RESOLVING CONTROVERSIES ABOUT DETERMINANTS OF INFLATION

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Muhammad Rehman

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APPROVAL SHEET

RESOLVING CONTROVERSIES ABOUT DETERMINANTS OF INFLATION

by

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Abstract

While there exist many models for the monetary sector in Pakistan, to the best of our knowledge, no one has applied Hendry's methodology to the construction of a model for inflation in Pakistan. Our contribution in this thesis is to apply this methodology, which has the potential for resolving many controversial issues. Some of the key features of this methodology is that the model should be consistent with theory. Our final model is consistent with a is a mark-up model of the price level. In addition, it has the statistical properties of being empirically constant, parsimonious; data consistent. It also has long run stable dynamic based on an error correction representation. It also encompasses existing models in the literature including those based on purchasing power parity and the Hybrid new Keynesian Phillips curve. In addition to the nested model evaluation procedures recommended by Hendry, we also exposit and utilize non-nested hypothesis testing procedure for model evaluation. In particular, we employ different non nested hypotheses testing procedures e.g. Cox-type tests, encompassing tests and Wald type tests etc, as well as appropriate model selection criteria to choose the relatively better approximation of true data generating process. In accordance with the key methodological idea of encompassing, we evaluate the relative empirical characteristics of statistical models for CPI inflation based upon the theory of price markup model with the non nested theory based models e.g. Model based on

Quantity theory of money, P-star model and a structural model. We find that, our markup model dominates its rival models. This research addresses a variety of econometric issues relating to cointegration, exogeneity, model selection, general to specific methodology, long run, short run properties, and impulse response of ECM model, mean and median lag calculations and forecasting etc which helps policy maker in designing and conducting policy in more accurately.

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First of all I would like to pay my profound thanks to Almighty Allah, "*the most Compassionate, Merciful, creator and sustainer of universe and Everlasting Refuge* ", who has given me chance, ability, potential and determination to complete this piece of research work. I offer my courteously respectful and heartfelt thanks to the Holy Prophet Hazrat Muhammad (Peace be upon Him) who urges his followers to "seek knowledge from cradle to grave".

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1: INTRODUCTION

Inflation is the extremely important worldwide macroeconomic problem for the most economies throughout the globe. It is a burning issue in macroeconomics owing to its serious implications for economic growth and income distribution. For Policy makers inflation always presented difficult dilemmas – theory prescribes tight monetary policy, which can lead to recessions and unemployment, making the cure worse than the disease. Recent research has led to greater awareness of the social and economic cost of price inflation and stable prices as a direct or indirect objective of macroeconomic policy. (Wesche-2008,Cuvak -2009).

According to the literature, price stability is desirable because

1) Rise in prices add inefficiencies and creates uncertainty in the market, which make difficulties for companies in planning long-term policies. This uncertainty may hamper real economic growth. . (Taylor, Timothy-2008).

2) "Inflation can act as a drag on productivity as companies are forced to shift resources away from products and services in order to focus on profit and losses from currency inflation" said Timothy-2008.

3) Unstable prices pose a grave risk to savings and growth. Unstable prices make future purchasing power of money uncertain this discourages investment and saving. (Buckley, George -March 1981).

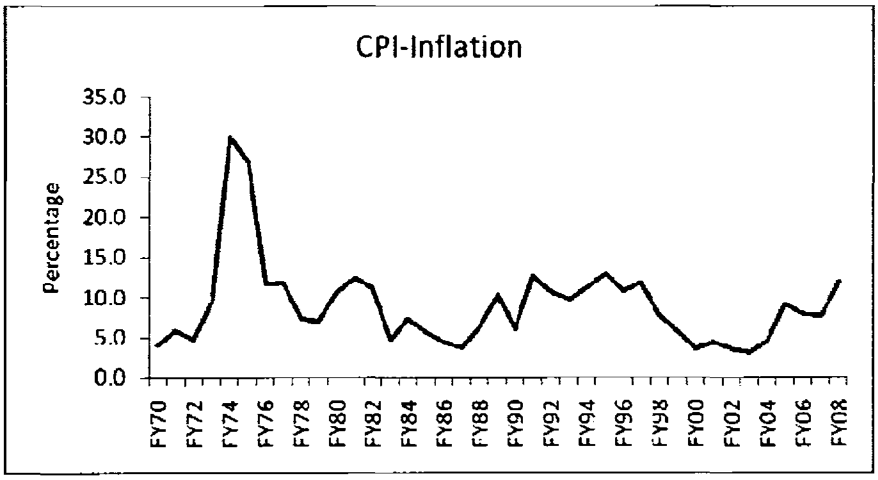
4) It restrains financial growth. In high inflation people start investing in non financial assets because high inflation erodes real return on financial assets. In that way it discourages savings. Lower savings would lead to lower investment and slower growth (Hasan-1995).

5) It appreciate the real exchange rate which drag down country's external competitiveness thereby increase the trade deficit. This scenario necessitates sharper currency deprecation which further fuels the inflation. (Hasan-1995).

6) It is a regressive tax. It negatively affects the poor because they have to invest major portion of their income to food items. (Schimmelpfennig-2006).

Pakistan, like most developing countries, has also experienced inflationary episodes in the last thirty years (Malik 2006).

Fig 1.1

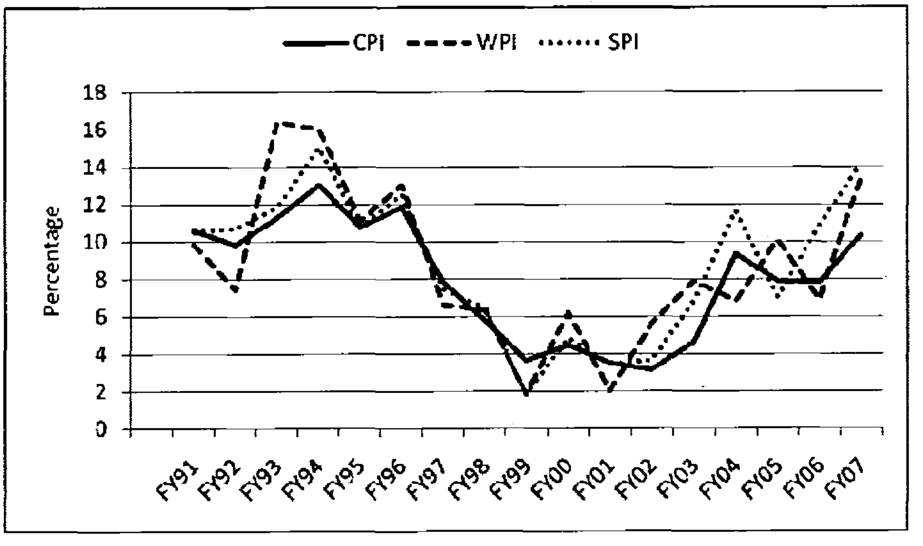


In 1960s, average price inflation rate was 3.3% a year which, to some extent shows price stability during this decade. In 1970s, inflation rate increased substantially and it touched average of 11.9 percent a year which is 2.9 percent higher than the threshold level calculated by Mubarik -2005. This surge in inflation could be the result of major oil shocks and the disintegration of country. Mark up model developed in chapter 4 also shows that the growth in oil prices have significant impact, both in short run and long run, on the CPI inflation. In 1980s average remained in single digit.

Again in early 1990s-the era of Gulf War, the rate of price inflation jumped to 12.6 percent it remained in double digit till 1996. In 1994-95 food inflation goes up to 16.5 percent which further exaggerated pressure on prices and the CPI inflation went up to 13.1 percent.

However, there was a declining trend in inflation during 1997-2002 periods. Few economists believe that the reduction in inflation was due to improved supply position, better macroeconomic policies and besides lower prices in international market. In chapter 4 we find that international price inflation plays important role in determining CPI inflation. The inflation rate dropped to 3.1 percent by 2002-03 as compared to 16.5 percent in 1994-95. Inflation again started rising from 2003, reaching at 10.3 in 2007-08.

Fig 1.2 Historical inflationary trend



Economists are studying causes and cures of inflation rate. The question now arises that what were the most significant explanatory factors of recent inflation in Pakistan? One part of this research attempts to answer this question.

1.2: THEORIES OF INFLATION AND SOME EMPIRICAL STUDIES

A large number of theories of inflation have been proposed in the literature; for example the demand-pull, the cost-push inflation, built-in-inflation, rational expectations theory, Anti-classical or backing theory and the quantity theory of money etc.

According to Keynesian economic approach, provided economy at potential level of output, any changes in money supply will translate into inflation indirectly via demand pressure in the economy. Keynesian economists normally put emphasis on the role of "*aggregate demand*" in the economy in determining inflation. For them the supply of real money is merely one determinant of aggregate demand. So they think that money supply is a major determinant, but it is not the only, source of inflation.

Keynesian economists have proposed three types of theories, the demand-pull, the cost-push inflation and built-in-inflation for explaining the behavior of prices. However, during 1970s stagflation was observed throughout the globe which was not consistent with Keynesian theories. For its explanation, three other rival models are forwarded specifically, (a) the QTM (b) The (Augmented) Philips Curve Model; and (c) the Structural Model of Inflation

1.2(a): Monetarist view

Monetarists suppose the most vital factor manipulating inflation or deflation is the management of money growth in an economy in the course of the easing or tightening of credit. They believe that fiscal policy is ineffective in controlling and engineering the inflation.

The monetarist model formally proposed by Friedman (1968, 1970, 1971) and empirically tested by Schwartz (1973) simply stated that the major factor explaining the current rate of price inflation is the past conduct of money to output ratio. In Friedman's (1968) words, "Inflation is always and everywhere a monetary phenomenon". Quantity theory supposes that real output is determined solely by real factors in the long run and prices are determined entirely by the money supply.

Afterward Monetarists, by augmenting the expectations in their model, argue that though inflation could be effected by factors other than money in the short run yet there exist no long run connection between money and the real variables of the economy. It simply means that inflation is just a monetary phenomenon and hence can be entirely explicated by the rate of change in the money supply in the long run. Many good fitting models fail to support this idea; our best model for Pakistan also shows that a purely monetary explanation of long run inflation does not fit the data for Pakistan.

1.2(b): Keynesian View

Keynesian believes that any excess demand in an economy will cause inflation. This excess demand can be created by an expansionary fiscal policy, by monetary growth, and higher spending by economic agents in national and international markets.

The Phillips curve model, which is based on an empirical investigation by Phillips and afterward was formalized by Lipsey (1960), merely says that at least in a short run, there exists a trade-off between inflation and unemployment in the economy.

Friedman criticizing the Philips curve said that if policy attempted to maintain output above its potential level, then wage-bargainers will get used to the higher prices and they will adjust nominal wage demands accordingly upwards. It will end with higher inflation without the stable low unemployment. Monetarists not only rejected the Phillips curve, they also criticized the entire basis for Keynesian economics, i.e. the supposition that the monetary policy might systematically influence output even in the short-run. To answer the above critique Keynesian economists attempted to build microeconomic justified models that also incorporate rational expectations.

The main focus of the both school of thoughts based upon demand side of the economy. So their models fail to explain the stagflation of the 1970's. The New Classical tried to fill the gap and floated the new approach in 70's stressing the supply side of the economy. They say that any shock just shift aggregate supply curve leftward pushing prices up, which creates stagflation.

Some researchers like Hasan et al (1995) believe that above theories has importance in explaining behaviour of inflation but individually they are incapable to explain fully the determinants of inflation especially for Third World countries because of the non-fulfillment of basic assumptions above models are based upon.[1]

> *Hasan* says *"In developing economies, neither rapid monetary growth nor persistence of high unemployment independently is sufficient to explain the phenomenon of chronic high inflation"*

They forwarded a model which is *"pragmatic in nature"*. They beheve that analysis for the derivers of CPI inflation must be undertaken on disaggregated level. For example market conditions of given sector, government demand management policies, tax policies, pricing policies, external shocks and expectations may play the major role in determining the inflation. Our mark up model, though theory based contrary to Hasan, also takes account of most of these drivers and finds similar results[2].

[1] For more detail see Hasan et all- 1995
[2] See result in section 4

1.3: EMPIRICAL STUDY- GENERAL TYPES OF MODELS

There are a large number of econometric models currently in use for explaining inflation. We list some of the prominent models below.

1. Hybrid New Keynesians Philips curve model,

$$\pi_t = \gamma_t E_t \pi_{t+1} + \gamma_b \pi_{t-1} + \lambda_0 x_t + \mu_t$$

Where π_t is the inflation rate at time t, x_t the explanatory variable(s)-usually taken as output gap or unemployment rate, $E_t\pi_{t+1}$ is the expected value at time t of the inflation rate prevailing at time t + 1 and μ t is disturbance term. (Fanelli, Luca 2005, Balakrishnan and Sam -2006, Tamim-2006),

2. Models based on the theories of Monetarists and new classical (King and Watson, 1993).

Monetarists forwarded the quantity theory of money (QTM) which states that money supply and price level has a direct, positive relationship. This theory relates money supply (M), velocity of money (V), prices (P), real income (Y) and can be written as

$$PY = MV$$

Its econometric counterpart and detail discussion is in 3.1a.

Similarly new classical developed a model based on Lucas aggregate supply and demand curve. Econometric presentation of the model is as under

$$\pi_t = \gamma_1 Y_t^g + \gamma_2 m_t - \gamma_3 Y^* + \varphi \sum_{i=0}^{n} \theta_i \pi_{t-1-i}$$

$$+ \vartheta_t \qquad 3.8$$

It state that current inflation (π_t) depends upon output gap (Y_t^g), aggregate amount of money (m_t)in circulation for given period of time in an economy, lagged values of inflation (π_{t-1-i}) and supply side shocks[3]. These models are based on monetarist ideas which allow little role for government interventions and try to picture free market as producing best possible outcomes.

