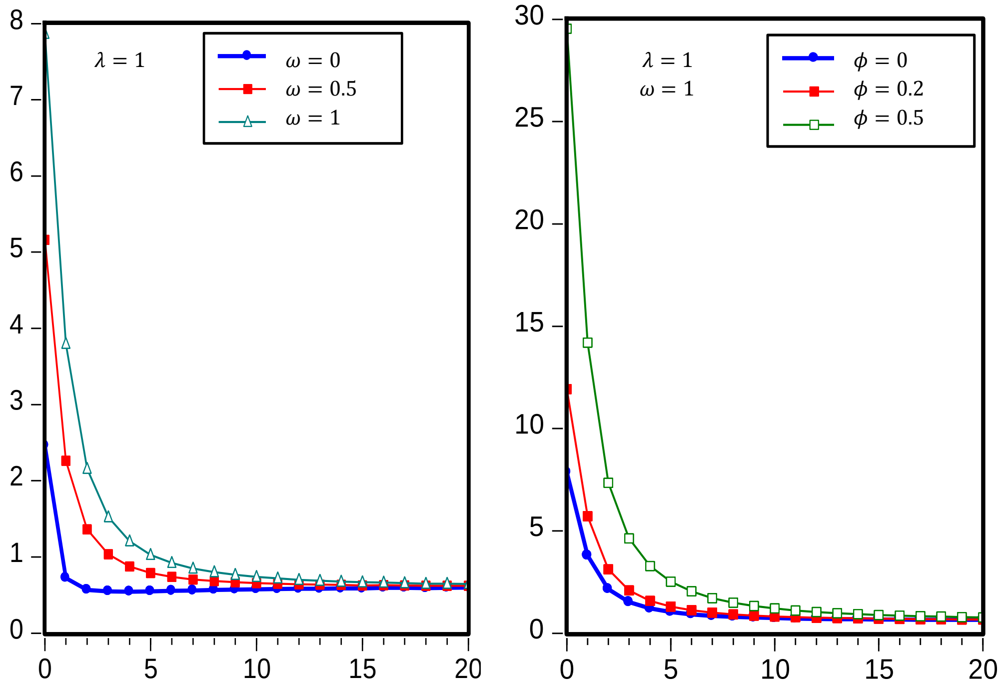
Graph 4.7: Loss functions for an aggregate demand shock



4.4. 2.3. OPH for an exchange rate shock:

As in the previous cases, the movement from transitory to persistent shock increases the OPH. That is, a transitory shock and a shock with $\phi = 0.2$ lead to an OPH of 4 quarters while a shock with higher degrees of persistence ($\phi = 0.5$) lengthen OPH to be 2 years (Panel C in table B4). Again, the inclusion of output concern only does not affect the OPH while accounting for instrument variability extends the required horizon to offset a transitory shock from 1 year to 18 and 20 quarters for ($\omega = 0.5$ and 1) respectively.

Graph 4.8: Loss functions for an exchange rate shock



Concerning the shape of the loss function, it is relatively the same irrespective of policy preferences and shock persistence. As in the aforementioned aggregate demand and supply shock, the asymmetry of loss function around the OPH makes the choice of a shorter horizon than the optimum more costly in comparison to longer horizon. In comparison with aggregate demand shock, a transitory shock requires 4 quarters to offset the inflationary pressures resulting from an exchange rate shock whereas it requires only 2 quarters for aggregate demand shock. Thus, different types of demand shock would require different policy horizons.

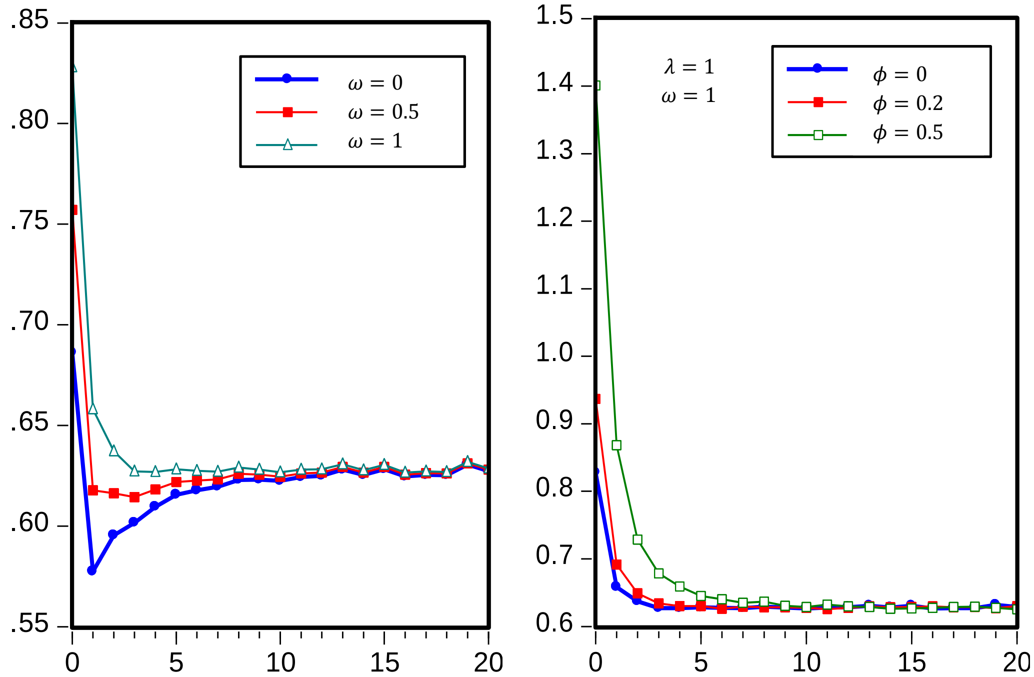
4.4.2.4. OPH for stock prices shock

The OPH in response to transitory and persistent shocks to stock prices are displayed in Panel D of table B4. To offset the inflationary pressures of such shock, policymakers are required to adopt a policy horizon of one quarter regardless the level of shock persistence in the absence of instrument penalty. This is due to the absence of trade-off between inflation stabilisation and output stabilisation at this short horizon. Conversely, when monetary authorities place some weight on interest rate variability ($\omega = 0.5$), this lengthens the best horizon to 3, 3 and 7 quarters for $\phi = 0, 0.2 \text{ and } 0.5$ respectively. Furthermore, a loss function that penalises the deviation of goal variables from target equally will even extend the horizon to 16, 19 and 20 quarters in face of a shock with for $\phi = 0, 0.2 \text{ and } 0.5$ respectively. Figure (4.9) shows that the frontier of the loss function in case of stock price innovation is comparable to that of aggregate supply shock.

As the stock shock has wealth effects on aggregate demand, it is classified as demand shock. Consequently, the OPH corresponding to such shock should be compared with the OPH for other demand-classified shocks. The required horizon to offset a shock to stock prices is shorter than other demand shocks. This could be attributed to the low effect of stock prices shock to inflation and output compared with the effect of output and exchange rate impulses on output and inflation. Thus, however the shock to s affects inflation with a lag of one quarter, the OPH is shorter than the required horizon to offset output and exchange rate shock. This may be attributed to the small initial interest rate response required to offset the shock. That is to offset the inflationary pressures of a transitory innovation to s; the interest rate should be adjusted by 1.07. On the other hand, if the CB tries to offset output and exchange rate shock with a horizon of one quarter, this requires a change of 4.55 and 6.6 in the instrument in comparison with the required response of 2.91 and 3.57 at the OPH. Undoubtedly, this shift from the OPH would raise the losses incurred by the monetary authorities.

Therefore, since OPH differs with different shocks even though if they are generally classified of the same type, monetary authorities should not aim at offsetting them with the same horizon to ensure the effectiveness of monetary policy.

Graph 4.9: Loss functions for stock price shock



4.5. Conclusions

The results reveal that the OPH depends significantly on the nature of the shock and the extent to which CB cares about other policy goals. Thus, for different kinds of the shocks, even if they are generally classified of the same type, the concern about instrument stabilisation affects the policy horizon. That is, the CB should aim at offsetting the transitory output shock within 2 quarters while an exchange rate and stock prices impulses require a horizon of four and one quarter respectively. This could be attributed to the fact that if policymakers choose a very long horizon to offset a transitory shock, monetary policy will affect the economy for a longer horizon rather than the shock itself which induces instability. However, accounting for instrument volatility extends the best horizon largely. Particularly, an innovation to output or exchange rate tends to lengthen the OPH significantly when the CB accounts for interest rate variability.

Therefore, to ensure the effectiveness of monetary policy, monetary authorities should not aim at offsetting the shocks that are generally classified of the same type at the same horizon. With respect to shock persistence, for all types of shocks, the horizon increases with the persistence of the shock as persistent shock distrusted over many period in comparison with transitory and less persistent shocks.

Appendix B

Table B1: VAR lag order selection criterions

Lag	LogL	LR	FPE	AIC	SIC	HQ
0	278.3279	NA	4.15e-14	-10.95012	-10.12346	-10.63904
1	613.0764	527.0508	2.27e-19	-23.10963	-20.35409*	-22.07270
2	683.8648	90.36828*	1.09e-19*	-24.03680	-19.35239	-22.27402*
3	740.4086	55.34074	1.31e-19	-24.35781*	-17.74452	-21.86919

* indicates the lag length selected by the corresponding criterion.
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SIC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table B2: Wild Chi-squared test statistics for lag exclusion:

	inf	e	r	y	S	l	g	Joint
Lag 1	49.638	77.385	15.98233	20.45	47.027	17.758	69.79	347.780
p-value	1.7×10^{-08}	4.7×10^{-14}	0.025	0.0047	5.51×10^{-08}	0.013	1.63×10^{-12}	0.00000
Lag 2	19.864	18.402	9.905	27.227	7.7173	9.994	27.540	149.4596
p-value	0.0059	0.01	0.194	0.0003	0.358	0.1889	0.00027	4.29×10^{-12}
df	7	7	7	7	7	7	7	49

Table B3: VAR residual serial correlation LM tests

Null Hypothesis: no serial correlation at corresponding lag order

Lags	LM-Stat	p-value
1	62.28983	0.0962
2	71.12001	0.0211
3	58.25679	0.1715
4	61.47486	0.1088
5	63.82276	0.0757
6	39.65923	0.8271
7	63.85044	0.0754
8	69.03594	0.0311
9	44.87637	0.6409
10	58.75734	0.1603
11	34.70062	0.9389
12	60.55703	0.1245

Table B4: OPH for different shocks with various persistence and degrees and CB preferences

	Strict IT	**Output stabilisation included**			**Both output stabilisation and interest rate volatility included**					
Weights	$\lambda = 0$ $\omega = 0$	$\lambda = 0.5$ $\omega = 0$	$\lambda = 1$ $\omega = 0$	$\lambda = 2$ $\omega = 0$	$\lambda = 0.5$ $\omega = 0.5$	$\lambda = 1$ $\omega = 0.5$	$\lambda = 2$ $\omega = 0.5$	$\lambda = 0.5$ $\omega = 1$	$\lambda = 1$ $\omega = 1$	$\lambda = 2$ $\omega = 1$
Panel A: Aggregate Supply Shock										
$\phi = 0$	1	1	1	1	3	3	3	6	6	6
$\phi = 0.2$	1	1	1	1	8	8	8	8	8	8
$\phi = 0.5$	1	1	1	1	10	10	10	20	20	20
Panel B: Aggregate Demand Shock										
$\phi = 0$	2	2	2	2	16	16	16	18	18	18
$\phi = 0.2$	3	3	3	3	18	18	18	20	20	20
$\phi = 0.5$	5	5	5	5	20	20	20	20	20	20
Panel C: Exchange Rate Shock										
$\phi = 0$	4	4	4	4	18	18	18	20	20	20
$\phi = 0.2$	4	4	4	4	20	20	20	20	20	20
$\phi = 0.5$	8	8	8	8	20	20	20	20	20	20
Panel D: Stock Price Shock										
$\phi = 0$	1	1	1	1	3	3	3	16	16	16
$\phi = 0.2$	1	1	1	1	3	3	3	19	19	19
$\phi = 0.5$	1	1	1	1	7	7	7	20	20	20

Figure B1: Responses of inflation and output to one percentage point positive shock to interest rate