3. Time series models ARIMA(p,1,q) for inflation , these are A-Theoretical models. They say let's just look at the data, without concern for theories.

$$\Delta P_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i P_{t-i} + \sum_{j=0}^{q} \gamma_j \mu_{t-j}$$

where P denotes average annual CPI inflation and μ denotes a white noise error term(Bokil and Schimmelpfennig-2006),

4. VAR(P) models

If we go through the literature we find lot of researchers for example Cuvak-2009, Lack -2006, who propose VAR models for modeling and forecasting inflation process. The general specification of the VAR model is given as...

$$y_t = \Gamma_1 y_{t-1} + ... + \Gamma_p y_{t-p} + \mu + \varepsilon$$

[3] For more detail discussion see 3.1b

where y_t is an (n x 1) vector of non-stationary time series, μ is an (n x 1) vector of constant coefficients and ε_t is an(n x 1) vector of error terms. Γ_1 through Γ_p represent (n x n) matrices of parameters to be estimated,

5. VARIMA model

VARIMA models are sub class of VAR-models. These address non-stationary behavior in multivariate time series. Traditionally, non-stationary behavior in multivariate time series has been handled by differencing each integrated variable separately; this practice could result in information loss and reduce performance of the model when cointegration is present. Methods for Cointegration can directly be built-in VAR model-based methods broaden their flexibility to examine non-stationary disturbances.

It is a widely use technique for the estimation of inflation process. For example Hendry -1999, Hyder and Sardar-2004, Choudhri and Khan-2002, Shamsuddin and Richard 1997, Bokil and Schimmelpfennig-2006 estimated inflation process using VARIMA model based technique.

The general specification of the VARIMA models is

$$\phi_0 W_t = \alpha + \phi_1 W_{t-1} + \ldots\ldots + \phi_{t-p} + \theta_0 v_t + \theta_1 v_{t-1} + \ldots\ldots \theta_q v_{t-q}$$

Where

$$W_t = \Delta^d Y_t \equiv diag(\Delta^{d1} Y_{1,t}, \Delta^{d2} Y_{2,t}, \ldots\ldots\ldots, \Delta^{dn} Y_{n,t})$$

And $\Delta^d Y_t = (1 - q^{-1})^d Y_t$

The parameters $\{\phi_i, v_i\}$ are n*n matrices and Y_t is a vector of n variables. The main idea of these models is to ensure that all variables are stationary prior to running regressions. Testing to see what level of differencing is required to achieve stationarity is done prior to specifying a VAR model.

6. VAR model calculated by Bayesian technique

VAR models usually face the "curse of dimensionality" dimensionality problem: there are a large number of parameters, which required very large samples for precise estimation. Doan et al (1984) attempted to cope with this problem in unrestricted VAR models. One way to handle this problem is by using Bayesian techniques which incorporate any prior information that is available to the researcher. Prior information can help resolve the problem of dimensionality, and substantially improve accuracy of estimates with limited amounts of data. In this thesis, we will also employ the Bayesian approach to the estimation of vector (VARs).

7. P star model

The P-star model is as follows:

$\ln P_t - \ln P_{t-1} = (\ln P_{t-1} - \ln P^*_{t-1}) + \sum b_i \Delta \ln P_{t-1} + u_t$

where Pt is price level, P* = MV*/Q*, M is domestic money stock and V* and Q* are long run equilibrium values of the velocity of M and of potential or capacity out put. (Tatom 1992- Qayyum and Bilquees (2005)),

8. Dynamic factor model

Pearson (1930) used factor model to investigate the dimension of human intelligence. Now a days DFMs are frequently used[4] to estimate and specially to forecast macro-economic variables in order to squeeze information from *many relevant* variables. In a factor model we decompose each observed variable into two components:

1) a common part 2) idiosyncratic part

Common part contains the information carried by the factors, and *an idiosyncratic* part is simply the residual of the decomposition. In addition, hnearity is assumed between the relationship of common part and the factors. This decomposition is performed by investigating the covariance matrix of the observable variables.

DFMs can easily be understood in simple geometry. Suppose we have T × N matrix, where T denotes the number of observations and N denotes the number of relevant variables. We suppose that there are K factors that generate the T × N matrix. Simply we are projecting N dimensional space to a K dimensional sub space.

Therefore factor analysis is basically a method of dimension reduction. It takes the information from a large dataset and resumes it using few unobservable common variables (factors). Usually it is assumed that the effect of the factors variables on observed series could be lagging, leading, or contemporaneous. In this sense it is called dynamic factor method. However selection of right factors is very sensitive issue which limits the application of DFMs.

9. ARFIMA models (Eckmier (2005)),

ARFIMA (P,d,q) process can be defined as

[4] Joerg Britung-2005,Chen Pu-2009 etc

$$R(L)\ (1-L)^d y_t = S(L)\mu_t$$

Where y_t is a t^{th} observation on the process of interest. μ_t are stationary innovations. R(L) and S(L) are polynomials of degree p and q respectively and have all roots outside the unit circle.

10. Artificial neural network models etc for forecasting inflation (Moshiri (1997))

Artificial neural network models (ANN) models are *non-linear* input-output models. The ANN models can also be viewed as vector mappers: they take set of inputs as an input vector and using inbuilt relationship encoded in their structure generate a parallel set of outputs as an output vector.

1.4: MODELS USED IN PAKISTAN[5]

To understand inflation dynamics empirically, researchers in Pakistan developed theoretical and a-theoretical models. As a theoretical models we have

Two equation model by 2SLS method (Ahmad 1999)

P Star model (Qayyum-2005)

Single Equation Model Based On QTM (Qayyum-2006)

In a-theoretical models, researchers estimated VAR[6] and ARIMA models with different technique, for example

VAR model (Kemal-2006, Hayder 2004)

VAR mode in first difference (Khan-2002)

VECM (Khan-2006,Simon- 1999)

ARIMA model (Shamsudin -1997)

It is obvious from above citations that although the relationship between inflation, growth rate of money and output and few demand and supply shocks is one of the most thoroughly researched topics in quantitative economic no consensus about the functional forms and economic theories seems to have developed in Pakistan. For example

i. Ahmad in 1991 suggested Real GNP growth, growth rate of unit value of imports, growth rate of M1/M2, lagged inflation as a determinant of inflation.

[5] The detailed discussion of results of these models is available in chapter 2. Single equation model based on QTM, P-Star model, VAR model etc are developed are discussed minutely in Chapter 3.
[6] Used different variables to estimate inflation, which are discussed in next paragraph

ii. Dhakal in 1993 forwarded M1, industrial production, interest rate, foreign interest rate, import prices as a determinants of inflation.

iii. Broad money, GDP growth, share of service sector, public debt, and import prices. Are the determinants of inflation according to Aslam (1996).

iv. U.S. dollar exchange rate, foreign price index by Khan (2002)

One of the key elements of the Hendry methodology was the attempt to deal with a proliferation of models. When there is a large variety of models, all based on different theoretical consideration, and all having some empirical validity, how do we choose among them? The encompassing methodology attempts to extract a single model which is the best among a class of models. We currently we have set of models to explain the dependent variable "CPI inflation" in Pakistan, but there is hardly any literature for statistical comparison of the performance of these models. *In order to comprehend the factors and structural form explaining the behavior of prices in Pakistan it is, therefore, crucial to build a structure which either explain, to some extent, the existing models or should be a hybrid of the above mentioned theories of price inflation. In this research we will develop a price mark up model as a bench mark model. Our study shows that this model has power to "explain the characteristics" (encompass) of all existing models.*

CHAPTER 2

REVIEW OF THE LITERATURE

There has been a long debate, without any consensus, in the economic literature on the factors driving inflation. Macro econometricians have carried out a lot of empirical research to test the validity of various self selected models. Here I review briefly some of the important empirical studies carried out on inflation in different countries and pay special attention to Pakistan case.

2.1: EFFECTS OF FISCAL AND MONETARY POLICIES

Wagner (1977) , Khan (1977), Hasan et al (1995) , Choudhary and Naved (1995), Khan and Qasim (1996), Agha and Khan (2006) and Hayder et al(2008) in their research tried to show that money creation to finance fiscal deficit is a cause of inflation in developing countries (Pakistan). Sargent et.al (1982) and Agha and Khan (2006) argued that the efficacy of monetary policy to control inflation depends upon monetary fiscal coordination. If Monetary policy is dominant and fiscal policy plays supportive role then Monetary policy can control the inflation however it does not if the role of fiscal and monetary policy is changed.

If dived deeper in above studies we extract the idea that segment of fiscal shortfall which is funded by money creation actually increase the stock of money and a higher money supply ultimately leads towards inflation. In their studies money has a dominant role in determining inflation. On the basis of this argument we tested money growth in our final model but it has not improved the performance of the model.

2.2: RESEARCHER GENERAL DISCUSSION ON FISCAL DEFICITS, MONEY, AND INFLATION

A number of researchers of developing and developed countries tried to find statistical relationship among fiscal deficits, money, and inflation but unfortunately results are mixed and inconclusive. Most of the early studies on industrial countries were focused on the United States. Researchers like Niskanen (1978), Dwyer (1982), and Jones (1985) of USA find statistically insignificant results, while few other like Barth et-all (1983), and Laney and Willet (1983) find significant monetization effect of almost all of the deficits. In developing countries, researchers from Fischer (1981) to De Haan (1995) and Zelhorst (1990) found insignificant relationship among the three variables while Tabellini (1991) studied 21 different developing economies and concluded that fiscal deficit is inflationary. Dornbusch et-al (1990) using the data of high-inflation economies concluded that money growth and deficits are determined by, and do not determine, inflation. We have tested that money growth do not directly determine inflation in Pakistan.

Right from Phelps (1973) and Click (1998), it has been argued that the major players for determination of inflation in developing economies are 1) inefficient and inadequate tax collection system, 2) immature and monopolistic domestic capital markets, 3), political turmoil and instability 4) inadequate access to foreign capital markets, and 4) Central bank dependence on government authorities.

If we analyze the above study simple logic suggests that all the factors mentioned in above study are revolving around the political stability because in immature political environment, it is hard to develop strong institutions. Political instable country also looses the credibility and hence access to foreign capital market. That's why we tested this variable in our final model and found it very important factor in explaining the inflation.

New Keynesian have modified Philips curve (PC), which treats monetary expansion as a cause for reduction in unemployment (when there is an output gap), and as a cause for inflation at full employment (when there is no output gap). Gali and Gertler (1999), modified the model and estimated the hybrid NKPC for USA using Generalize Method of Moment- GMM estimation techniques. They suggested that marginal cost rather than output gap is relevant measure of inflation. Their study shows that marginal cost and expected inflation are the main derivers of inflation. Our results also show that marginal cost and expected inflation play important role in determining the inflation. Stuart and Reid (1990), Balakrishnan and Ouliaris (2006) mainly focused on secular and cyclic movements of inflation. They studied both traditional Phillips curve (TPC) and new Keynesian Phillips curve (NKPC) models of inflation, and concluded that the long-run turn down in secular rate of change of prices cannot be determined in terms of changes in foreign trade however it is important in determining cyclic component of inflation. In our analysis we use import prices as a foreign trade index and found short term relationship between CPI inflation and import prices. King and Watson (1993) develop a long run Philips curve which has special feature that it works with three alternatives Keynesian, Monetarist, and real Business cycle identification. This alternative identification is specified via error terms by applying the particular set of assumptions in the bivariate VAR model. They concluded that Monetarist approach is more compelling. This was a theoretical attempt to explain different scenarios. The study of King and Watson reflects monetary growth is sole deriver of inflation but our final model does not support the idea for Pakistan. Our final model (chapter 4) encompasses new Keynesian Philips curve model and the model based on Quantity theory of money –a monetarist's model.

Wesche (2008) found that there is close relationship between real output growth, money growth and inflation in the Japan but only at low frequencies, these correspond to long run patterns in time. Output gap is related with inflation at higher frequencies, these correspond to short run patterns. This study ignored the suggestions of Gali and Gertler (1999) who advise to use marginal cost instead of output gap as a driver of inflation. We tested both variable and found, in our final model, that marginal cost has significant affect on inflation. Research undertaken at the Bank of England (1999) has explored the empirical evidence on forward looking Phillips curves. If we consider the lead of inflation as a proxy of expected future inflation our study also shows that expected inflation plays important role in determining current inflation. Bordo and Filardo (2005 and 2006) study the inflation for number of countries concluded that though money growth usually does not contain useful information for inflation when it is low and stable, yet it is a major contributor in episode of high inflation. For Japan, Fujiwara(2000) showed positive relationship between base money and prices while Miyao (2005) reported the conflicting result that money growth is statistically insignificant in forecasting inflations.

The crux of above studies is that money growth, marginal cost, political instability and expected inflation are the main sources of inflation.

Efforts to select significant factors from data based methods: Gavin and Kliesen (2006) developed a data rich model. They used a dynamic factor model to select few common factors from 124 series. Their results showed that monetary growth and unemployment rate are the major drivers of inflation in long run as well as short run. Our study also supports this result, since high unemployment and marginal costs are directly related. High unemployment reduces marginal cost and our study shows that low marginal cost result in low inflation in other things being equal.

Right from Duesenberry (1950), "Price mark-up model" has been used in economics [see Franz and Gordon (1993), Ericsson (1998), Eilev (2004) and Heino and Christopher (2006)]. In the equilibrium, with the assumption of linear homogeneity, the *common* mark up equation for the domestic consumer price level can be written as:

$$P = \mu.(ULC^{\gamma}).(IP^{\delta}).(PET^{k}).(TAX^{\tau})$$

Where P represents the underlying consumer price index, ULC is an index of the nominal cost of labor per unit of output, IP is an index of import prices in domestic currency, PET is an index of petrol prices in domestic currency, and the variable TAX is the ratio of GDP at market prices to GDP at factor cost. While γ, δ and κ are elasticities of the CPI with respect to ULC, IP and PET respectively and are assumed to be positive. The value of μ□ is mark-up over costs. Above equation can be obtained from a profit maximizing model with Cobb-Douglas production function.

Brouwer and Ericsson (1995) used CPI prices; average unit labor costs; import prices as key variables. Nielsen and Bowler (2006) used a UK data to estimate price markup model. They used cointegrated VAR approach for estimation. In their model, they used CPI prices; average unit labor costs; import prices and real house hold consumption growth as key variables. A central finding is that import price inflation may be adjusted through reduction in productivity in tune real wages such that the rate of change CPI inflation is moderated[7]. In literature this model has been claimed as a general model of CPI inflation (Brouwer and Ericsson (1995) . We will also estimate and use it as a bench mark-or a general model.

Akhtar (1990) tested the monetarist vs. New Keynesian[8] visions for the high inflation in Pakistan, Seri Lanka, Bangladesh, India and Nepal. The important finding in this study is that bond-financed government expenditures have no significant impact on the acceleration of inflation independently. It supports Monetarist view, who believes that bond financing has no real impact on aggregate demand and hence prices until the money is held constant. Their study consistently holds up the monetarist view that growth of real money balances is the sole determinant of long run inflation. Therefore in our final model we tested growth of real money instead of bond-financed government expenditures as explanatory variable however growth of real money has not improved the performance of the model. Our final model encompasses (not encompassed by) the model based on quantity theory of money. It means that money most likely has impact on CPI inflation but the channels are not direct.

[7] For more detailed discussion see chapter 4
[8] Discussed in Section 1.2

Ahmad (1991) discussed the determinant of inflation in Pakistan. He pointed out that inflation is mainly determined by real output growth, unit value of import growth, inflation inertia and nominal money growth. Our results show that instead of inflation inertia, leads of inflation has positive significant affect on CPI inflation. In analysis we find that import prices have power to explain the CPI inflation. We used marginal cost as an explanatory variables as suggested by Gali and Gertler (1999).

Byers (1993) and Qayyum (2006) argue that annual data in Pakistan supports the simple version of quantity theory. The short run impact of money growth on CPI inflation is good deal smaller. Husain (2006) stated comparable results. According to their study, taking care of shifts, there exist unidirectional causality from money to prices in long run and no causality in short run. Our model encompasses but is not encompassed by the model based on QTM. This means that we can screen out growth of money balances as a direct and sole deriver of inflation. We develop QTM model in chapter 3.

Hasan et al (1995) analyzed the factors liable for price inflation in Pakistan. The most important determinants of price inflation emerges as the rise in support prices of wheat etc, administered prices, indirect taxes, imported inflation and inflation expectations.

Our results show that imported inflation, tax wedge and inflation expectations are important derivers of inflation. Khan and Schimmelpfennig (2006) in their paper argue that in long run support prices of wheat are not inflationary. We also tested support prices in our final model but found them statistically insignificant. So we have not selected support prices of wheat as a determinant of inflation.

Ahmad and Ali (1999) in his study finds that while purchasing power parity does not bind in a short run, there exists an inclination in the system to get back relative parity in the long run. in addition continuous shocks can generate a "persist but non-accelerating deviation" between rate of change of prices and devaluation. Furthermore he pointed out that direction of transitory disparity between rate of inflation and devaluation depends upon origin of the shock. Lastly, he showed that the link between price level and exchange rate is bidirectional, while the short run impact of devaluation on inflation is little bit smaller than that of inflation on devaluation. However Hyder and Shah (2004) examined via recursive VAR on data from January 1988 to September 2003 that the exchange rate pass through to Pakistan CPI inflation is low. In chapter 4 we tested exchange rate and exchange rate depreciation as a relevant variable in our final model but do not find them significant.

Choudhary and Khan (2002) tested and afterward rejected the most accepted vision that devaluation of the rupee leads to inflation in Pakistan. Using the data from 1982 to 2001 they find no significant effect of devaluation of rupee on price inflation. In end of chapter4 we also tested this variable. Our findings are in agreement – devaluation does not have additional explanatory power in our final model

Qayyum and Bilquees (2005) developed and compared a P-Star model for Pakistan data with simple autoregressive model and the M2 growth augmented model and tried to show that the P-star model might be used to obtain the leading indicator of inflation in Pakistan. Our final model encompasses, but not encompass by, the P-star model. It does not mean that variable in P-star model are not important. For example P-star model gives importance to lag of inflation. This is most likely an important variable however our model suggests that it does not affect inflation directly, it uses other channels for example future expectation of inflation or marginal cost etc to influence the inflation. 0Results are discussed in chapter 4.

Khalid (2005) suggested that imported inflation, seigniorage and openness are major players of inflation in Pakistan. His result also point out that deficit GDP ratio, seigniorage, money depth, exchange rate depreciation and domestic credit also play important role in determination of inflation in Pakistan. We individually and collectively tested the relevance of these variables in our final parsimonious model developed in chapter 4 but found no direct relevance of these variables in improvement in the model. These variables might be important but their channel would be through unit labor cost, import prices, output gap or petrol prices etc. These channels can be explored.

Similarly Kemal (2006) finds in his paper that Quantity theory of money holds for Pakistan in long run however the impact of money growth appears after 9 months. On quarterly data he used cointegration technique to test the long run relationship and to verify the short run dynamics vector error correction mechanism is applied. Significant result that comes out from this study is that system takes long time to converge the equilibrium whenever system faces the shocks in any of the variables among Prices, money supply or GDP. Our final model encompasses the QTM based model which means that has ability to explain the model based on QTM. It does not mean that broad money has no affect on inflation; it may and most likely does affect inflation but its channel might be marginal cost, import prices, petrol prices output gap unit labor cost etc. Results are discussed in chapter 4.

Khan and Schimmelpfennig (2006) using the monthly data in their paper try to determine the drivers of inflation in Pakistan. Mainly he used wheat support price, Exchange rate, interest rate, money supply, credit to private sector as a test variable in his model. Results show that monetary factors have dominant role in current inflation. The impact of these variables appears on prices with a one year lag. He showed that growth rate of broad money and private sector credit would be used as leading indicators of inflation in Pakistan. Furthermore they said that in short but not in a long run wheat support prices are inflationary. As discussed earlier, most of these variables are added in final model (4.12) in chapter 4 but they have not improved anything in our final model. They are found statistically insignificant in model.

Qayyum (2006) attempted to examine the Quantity theory of money in Pakistan. He finds that changes in money supply effect real GDP growth which in turns effects the inflation in Pakistan. The significant conclusion from the study is that the excess money supply growth is a leading indicator of inflation during the study period. He proposed that inflation problem can be cured through the tight monetary policy. Our final model encompasses the QTM based model. Our final model shows that money has effects on inflation but channels are not direct.

Malik (2006) tested whether the monetary policy instruments effect the inflation in Pakistan or not by using Near-VAR approach on quarterly data of CPI inflation, real GDP and reserve money. He showed that impact of changes in money supply growth passes on into inflation in a year. He believes that inflation could be cured by adopting flexible inflation targeting.

Contrary to Qayyum (2006) and Malik (2006), Omer and Farooq (2008) showed that inflation is not a monetary phenomenon in Pakistan. In their study they explicitly established a positive relation between measures of political instability and price inflation. We tested it in our final model and found similar results. Inclusion of this variable increases forecasting power of the model. Because they do not include other relevant variables in their model, our model improves on theirs while incorporating their idea of the significance of political instability.

Aleem et al (2007) discussed the determinants of inflation in Pakistan. According to the study the most crucial determinants of inflation are adaptive expectations, private sector credit and ever rising import prices. The fiscal policies transmit little to inflation. Our final study also does not find any role for fiscal policy and supports Aleem et al (2007) study.

Khan et al (2008) tried to analyze impact of political instability on prices in Pakistan. In the study they find that the monetary factors have only marginal impact on inflation. Their impacts are mostly associated with political environment. Using GMM mechanism on nonmonetary model they found a significant effect of political instability on price inflation. Our final model also finds that political instability is significant. However, our model also gives an important role to monetary factors and performs significantly better than Khan et. al.

CHAPTER 3

STRUCTURAL AND TIME SERIES MODELS FOR INFLATION

Two types of models have been developed and used by the researchers, one based on theories aimed to set up meaningful, stable, significant and consistent relationships among the variables and second based upon the behaviour of the data .The former methodology is known as structural modeling and the later is known as time series modeling. In time series modeling researcher suppose that data contains all the relevant and sufficient information to analyze the conduct of a variable. VAR models offer an alternative to structural macroeconomic models and are usually used for forecasting purposes (Kenny et.al-1998). At present there is no consensus on the superiority of these the methodologies. Time series models claim to be free from pre-supposed assumptions, less vulnerable to misspecification and to be able to handle structural changes in economy due to adaptive mechanisms However; these a-theoretical models have been criticized on the grounds of not utilizing valid economic information, as well as using implicit statistical assumptions of uncertain validity. Clements and Hendry (1999) say that major failure in forecasting time series models occur due to structural breaks and shocks. Many tests are available to detect the structural breaks. However Stock (2001) says that performance of these tests can be improved by expert judgment[9]. Despite the shortcomings, we can use naïve models (time series) "ARIMA, VAR etc" to check the validity and performance of structural models (Clement and Hendry (2007)).

As mentioned above researchers developed various structural and time series model for Pakistan. As required by the encompassing methodology, we plan to compare all these models within a common framework. Here we use two approaches to model comparison: One based on nesting where a theory based general model nesting some famous theoretical models available in literature, are tested and second approach is non-nested, where we work with all theoretic and some a-theoretic models separate without attempting to nest them. Both lead to the same outcome for the best model develops in chapter 4.

In a later chapter, we will consider the same issue using non-nested testing procedure, which does not require homogenization of the models. Among the structural model I will develop model based on quantity theory of money, aggregate demand -aggregate supply model, P-star model. In time series models we will develop ARIMA and VAR model.

3.1 a) Model based on Quantity Theory of Money

The quantity theory of money (QTM) states that money supply and price level has a direct, positive relationship. This theory relates money supply (M), velocity of money (V), prices (P), real income (Y) and can be written as

[9] For more information visit http://www.economics.harvard.edu/faculty/stock/files/lsb201120.pdf

$$PY = MV \qquad 3.1$$

Taking log on both sides we have

$$p = m + v - y \qquad 3.2$$

By differentiating on both side we have

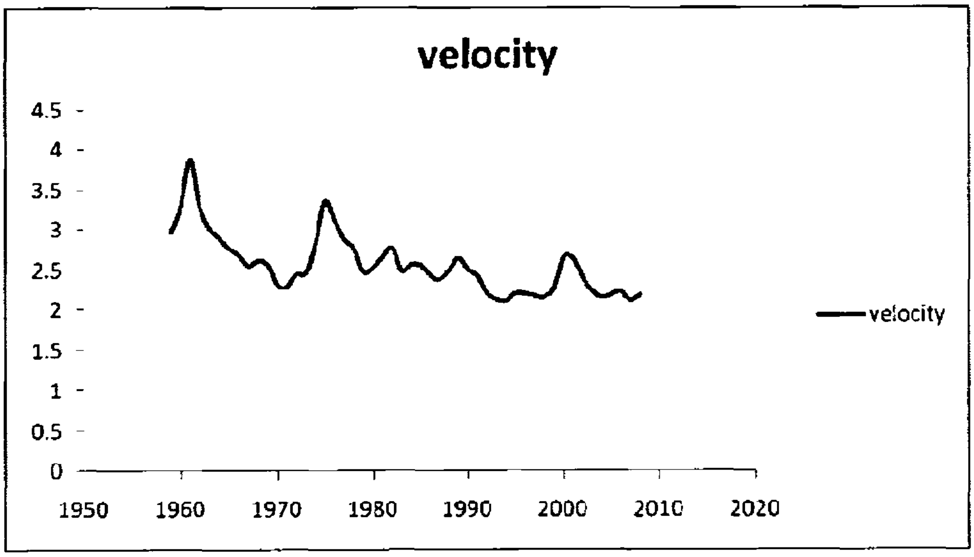
$$\frac{1}{P}\frac{dP}{dt} = \frac{1}{M}\frac{dM}{dt} + \frac{1}{V}\frac{dV}{dt} - \frac{1}{Y}\frac{dY}{dt}$$

$$\frac{P^{\cdot}}{P} = \frac{M^{\cdot}}{M} + \frac{V^{\cdot}}{V} - \frac{Y^{\cdot}}{Y}$$

$$g_p = g_m + g_v - g_y \qquad 3.3$$

Equation (3.3) shows that growth in prices is function of growths of money supply, velocity, and real income. Quantity theory identifies that money supply is the key factor that effects the changes in price level as V and Y remain almost constant. However figure below shows that velocity of money for Pakistan depict a decreasing trend over time.