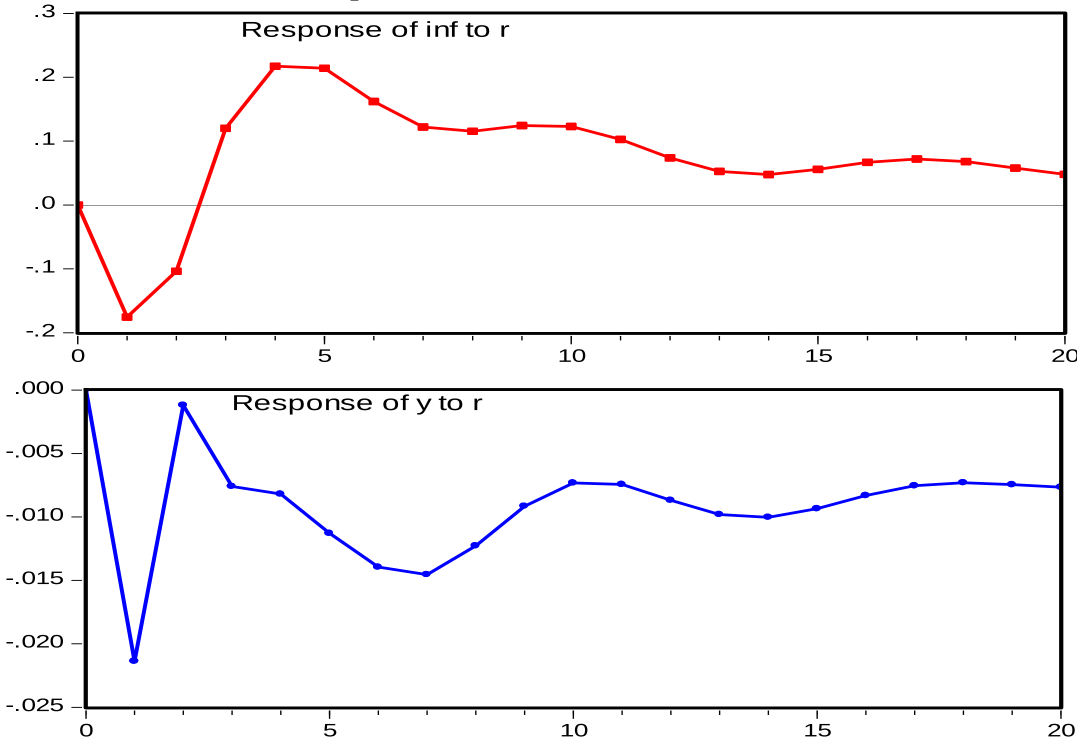


Figure B2: Responses of inflation and output to one percentage point positive shock to exchange rate

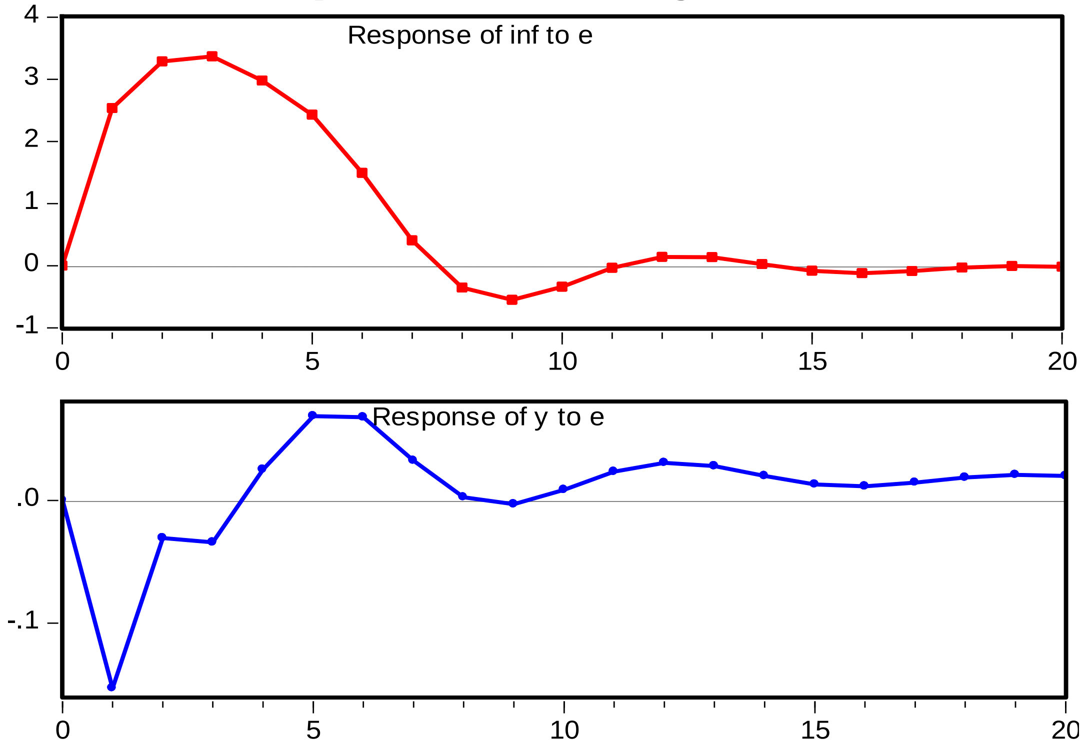


Figure B3: Responses of inflation and output to one percentage point positive shock to output

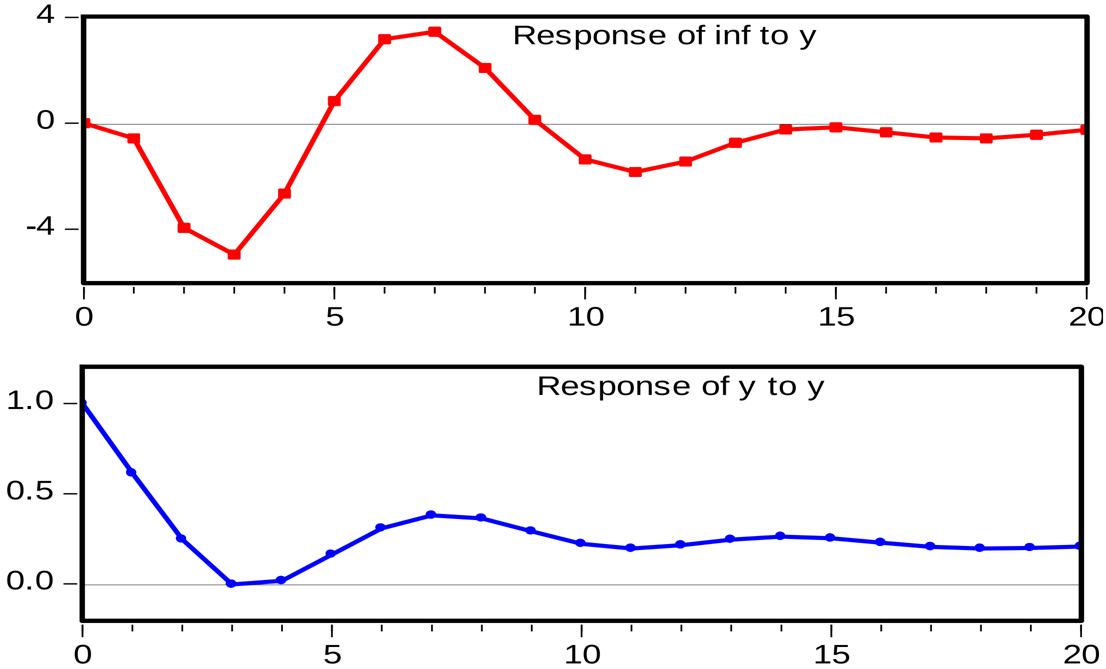


Figure B4: Responses of inflation and output to one percentage point positive shock to inflation

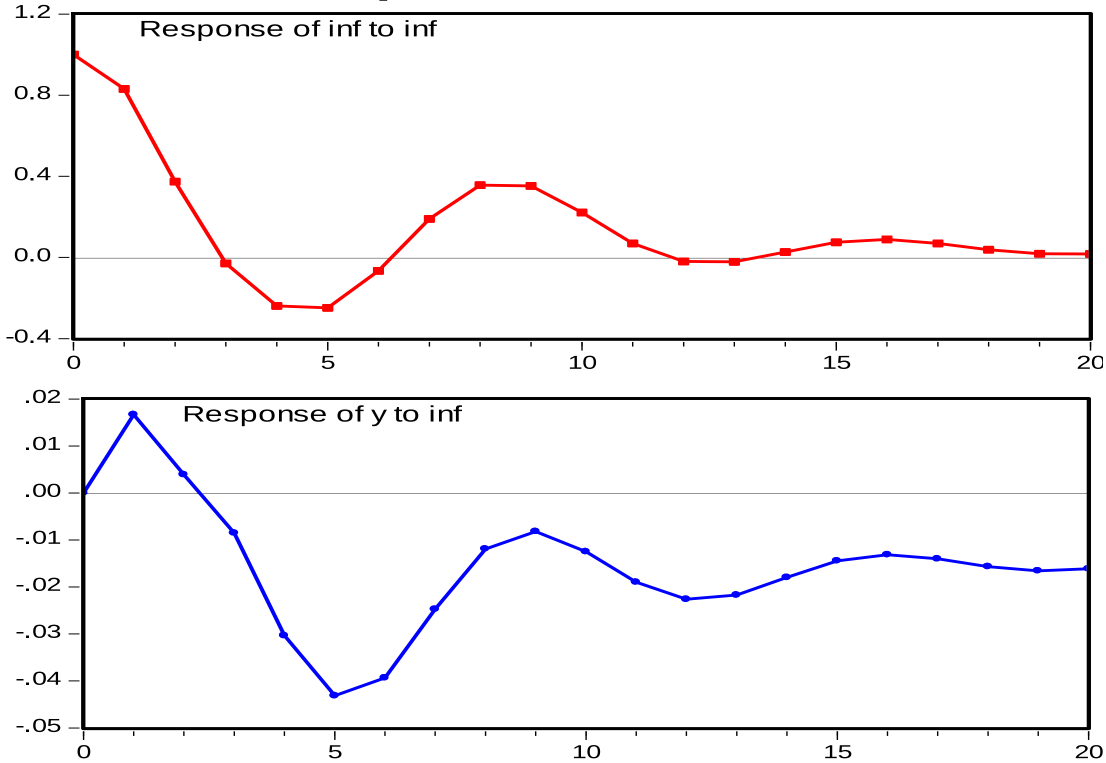
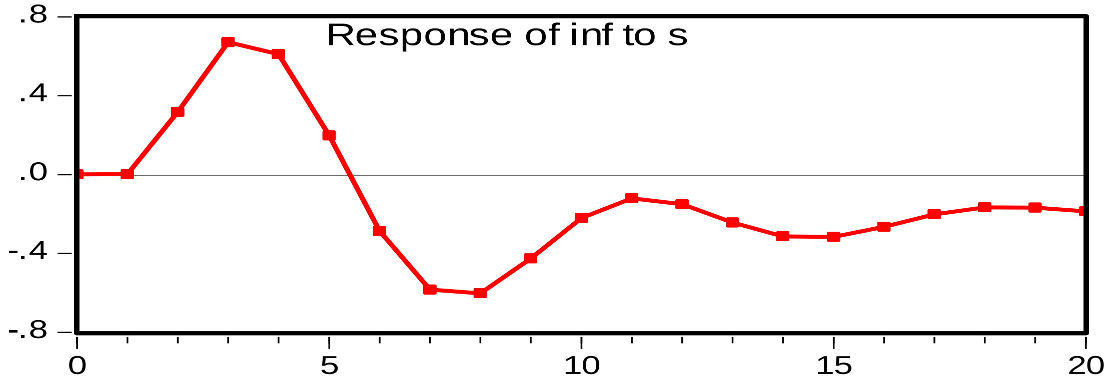
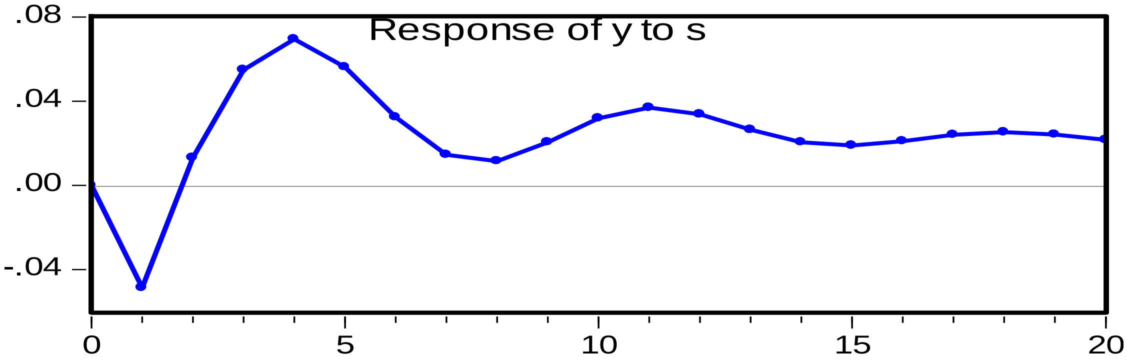


Figure B5: Responses of inflation and output to one percentage point positive shock to stock prices





Chapter Five

Modelling the Density of Inflation Using Autoregressive Conditional Heteroscedasticity, Skewness, and kurtosis Models.