Fig 3.1: Trend in Velocity of Money



Econometric counterpart of (3.3) is as follows.

$$g_p = \beta_0 + \beta_m g_m + \beta_v g_v + \beta_y g_y + \vartheta \qquad 3.4$$

Equation (3.4) shows that growth in money supply, growth in real income, growth in velocity and some other hidden factors determine the CPI inflation. Theory suggests that $\beta_m > 0 \; and \; \beta_v > 0$ where as $\beta_y < 0$. As growth of real income is determined by labor, capital and technology, these factors are independent of growth of money. Growth of velocity of money is a function of financial structure, budget deficit etc. These are relatively unaffected by the growth of real money supply. If this is the case then equation (3.4) depicts that there is one to one corresponding between growth in money supply and price level. One unit change in money supply will bring one unit change in CPI inflation. That is $\beta_m \approx 1$ [10]. This equation will be used for estimation purpose.

3.1 b) Macroeconomics based inflation model

Another approach to determine the major factors governing the behaviour of inflation is based on aggregate supply and demand based macroeconomic models.

The aggregate supply equation which is driven from labor market and the firm's optimization problem is[11]

$$Y_t^g = \beta_1 Y_{t-1}^g + \beta_2(\pi_t - E_t(\pi_{t+1})) + \mu_t \qquad 3.5$$

Where Y_t^g is output gap which is measured difference between potential output and realized output at time t. π_t represents CPI price inflation at time t and $E_t(\pi_{t+1})$ is expected future inflation at time t. μ_t represent the supply shock. This equation state that output gap depends upon its inertia, surprise change in price and supply shock. In new Keynesian frame of work this equation is called Expectation Augmented Phillips curve and in new- classical view it is known as Lucus aggregate supply equation.

The demand equation is

$$Y_t^g = \alpha m_t - \beta Y^* + \delta E(\pi_t) \qquad 3.6$$

Here Y^* represents the potential output and m_t denote real money supply in an economy.

[10] See for more discussion Qayyum-2006

[11] For derivation and detail see Scarth- 1988

Since expected Inflation is not observable, we will assume that expected inflation is adaptive. In simplified form it can be written as

$$E_t(\pi_{t+1}) = \sum_{i=0}^{n} \theta_i \pi_{t-1-i} \qquad 3.7$$

By solving (3.5) and (3.6) and substituting (3.7) we can have[12]

$$\pi_t = \gamma_1 Y_t^g + \gamma_2 m_t - \gamma_3 Y^* + \varphi \sum_{i=0}^{n} \theta_i \pi_{t-1-i} + \vartheta_t \qquad 3.8$$

Equation (3.8) states that current inflation depends upon output gap, aggregate amount of money in circulation for given period of time in an economy, lagged values of inflation and supply side shocks. (3.8) is a basically reduced form equation. By using simple algebra one can recover the deep parameters from the parameters of this equation. Usually researchers take import prices as a supply side shock as it is exogenous and independent of domestic economic environment. [13]. The equation (3.8) will become

$$\pi_t = \gamma_1 Y_t^g + \gamma_2 m_t + \gamma_3 Y^* + \varphi \sum_{i=0}^{n} \theta_i \pi_{t-1-i} + \gamma_4 Imp_t + \epsilon_t \qquad 3.9$$

We will use this equation for estimation purpose in section 3.3c.

3.1 c) P-Star Inflation model

Halman, Porter and Small (1989) developed the P-Star model. They said that the price level is determined by the ratio of money stock to potential output and long run equilibrium level of velocity of money. It is developed on the long-term QTM and

[12] Moshiri-1997 used this equation for estimation purpose
[13] see Scarth- 1988

therefore combines the factors of the price level in long term with changes in current inflation in short term. P-star model is appealing to many people because it utilizes future rate of inflation as additional information. It has simple and plausible assumptions. Its most appealing characteristic is its consistency with the widely acceptable and used Quantity theory of money. But studies show that P-Star model does not outperform other models.[14] This is also evident from our result because it is encompassed by but not encompasses the general model developed in section 4.

In P-Star model price level is define as the total money stock in an economy per unit of potential output.

$$P^{*} = MV^{*}/Y^{*} \qquad 3.10$$

Where M is the total domestic money stock and V^{*} and Y^{*} are respectively values of the velocity of M and potential output in long run.

The price gap can be obtained by combining QTM and P*, which shows the long run price level.

Dividing (3.7) from (3.1) we have

$$\frac{P^{*}}{P} = \left(\frac{Y}{Y^{*}}\right) * \left(\frac{V^{*}}{V}\right) \qquad 3.11$$

Taking log on both sides we have

$$(P^{*} - P) = (Y - Y^{*}) + (V - V^{*}) \qquad 3.12$$

[14] For more detail see Lawrence J. Charistiano-1989.

Equation (3.9) indicates that price gap, the gap between current price and the equilibrium price level on the left hand side of the equation, can be decomposed into two other gaps namely the output gap, $(Y^* - Y)$ and liquidity gap- $(V - V^*)$.

The central idea of the P-Star model is that the price level converges to an equilibrium which is largely determined by the domestic liquidity. A consequence of this outcome is that the price gap- is supportive in forecasting future inflation. However the crucial conclusion is that the changes in money stock can influence the CPI and, thereby, the long run price level.

In the P-star model, prices follow the error-correction mechanism" (ECM) to adjust to the potential level. The P-star model is usually estimated as:

$$\Delta p_t = \alpha_0 + \alpha_1(p_{t-1} - p^*_{t-1}) + \sum_{i=1}^{n} \beta_i \Delta p_{t-1} + \epsilon_t \qquad 3.13$$

This is basically a constrained version of ECM.

The coefficient α_1 is the speed of adjustment of prices to P* and the coefficients of β_i represent the lag of the actual rate of inflation.

3.2: THE DATA

To estimate the inflation based on structural as well as time series models which were presented above, data on the following variables are needed: CPI price level, GDP, unit labor cost, money supply and tax rate. We use annual data from 1973 to 2007, Data are collected from IF and various issues of Federal Bureau of Statistics and SBP annual reports- see data appendix for details.

- GDP, measured at fixed factor cost.
- The price level, P, is measured by the consumer price index, Units: 2000=100 (SBP).
- ULC, (unit labor cost) is defined as whole economy labor wages and salaries paid (approximated) per unit of GDP at factor cost.
- Imports prices are defined as Tariff-adjusted import price index of merchandise imports.
- The variable TAX is the ratio of GDP at market prices to GDP at factor cost[15].
- The output gap, measures the deviation of the natural log of GDP from the natural log of trend GDP, where the latter is obtained using the Hodrick-Prescott filter (1997) with the smoothing parameter set to 100[16].

[15] Bowdler 2004 used tax as a proxy for informal taxes.

[16] (HP filter is a two sided linear filter that minimizes the variance of series y around the s (smooth series)). Also cite literature source explaining how this is used ot measure outpout gap. Its matlab code is available in appendix

CPI inflation is calculated as

$$\pi_t = 100 * (p_t - p_{t-1}) \qquad 3.14$$

Where p_t represents the log of price index in t.

All other variables and their growth rates are plotted in fig 3.2 vis-à-vis cpi. It is evident from the fig 3.2 that all variables show increasing trend except petrol prices (pet) over time – this suggests that pet is a significant determinant of cpi. Unit Labor Cost (ulc) increases less rapidly as compared to price. An increase in unit labor costs indicates that growth in average employee compensation exceeds growth in labor productivity, which may create pressure on producer prices. A moderate grow in ulc, implies that growth in nominal wage is just about in line with labor productivity. This is essential for preserving the competitive cost advantage of the economy. Import prices (ip) grows at faster pace relative to p, while pet first declines but then increases reducing the gap between two. The maximum gap difference can be observed from

Fig 3.2

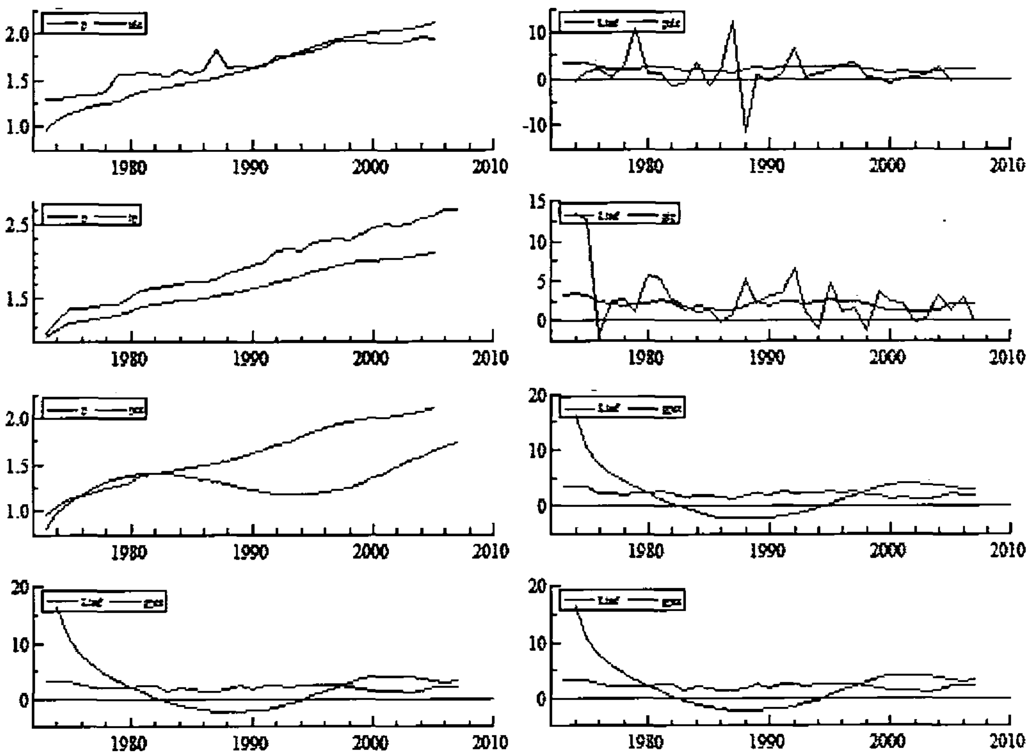
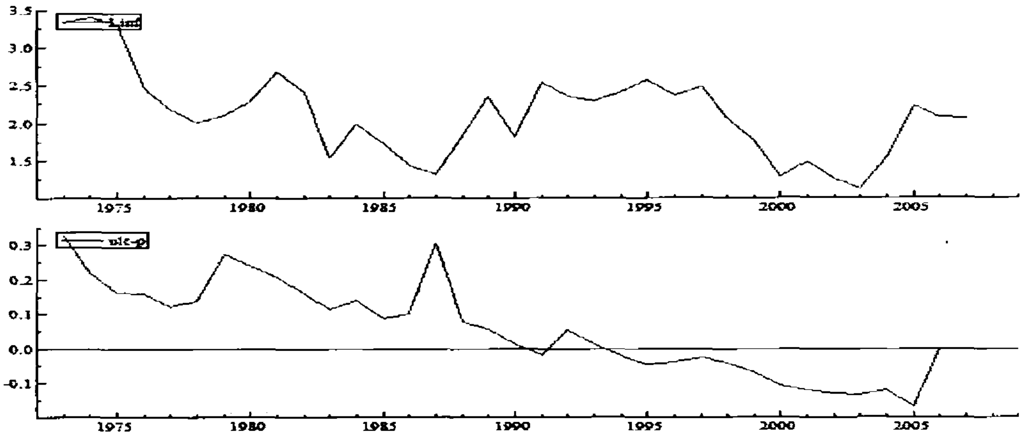


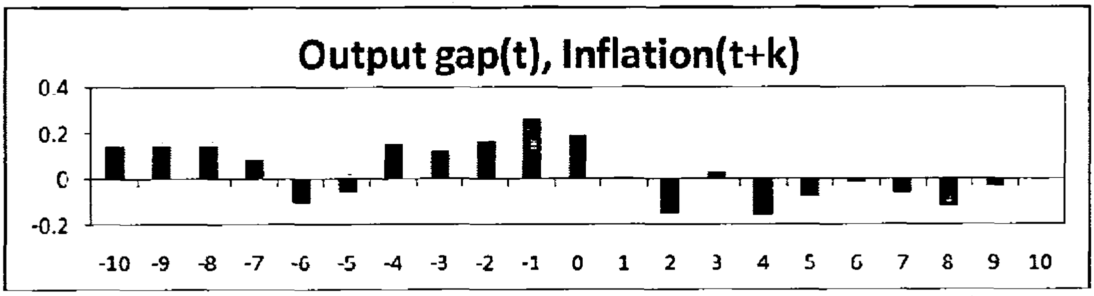
Fig 3.3 represents the first difference of the log CPI, Δpt, which is the measure of the annual inflation rate and log of real unit labor cost. A unit labor cost (ULC) characterizes a link between productivity and the labor cost in production. A negative slope of real unit labor cost indicates the technology growth.

Fig 3.3:



Output gap is another important variable. Fig 3.4 reflects dynamic cross correlation of current output gap with lag and leads of inflation rate. It indicates clearly, the current output gap co-moves negatively with future inflation and almost positively with lagged inflation. Note that this is the opposite of the Phillips curve relationship – high inflation (current & past) is generally associate positively with high output gap - low unemployment. For Future inflation rates we see a Phillips curve type relationship, suggesting that low unemployment in present leads to high inflation in the future.