5.1. Introduction[20]

Exploring the relation between inflation and its higher-order moments is quite important for CBs especially under IT framework. That is because policymakers are increasingly worrying about complete density forecasts that allow a much richer setting of anti-inflation policy. Therefore, the paper aims at exploring the relation between CPI inflation and its higher-order moments that allows better understanding of the risks involved in inflation.

As indicated by Engle (1982), unpredictability of inflation causes high levels of welfare loss associated with inflation. The reason behind that is however the expected inflation is costly due to institutional rigidities, government intervention, and transaction costs, these costs will be minimized in the long-run if these agents use different forms of indexation. On the other hand, the lack of ability to predict future inflation affects risk averse agents as it damage the efficiency of allocation decisions between current and future periods, due to uncertainty, even though the prices and quantities are perfectly flexible in all markets. Additionally, as many countries have adopted an IT regime, this requires the existence of efficient inflation forecasts models. Given that the CBE announced its intention to adopt an IT framework to anchor its monetary policy when the basic prerequisites are satisfied (CBE, 2005), it must have accurate models to forecast future inflation.

Literature on inflation forecasting is still very limited in Egypt. However, some studies analysed and estimated the sources of inflation but it did not assess

[20] This chapter has been selected as the best paper submitted to the Fifth Prize of Economic Research of Ensayos Revista de Economía.

the ability of these models to forecast inflation. Noureldin (2005) assessed the robustness of three alternative approaches to forecast inflation in Egypt. These three approaches are output gap (Phillips curve), money gap model, and VAR model. However, point forecast does not provide a full description of the uncertainly associated with the forecast. Actually, the Business and Economic Statistics Section of the American Statistical Association (ASA) and the National Bureau of Economic Research (NBER) initially published the first series of density forecasts in macroeconomics in 1968. They jointly started a quarterly survey of macroeconomic forecasters in the United States which known as the ASA-NBER survey (Tay and Wallis, 2000). Additionally, the Bank of England has published a density forecast of inflation in its quarterly Inflation Report since February 1996 (Wallis, 2004).

Examining monthly Egyptian CPI inflation data reveals that it exhibits high degree of volatility which is a necessary condition to apply the models that allow for time-varying conditional variance, skewness, and kurtosis. Forecasting monthly inflation is highly needed by CBs as many of them including CBE publish monthly bulletin including inflation data. For inflation targeters, it is more appropriate to publish monthly forecasts to enable monetary authority to better decision making in terms of altering instruments. To investigate the importance of including second, third, and fourth moments, six models have been estimated assuming different distributions for the error term. The first two models are GARCH-M, and its threshold (TARCH-M) extension assuming a normal distribution for the error term while the third is a GARCH-M model when the error term follows a GED distribution.

Nevertheless, the main contribution of the current paper is modelling the relationship between inflation and its second, third, and fourth moments that represent the full risks involved in inflation. Thus, the other models employed here are developed versions of GARCH and TARCH models that allow for jointly modelling the relation between inflation, its volatility, skewness, and kurtosis. This development is attributed to (LRS, 2005), who model time-varying second, third and fourth moments jointly by applying a G-C series expansion of the normal density function. They extended the basic GARCH and NGARCH models and employ their methodology to different stock indices and exchange rates. Consequently, I will apply their methodology using GARCH-M and TARCH-M specification in measuring and forecasting inflation in the case of Egypt.

However, this paper differs from those of LRS (2005) in three points. First, it uses inflation instead of stock returns and exchange rates. Secondly, current paper applies a TARCH specification of the conditional variance equation instead of NGARCH applied by them. Moreover, I allow the conditional skewness and kurtosis equation to have an asymmetry term (i.e., TARCH specification for conditional third and fourth moments). The results show that specifications that allow skewness and kurtosis to vary with time outperform specifications that keep them constant. However, allowing both conditional skewness and kurtosis to follow a TARCH structure is inferior to allowing them to have a GARCH-type process. The chapter is structured as follows. Section 2 is devoted to review the existing literature. Section 3 presents the different models while the preliminary check for the data, analysis of the results and comparison of different models is the core of section 4. Finally, section 5 applies the methodology to Mexico inflation data to show the applicability of the model to other economies. Finally, section 6 concludes and draws some policy implications.

5.2. Literature review

As indicated before modelling the relation between inflation and its higher-order moments is quite important for policymakers to provide better understanding of the uncertainty of inflation. Regarding the relation between inflation and its volatility, Friedman (1977) asserts that high inflation leads to more variable inflation. This inflation uncertainty is costly since it distorts relative prices and increases risk in nominal contracts (Berument et al, 2001). From the empirical viewpoint, Engle (1982) find that for some kinds of data including inflation, the variance of the disturbance term is not stable as usually assumed by OLS model. Assuming that the error term exhibits heteroscedasticity, however with a zero and serially uncorrelated mean, he found that UK inflation follows ARCH process (i.e., variances conditional on past value of the error term are time-varying while unconditional variance is constant). He uses ML methodology to estimate this model and claimed that the ML estimator is more efficient than OLS estimator. To detect the existence of ARCH effects, he applied a LM test based on the autocorrelation of the squared OLS residuals.

However, the basic ARCH model has some shortcomings including the absence of clear approach to choose the suitable number of lags of the squared residuals to be included in the model. Additionally, this number of lags may be quite large leading to non-parsimonious model and violation of the nonnegativity constraints on variance parameters. Moreover, it assumes that the current conditional volatility depends only on the past values of residuals squared which may be unrealistic assumption as volatility response to positive and negative shocks are not similar (Engle,1995; Rachev et al,2007; and Brooks,2002).

The basic ARCH model has been extended many times. Bollerslev (1986) introduced generalized version of the ARCH process by allowing the conditional variance to be an ARMA process which permits a more flexible lag structure without the violation of the nonnegativity restrictions.

However, the basic GARCH model is criticised as it assumes that the response of variance to negative and positive shocks is similar. Due to the observed asymmetry of the variance response to shocks with different signs, some variant models have been developed to account for this asymmetry. The first variant is the exponential GARCH (EGARCH) model suggested by Nelson (1991) to permit conditional volatility to be a function of both the size and the sign of lagged residuals assuming that the residuals follow generalized error distribution (GED). However this distribution allows shocks of different signs to have different impact on volatility, but it is still symmetric like the normal distribution (Harvey and Siddique, 1999). Additionally, Glosten, Jagnnnathan and Runkle (1993) introduced a formula that captures the leverage effect of financial time series, namely threshold ARCH (TARCH) or GJR specification[21].

Although ARCH family models are quite useful in modelling time-series variation in conditional volatility, these models assume that the conditional distribution are time-varying only in the first two moments and ignore the

[21] For more details about the different extensions of ARCH/GARCH models, see Bollerslev (2008).

information content in higher-order moments (Chaudhuri, Kim, and Shin, 2011). To fill this gap, Harvey and Siddique (1999) developed a new approach to estimate nonconstant conditional skewness. They extended the traditional GARCH (1,1) model by explicitly modelling the conditional variance and skewness using ML framework assuming that the standardized errors follow noncentral t-distribution. To allow for nonconstant conditional kurtosis, LRS (2005) developed the methodology of Harvey and Siddique (1999) by jointly modelling time-varying variance, skewness and kurtosis (GARCHSK model) assuming that the error term is derived by G-C series expansion of the normal density function which is easier to estimate than the noncentral t-distribution suggested by Harvey and Siddique (1999).

Chaudhuri, Kim, and Shin (2011) introduce a semi-parametric functional autoregressive (FAR) model for forecasting a time-varying distribution of the sectoral inflation rates in the UK. Their approach employs the autoregressive operator to specify the time-dependence of the distribution function and thus allows all the moments to depend on all the past moments. Thus, they do not impose particular moment specifications like those in the conventional parametric models.

Concerning the relationship between inflation and skewness, it could be investigated using two models that differ in the degree of flexibility in the economy. Under a sticky price model, Ball and Mankiw (1995) argue that when the economy is exposed to a supply shock, firms can adjust their prices but they have to face a menu cost. Thus, the firm will change its price if the shock is large enough and the menu cost is less than the loss resulting from keeping the price unchanged. Therefore, large shocks have unequal effects on the price level. They conclude that aggregate inflation depends on the distribution of relative price changes. As the distribution of the relative price shock is asymmetric, it will cause the distribution of aggregate inflation to be asymmetric as well. This asymmetry distribution for the relative price shocks cause temporary fluctuations in the mean of prices and hence will lead to a positive correlation between the mean and skewness of the price-change distribution. However, the model assumes that the mean-skewness correlation vanishes in the long-term since this correlation is attributed to short-run considerations. Therefore, the correlation must be declined and die out as the time length used to measure price changes increases.

On the other hand, under a flexible price model, Balke and Wynne (1996) show that allowing the prices to be flexible does not capture the observed relation between mean and skewness of the relative price changes. However, when the model is amended to include the input-output relationships between sectors as well as the variance of productivity (or supply) shocks, the mean-skewness relation is captured by the flexible price model. Thus, a supply shock could affect prices through two channels. The first one, it changes the level of output and hence the aggregate price level given a certain level of money supply. The other channel works through the inter-firm purchases that causes different price changes on different sectors of the economy. The relative price changes are conditional on the influence of supply shock on the level of productivity in a certain sector. Since the input-output structure is asymmetric, the distribution of price changes will be skewed. Thus, this model assumes a positive correlation between the first and the third moment of inflation. Moreover, they assume that this relation should persist or even it may be strengthened in the long-run. Therefore, the skewness of inflation may be of a great importance in investigating and forecasting future inflation.

In fact, Bryan and Cecchetti (1999) reported fat-tailed properties in inflation data. Additionally, Roger (2000) found evidence towards right skewness. In addition, (Chaudhuri, Kim, and Shin, 2011) found that the mean inflation is positively correlated with variance and skewness. These results suggest that a greater attention must be paid to increases than decreases of inflation rates.

Given the growing importance of accounting for nonconstant higher order moments, I will apply the specification proposed by LRS (2005) for conditional third and fourth moments to Egyptian inflation data. This will followed by examining the possibility to apply the methodology to Mexican CPI inflation.

5.3. Empirical Models:

This section presents the basic GARCH model briefly as well as the TARCH extension to account for the leverage effect. Additionally, a GARCH-M specification will be presented in short. These standard models are presented as their parameter estimates will be used in the developed models that allow conditional skewness and kurtosis to vary across time. Then, these extended models of LRS (2005) will be introduced in details.

5.3.1 Basic Models of time-varying conditional volatility:

As indicated in the introduction, Bollerslev (1986) extended the basic ARCH model to relate the conditional variance to both past squared errors and past conditional variances. The GARCH(1,1) model has the following specification of the conditional variance

$$h_t = \beta_0 + \beta_1 \varepsilon_{t-1}^2 + \beta_2 h_{t-1}$$

Where h_t is the conditional variance, h_{t-1} is the past volatility which is used as a measure of variance persistence and ε_{t-1}^2 is the past squared errors.

In order to ensure that the conditional variance is strictly positive, the following inequality restrictions are to be imposed: $\beta_0 \geq 0$, $\beta_1 \geq 0$, $\beta_2 \geq 0$. Additionally, to insure stationarity, it is also required that $\beta_1 + \beta_2 < 1$ where the persistence of variance becomes higher as β_2 approaches 1.

One of the key restrictions of GARCH (p,q) models is that they enforce a symmetric response of volatility to positive and negative shocks. GJR specification that captures the leverage effect of financial time series could be written as

$$h_t = \beta_0 + \beta_1 \varepsilon_{t-1}^2 + \beta_2 h_{t-1} + \beta_3 \varepsilon_{t-1}^2 (\varepsilon_{t-1} < 0)$$

According to the TARCH model, the conditions $\beta_0 > 0$, $\beta_1 > 0$, $\beta_1 + \beta_3 > 0$, $\beta_2 \geq 0$ are sufficient to ensure a strictly positive conditional variance. The asymmetry parameter β_3 is allowed to be of either sign to capture the asymmetric effects. This parameter measures the contributions of shocks to both short run persistence $(\beta_1 + \beta_3/2)$ and long run persistence $(\beta_1 + \beta_2 + \beta_3/2)$. Another interpretation of the relation between the mean inflation and its uncertainty allows the conditional variance to be a regressor in the mean equation. This GARCH in mean specification denoted GARCH-M add another term in the equation of the mean as follows

$$\pi_t = \mu h_t + \sum_{i=1}^{n} \alpha_i \pi_{t-i} + \varepsilon_t$$

Where π_t refers to inflation, h_t is the conditional volatility. Actually, the relation between inflation, volatility and price dispersion has been investigated using GARCH-M specification (Grier and Perry, 1996). Their results suggest that inflation volatility is superior to trend inflation in investigating price dispersion. Additionally, Wilson (2006) employs an EGARCH-M model to explain the relation between inflation, its volatility and output gap. Their results suggested that higher uncertainty do raise inflation and reduce output that supports Freidman (1977) argument.

5.3.2. Modelling conditional Variance, Skewness and Kurtosis[22]:

LRS (2005) developed a new approach allowing for modelling time-varying variance, skewness and kurtosis jointly as a GARCH process. The employed likelihood function, based on the series expansion of the normal density function is less complicated to estimate in comparison with the likelihood function proposed by Harvey and Siddique (1999) that assumes non-central t distribution for the model errors.

First, an inflation model is specified as GARCH (1,1)-M or TARCH (1,1)-M. Then, a GARCH(1,1) specification for both conditional nonconstant skewness and kurtosis is included. Let GARCHSK-M refer to the model when the conditional variance is derived by a GARCH specification while TARCHSK-M when conditional variance is derived by the TARCH (1,1)-M model. In addition, denote the

[22] This section is mainly based on LRS (2005) and their development to the GARCH-type model of skewness and kurtosis.

specification that allows for an asymmetry term in the skewness and kurtosis equation by TARCHTSK-M. Thus, the different models specified as follows

Mean equation: $\pi_t = \mu h_t + \sum_{i=1}^{n} \alpha_i \pi_{t-i} + \varepsilon_t \qquad \varepsilon_{t\approx(0,\sigma_\varepsilon^2)}$ 5.1

$$\varepsilon_t = \eta_t\sqrt{h_t} \quad ; \quad \eta_t \approx (0,1) \quad E(\varepsilon_t | I_{t-1}) \approx (0, h_t)$$

Variance (GARCH): $h_t = \beta_0 + \beta_1\varepsilon_{t-1}^2 + \beta_2 h_{t-1}$ 5.2

Variance (TARCH): $h_t = \beta_0 + \beta_1\varepsilon_{t-1}^2 + \beta_2 h_{t-1} + \beta_3\varepsilon_{t-1}^2(\varepsilon_{t-1} < 0)$ 5.3

Skewness (GARCH): $s_t = \gamma_0 + \gamma_1\eta_{t-1}^3 + \gamma_2 s_{t-1}$ 5.4

Skewness (TARCH): $s_t = \gamma_0 + \gamma_1\eta_{t-1}^3 + \gamma_2 s_{t-1} + \gamma_3\eta_{t-1}^3(\eta_{t-1} < 0)$ 5.5

Kurtosis (GARCH): $k_t = \delta_0 + \delta_1\,\eta_{t-1}^4 + \delta_2 k_{t-1}$ 5.6

Kurtosis (TARCH): $k_t = \delta_0 + \delta_1\,\eta_{t-1}^4 + \delta_2 k_{t-1} + \delta_3\eta_{t-1}^4(\eta_{t-1} < 0)$ 5.7

Where ε_t is the error term, η_t is the standardized residuals, $h_t, s_t,$ and k_t are conditional volatility, skewness and kurtosis corresponding to η_t respectively. They establish that $E_{t-1}(\eta_t) = 0, E_{t-1}(\eta_t^2) = 1, E_{t-1}(\eta_t^3) = s_t$ and $E_{t-1}(\eta_t^4) = k_t$. First, two basic models are estimated, a GARCH (1,1)-M (equations (5.1) and (5.2)) and a TARCH (1,1)-M (equations (5.1) and (5.3)). This followed by models with nonconstant higher order moments, GARCHSK-M (equations (5.1), (5.2), (5.4) and (5.6)), TARCHSK-M (equations (5.1), (5.3), (5.4) and (5.6)), and a TARCHTSK-M (equations (5.1), (5.3), (5.5) and (5.7)).

They employed G-C series expansion of the normal density function and truncated at the fourth moment to get the following density function for the standardized errors

$$f(\eta_t|I_{t-1}) = \phi(\eta_t)\left[1 + \frac{s_t}{3!}(\eta_t^3 - 3\eta_3) + \frac{k_t - 3}{4!}(\eta_t^4 - 3\eta_t^2 + 3)\right] = \phi(\eta_t)\psi(\eta_t) \quad 5.8$$

Where $\phi(.)$ denotes the probability density function (pdf) corresponding to the standard normal distribution. Since some parameter estimates may lead to negative value of $f(.)$ due to the component $\psi(.)$, therefore, $f(.)$ is not a real density function. Additionally, the integral of $f(.)$ on R is not equal to one. Therefore, LRS (2005) introduced a true pdf, by squaring the polynomial part $\psi(.)$, and dividing by the integral of $f(.)$ over R to assure that the density integrates to one. The resulting form of pdf is as follows:

$$w(\eta_t|I_{t-1}) = \phi(\eta_t)\psi^2(\eta_t)/\Gamma_t \quad 5.9$$

Where

$$\Gamma_t = 1 + \frac{s_t^2}{3!} + \frac{(k_t - 3)^2}{4!}$$

Thus, the logarithm of the likelihood function for one observation corresponding to the conditional distribution $\varepsilon_t = \eta_t\sqrt{h_t}$, whose pdf is $\sqrt{h_t}w(\eta_t|I_{t-1})$ could be reached after deleting the redundant constants as follows

$$l_t = -\frac{1}{2}ln h_t - \frac{1}{2}\eta_t^2 + ln\left(\psi^2(\eta_t)\right) - ln(\Gamma_t) \quad 5.10$$

One advantage of this likelihood function is the similarity with the standard normal density function in addition to two adjustment terms to account for time-varying third and fourth moments. What is more, the aforementioned developed density function in equation (5.9) nests the normal density function (when s_t= zero and k_t= 3). Thus, the restrictions imposed by the normal density functions (i.e., $\gamma_0 = \gamma_1 = \gamma_2 = \delta_0 = \delta_1 = \delta_2 = 0$) could be tested by conducting a likelihood ratio test.

5.4. Empirical results:

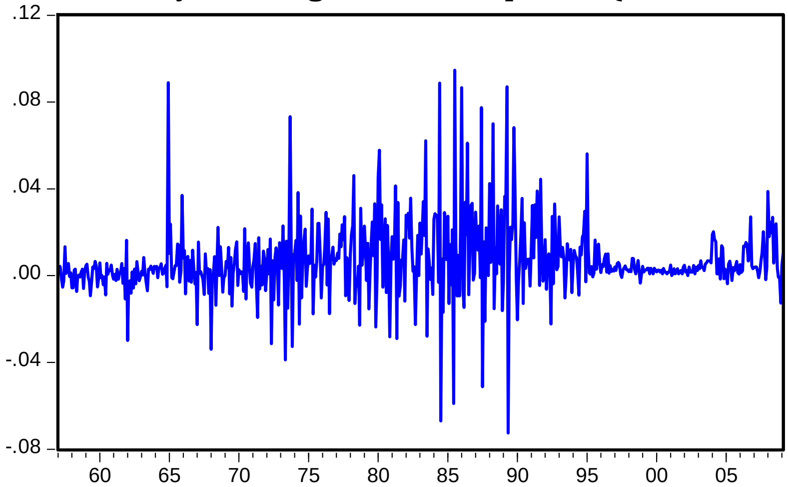
5.4.1. Data and preliminary check:

The data of monthly CPI is collected from IMF's International Financial Statistics (IFS) and cover the period 1957:1 to 2009:2. Inflation data is computed as monthly changes in the logarithm of CPI. The sample is chosen to include the largest number of available observations to provide more accurate results. Table (5.1) gives the basic descriptive statistics for the data. It is clearly shown that the distribution of the data is right-skewed and leptokurtic (i.e., the data are not normally distrusted as indicated by Jarque-Bera test statistic).

Table 5.1: Descriptive statistics of the logarithm of monthly inflation rate for the Period (1957:1 to 2009:2)

Mean	0.006824
Median	0.003992
Maximum	0.094638
Minimum	-0.072543
Std. Dev.	0.016699
Skewness	1.096764
Kurtosis	10.24989
Jarque-Bera	1494.077
Probability	0.000000

Figure 5.1: Monthly inflating rate for the period (1957:1 to 2009:2)



Before estimating models concerned with the dynamics of conditional volatility, skewness, and kurtosis, the dynamics structure in the conditional mean are examined. To explore the dynamics of the conditional mean, the correlogram of inflation have been analysed as guidance for selecting the appropriate mean specification.

According to Brooks (2002), a given autocorrelation coefficient is classified as significant if it is outside a range of $\pm 1.96 \times 1/\sqrt{N}$, where N is the number of observations. In this case, it would imply that a correlation coefficient is classified as significant if it were outside the band of -0.08 and 0.08. Examining the correlogram of the data reveals that autocorrelation and partial autocorrelation coefficients are significant under that rule for first, second, sixth, seventh and twelfth lags. Therefore, an ARMA process seems to be suitable, although it is hard to determine the appropriate order precisely given these results. Thus, the information criteria are employed to determine the appropriate order.

Accordingly, different specification for the mean equation has been applied using different orders of AR and MA terms. In the underlying case, criteria choose different models. That is while AIC selects an ARMA(3,3) specification of the mean equation, SIC chooses ARMA(2,1). However, by checking Ljung-Box Q statistic to see if the models are free from autocorrelation leads to the rejection of the null hypothesis of no autocorrelation. Therefore, both specifications are not valid. Re-examining the values of both criterions show that many different models provide almost identical values of the information criteria, which indicates that the chosen models do not provide particularly sharp characteristics of the data and other specifications could fit the data almost as well.

As a result, I have estimated many different specifications using different significant lags detected from the correlogram. The results show that any specification does not include second and twelfth lags would exhibit serial correlation between the residuals. According to SIC, the chosen model should include first, second and twelfth lags of inflation. Diagnostic checks reveal the absence of serial autocorrelation amongst the residuals while it exists in the sequences of squared, cubed, and the fourth power of residuals. Additionally, ARCH LM test indicates the existence of ARCH effects in the residuals. Therefore, a model that allow second, third, and fourth order moments to be time-varying would be more appropriate in modelling inflation.

As the likelihood function is highly nonlinear, good starting values of the parameters are required. Thus, the models should be estimated in steps starting from simpler models that nested in the complicated ones. In other words, the estimated parameters of the simpler models are used as starting values for more complex ones. Accordingly, I started by modelling inflation using basic GARCH(1,1)-M model followed by TARCH(1,1)-M model to test the asymmetry of volatility response to the sign of the shock to inflation. It is worth noting that the variance equation is allowed to include two dummies, d74 and July. The first dummy captures the effects of shifting to the open door policy in 1974 that leads to a high increase in the inflation rate. The second dummy is included to capture the beginning of the financial year that witnesses the annual increase in wages. Addition of these dummies to the volatility equation allows for exploring their effect on the variability of inflation. Furthermore, both dummies are essential to insure covariance stationarity in TARCH-M model and its extensions. Moreover, I have estimated a GARCH-M model with GED distribution for the error term. This is done to compare the effect of choosing a non-normal distribution of the error term with constant skewness and kurtosis with models that allow skewness and kurtosis to vary with time.

5.4.2. Results

Table (5.2) reports the results of two basic models, GARCH-M with normal distribution, GED distribution, and the GARCHSK-M model with time-varying conditional third and fourth moments. Results indicate a significant presence of conditional variance persistence as the parameter of lagged volatility is positive and significant across the different models. Thus, high conditional volatility leads to higher conditional volatility next periods. Additionally, the coefficient of volatility persistence decreases by allowing nonconstant conditional skewness and kurtosis in GARCHSK-M specification. Thus, a time-varying conditional third and fourth moments lowers the magnitude of both volatility persistence and of shocks to conditional variance. Moreover, allowing the error term to follow a GED distribution leads to the highest volatility persistence. Concerning the conditional skewness, it is found that skewness persistence is positive and significant however its magnitude is much lower than the variance case. In addition, shocks to skewness are significant and less than shocks to conditional variance. Similarly, the conditional kurtosis equation indicates that months with high kurtosis are followed by months with high kurtosis as conducted from the positivity and significance of lagged kurtosis parameter. Moreover, the coefficient of lagged kurtosis is higher than that of the lagged skewness and it is close the variance persistence parameter in the basic GARCH-M model. Finally, shocks effect to kurtosis are the highest related to the effects of shocks to volatility and skewness.

With respect to dummies effect in the variance equation, d74 is positive and significant in all cases. Additionally, July is negative in all models but insignificant in GARCH-M where the error term follows a GED distribution.

Results of models that allow for asymmetries are displayed in table (5.3). First, the asymmetric parameter in the volatility equation β_3 is found to be positive however insignificant in the basic TARCH model. Allowing the conditional skewness and kurtosis to follow a GARCH-type process lowers β_3 and keeps it insignificant while it turns to be significant with a little negative magnitude when the conditional skewness and kurtosis follow a TARCH-type process. Therefore, an unexpected decline in inflation has higher effect on volatility than that of unexpected rise according to the TARCHTSK model. On the other hand, both negative and positive shocks have the same effect on inflation variability under the basic TARCH-M and TARCHSK-M model where skewness and kurtosis is derived by GARCH process.