Fig 3.4



In Phillips curve-like relationship:

$$\pi_t = \gamma k x_t + \beta E_t\{\pi_{t+1}\} \tag{3.15}$$

In particular, Eq. (3.15) implies that current change in inflation should depend negatively on the lagged output gap. To see, lag equation (3.15) one period; and then assume β=1, then

$$\pi_{t-1} = \gamma k x_{t-1} + \beta E_t\{\pi_t\} \ ;$$

$$\pi_{t-1} - \gamma k x_{t-1} - \beta E_t\{\pi_t\} = 0 \ ;$$

$$\pi_t = \pi_{t-1} - \gamma k x_{t-1} - \beta E_t\{\pi_t\} - \pi_t$$

Which implies ....

$$\pi_t = -\gamma k x_{t-1} + \pi_{t-1} + \epsilon_t \tag{3.16}$$

Where $\varepsilon_t = \pi_t - E_{t-1}(\pi_t)$ and x_{t-1} is an output gap. Estimating Eq. (3.6) with Pakistani data

$$\pi_t = -0.24 x_{t-1} + \pi_{t-1} + \epsilon_t \tag{3.17}$$

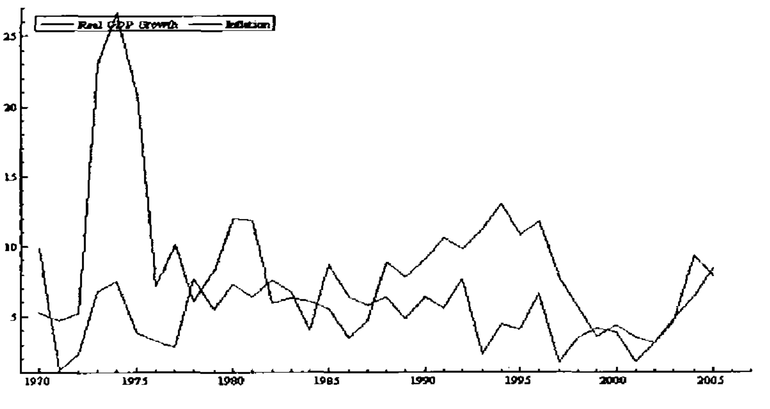
i.e the inflation rate depends negatively on the lagged output gap which is consistent with the theory.

Figure 3.1 plots real unit labor costs and real import prices. They are both moving in opposite directions.

3.2 a): An overview of Inflation and Growth

Sarel (1996), Andres & Hernando (1997) and Ghosh & Phillips (1998),Khan & Senhadji (2001) and Gokal (2004) amongst others does suggest a negative(weak) relationship between inflation and economic growth. However, as a motivation, visual examination is crucial to observe the relationship between these variables.

Fig 3.5 -Inflation and Real GDP Growth Rates, 1970-2005



The figure to some extent shows a negative relationship between inflation and output growth rates. As demonstrated, in seventies and nineties double digits where as the growth performance remained dismal.

Now to develop more precise relationship between these two variables, I divided whole sample into 12 ranges of inflation. In this range of inflation, we have calculated average GDP growth rates against each linear level of inflation.

Fig 3.6 Average GDP Growth and Inflation

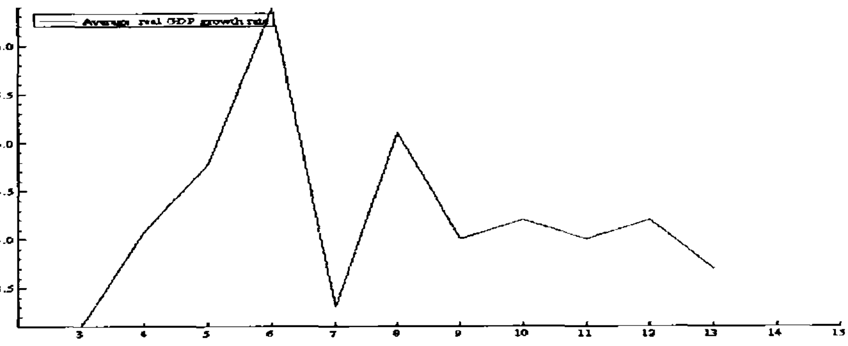
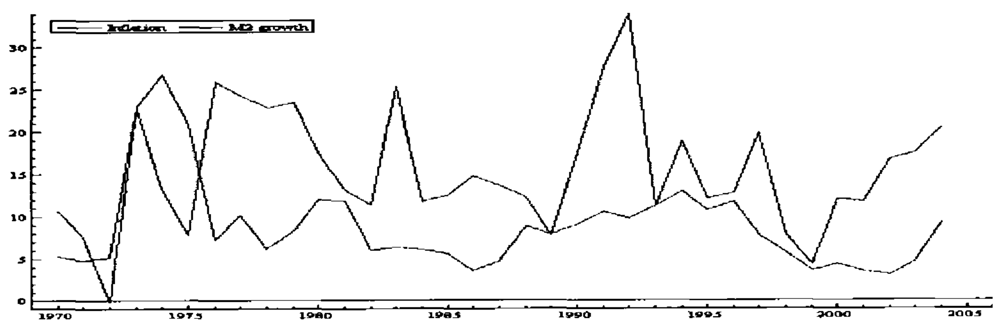


Figure 3.6 shows that GDP growth and inflation have almost positive relationship up to 6 percent inflation; and beyond that level there is a no relationship[17]. This simple analysis suggests that High inflation has a negative effect on economic growth, while low inflation is good.

Fig 3.7: Inflation and Money Growth



The figure shows a positive relationship between inflation and out money growth rates.

[17] For more detailed analysis see Mubarik -2005

Average money Growth and Inflation

Again to get little insight, I divided whole sample into 12 ranges of inflation. Within this band of inflation, average money growth rates are calculated against each linear level of inflation.

Fig 3.7

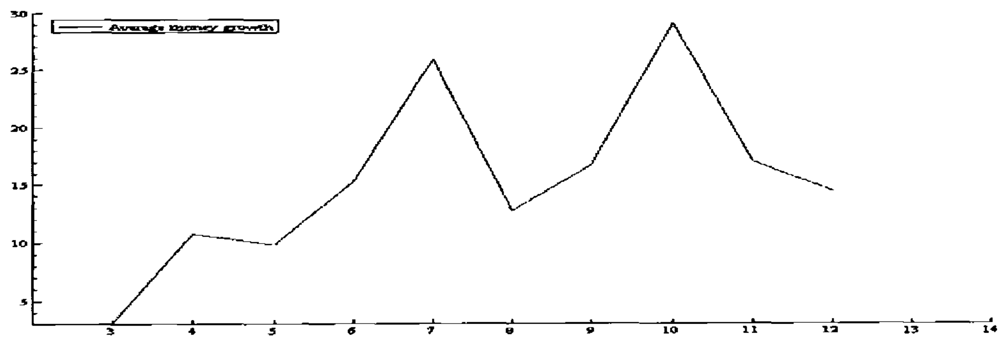


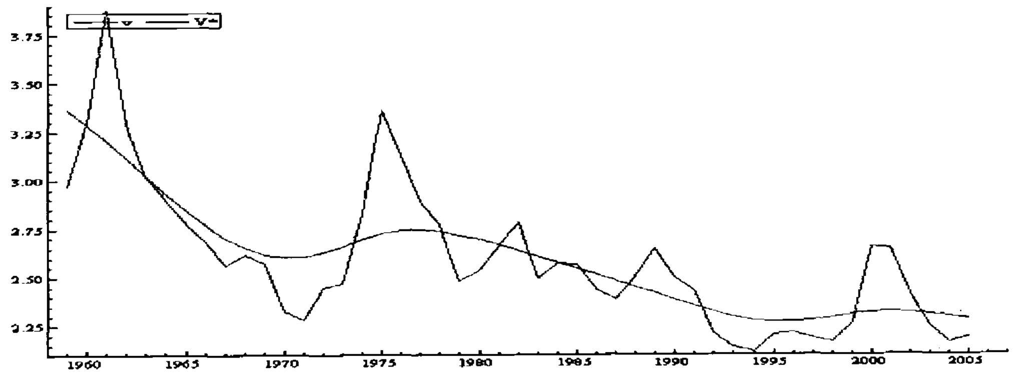
Figure shows that broad money growth rates and inflation have strong positive relationship.

Trends in inflation, money growth and the real GDP growth during 1960-2005 are presented in fig1. Average rate of inflation, money growth, real GDP growth, and velocity of money is presented below.

Table 3.1 Trends in economic indicators

	Money growth	CPI inflation	Real GDP(MP) growth	Velocity	Velocity growth
1973-1979	20.08	14.8831	6.57	3.20	0.05
1980-1989	14.04574	7.26489	5. 2	3.0243	-1.64
1990-1999	16.32928	9.71730	3.99	2.67	0.172
2000-2007	14.80780	5.03754	5.2	2.31	0.684

The following figure depicts that velocity of money has downward trend which is calculated by HP filter. Researchers (for example Qayyum-2006) believe that changes structure of financial sector and process of monetization in Pakistan is mainly responsible for fluctuation and downward trend in the income velocity of money.



3.3: THEORETICAL MODELS

3.3 a) Model based on Quantity Theory of Money

First we try to estimate a structural model based upon the Quantity theory of money. Its econometric counterpart was given in equation (3.4) which is

$$g_p = \beta_0 + \beta_m g_m + \beta_v g_v + \beta_y g_y + \vartheta \qquad 3.4$$

As we know that if the variables are not stationary the inferences driven from it would yield spurious results. So before estimating the equation all variables are tested for stationarity. Phillips-Perron unit root test indicates that all variables used in equation (3.4) are stationary. Their values are given in table 3.2

Table 3.2 Phillips-Perron unit root test

	Phillips-Perron-t statistics	p-value
Gp	-2.95	0.0498
Gv	-4.82	0.004
gm	-4.367	0.0015
Gy	-3.82	0.0062

Therefore these variables can be used for estimation. We estimated the equation applying the general to specific methodology on auto-regressive distributive lag frame via PC Gets to capture long run and short run effects. The final equation is as under

$$\inf_t = -0.90g_{yt} + 0.71g_{vt} + 0.53g_{mt} + 0.37g_{mt-1} + 0.36g_{vt-1} + \mu_t \qquad 3.18$$

(SE) (0.144) (0.071) (0. 077) (0.06) (0.05)

R^2 = 0.90, Adjusted R^2 = 0.88, Sum of square residuals = 62.62,

Jarque Bera = 0.77, White Hetroskedasticity test =0.91, SC=1.4,

ARCH test = 0.14, Breusch-Godfrey Serial correlation LM test =0.49,

Chow(85:1)= 0.69 , Chow(2001:1)= 0.25,

We applied battery of tests on above equation (3.18) and it passed almost all the tests. Residuals are normally distributed. Tests fail to reject the homoscedastic assumption of residuals. Breusch-Godfrey Serial correlation showed that there is no evidence of serial correlation in the residuals. We found no evidence of structural break.

Solving equation (3.18) for long run equilibrium, we will get

$$\inf = -1.19g_y + 1.086g_v + 0.9893g_m + \mu_t \qquad 3.19$$

The signs of coefficients of growth of money, growth of output and growth of velocity the Equation (3.19) are in conformity with the QTM. These indicate one to one correspondence between inflation and growths of velocity, money and income. The finding that the growth of money and inflation has one to one correspondence in the long run is consistent with the literature as well as the theory (QTM) which says that money is the main driver of inflation. For example Qayyum (2006) finds that in long run coefficient of growth of money is equal to 1.09 which is very close to results presented in equation (3.19).

Dwyer and Hafer (1988) studied the relationship between money growth and inflation for 62 countries and McCandless and Weber (1995) for 110 countries and found the strong positive correlation between these variables. It ranges from [.89 .95]. It supports the Monetarists point of view who believe that the inflation is always and every where a monetary phenomenon. Strong negative relation between inflation and output growth is not evident from most of the previous studies. For example McCandless and Weber (1995) find very weak correlation ranges from [-.10 -.34] between inflation and output growth for 110 countries. However Kormendi and Meguire (1985), Ericsson, Irons, and Tryon (1993), and Barro (1995) believe in negative relation and Qayyum (2006) believes in strong negative relationship between these variables. Equation 3.21 also shows strong negative relationship between these variables. These differences show that the true relationship between inflation and output growth in west is *"still uncertain"*. So this needs detailed analysis. In analysis of inflation and output growth in section 3.2a we find that GDP growth and inflation have almost positive relationship up to 6 percent inflation; and beyond that level there is a negative relationship. This simple analysis suggests that High inflation has a negative effect on economic growth, while low inflation is good. This is consistent with the results of Mubarik (2005).

3.3 b) P-star model

Secondly we try to estimate equation (3.13).

$$\Delta p_t = \alpha_0 + \alpha_1 (p_{t-1} - p^*_{t-1}) + \sum_{i=1}^{n} \beta_i \Delta p_{t-1} + \epsilon_t \qquad 3.13$$

In this regard we first calculated the ADF that is reported in the table 3.3.

Table 3.3 Augmented Dickey-Fuller unit root test for variables of P-star model

Augmented Dickey-Fuller				
Variables	Test statistics	lag	t	p-value
Log(V)	Constant	1	-2.6	0.1
Δlog(V)	Non	0	-4.6	0.00
Log(pstar)	Constant+intercept	0	-2.3	0.38
ΔLog(pstar)	Constant	0	-5.45	0.001
Log(p)	Constant+Intercept	1	-3.4	0.064
ΔLog(p)	Constant	1	-4.48	0.00
pstar inflation	Constant	1	-4.414	0.003

Table 3.3 reveals that velocity of money is not stationary but its difference is stationary which violates the basic assumption of Hallman, et al. (1989) which supposes "that velocity of money is stationary and long run equilibrium can be obtained by simple average". So we cannot calculate the long run equilibrium by simple average. We calculated the long run equilibrium of V by HP filter[18].