Secondly, the shocks to inflation β_1, it is found to be significant in the standard TARCH-M model and allowing for time-varying third and fourth moments raises its magnitude while still significant. Additionally, the persistence parameter in the variance equation is significant in all models with the highest magnitude in TARCHTSK-M model where both skewness and kurtosis are allowed to have an asymmetry parameter. Regarding skewness equation, the persistence parameter is positive and significant although it is less than that of the variance equation. As before, shocks to conditional skewness are lower in magnitude relative to shocks to conditional variance. Furthermore, as the coefficient for lagged kurtosis is positive and significant, months with high kurtosis are followed by months with high kurtosis. In addition, shocks to kurtosis have small magnitude close to the magnitude of shocks to conditional skewness. Finally, the asymmetries parameters γ_3 and δ_3 are significant with tiny magnitudes and positive in the case of skewness however it is negative in the kurtosis equation.

In addition, the parameter of GARCH in mean is significant in all models. Moreover, this estimate declines when moving from the simpler to the advanced models. In other words, inclusion of time-varying conditional skewness and kurtosis leads to a decline in μ.

Concerning the specification of the models, the Ljung-Box Q-statistics for the both standardized residuals and its squares are insignificant for lag length even larger than 20. Thus, there is evidence that both the level and squares of standardized residuals do not exhibit any serial correlation. Furthermore, ARCH LM tests indicate the absence of any further ARCH effects in the standardized residuals.

To choose the best model, SIC criterion is set to be equal to $\ln(LML) - (q/2)\ln(N)$, where q is the number of estimated parameters, N is the number of observations, and LML is the value of the log likelihood function using the q estimated parameters. Then, the best model is the one with the highest SIC. According to SIC criterion, the specification that allow for nonconstant third and fourth moments without an asymmetric term while the variance is structured as GARCH process (TARCHSK-M) is the best model.

To sum up, these results support Friedman (1977) hypothesis concerning the positive correlation between inflation and its uncertainty, as volatility persistence and GARCH in mean coefficients are significant in all models. Additionally, the results show the evidence of positive skewness that is consistent with Balke and Wynne (1996) that the mean-skewness correlation could persist even in the long-run.

Table 5.2: GARCH-M , GARCH-M (GED) and GARCHSK-M Models for inflation:

Mean equation: $\pi_t = \mu h_t + \alpha_1 \pi_{t-1} + \alpha_2 \pi_{t-2} + \alpha_3 \pi_{t-12} + \varepsilon_t$

Variance equation: $h_t = \beta_0 + \beta_1 \varepsilon_{t-1}^2 + \beta_2 h_{t-1} + \kappa_1 d74 + \kappa_2 July$

Skewness Equation: $s_t = \gamma_0 + \gamma_1 \eta_{t-1}^3 + \gamma_2 s_{t-1}$

Kurtosis Equation: $k_t = \delta_0 + \delta_1 \eta_{t-1}^4 + \delta_2 k_{t-1}$

Model		GARCH-M		GARCH-M (GED)		GARCHSK-M	
		estimate	**p-value**	**estimate**	**p-value**	**estimate**	**p-value**
Mean Equation	μ	16.57217	**0.0000**	13.94960	**0.0000**	14.65763	**0.0000**
	α_1	-0.076226	0.1434	0.075078	**0.0020**	-0.053183	**0.0000**
	α_2	0.139471	**0.0039**	0.102082	**0.0001**	0.149367	**0.0000**
	α_3	0.244509	**0.0000**	0.213028	**0.0000**	0.174258	**0.0000**
Variance equation	β_0	$1.71\times10\text{-}5$	**0.0000**	$3.36\times10\text{-}6$	**0.0740**	0.000494	**0.0000**
	β_1	0.135005	**0.0047**	0.061078	**0.0002**	0.107057	**0.0000**
	β_2	0.800171	**0.0000**	0.911308	**0.0000**	0.757790	**0.0000**
	k_1	$2.48\times10\text{-}5$	0.1027	$1.87\times10\text{-}5$	**0.0225**	$-3.86\times10\text{-}5$	**0.0000**
	k_2	-7.56×10^{-5}	**0.0000**	-1.69×10^{-5}	0.3909	-0.000253	**0.0000**
	GED			0.846461	**0.0000**		
Skewness Equation	γ_0					-0.270272	**0.0000**
	γ_1					0.076670	**0.0000**
	γ_2					0.640609	**0.0000**
Kurtosis Equation	δ_0					0.117602	**0.0000**
	δ_1					0.147469	**0.0000**
	δ_2					0.807013	**0.0000**
Log-likelihood		1684.490		1787.573		2542.654	
SIC		1655.879		1755.784		2494.969	
Ljung-Box Q-stat.							
Residuals (lag 20)		16.591	(0.679)	22.055	(0.338)	21.690	(0.358)
squared (lag 20)		2.1088	(1.000)	0.6610	(1.000)	26.019	(0.165)

The basic GARCH-M with normal distribution is estimated using Quasi Maximum Likelihood (Bollerslev-Wooldridge (1992)) while GARCH-M (GED) and GARCHSK-M models are estimated using ML estimation. All models are estimated using Marquardt algorithm. Significant p-values are indicated by bold.

Table 5.3: TARCH-M, TARCHSK-M, and TARCHTSK-M Models:

Mean equation: $\pi_t = \mu h_t + \alpha_1 \pi_{t-1} + \alpha_2 \pi_{t-2} + \alpha_3 \pi_{t-12} + \varepsilon_t$

Variance equation: $h_t = \beta_0 + \beta_1 \varepsilon_{t-1}^2 + \beta_2 h_{t-1} + \beta_3 \varepsilon_{t-1}^2 (\varepsilon_{t-1} < 0) + \kappa_1 d74 + \kappa_2 July$

Skewness (GARCH): $s_t = \gamma_0 + \gamma_1 \eta_{t-1}^3 + \gamma_2 s_{t-1}$

Skewness (TARCH): $s_t = \gamma_0 + \gamma_1 \eta_{t-1}^3 + \gamma_2 s_{t-1} + \gamma_3 \eta_{t-1}^3 (\eta_{t-1} < 0)$

Kurtosis (GARCH): $k_t = \delta_0 + \delta_1 \eta_{t-1}^4 + \delta_2 k_{t-1}$

Kurtosis (TARCH): $k_t = \delta_0 + \delta_1 \eta_{t-1}^4 + \delta_2 k_{t-1} + \delta_3 \eta_{t-1}^4 (\eta_{t-1} < 0)$

Model		TARCH-M		TARCHSK-M		TARCHTSK-M	
		estimate	**p-value**	**estimate**	**p-value**	**estimate**	**p-value**
Mean equation	μ	15.20880	0.0000	14.33151	0.0000	10.99486	0.0000
	α_1	-0.066469	0.2109	-0.027512	0.0000	-0.040836	0.0000
	α_2	0.149982	0.0015	0.164858	0.0000	0.080036	0.0000
	α_3	0.251071	0.0000	0.254065	0.0000	0.230157	0.0000
Variance equation	β_0	1.71×10-5	0.0000	4.74×10-5	0.0000	2.01×10-5	0.0000
	β_1	0.076294	0.1155	0.135653	0.0000	0.120574	0.0000
	β_2	0.806646	0.0000	0.798135	0.0000	0.874757	0.0000
	β_3	0.113107	0.2040	0.001450	0.6793	-0.008974	0.0113
	k_1	2.59×10-5	0.0477	0.000135	0.0000	3.28×10-5	0.0000
	k_2	-7.73×10^{-5}	0.0000	-0.000184	0.0000	-5.45×10^{-5}	0.0000
Skewness equation	γ_0			-0.046571	0.0000	0.050332	0.0000
	γ_1			0.004812	0.0000	0.010138	0.0000
	γ_2			0.680600	0.0000	0.693480	0.0000
	γ_3					0.041699	0.0000
Kurtosis equation	δ_0			0.448608	0.0000	0.836251	0.0000
	δ_1			0.000401	0.0000	0.002240	0.0000
	δ_2			0.810595	0.0000	0.650395	0.0000
	δ_3					-0.005481	0.0000
Log-likelihood		1687.417		2634.648		1986.751	
SIC		1655.627		2583.785		1929.531	
Ljung-Box Q-stat.							
Residuals (lag 20)		15.384	(0.754)	15.384	(0.754)	16.209	(0.704)
Residuals squared		2.2548	(1.000)	2.2042	(1.000)	2.6569	(1.000)

The basic TARCH-M with normal distribution is estimated using Quasi Maximum Likelihood (Bollerslev-Wooldridge (1992)) while other models are estimated using ML estimation. All models are estimated using Marquardt algorithm. Significant p-values are indicated by bold.

5.4.3. Diagnostic tests:

To compare models, I started with comparing the behaviour of the standardized residuals obtained from different models. The standardized residuals of GARCHSK-M model have a skewness of 0.73 and kurtosis of 9.19. In comparison, the standardized residuals obtained from the basic GARCH-M model have a skewness of 1.99 and excess kurtosis of 23.42. Similarly, the standardized residuals from TARCHSK-M and TARCHTSK-M have skewness and kurtosis less than the residuals from TARCH-M model. Moreover, allowing the error term to follow a GED distribution leads to the highest dispersion among all models. Thus, the standardized residuals series from models with time-varying higher order conditional moments have a lower dispersion than those resulting from time-invariant conditional skewness and kurtosis.

Another way to compare models is to evaluate the behaviour of conditional volatilities resulting from the six different models. Figure (5.2) shows that conditional variances obtained from models with nonconstant conditional skewness and kurtosis are smoother than conditional volatility generated by standard GARCH-M and TARCH-M models. The same conclusion could be conducted from examining the descriptive statistics of these conditional variances displayed in table (5.5). It is obvious that TARCHSK-M model have the lowest Jarque-Bera statistic that measures the difference of skewness and kurtosis of the series with those from the normal distribution. Additionally, the variances of TARCHSK-M and TARCHTSK-M models have skewness and kurtosis that are lower than the variance of TARCH-M model. On the other hand, the resulting variance from GARCH-M has skewness higher than that resulting from GARCHSK-M model while the latter has higher kurtosis than the former.

The final diagnostic test is to conduct a likelihood ratio test. As it is mentioned earlier, the normal density function is nested in the G-C series expansion when s_t= 0 and k_t= 3. Therefore, the constraints imposed by the normal density function with respect to the more general density based on a G-C series expansion can be tested by applying a likelihood ratio test. To compare GARCH-M and GARCHSK-M, the value of the LR statistic is quite large resulting in rejection of the null hypothesis that the restricted density (i.e., the normal density function) is the correct density. Similarly, the value of LR statistic is very high in case of comparing TARCH-M with its extensions, TARCHSK-M and TARCHTSK-M. Thus, the density that restricts the skewness and kurtosis to be time-invariant is inferior to the density that permits them to vary over time. A final remark, it was not possible to run a LR test to choose between TARCHSK-M and TARCHTSK-M as the log likelihood of the latter is less than the log likelihood of the former. Thus, the specification that allow conditional skewness and kurtosis to follow a GARCH process while the variance is derived by a TARCH process outperforms the specification that assume a TARCH structure for conditional variance, skewness and kurtosis.