Next we tested the important assumption of the theory that there exist long run relationship between p and p*, this relation is one to one.

[18] The program of Hp filter is available in Appendix. It is a two- sided linear filter used as a mathematical tool for separating cyclic component of a series. Detail is available in http://en.wikipedia.org/wiki/Hodrick-Prescott_filter

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.408043	24.60775	20.26184	0.0118
At most 1	0.236222	8.353806	9.164546	0.0711
Trace test indicates 1 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

Trace test indicates one cointegrating equation and that is

$$p = 1.01p^{*} - 0.04 \quad 3.20$$

This establishes a long run relationship between p and p^{*}. Next we will estimate error correction model define in equation (3.13) using the general to simple approach. To show that it is an adequate model we will apply a battery of test on it.

$$dp_t = 0.91dp_{t-1} - 0.19 * e \quad 3.21$$

Equation (3.21) passes all the specification tests. e is equilibrium correction term. Magnitude of coefficient is small which indicates the slow (20%) speed of adjustment towards long run equilibrium. This is little bit low (7%) as compare to Qayyum and Bilquees (2005). It could be due to change of

Here e is significant which depict that P-star inflation causes the future inflation. If the today's actual prices are higher than the potential prices it will cause deflation tomorrow. Results are in conformity with Qayyum and Bilquees (2005). We will show later that this equation can be encompassed by our final model. This means that effects of P* are screened by the variables in our model. P* does not directly effect equilibrium but only through the variables included in our final model. In the above equations, significance of P* arises only because factors which directly affect inflation have been omitted.

3.3 c) Structural model

To estimate the structural model presented in equation (3.9) we first apply the ADF test on the variables.

Table 3.4 Augmented Dickey-Fuller unit root test for variables of structural model

Null Order	P	m	ip	og
I(1)	-2.93	-1.24	-1.09	-3.15*
	(-0.18)	(-0.03)	(-0.0004)	(-0..35)
I(2)	-2.69**	-5.4**	-6.36**	-5.8**
	(-0.16)	(-0.8)	(-0.78)	(-0.01)

It is evident from table 3.4 that ADF test for unit root can't be rejected for any of above variables at 1% critical values. So we use the difference of the variables in the regression analysis. We estimate equation (3.9) by General to specific methodology. We started with maximum of four lags of inflation, as our data is annual and applying methodology similar to section 4.

The final parsimonious model for equation (3.9) is

$$\pi_t = 0.92gm_t + 0.46\pi_{t-1} + 0.05gImp_t + \epsilon_t \qquad 3.22$$

R^2 = 0.73, Adjusted R^2 = 0.71, Sum of square residuals = 14.87,

Jarque Bera = 0.43, White Hetroskedasticity test =0.91, SC=1.4,

ARCH test = 0.29, Breusch-Godfrey Serial correlation LM test =0.44

Chow(2001:1)= 0.75,

We estimate this model for Pakistan first time so that we can check whether our final model (develop in chapter 4) encompass theory based model along others discussed in this chapter. Signs of coefficient are almost similar to those of Moshiri (1997). We found in chapter 5 that our final model developed in chapter 4 encompasses(but not encompassed by) this model.

3.4: BAYESIAN VECTOR AUTOREGRESSIVE (BVAR) ESTIMATES FOR INFLATION MODELS

Bayesian approach is based on prior parametric assumptions. It was first proposed by Litterman (1986). Commonly Vector autoregression (VAR) is used as an alternative to structural macroeconomic models however; the problem of VAR is that there are too many parameters and they are estimated very imprecisely; this can be fixed by Bayesian techniques. Doan et al (1984) attempted to improve the performance of VARs (unrestricted). They believe that VARS can be estimated using Bayesian techniques which incorporates any prior information which available to the researcher. Here we will employ the empirical Bayesian approach to the estimation of vector (VARs).

Bayesian Vector Autoregression statistics

The most common prior used by Doan et al (1984) is known as Litterman or Minnesota prior for non stationary variables of **n** dimensional VAR model. The most common prior assumption is

$$X_t = a + X_{t-1} + \vartheta_t \qquad 3.23$$

Where ϑ is a white noise error.

i.e. Behaviour of each variables is a random walk with drift.

The Minnesota or Litterman prior for the coefficients are as follows

$$\beta_i \sim (1, \alpha); \quad i = 1$$

$$\beta_i \sim (0, \gamma/i); \quad i = 1,2$$

$$\beta_j \sim \left(0, \frac{\left(\frac{\gamma}{d}\right)\varphi\hat{\sigma}_i}{\sigma_i}\right); \quad j = 1,2$$

According to this specification, β_i the coefficient of lag of the dependent variable has mean one and variance equal to γ. Here γ estimates the tightness of the lags of CPI inflation. The prior distributional mean of all other coefficients are equal to zero. β_2 represents the coefficient of lag of order two of the dependent variable. The SD of the prior distribution can be calculated for the coefficient of variable j on lag d in equation i as:

$$sd_{ij}^{d} = \frac{\gamma}{d}, \quad ; if\ i = j$$

$$sd_{ij}^{d} = \frac{\left(\frac{\gamma}{d}\right)\varphi\hat{\sigma}_i}{\sigma_i}, \quad ; if\ i \neq j \qquad 3.24$$

where γ and φ captures the tightness of the lags on dependent variables and other variable respectively. $\hat{\sigma}_i$ is SE of residual of AR model of variable i. The factor $\frac{\hat{\sigma}_i}{\sigma_i}$, shows that the prior cannot be specified without the information of the data. This factor corrects the tightness of SD of dependent variable coefficients with that of the other variables.

We selected the Litterman (1987) prior for the prior distribution of coefficients and the values of γ and φ are set equal to 0.2.

The Bayesian approach is commonly used in forecasting economic time series. Using equation (3.9) we will estimate a VAR model for inflation, output gap, import prices and growth of real money by Bayesian technique[19]. Using specification given in above, the VAR model is given as.

Table 3.5 Results of VAR model estimated by Bayesian technique

Variable		Coefficient	t-statistic	t-probability
Growth of money	lagl	-0.002	-0.050	0.961
Growth of money	lag2	0.062	1.338	0.191
Inflation	lag1	0.485	2.937	0.006
Inflation	lag2	-0.027	-0.207	0.838
Import price inflation	lag1	-0.056	-0.304	0.763
Import price inflation	lag2	-0.051	-0.299	0.767
Output gap	lag1	-0.225	-0.887	0.382
Output gap	lag2	-0.378	-1.462	0.154
Constant		0.030	2.662	0.013

R^2= 0.60

This appears to be the first time a VAR model has been estimated on the basis of Bayesian technique for Pakistan. We develop and estimate this a-theoretical model to full fill our main objective to test the encompassing capability, of general model develop in chapter 4, to both theoretical and a-theoretical model. Sign are

[19] Similar approach is discussed by Moshiri, S. (1997)

inconformity with literature[20]. Our final model developed in chapter4 encompasses (but not encompassed by) VAR model estimated by Bayesian technique.

3.5 Forecasting

Forecasting is the procedure of making statement regarding future events. Econometric forecasting permits researchers to assess past trends in data and forecast how current economic changes will alter, ceteris paribus, the outline of past trends. To assess the relative performance of the models we will compare the forecasts accuracy of the above estimated models.

3.5.1 Plan for forecasting

We used recursive forecasting strategy here because it utilizes all available information. Here data is divided into two parts: 1973 to 2000 and 2001 to 2007. First all models are estimated using the first group of data i.e.1973:2000 and after that forecasting is done for 2001. Then we re-estimated the models from 1973: 2001 and obtained forecasts for 2002. This procedure continued till 2007. For each model two types of forecasts are obtained 1) Static and 2) Dynamic. In static forecasts we use actual values of the lag of dependent variable while in dynamic we use forecast values of the lag of dependent variable for forecasting.

3.5.2 Measure of forecasting results

To evaluate the relative performance of forecast outcome we will use Root Mean Square Error (RMSE) which can be define as

[20] See Moshiri, S. (1997)

$$RMSE = \sqrt{\frac{\sum_{t=1}^{T}(y_t - \hat{y}_t)^2}{T}} \qquad 3.25$$

Here y_t represents the actual value and $\hat{y}_t$ represents the forecast values of dependent variable.

The RMSE of forecast for above models are given in table 3.4.

Table 3.6 Forecast RMSE

Models	RMSE -Static	RMSE-Dynamic
Structural equation	0.46	0.6
QTM	1.6	1.6
P-star	0.174	0.172
BVAR	0.15	0.13

Table 3.4 shows that the VAR estimated by Bayesian technique has lowest RMSE both in static as well as in dynamic forecasting. So BVAR clearly outperform the structural models in forecasting. P-Star model has the second lowest RMSE errors in both forecasting techniques. In chapter 4, we will measure forecast performance of the models with a bench mark model on the basis of root mean square error. On the basis of this test we will see that our final model provides better forecast performance than all of these models proposed in the literature earlier.

CHAPTER 4

A GENERAL DYNAMIC MODEL FOR INFLATION FOR PAKISTAN

In the era of high inflation and commitment of SBP to pull it down and preserve low stable inflation in Pakistan, there is a vital need to understand inflation dynamics. The existing models for inflation in Pakistan provide only a partial explanation of CPI behavior[21]. So there is dire need to develop a general model, which helps in pointing out the true drivers of inflation in our economy. These drivers will improve and broaden our understanding and vision about the behavior of inflation and may set a road map for the state bank for designing future policies to preserve stable low inflation in Pakistan. This chapter is devoted to develop a general parsimonious empirical model for the Pakistan's consumer price index (CPI) that encapsulate several existing empirically evaluated structural macroeconomic models of inflation and tests the restrictions. We will use general to specific approach for model specification. . Following the literature[22] the basic economic theory that is used to develop the empirical model is a mark-up model for prices, but the resulting empirical model also incorporates Hybrid new Keynesian Phillips curve .The empirical model explains the relative importance of drivers of consumer price inflation.

[21]. *See detail in 1st chapter*

22 Christopher and Jansen, A Markup model of inflation for the Euro area

4.1: ATHEORETICAL STRUCTURE

Different theoretical models for inflation have been tested in Pakistan by different empirical economists but a general representation is missing in these models. This study is an attempt to fill this gap. We in this study use a price mark up model which is more general as it embeds several other well known models. The essence of price mark up model is that the domestic general price level is set as a mark-up on a function of input costs in the equilibrium. In literature unit labor costs, import prices, taxes and energy prices are used as input costs [De Brouwer and Ericsson (1998), Aron and Muellbauer (2000), Hendry (2001) and Bowdler (2004)].

Since Duesenberry (1950), "Price mark-up model" has been used in economics [see Franz and Gordon (1993), De Brouwer and Ericsson (1995), Bowdler and Eilev (2004) and Heino and Christopher (2006)]. We follow the major features of a markup model for the CPI from the description in de Brouwer and Ericsson (1995). In the equilibrium, with the assumption of linear homogeneity, the mark up equation for the domestic consumer price level can be written as:

$$P = \mu.(ULC^{\gamma}).(IP^{\delta}).(PET^{k}).(TAX^{\tau}) \qquad (4.1)$$

Where P represents the underlying consumer price index, ULC is an index of the nominal cost of labor per unit of output, IP is an index of import prices in domestic currency, PET is an index of petrol prices in domestic currency, the variable TAX is the ratio of GDP at market prices to GDP at factor cost. and trend is time trend. While γ, δ and κ are elasticities of the CPI with respect to ULC, IP and PET respectively and are assumed to be positive. The value of μ□ is mark-up over costs.

Equation (4.1) can be obtained from a profit maximizing model with Cobb-Douglas production function[23].

The log-linear representation of (4.1) is as follows:

$$p = \ln(\mu) + \gamma.ulc + \delta.ip + k.pet \ + \tau.tax \qquad (4.2)$$

Where lower case variables represent logs of corresponding upper case variables

Here we assume that CPI is linear homogeneous in input costs i.e

$$\gamma + \delta + k = 1 \qquad (4.3)$$

If above restriction is found to be compatible with the data then deviations of the price level from steady-state can be written as the sum of a constant and a weighted average of three relative price terms, i.e.

Deviation from a steady state $= \ln(\mu) + \gamma(ulc - p) + \delta(ip - p) + k(pet - p -)$ (4.4)

These relative price terms measure the distance between the price level at time t and its steady-state value and hence define the scope for equilibrium correction effects to set the inflation rate. Additionally, through the term (ip-p)[24], (4.4) clarifies how the hypothesis of purchasing power parity is embedded in the mark-up model in (4.1). As discussed later, the empirical implementation also has ties to the Phillips curve by

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[23] *The mark-up and costs may vary over the cycle.*

24 PPP hypothesis can be defined as $e_t = p_{1,t} - p^*_{1,t}$, where e_t is the domestic currency price of a unit of foreign exchange at time t and $p_{1,t}$ is the logarithm of an index of traded goods prices at time t and $p^*_{1,t}$ denotes the foreign tradable good prices. The analogue econometric equation is $e_t = \gamma p_{1,t} + \gamma^* p^*_{1,t} + \varepsilon_t$

allowing the mark-up μ-1□ to depend upon the output gap. Large gap means high unemployment – if the coefficient is negative this would lead to low inflation and support Phillips curve. (for more discussion see-Golden De Brouwer-1998).