Figure 5.2: Estimated Conditional Variances from GARCH-M, GARCHSK-M, TARCH-M and TARCHSK-M models

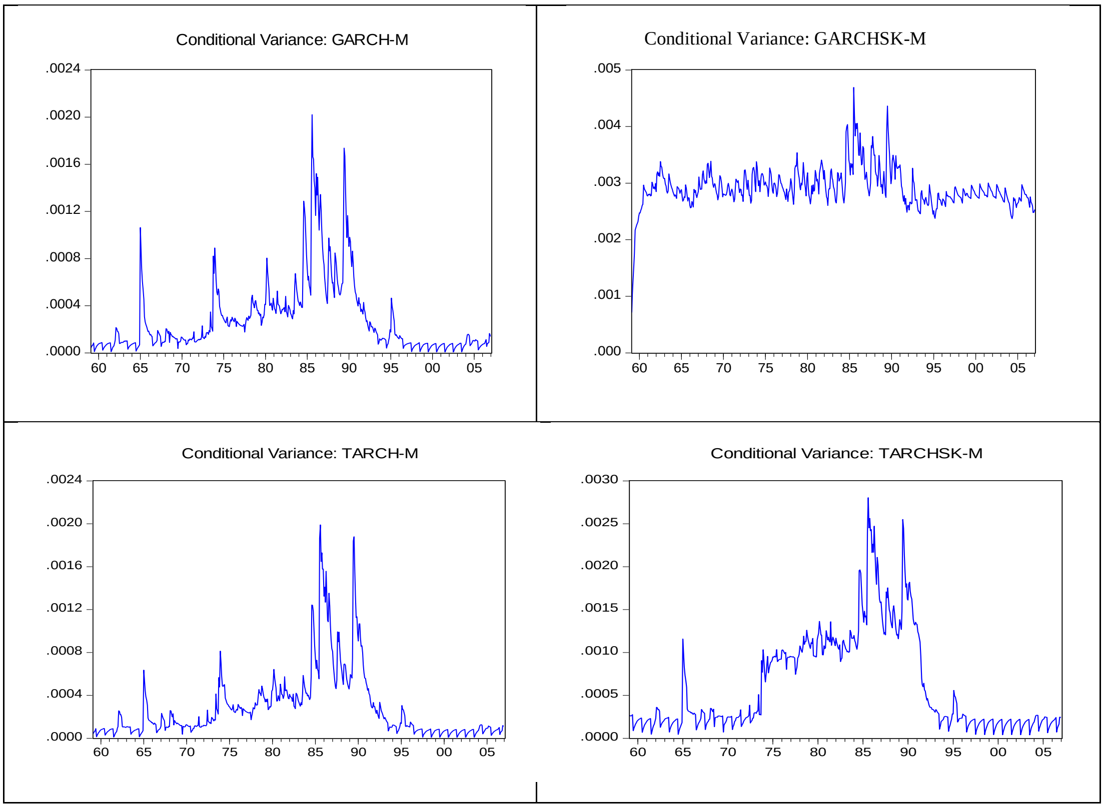


Table 5.4: Descriptive statistics for standardized residuals

Statistic	GARCH-M	GARCH-M (GED)	GARCHSK-M	TARCH-M	TARCHSK-M	TARCHTSK-M
Mean	0.079326	0.101916	-0.697897	0.086074	-0.133299	0.025444
Median	0.042160	0.053838	-0.732487	0.042998	-0.140971	-0.012598
Maximum	10.29504	14.64040	0.842837	10.12453	6.225940	7.245058
Minimum	-3.914970	-4.119234	-2.117273	-3.722729	-2.728351	-2.927933
Std. Dev.	0.997464	1.120017	0.296164	0.996351	0.685996	0.728253
Skewness	1.986015	3.847826	0.725296	1.857173	1.680308	1.900507
Kurtosis	23.42197	53.01585	9.193916	22.04523	19.06223	21.90398
Jarque-Bera	10406.05	61566.10	972.9378	9052.096	6474.159	8938.892
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Table 5.5: Descriptive statistics for conditional variances

Statistic	GARCH-M	GARCH-M (GED)	GARCHSK-M	TARCH-M	TARCHSK-M	TARCHTSK-M
Mean	0.000285	0.000291	0.002915	0.000284	0.000614	0.000470
Median	0.000155	0.000127	0.002867	0.000144	0.000275	0.000260
Maximum	0.002020	0.001581	0.004689	0.001989	0.002805	0.002431
Minimum	5.14×10-6	1.50×10-5	0.000713	5.65×10-6	3.92×10-6	9.43×10-6
Std. Dev.	0.000316	0.000321	0.000344	0.000324	0.000570	0.000421
Skewness	2.207727	1.546118	0.039775	2.435293	1.195691	1.700310
Kurtosis	8.542156	4.986887	10.64108	9.886839	3.804254	5.890463
Jarque-Bera	1207.174	324.7943	1403.852	1710.592	153.0380	478.8859
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Table 5.6: Likelihood ratio tests

GARCH-M vs. GARCHSK-M		GARCH-M vs. TARCH-M	
Logl(GARCH-M)	1684.490	Logl(GARCH-M)	1684.490
Logl(GARCHSK-M)	2542.654	Logl(TARCH-M)	1687.417
LR	1625.386	LR	5.853
p-value	0.0000	p-value	0.0155
TARCH-M vs. TARCHSK-M		**TARCH-M vs. TARCHSTK-M**	
Logl(TARCH-M)	1687.417	Logl(TARCH-M)	1687.417
Logl(TARCHSK-M)	2634.648	Logl(TARCHTSK-M)	1986.751
LR	1804.257	LR	508.463
p-value	0.0000	p-value	0.0000

5.4.4. Forecasting Performance

The predictive power of the different models is evaluated by applying several measures reported in table (5.7). The first two forecast error statistics depend on the scale of the dependent variable. Thus, they are relative measures to compare forecasts across different models. According to these criterions, the smaller the error, the better is the forecasting ability of the related model. With respect to Theil inequality coefficient, it must lies between zero and one, where zero is a sign of perfect fit. Additionally, the bias and variance proportion are indications of how far the mean and variation of the forecast are from the mean and the variance of the actual series while the covariance proportion measures the remaining unsystematic forecasting errors. These different proportions must sum up to one where smaller bias and variation proportion refers to a better forecasts. Thus, the most of the bias should be concentrated on the covariance proportion.

Table 5.7: Different Criterions of Forecasts Power

1. Mean square error	$MSE = \frac{1}{N}\sum_{t=T+1}^{T+N}(\hat{\pi}_t - \pi_t)^2$
2. Mean absolute error	$MAE = \frac{1}{N}\sum_{t=T+1}^{T+N}\lvert\hat{\pi}_t - \pi_t\rvert$
3. Theil inequality coefficient	$TIC = \frac{\sqrt{\frac{1}{N}\sum_{t=T+1}^{T+N}(\hat{\pi}_t - \pi_t)^2}}{\sqrt{\frac{1}{N}\sum_{t=T+1}^{T+N}\hat{\pi}_t^2} + \sqrt{\frac{1}{N}\sum_{t=T+1}^{T+N}\pi_t^2}}$
Bias Proportion	$BP = \frac{\left(\bar{\hat{\pi}} - \pi\right)^2}{\frac{1}{N}\sum_{t=T+1}^{T+N}(\hat{\pi}_t - \pi_t)^2}$
Variance proportion	$VP = \frac{(\sigma_{\hat{\pi}} - \sigma_{\pi})^2}{\frac{1}{N}\sum_{t=T+1}^{T+N}(\hat{\pi}_t - \pi_t)^2}$
Covariance proportion	$CP = \frac{2(1-r)\sigma_{\hat{\pi}}\,\sigma_{\pi}}{\frac{1}{N}\sum_{t=T+1}^{T+N}(\hat{\pi}_t - \pi_t)^2}$

Where $\sigma_{\hat{\pi}}, \sigma_{\pi}$ are the biased standard deviations of $\hat{\pi}$ and π, and r is the correlation between of $\hat{\pi}$ and π.

Table (5.8) displays he results of different measures for the out-of-sample (2007:2 to 2009:2) period. The selected sample includes two years, as inflation in actual policy conduct is likely to be forecasted in a two-year horizon. Comparing GARCH-M with GARCHSK-M model reveals that for the first criterion, GARCH-M does a better job in forecasting inflation during the out-of-sample period.

For GARCH-M, TIC of 0.66 indicates a relatively poor fit between forecasted and actual values. The bias proportion accounted for 0.17 of TIC referring to the difference between the predicted and the actual mean. Additionally, the variance proportion equals 0.615318 that is the highest amongst different models indicating the failure in tracking the actual variance path. Additionally, the bias proportion for GARCHSK-M is the highest indicating significant difference between the forecasted and actual mean. Furthermore, MAE and MSE are also the highest value, which is another indication of poor predictability of inflation. Thus, comparing GARCH-M and GARCHSK-M reveals that accounting for higher order moments did not improve inflation forecasting. In addition, allowing the error term to follow a GED distribution does not improve the forecasting also as TIC is the highest coefficient relative to other models. Moreover, both BP and VP are very high which indicates the low ability to trace both actual mean and variance. Therefore, however GARCHSK-M is the best model according to the diagnostic tests, all models based on GARCH-M specification show poor forecasting performance.

Concerning TARCH-M model, comparing it with the previous models does not imply superiority to others in most of those criterions. For TARCHSK-M where skewness and kurtosis are derived by a GARCH process, TIC of 0.52 is the lowest value compared with other models. Thus, it indicates a relatively moderate fit between forecasted and actual values. The bias proportion accounted for 0.04 of TIC referring to the similarity between the predicted and the actual mean. However, the high value of VP is an indication of the significant difference between the actual variance and the predicted from the model. Overall, this model could be regarded as the best model compared to other models as CV equals 0.44. Thus, a high proportion of the dispersion is attributed to the unsystematic forecasting errors.

According to these criterions, the model that allows nonconstant conditional skewness and kurtosis to follow a GARCH process whereas the conditional variance is derived by a TARCH process outperforms all other models.

Thus, a specification that allows conditional third and fourth moments outperforms all other specification that keeps them constants.

Figure 5.3: Actual versus predicted inflation from different models

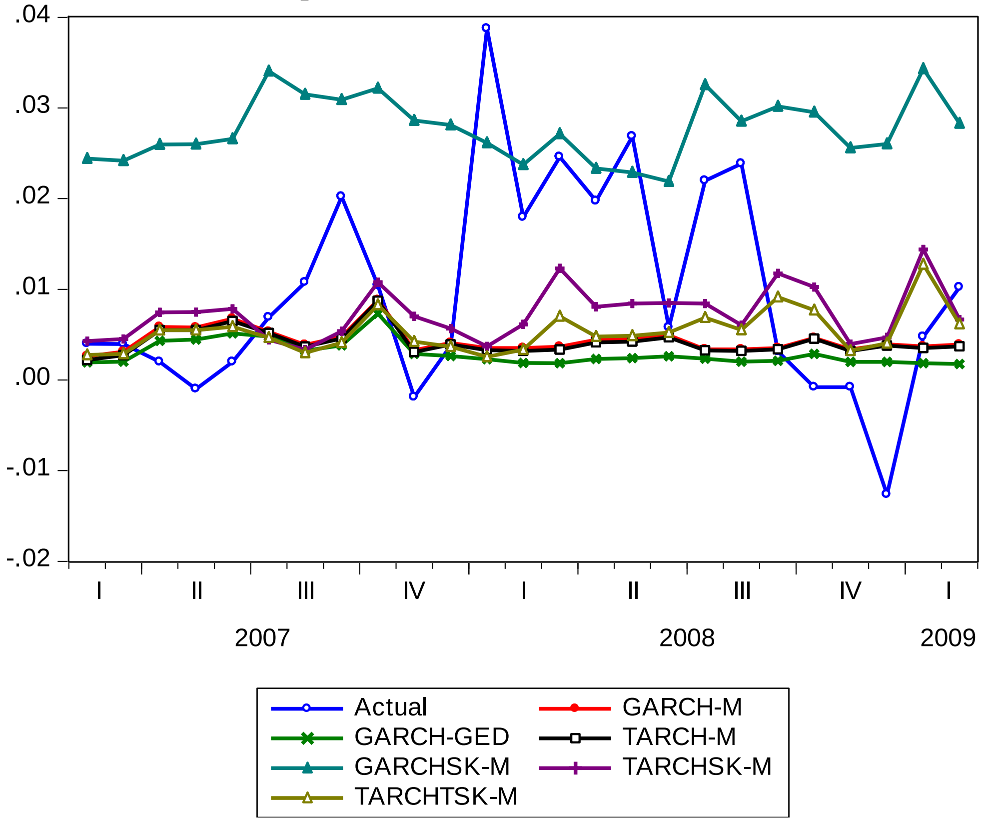


Table 5.8: Out-of sample Forecasts power of different models

	GARCH-M	GARCH-M (GED)	GARCHSK-M	TARCH-M	TARCHSK-M	TARCHTSK-M
MSE	0.000166 [3]	0.000184 [5]	0.000467 [6]	0.000169 [4]	0.000145 [1]	0.000161 [2]
MAE	0.009231[1]	0.009809 [5]	0.030476 [6]	0.009307 [2]	0.009391 [3]	0.009486 [4]
TIC	0.658177[4]	0.744276 [6]	0.591939 [2]	0.670647 [5]	0.527362 [1]	0.608068 [3]
BP	0.177879 [3]	0.255730 [5]	0.863351 [6]	0.189682 [4]	0.043756 [1]	0.122149 [2]
VP	0.615318 [6]	0.553804 [4]	0.067531 [1]	0.602909 [5]	0.508448 [2]	0.518346 [3]
CP	0.206802 [4]	0.190466 [5]	0.069118 [6]	0.207410 [3]	0.447795 [1]	0.359506 [2]

The numbers in the square brackets indicate rankings of the models where [1] indicates the best models according to the corresponding measure.

5.4.5. Applying encompassing tests for forecasts evaluation

Given the relatively disappointing forecasting performance of the models that allow for nonconstant higher order moments, their forecasts have to be compared with the traditionally used models. Therefore, the forecasts from the reduced-form

VAR model employed in chapter four will be compared with the models developed in the current chapter using the encompassing tests. The idea behind the using the encompassing test is as follows: suppose that we have two alternative sets of forecasts f_1 and f2 of a variable where the performance of f_1 outperforms f_2 according to some criterion, say MSE. Then, if the f_2 contains no useful marginal information, than it is said that f1 encompasses f_2. It follows that if f_2 is not encompassed by f_1, this means that f_2 may provide some marginal information that is not contained in the better forecast. In this case, the two forecasts could be combined together to form a combined forecast (Kışınbay, 2007).

To compare the predictive ability of the competing forecasts, I applied the test developed by Diebold and Mariano (DM) (1995). Their test statistic is used to test for equal predictive ability of two competing forecasts. It considers a sample of loss differential series d_t, defined as $d_t = L(e_{1t}) - (e_{2t})$ where L is some arbitrary loss function[23] like MSE , e_{it} is the t-step ahead forecasts of the model i=1,2 and t=1,2,…….,T. Equal predictive accuracy amounts to $E(d_t) = 0$, and the test depends on the observed sample mean $\bar{d} = \frac{1}{T}\sum_{t=1}^{T} d_t$. Assuming the covariance stationarity in the loss deferential series, the DM test statistic is asymptotically normally distributed under the null hypothesis of equal predictive accuracy of competing forecasts. The test statistic is as follows

$$DM = \frac{\bar{d}}{\sqrt{\hat{V}(\bar{d})}}$$

[23] loss function need not be quadratic or even to be symmetric, and forecast errors can be non – Gaussian, nonzero mean, serially correlated and contemporaneously correlated.

Where $\widehat{V}(\bar{d})$ is a consistent estimate of the asymptotic variance of d, and assuming that τ-step-ahead forecasts exhibit dependence up to order τ–1, it is obtained as:

$$\hat{V}(\bar{d}) \approx \frac{1}{T}\left(\gamma_0 + 2\sum_{i=1}^{\tau-1}\gamma_i\right)$$

Where γ_i is the ith autocovariance of $\bar{d}$, estimated by $\hat{\gamma}_t = \sum_{t=i+1}^{T}(d_t - \bar{d})(d_{t-i} - \bar{d})$.

The reduced-form VAR model has been estimated using quarterly data over the period 1993:1- 2007:1 and then forecasted over the two-year horizon to be comparable with the models developed in the current chapter. However, as the employed models here are estimated using monthly data, the average of each three months has been computed to form the quarterly forecasts of the relevant models. Once the out-of sample forecasts are obtained, the following steps are done to eliminate the forecasts that encompassed by others (Kışınbay, 2007).

1. Compute the MSE of the out-of-sample predictions for each model and rank the models according to their performance based on MSE.
2. Select the best model (i.e., with the lowest MSE), and test successively whether the best model forecast encompasses other models, using the DM test. If the best model encompasses the alternative model at some significance level α, then we exclude the encompassed model from the list of models.
3. Repeat Step 2, with the second best model. The list of the models contains only those that are not encompassed by the best model, and the best model.

4. Continue with the third best model, and so on, until no encompassed model remains in the list.

According to MSE criterion, GARCH-M model is the best one. Therefore, the comparisons between the forecasts of GARCH-M and its alternative models are done bilaterally using the DM (1995) forecast encompassing test. The results show that the null hypothesis of equal forecasting accuracy cannot be rejected at all the conventional significance level excluding GARCHSK-M. For the latter model the test statistic value of -3.64351 implies a p-value of 0.000134. This implies that all models excluding GARCHSK-M model contain marginal information that is not included in the best model according to the MSE criterion, GARCH-M.

As mentioned earlier, if some forecasts are not encompassed by the best forecast, they could be combined together to produce one forecast. Therefore, calculating the combined forecasts could be an area for further research.

5.5. Applicability of the model to other economies: evidence from Mexico

The section is devoted to check the applicability of the model to other countries conditional on that inflation data show the existence of conditional volatility. First, the appropriate mean equation has been specified according to the methodology followed in section (5.4). Accordingly, inflation in Mexico is regressed on its first, fourth, and eleventh lags. Comparing the results of GARCH and TARCH models displayed in table (5.9) shows that TARCH specification is superior to the GARCH model. Therefore, the analysis will extend TARCH model to allow for time-varying conditional skewness and kurtosis.

Table (5.9) reports the results of two basic models, GARCH and TARCH with normal distribution, and the TARCHSK model with time-varying conditional third and fourth moments. First, the shocks to inflation β_1, it is found to be significant in the standard TARCH model and allowing for time-varying third and fourth moments lowers its magnitude while still significant. Additionally, the persistence parameter in the variance equation is significant in all models with the highest magnitude in TARCHSK model where both skewness and kurtosis are allowed to follow a GARCH-type process. Concerning the asymmetry term β_3 , it is found to be negative and significant in the basic TARCH model. Allowing the conditional skewness and kurtosis to follow a GARCH-type process raises β_3 and keeps it significant.

Regarding skewness equation, the persistence parameter is positive and significant although it is less than that of the variance equation. Finally, the coefficient for lagged kurtosis is the highest persistence coefficient while shocks to kurtosis have the smallest magnitude in comparison with shocks to conditional volatility and skewness.

Concerning the specification of the models, the Ljung-Box Q-statistics for the both standardized residuals and its squares are insignificant up to the twelfth lag. Thus, there is evidence that both the level and squares of standardized residuals do not exhibit any serial correlation. Finally, according to SIC criterion, TARCHSK model that allow conditional skewness and kurtosis to be time-varying is the best model.

Table 5.9: GARCH, TARCH, and TARCHSK Models:

Mean equation: $\pi_t = \alpha_1 \pi_{t-1} + \alpha_2 \pi_{t-4} + \alpha_3 \pi_{t-11} + \varepsilon_t$

Variance equation: $h_t = \beta_0 + \beta_1 \varepsilon_{t-1}^2 + \beta_2 h_{t-1} + \beta_3 \varepsilon_{t-1}^2(\varepsilon_{t-1} < 0)$

Skewness equation: $s_t = \gamma_0 + \gamma_1 \eta_{t-1}^3 + \gamma_2 s_{t-1}$

Kurtosis equation: $k_t = \delta_0 + \delta_1 \eta_{t-1}^4 + \delta_2 k_{t-1}$

Model		**GARCH**		**TARCH**		**TARCHSK**	
		estimate	**p-value**	**estimate**	**p-value**	**estimate**	**p-value**
	α_1	0.591692	**0.0000**	0.654241	**0.0000**	0.721093	**0.0000**
	α_2	0.116641	**0.0022**	0.135846	**0.0000**	0.118370	**0.0000**
	α_3	0.158530	**0.0000**	0.119093	**0.0000**	0.006947	**0.0000**
Variance equation	β_0	1.34×10^{-05}	**0.0000**	1.22×10^{-05}	**0.0000**	2.34×10^{-05}	**0.0000**
	β_1	0.535467	**0.0000**	0.710816	**0.0000**	0.505230	**0.0000**
	β_2	0.444531	**0.0000**	0.487616	**0.0000**	0.717362	**0.0000**
	β_3			-0.637900	**0.0000**	-0.504689	**0.0000**
Skewness Equation	γ_0					0.070435	**0.0000**
	γ_1					-0.258186	**0.0000**
	γ_2					0.599714	**0.0000**
Kurtosis Equation	δ_0					0.496505	**0.0000**
	δ_1					0.007377	**0.0000**
	δ_2					0.787612	**0.0000**
Log-likelihood		2018.093		2032.159		2162.807	
SIC		1981.830		1995.895		2126.585	
Ljung-Box Q-stat.							
Residuals (lag 12)		25.363 (0.013)		17.458 (0.133)		17.313 (0.099)	
squared (lag 12)		15.138 (0.234)		14.215 (0.287)		15.670 (0.207)	

The basic GARCH and TARCH models are estimated using Quasi Maximum Likelihood (Bollerslev- Wooldridge (1992)) TARCHSK-M model is estimated using ML estimation. All models are estimated using Marquardt algorithm. Significant p-values are indicated by bold.

As before, to evaluate different models, the behaviour of the standardized residuals is compared. As displayed in table (5.10), the standardized residuals of TARCHSK model have the smallest standard deviation, skewness and kurtosis. Thus, the standardized residuals series from models with time-varying higher order conditional moments have a lower dispersion than those resulting from time-invariant conditional skewness and kurtosis. In addition, the behaviour of conditional volatilities resulting from different models is compared. Based on table (5.11), the results indicate that conditional variance resulting from TARCHK model has the lowest skewness and kurtosis.

The final diagnostic test is to conduct a likelihood ratio test. To compare GARCH and TARCH specifications, the value of the LR statistic is quite large resulting in rejection of the null hypothesis that the restricted model (i.e., GARCH) is the correct model. Similarly, the value of LR statistic is very high in case of comparing TARCH with its extension. Thus, the density that permits the skewness and kurtosis to be time-varying outperforms the density that keeps them constant.

Table 5.10: Descriptive statistics for standardized residuals

Statistic	GARCH	TARCH	TARCHSK
Mean	0.242378	0.189668	0.181784
Median	0.094101	0.059529	0.092059
Maximum	5.591658	5.638982	3.377584
Minimum	-2.422844	-2.401694	-1.855432
Std. Dev.	0.972287	0.983745	0.614443
Skewness	1.911525	1.763339	1.571154
Kurtosis	10.10418	9.133696	8.416244
Jarque-Bera	1591.871	1224.376	959.0062
Probability	0.000000	0.000000	0.000000

Table 5.11: Descriptive statistics for conditional variances

Statistic	GARCH	TARCH	TARCHSK
Mean	0.000119	0.000122	0.000224
Median	4.26×10-05	4.02×10-05	0.000122
Maximum	0.002811	0.003387	0.003065
Minimum	2.42×10-05	2.40×10-05	8.42×10-05
Std. Dev.	0.000248	0.000284	0.000297
Skewness	6.466846	7.044763	5.261333
Kurtosis	56.76229	66.05730	39.21945
Jarque-Bera	74785.37	102107.1	34793.82
Probability	0.000000	0.000000	0.000000

Table 5.12: Likelihood ratio test

GARCH vs. TARCH		TARCH vs. TARCHSK	
Logl(GARCH-M)	2018.093	Logl(TARCH-M)	2032.159
Logl(TARCH-M)	2032.159	Logl(TARCHSK-M)	2162.807
LR	28.13154	LR	261.2965
p-value	0.0000	p-value	0.0000

The predictive power of different models is calculated for the out-of-sample (2007:2 to 2009:2) period. The results are displayed in table (5.13) reveal the superiority of TARCHSK model according to all the measures. Finally, figure (5.4) shows the ability of TARCHSK model to trace the inflation path in comparison with standard GARCH and TARCH models. Thus, a specification that allows conditional third and fourth moments outperforms other specifications that keep them constants.

Figure 5.4: Actual versus predicted inflation from GARCH, TARCH and TARCHSK models

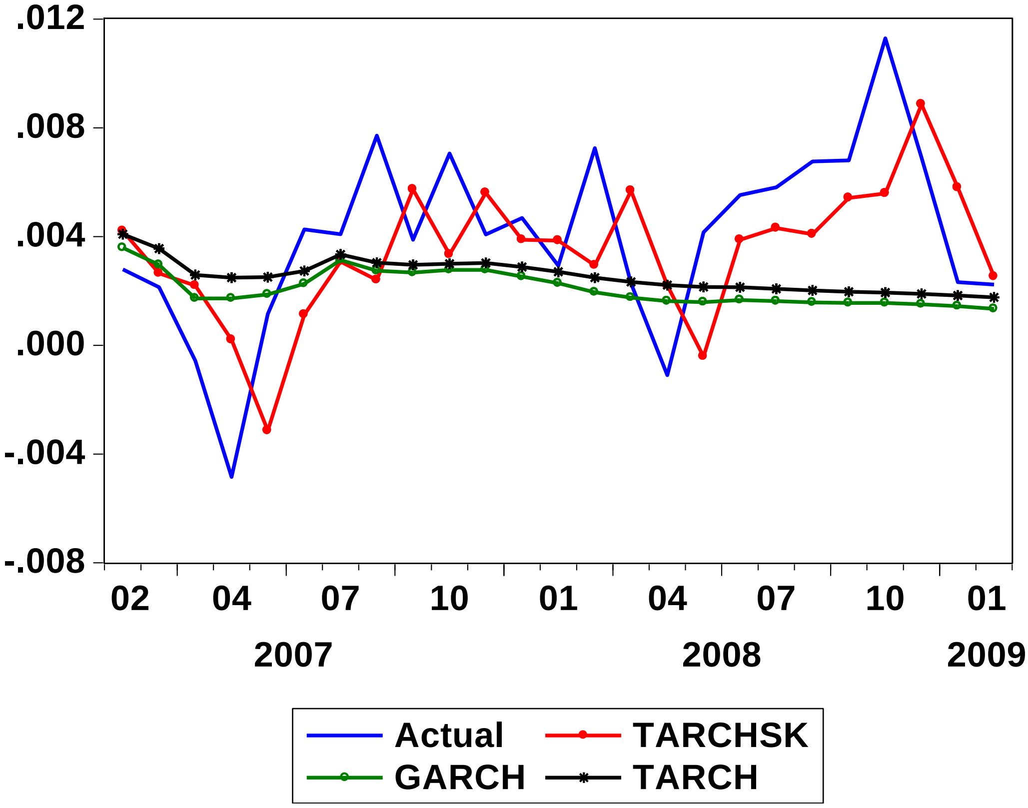


Table 5.13: out-of sample Forecasts power of different models

	GARCH	TARCH	TARCHSK
MSE	1.45×10^{-05} [3]	1.35×10^{-05} [2]	9.55×10^{-06} [1]
MAE	0.003010 [3]	0.002871 [2]	0.002663 [1]
TIC	0.519435 [3]	0.474202 [2]	0.331450 [1]
BP	0.248738 [3]	0.152401 [2]	0.030950 [1]
VP	0.482294 [3]	0.531685 [2]	0.081665 [1]
CP	0.268968 [3]	0.315914 [2]	0.887385 [1]

The numbers in the square brackets indicate rankings of the models where [1] indicates the best models according to the corresponding measure.