4.2 STATISTICAL ANALYSIS

Analysis of the time series properties of the data is pre requisite for identification of econometric techniques to be used for empirical analysis. These include unit root test, cointegration, exogeneity, homogeneity etc. In this section we analyze the properties. Before estimating the model, it is useful to determine the order of integration of the variables of interests i,e CPI, Unit labor cost , Import prices, tax and gasoline prices.

4.2a Testing for Unit Root

First step to check the time series properties is unit root test. In literature different unit root tests have been used to check the stationarity for example augmented Dickey–Fuller test, Philips-Perron test, Ng-Perron test, Kwaitkowaski-Phillips-Schmidt-Shin test etc. An augmented Dickey–Fuller test (ADF) is a test for a unit root in a time series sample. For a variable x_t, the augmented Dickey-Fuller (1981) statistic ADF(k) is the t ratio on π from the regression

$$\Delta x_t = \pi x_{t-1} + \sum_{i=1}^{k} \theta_i \Delta x_{t-1} + \gamma + \alpha t \qquad 4.5$$

The results of ADF and PP test unit root tests are given in the table 4.1a and 4.1b respectively.

Table 4.1a: ADF Statistics for the variables of mark up model

Null Order	P	ulc	ip	pet	t
I(1)	-2.93	-1.38	-1.09	-0.4	-3.20*
	(-0.18)	(-0.188)	(-0.0004)	(-0.001)	-0.033
I(2)	-2.69**	-3.62**	-6.36**	-5.9**	-4.524**
	(-0.16)	(-1.3)	(-0.78)	(-0.02)	-0.9808

Table 4.1b Philips Peron unit root test Statistics for mark up model

Null Order	P	ulc	ip	pet	t
I(1)	-5.25	-2.02	-1.83	-1.89	-3.86*
	(0.02)	(-0.22)	(-0.02)	(-0.07)	-0.22
I(2)	-2.62**	-6.25**	-10.42**	-3.08**	-4.188**
	(-0.14)	(-1.00)	(-0.998)	(-0.15)	-0.47

Note * and ** denote rejection at the 5% and 1% critical values.

For each null order of unit root, we reported two values of each variable...1) the t statistic of ADF (lag length selection is automatic based on SIC, Maxlag=8) in table 3.1a and PP for 3.1b and.... 2) (in parentheses) the estimated coefficient on the lagged variable x_{t-1} for each statistics.

Empirically, all variables appear to be integrated of order one at 5% critical value. The critical values for this table are calculated from MacKinnon (1996). Thus, all four price series are treated below as if they are I(1).

4.2b cointegration

4.2b1 Testing for Lag length

For cointegration analysis first we need to specify the lag length of the unrestricted VAR model. Keeping in view that we have an annual data we started with the unrestricted VAR (2) to specify the lag length. The variables of VAR (2) are p, ulc, pet, ip and indirect taxies. Table 4.2 reports different statistics for the maximum lag selection[25].

Table 4.2 various statistics for maximum lag selection

Sample: 1973 2007 , Included observations: 35						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	237.1807	NA	1.30e-13	-15.47871	-15.24518	-15.40400
1	300.1507	100.7520	1.07e-14	-18.01005	-16.60885	-17.56179
2	359.4282	75.08488*	1.26e-15*	-20.29522	-17.72635*	-19.47342
3	383.9373	22.87515	2.02e-15	-20.26249	-16.52596	-19.06714
4	426.6238	25.61188	1.79e-15	-21.44159*	-16.53740	-19.87269*
* indicates lag order selected by the criterion						
LR: sequential modified LR test statistic (each test at 5% level)						
AIC: Akaike information criterion				FPE: Final prediction error		
HQ: Hannan-Quinn information criterion				SC: Schwarz information criterion		

From the above table we observe that the magnitudes of Final prediction error and Schwarz information criterion statistics have minimum values at lag length 2. LR test also specifies the optimal lag length 2. AIC and HQ do not support this result. But Majority of tests statistics in table 4.2 show that the optimal lag length is two. This

[25] All the criteria are discussed in Lütkepohl (1991, Section 4.3).

also supported by intuition because we have annual data. Therefore we will use the VAR (2) for further analysis.

4.2b2 Testing for Co integrating Rank

After the selection of lag length of the unrestricted VAR model and confirmation that all series are integrated of order one, next step is to see whether these series are integrated or not?

From table 4.1 we find that time series p,ulc, ip and pet contain a unit root so they are non stationary series. According to Engle and Granger (1987) there is a possibility that linear combination of non-stationary series may yield a stationary series. Such linear combination is known as cointegrating equation and may be interpreted as a long-run equilibrium relationship among the variables. Policy makers are always interested in long run relationship among the variables.

To find such linear combination we use VAR (2) to calculate unrestricted co integration rank test and maximum eigenvalue tests.

Table 4.3 Unrestricted Cointegration Rank Test (Trace)			
Hypothesized No. of CE(s)	Trace Statistic	0.05 Critical Value	Prob.**
None *	139.5028	88.80380	0.0000
At most 1 *	82.43947	63.87610	0.0006
At most 2 *	46.05235	42.91525	0.0235
At most 3	25.47842	25.87211	0.0559
At most 4	6.987303	12.51798	0.3458
* denotes rejection of the hypothesis at the 0.05 level			
**MacKinnon-Haug-Michelis (1999) p-values			

In table 4.3 we computed trace statistics. In this statistics null hypothesis suppose r cointegration relationship. This is LR test. Trace test indicates 2 cointegrating eqn(s) at the 1% level

Table 4.4 Unrestricted Cointegration Rank Test (Maximum Eigenvalue)			
Hypothesized No. of CE(s)	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	57.06328	38.33101	0.0001
At most 1 *	36.38713	32.11832	0.0141
At most 2	20.57393	25.82321	0.2119
At most 3	18.49111	19.38704	0.0671
At most 4	6.987303	12.51798	0.3458
Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 1% level			
* denotes rejection of the hypothesis at the 0.05 level			
**MacKinnon-Haug-Michelis (1999) p-values			

Unrestricted cointegration rank test (trace) indicates 1 co integrating eqn(s) at the 1% level.

Similarly Max-eigenvalue test (trace test) indicates 3 cointegrating eqn(s) at the 0.05 level and two co integration equations at 0.01 levels. We will use only one cointegration equation here because of two reasons 1) the sample size is small and 2) we have no economic explanation of other two results[26].The normalized co integration equation with respect to of cpi is as follows

$$p_t = 0.367pet_t + 0.50ip_t + 0.125ulc_t + 0.076tax_t + \log(\epsilon_t) \qquad 4.6a$$

[26] For detail discussion See Gorden De Brouwer (1995)

4.3 Discussion on signs of the coefficients

After estimating empirically a long run relationship between cpi prices and pet, ulc,ip and tax now we turn to the built in restrictions of the model. In the model specification, it was hypothesized that elasticities of the consumer price index with respect to ULC, IP and PET are γ, δ and κ, respectively, to be greater than or equal to zero. In equation (4.6) coefficients have expected signs. They are all greater than zero.

4.4 Testing for Long run unit homogeneity

Model imposes another restriction on the coefficients so called linear unit homogeneity condition i.e sum of elasticities of the consumer price index with respect to ULC, IP and PET are γ, δ and κ, respectively must equal to one.

In equation (4.6) the sum of coefficients is (0.992) which is closed to one. Statistically we can check the long run unit homogeneity of variables using Wald test

The Wald test statistic for null hypothesis H_3: $K'\beta = 0$ versus H_2: $\pi = \alpha\beta$ for r=1 (number of restrictions) is given by

$$\omega = T^{\frac{1}{2}} K^{*\prime} \hat{\beta}_1^* / \{(\hat{\lambda}_1^{*-1} - 1)(\sum_{i=2}^{4} (K^{*\prime} \hat{v}_i^*)^2)\}^{1/2}$$

Where $\hat{\lambda}_i (H_i)$ shows the eigenvalue and $\hat{v}_i^*$ represents the corresponding eigenvectors. ω is asymptotically Gaussian with mean 0 and variance 1.. The statistic can easily be calculated by table 3.5, $\omega = 0.06$.Normsdist((0.06) = 0.54. Thus the hypothesis of sum of elasticities equal to one in long run statistically cannot be rejected.[27]

If we impose long run homogeneity restriction on equation (4.6) we get

$$p_t = 0.3676pet_t + 0.5002ip_t + 0.1251ulc_t + 0.0763tax_t \quad + \log(\epsilon_t) \qquad 4.7$$

Table 4.5

	Comp 1	Comp 2	Comp 3	Comp 4	Comp 5
Eigenvalue	0.732	0.650	0.144	0.010	0.004
	Eigenvectors				
Variables	Vector 1	Vector 2	Vector 3	Vector 4	Vector 5
P	-0.481	0.145	0.275	0.461	0.677
Tax	-0.479	0.138	0.347	-0.793	0.029
Ulc	0.456	-0.166	0.869	0.074	-0.044
Ip	-0.480	0.178	0.215	0.389	-0.733
Pet	-0.314	-0.948	-0.018	0.015	-0.022

[27] (see Soren Johansen (1989) for more discussion)

4.5 TESTING FOR FEEDBACK EFFECT.

From above trace tests and eigenvalue tests we can conclude that there exists a cointegration relation among the variables. That relation is available in equation (4.7). Such Cointegration relationship by itself neither entails which variable do not adjust to "previous disequilibria" nor it talks about speed of adjustment. These features are very important for policy implications. So there is need to explore them. We can find such features in Unrestricted Adjustment Coefficients (alpha). It measures feedback (response) effect of previous (lagged) disequilibria in cointegration relationship onto the variables of VAR. The results of this test are given in table 4.6 below. Here for example 0.000195 is feedback effect of CPI equation which shows that excess markup increases inflation. The small numerical values indicate slow adjustment to previous (lagged) disequilibria.

Table 4.6 Unrestricted Adjustment Coefficients (alpha)

D(P)	0.000	-0.017	-0.005	-0.006	-0.001
D(IP)	-0.008	-0.009	-0.026	-0.001	0.007
D(OP)	-0.007	-0.001	0.001	0.000	0.000
D(U)	0.019	0.150	0.003	-0.108	-0.024
D(T)	0.109	-0.035	-0.002	-0.025	0.104

4.7 Testing for weak Exogeneity

4.6a Investigation of individual weak exogeneity

One of the problems, while estimating models with VAR or VECM technique is the identification of a large number of parameters of VAR or VECM. In each equation we need to estimate m × k lag coefficients. Even for reasonable moderate values of m and k we need large sample for econometric research. One approach to deal with the dimensionality problem is to test and impose weak exogeneity assumptions. Pierre (1992) prove in his study (Proposition -2) that exogeneity is a sufficient condition for cointegrating VAR or VECM, if the parameters of interest are both the long run and short run coefficients. Therefore it is very important to test the weak exogeneity of the variables. Process of testing weak exogeneity is as follows.

In VECM, the i^{th} endogenous variable with respect to β is supposed to be weakly exogenous if i^{th} row of adjustment coefficient α matrix is all zero[28]. In the case when $\alpha = 0$ it simply means that cointegrating relationship will not feed back onto the associative variable. Following the strategy of Johansen (1992b), we examine the null hypothesis, $H_0: \alpha_x = 0$ for each contestant exogenous variable and from table 4.5 we find that unit labor cost, import prices, oil prices and taxes are all individually weak exogenous.

Table 4.7: Chi square test for weak exogeneity

	P	ulc	ip	pet	tax
$\chi^2(1)$	57.11**	0.22	0.01	2.68	3.19
P value	[00]	[0.63]	[0.89]	[0.10]	[0.08]

[28] See Johansen (1992b) for the definition and other results of weak exogeneity

4.6b Investigation of Joint weak exogeneity

When we test the joint weak exogeneity of ulc, ip and tax the corresponding test result is $\chi^2(3) = 1.476$ [0.68] (In parenthesis we have p value of chi square). Which shows that collectivity these variables is exogenous. These variables are also appear weak exogenous when tested along with homogeneity condition: $\chi^2(3) = 1.90$ [0.59]. These results to some extent fortify theoretical underpinnings of macroeconomic variables for Pakistan. Imports and oil prices are set independently of domestic prices. Similarly unit labor cost is not indexed to inflation in Pakistan.

In view of weak exogeneity results one can easily conclude that the cointegrating vector and the feedback coefficients enter only the CPI equation. So there is no need to take these variables on the left side of the VECM which means we need a single equation. It simply implies that without any loss of information, from conditional model of cpi we can infer about the parameters of these variables. This is the beauty of weak exogeneity that it allows a simpler modeling strategy. [29]

4.7 Strategy for Choosing a Dynamic Specification

So for we were discussing the time series properties of dependent and independent variables, now we move to the next step in which we try to built the econometric model. In this regard we will have to focus simultaneously on two different but important things. On one hand we try to capture temporal aspects of economic agents by statistical specification. Attaining such statistical specification that, to some extent,

[29] For detail discussion Jean-Pierre Urbain-1992.

reliably explains the economic dynamics (lag/lead effects) is a difficult task. It needs a good deal of attention in field of theoretical and empirical behavior of individual time series and the structural relationship that may exist among them. We have good deal of literature in the field of model specification but unfortunately analysts have spent little time familiarizing themselves with the kinds/types of dynamic specifications that are relevant for the most economic data.[30] We always face the problems of interpretation, or problems of relating econometrics and economics. For this purpose we need to specify the exact form of the model. Suppose we are studying dynamic model. Which model should we use among ADL or ECM or GECM or Barden ECM etc .Observe all these models are isomorphic. Here our choice depends upon interpretation. For more discussion about the topic see Boef-2005

And on the second hand we will focus on form of the isomorphic models.