5.5. Conclusion:

Given that inflation forecasts are of major important in the actual monetary policy conduct especially under an IT regime, CBs must have accurate inflation forecasts. Additionally, since understanding the risks included in inflation more fully would improve anti-inflation policy settings, a density forecasts could help improving inflation forecasting. Therefore, the paper applied the methodology proposed by (LRS, 2005) for modelling nonconstant conditional second, third and fourth moments to explore the full density of inflation.

The employed methodology includes GARCH-M and TARCH-M models along with their extensions that permit conditional skewness and kurtosis to follow GARCH and TARCH structures. Additionally, a GARCH-M specification with GED distribution for the error term is modelled and compared with models that assume normality and models that assume a G-C series expansion. The results indicate that there is a significant persistence in conditional variance, skewness and kurtosis. Additionally, comparing different models by examining the behaviour of standardised residuals, conditional variances and conducting a likelihood ratio test reveal that models with nonconstant second, third and fourth moments are superior to models with time invariant volatility, skewness and kurtosis. Finally, applying the encompassing test of

Applying the methodology to Mexican inflation data also support TARCHSK model that allow for time-varying conditional skewness and kurtosis. As a result, we could conclude that monthly inflation is indeed highly asymmetric in both countries. Therefore, CBs should care about the full density of inflation in constructing their future forecasts. Finally, using annual inflation data from different counties including Egypt, Mexico, Colombia, Denmark and Finland show that annual inflation is not volatile which means the methodology applied here is not valid for them. On the other hand, checking annual inflation for both Belgium and Turkey shows evidence of the existence of ARCH effects. Thus, annual data gives mixed results regarding the possibility of applying the underlying models. The paper could be extended to check the applicability of the underlying methodology for other countries using different frequencies.

Chapter Six

Conclusion

This thesis has attempted to produce contribution to the potential operational framework of IT in Egypt. Therefore, it addresses the following questions:

(1) Is Egypt ready to shift to IT regime?

(2) Should the CBE shift to IT or continue with the current monetary policy framework MAT?

(3) What the OPH should CB choose to target inflation?

(4) Does modelling inflation using models that allow for time-varying conditional variance, skewness and kurtosis helps in better understanding of inflation uncertainty?

Examining the extent to which the preconditions of IT are met in Egypt has been the core of chapter two. First, related to CBI, the analysis shows that the CBE independence should be confirmed further through revision of MPC membership or limits the right of government members to vote. Additionally, the deleted article concerning the dismissal of the governor before the end of its mandate should be reintroduced. Furthermore, it is required to amend the law to ensure that monetary financing of fiscal deficits is prohibited and the CBE should increase communication with the public via inflation reports, annual reports, or press releases to fully explain the reasons of the underlying CBE's actions. This would certainly contribute to enhance transparency of monetary policy and raise credibility. Second, concerning soundness of financial sector, the undertaken reforms by government are considered good progress. However, these reforms need to be taken further steps by supporting the private sector participation in the banking system as well as developing the bond market and introducing new products.

Third, the condition that the system must have a sole target is guaranteed by *Law no. 88 of 2003.* Fourth, the fiscal reforms that aimed at improving fiscal consolidation were largely successful. Nevertheless, a reform in the budgetary institutions including all the rules and regulations related to budgets preparation, approval and implementation is highly essential. Besides, the fiscal transparency and accountability must be emphasized. Based on the abovementioned evaluation of IT conditions in Egypt, the CBE could move towards applying an IT regime to anchor its monetary policy conditional on achieving the required reforms. This is believed to contribute in achieving macroeconomic stability.

Since the preconditions of IT are moderately met in Egypt, this raises an important question regarding the rationality of shifting to IT. Thus, if the CBE can achieve monetary stability using its current monetary policy MAT, it should continue target monetary aggregates. A successful MAT regime hinges on two pillars: (1) the stability of the relationship between that targeted monetary aggregate and nominal GDP which implies a stable velocity of circulation. (2) The monetary aggregate must be under the control of the CB which requires the stability or predictability of MM. The stochastic structure of both MM and velocity of M1 and M2 are examined using VR tests of LOMAC (1988) and (1989), CHODE (1993) and wild bootstrap of Kim (2006).

The employed methodology assumes that both variables are stable if they are mean-reverting over a period of time. Thus, the procedure is as follows: first, testing for the RWH using the VR tests. Then, if the RWH is rejected, the value of the VR should be examined. Checking the value of VR would result into two cases: first, when the VR is less than unity, this suggests a negative serial correlation in the first differences and hence the series is mean-reverting, i.e., stable. Second, if the VR is greater than one, then there exist positive serial correlation and hence the series is not stable. Finally, non-rejection of the null hypothesis also indicates unpredictability or instability of both variables.

The results indicate that the three variables follow RW process. Therefore, they are unpredictable random sequences. With respect to MM, given that the RWH cannot be rejected which implies that the MM is not mean-reverting, then the relationship between the money supply and the money base is not stable. Under MAT, the CBE is required to control money supply to be consistent with maintaining low inflation rate by altering the monetary base conditional on the prediction of MM. That is to say that given the instability of MM, the CBE cannot achieve the desired level of money supply by changing the monetary base. Therefore, the CBE cannot achieve its main goal of low inflation as the money supply would be outside its control.

Concerning VM, as it provides the linkage between the monetary aggregate and GDP, providing that the CBE can achieve the desired level of money supply, the attainment of achieving a nominal GDP target is dependent on the accuracy of VM forecast. However, the CBE cannot achieve the targeted money supply since the MM is instable. This implies that the CBE would not be able to attain the nominal GDP target. Furthermore, even if the MM is stable and the CBE can achieve the desired level of money supply, it would not be able to achieve the required nominal GDP target since the VM is instable. Based on that, the CBE cannot achieve its goals including low inflation and promoting output growth under the current policy framework based on monetary aggregates. The results are in line with Awad (2010) who provides an evidence of instability of velocity of circulation using cointegration analysis. Therefore, the CBE should take further steps towards the full-fledged IT regime

To answer the third question related to the choice of the best horizon required to offset inflationary pressures, chapter four employed a reduced-form VAR consists of seven variables. The OPH corresponding to different types of shocks has been calculated. The results show that the OPH is largely related to the nature of the shock and the weights placed on other policy objectives in the CB loss function. Particularly, the inclusion of interest rate volatility in the loss function tends to lengthen the horizon. In the absence of instrument variance, the horizon is relatively short for transitory shocks. That is, the monetary authorities should try to outweigh the inflationary pressures within 1, 2, 4, and 1 quarters in response to transitory aggregate supply, aggregate demand, exchange rate and stock prices shock respectively. However, the horizon is extended to be 3, 16, 18, and 3 quarters for the aforementioned shocks when a weight of 0.5 is assigned to instrument volatility. Thus, the difference between strict and flexible IT is not significant unless we account for instrument variability. This could be explained by two reasons: first, since the data of output is interpolated from annual series, it could is regarded as indicative rather than providing the true values of output. Therefore, the true variation of output may not be captured fully resulting in low standard deviation of output leading to a reduction in the term of output volatility in the CB loss function. Second, if policymakers choose a very long horizon to offset a transitory shock, monetary policy will affect the economy for a longer horizon rather than the shock itself which induces instability.

The results also suggest that different shocks that are classified as the same type requires different policy horizons. Based on these results, monetary authorities should not aim at offsetting the shocks that are generally categorized of the same kind at the same horizon to ensure the effectiveness of monetary policy. Finally, if the shocks are persistent, this leads to longer horizon as the persistent shocks are distributed over many periods relative to a transitory shock.

To answer the fourth question, chapter five applied the methodology proposed by (LRS, 2005) for modelling nonconstant conditional second, third and fourth moments to explore the full density of inflation. This is done by estimating six different models, GARCH-M and TARCH-M models where the parameter estimates of these models are used as starting values for the developed models that assume nonconstant third and fourth moments. Additionally, a GARCH-M specification with GED distribution for the error term is modelled and compared with models that assume normality and models that assume a G-C series expansion. The results provide evidence for a significant persistence in conditional variance, skewness and kurtosis. Additionally, comparing the behaviour of standardised residuals, conditional variances resulting from different models suggests that the models with time-varying third and fourth moments outperforms those that assuming the distribution is time-varying only in the first two moments. Furthermore, applying a likelihood ratio test, the null hypothesis that the restricted density, i.e., that assume normal distribution is the correct density is rejected. Thus, as the results indicate that the monthly inflation is indeed highly asymmetric, CBE should pay more attention to explore the density of inflation.

These results support Friedman (1977) hypothesis concerning the positive correlation between inflation and its uncertainty, as volatility persistence and GARCH in mean coefficients are significant in all models. Additionally, the results show the evidence of positive skewness that is consistent with Balke and Wynne (1996) that the mean-skewness correlation could persist even in the long-run. Given the positive association between past inflation and uncertainty, the CBE should aim at achieving low average inflation rate to decrease the negative consequences of uncertainty. This is could be achieved by shifting to full-fledged IT as the evidence from inflation targeters showed that there is a negative influence from IT on long-run uncertainty. Additionally, the CBE should account for this high uncertainty when choosing the target range. Therefore, it is recommended that the CBE should adopt a broader band to give it flexibility in responding to short-term shocks and to have more scope to stabilise output as well. Also, this wide band should reduce the instrument volatility which in turn implies stability in financial markets.

Finally, given the reasonably poor forecasting power of the models that allow for nonconstant higher order moments, their forecasting accuracy is compared with the traditional VAR model using the encompassing test of DM (1995). The results shows that the null hypothesis of equal forecasting accuracy cannot be rejected at all the conventional significance level excluding GARCHSK-M model. This implies that all models excluding GARCHSK-M model contain marginal information that is not included in the best model according to the MSE criterion, GARCH-M. Therefore, as all forecasts except GARCHSK-M are not encompassed by the best forecast, they could be combined together to produce one projection.

Therefore, the CBE could try to use combined forecast to form its inflation predictions as the individual forecasts from the models are not quite satisfactory.

Examining Egyptian annual inflation does not provide support for the possibility of testing the model; however the applicability of the model to quarterly data could be investigated as the CBE issues quarterly inflation reports besides the monthly ones.

However, the thesis is limited by the following:

1. Concerning testing for the RWH in the VM and MM series, all the employed VR tests are designed to detect serial linear dependence. Therefore, the methodology does not account for the possibility that underlying series may exhibit nonlinear serial dependence.
2. However the study calculates the OPH corresponding to various types of demand shock, the study is limited in deriving the OPH for aggregate supply shock only. The reason behind that is the lack of availability of data on productivity, wages and unemployment rate which is considered essential to derive disaggregate supply shocks. Additionally, the study did not account for the effect of size and sign of the shocks on the OPH. Also, the thesis did not consider the case when the economy faces a combination of several shocks and its effect on the OPH. Therefore, this could be a possible area for future research. Finally, since the data of GDP and government expenditure are available only on annual basis, a quarterly series of them are interpolated. This interpolated series is considered to be suggestive rather than providing the true values of the underlying series.

3. Regarding using the models that allow for time-varying higher order moments for inflation forecasts, as the likelihood function is highly nonlinear; using different optimisation algorithms could lead to different estimates and standard errors. Another drawback is that the model is very sensitive to the choice of the starting values. In particular, setting the initial values of the parameters to zero or close to zero would result in the existence of many local maximum of the likelihood function. Therefore, a special care should be taken in consideration by setting the initial values away from zero to avoid the possibility of various local maxima.

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