In a time series modeling we might encounter with two types of effects

1) An exogenous variable may only affect the outcome variable in short term. This can occur at any lag but it does not persist in future. Here effect of exogenous variable on outcome has no memory.

2) An exogenous variable may affect the outcome variable in short term as well as in long term. This effect can persist for few or possibly many future time periods. How many periods this effect will persist is a natural question. Data and economic theory can only answer this question.

[30] Specification screech-Kevin D Hooder -1999, similarly David F Hendry developed a software that deals the model specification known as PcGets etc

Here we need a specification that may capture both short run and long run effects. Since dynamic specification has ability to estimate and test both type of effects. We try to develop such a highly general but parsimonious dynamic model that may encompass possible temporal effects. For this purpose the general model we will use is an auto regressive distributive lag model. The ADL model is the pivotal point of all dynamic regressions. ADL have many properties that we can exploit for smooth economical interpretation of the model. From ADL one can easily derive

the long run solutions e.g long run multipliers, long term equilibrium, mean/median lag lengths etc Economists have special interest in these solutions.

ADL has power to encompass the models in level as well as in difference.

ADL is isomorphic to Error Correction Models (ECMs) and consequently contain the same information. As a result ECM can be used for analysis of same underlying dynamics. (For details see Suzanna De Boef-2005). Nevertheless, ECMs permit opportunity for testing long run effects which are of special interest.

4.7a ADL Model

With given variables in annual frequency second order ADL model may be a natural starting point for single equation inflation modeling. As proposed by Brouwer(1995) out put gap(og) is include to measure the fluctuation in mark up. I extended Brouwer (1995) by including tax (the ratio of GDP at market prices to GDP at factor cost) as a explanatory variable which is recommended by different researchers like Bowdler(2004). Now the ADL model for CPI can be written as

$$p_t = a_0 + \sum_{i=1}^{2} a_{1i}\, p_{t-i} + \sum_{i=0}^{2} a_{2i} ulc_{t-i} + \sum_{i=0}^{2} a_{3i}\, pet_{t-i} + \sum_{i=0}^{2} a_{4i}\, og_{t-i}$$

$$+ \sum_{i=0}^{2} a_{5i} tax_{t-i} + \sum_{i=0}^{2} a_{6i}\, ip_{t-i} + \upsilon_t \qquad (4.7)$$

Where υ_t is white noise, $|\sum a_{1i}| < 1$, so that p_t is stationary and explanatory variables X_j are weakly stationary so that

$$E(v_t, X_j) = 0$$

It is statistically demonstrated above that all explanatory variables are individually and collectively weakly exogenous so fulfill the condition of ADL model. Since we do not have any contemporaneous dependent variable on the left hand side so one can consistently estimate ADL by OLS (Davidson & MacKinnon 1993)

Equation (4.7) can be used to share long run multiplier effect. The long run equilibrium can be found by unconditional expectations. If these series move together in the long run they will converge to the following equilibrium

$$\left(1 - \sum_{i=1}^{2} a_{1i}\right) p^*$$

$$= a_0 + ulc^* \sum_{i=0}^{2} a_{2i} + pet^* \sum_{i=0}^{2} a_{3i} + og^* \sum_{i=0}^{2} a_{4i} + tax^* \sum_{i=0}^{2} a_{5i}$$

$$+ ip^* \sum_{i=0}^{2} a_{6i} \qquad (4.8)$$

The long term multiplier effect of ulc_t on p_t is k_1(say)

$$k_1 = \sum_{i=0}^{2} a_{2i} \Big/ \left(1 - \sum_{i=1}^{2} a_{1i}\right) \tag{4.9}$$

This measure the total effect of ulc_t on p_t. Similarly multiplier effects of other variables can be calculated. In one sense these are the constraints to sustain the long run equilibrium.

The magnitude of long run multiplier only measures the effect of the total shock but it does not tell when it will dissipate? The mean and median of the lag distribution of explanatory variables provide information about the pattern of adjustment to disequilibrium. So this is also very important statistic. (For detail discussions see Suzanna De Boef-2005).

We will calculate these statistics in section 4.8.

With small algebraic handling equation (4.7) can be written as

$$\begin{aligned}\Delta p_t = {} & a_0 + b_1 \Delta p_{t-i} + \sum_{i=0}^{1} b_{2i} \Delta ulc_{t-i} + \sum_{i=0}^{1} b_{3t} \Delta\, pet_{t-i} + \sum_{i=0}^{1} b_{4i} \Delta\, og_{t-i} + \sum_{i=0}^{1} b_{5i} \Delta tax_{t-i} \\ & + \sum_{i=0}^{1} b_{6i} \Delta\, ip_{t-i} \\ & + c_1 p_{t-1} + c_2 ulc_{t-1} + c_3 pet_{t-1} + c_4 og_{t-1} + c_5 tax_{t-1} \\ & + c_6 ip_{t-1+} \upsilon_t \end{aligned} \tag{4.10}$$

(4.10) Implies

$$\Delta p_t = a_0 + b_1 \Delta p_{t-1} + \sum_{i=0}^{1} b_{2i} \Delta ulc_{t-i} + \sum_{i=0}^{1} b_{3t} \Delta pet_{t-i} + \sum_{i=0}^{1} b_{4i} \Delta og_{t-i} + \sum_{i=0}^{1} b_{5i} \Delta tax_{t-i}$$
$$+ \sum_{i=0}^{1} b_{6i} \Delta ip_{t-i}$$
$$+ c_1 (p_{t-1} - \gamma ulc_{t-1} - kpet_{t-1} - \delta ip_{t-1} - \alpha tax_{t-1}) + c_4 og_{t-1}$$
$$+ \upsilon_t \qquad (4.11)$$

Equation (4.11) is representation of ECM where c_1 measure the feedback effect of disequilibrium. For stability of equilibrium in (4.11), c_1 should be negative[31].

4.9 Procedure for the estimation of ECM

Now we estimate first order ADL and then transform to unrestricted ECM.

Table 4.8records the estimates of the coefficients for the general specification of second-order transformed ADL (4.10).

[31] For more detail see De Brouwer and Ericsson (1995)

Table 4.8 Dependent Variable: DP

Method: Least Squares

Sample (adjusted): 1975 2005				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
DP(-1)	-0.179	0.236	-0.758	0.461
DU	0.065	0.032	2.025	0.062
DU(-1)	-0.021	0.034	-0.620	0.545
DIP	0.422	0.130	3.254	0.006
DIP(-1)	-0.216	0.137	-1.576	0.137
DOG	0.332	0.174	1.905	0.078
DOG(-1)	0.202	0.192	1.054	0.310
DOP	-1.043	1.696	-0.615	0.549
DOP(-1)	1.245	1.505	0.828	0.422
D(T)	-0.339	0.182	-1.862	0.084
DT(-1)	-0.221	0.199	-1.111	0.285
P(-1)	-0.307	0.094	-3.276	0.006
OP(-1)	-0.166	0.075	-2.220	0.043
IP(-1)	0.618	0.168	3.682	0.003
U(-1)	0.097	0.036	2.656	0.019
T(-1)	0.011	0.017	0.691	0.501
OG(-1)	0.066	0.209	0.314	0.758
R-squared	0.889	Mean dependent var		0.082
Adjusted R-squared	0.762	S.D. dependent var		0.041
S.E. of regression	0.020	Akaike info criterion		-4.665
Sum squared resid	0.005	Schwarz criterion		-3.879
Log likelihood	89.31	Durbin-Watson stat		2.178

Following variables are found statistically insignificant

$\Delta ulc_t, \Delta og_t, \Delta pet_t, \Delta tax_t$

$\Delta Pt\text{-}1, \Delta ulc_{t-1}, \Delta ip_{t-1}, \Delta og_{t-1}, \Delta pet_{t-1}, \Delta tax_{t-1}$

og_{t-1}

To build a parsimonious model one can test above restriction on the model. Few other restrictions can also be tested. For example Long run homogeneity.

On the basis of these restrictions we can build following models

Model 1: The unrestricted transform ADL model (ECM) reported in Table 3.5

Model 2: Model 1, excluding $\Delta Pt\text{-}1, \Delta ulc_{t-1}, \Delta ip_{t-1}, \Delta og_{t-1}, \Delta pet_{t-1}, \Delta tax_{t-1}$

Model 3: Model 2, excluding og_{t-1}

Model 4: Model 3, excluding $\Delta ulc_t, \Delta og_t, \Delta pet_t, \Delta tax_t$

Model 5: Model 4, with long-run price homogeneity

For selecting general specification we will asses' model on the basis of the following tests.

Jarque Berra test for the Normality of residuals

χ^2 test for auto correlation of the residuals.

ARCH LM test for auto correlation conditional hetroscedasticity

Chow test for in sample stability

$\hat{\sigma}$- the standard error

R^2 and adjusted R^2

Whether over reductions are valid we will use F-statistics for testing each restriction.

Table 4.9 reports the results.

Table 4.9

Null Hypothesis			Alternative Hypothesis			
Model			1	2	3	4
	sigma	Schwarz criterion				
1	0.020	-3.879				
2	0.021	-4.089	0.27			
3	0.021	-4.161	0.29	0.39		
4	0.028	-3.932	0.03	0.005	0.0029	
5	0.022	-4.418	0.04	0.008	0.0054	0.9836

After long investigation and using the Pesaran and Shin (1999) suggestion who advocate using leads of the dependent variable, the most parsimonious model is reported in (4.12).

$$\begin{aligned}\Delta p_t = 0.760\,(\Delta p_{t+1}) + 0.012\Delta pet_t + 0.005mc_{t-1} \\ - 0.034(p_{t-1} - 0.125ulc_{t-1} - 0.367pet_{t-1} - 0.50ip_{t-1} \\ - 0.764tax_{t-1}) + \upsilon_t \qquad (4.12)\end{aligned}$$

R-squared	0.679	ARCH Test	0.19[0.665]
Adjusted R-squared	0.640	Normality-JB-test	0.68[.71]
LM Test 0.051	[0.95]	RESET Test	0.18[0.83]

White Heteroskedasticity	[0.6]	SE of regression	0.13
Chow Break Point test (1985:1)	[0.71]	DW stat	2.0305
Chow Break Point test (1999:1)	[0.22]		

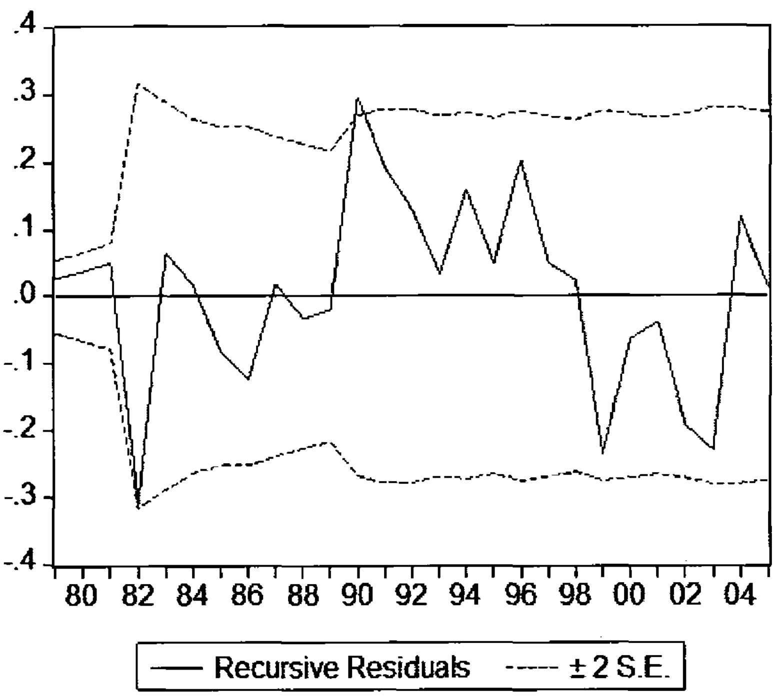
From the residuals one can analyze the statistical properties of the model. For these

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
. *| . |	. *| . |	1	-0.058	-0.058	0.1089	0.741
. | . |	. | . |	2	0.030	0.026	0.1384	0.933
. | . |	. | . |	3	-0.023	-0.020	0.1561	0.984
. | . |	. | . |	4	-0.018	-0.021	0.1678	0.997
.**| . |	.**| . |	5	-0.189	-0.191	1.5111	0.912

purpose residuals estimates from full-sample and subsample are both useful. We first check the performance of equation (4.12) under standard (full-sample) diagnostic tests. From the battery of the tests applied on the empirically estimated model one can easily conclude that the finally selected parsimonious model behaves well under standard (full-sample) diagnostic tests. These tests show that, the residuals are homoscedastic, serially uncorrelated and normally distributed. The estimated model satisfies all test statistics at the 5% level of significance also all coefficients are statistically significant and values of coefficient estimates accord with theoretical predictions. The coefficient of long run disequilibrium is negative which is essential for the sustainability of equation. The performance of the estimated equation can also be checked by plotting the actual and fitted values. The curves of actual and fitted values can be seen in Figure 4.2.It is evident from the graph that how well estimated equation explains the data.

To observe the subsample statistical properties of the model we will use the recursive algorithm. In subsample properties we will mainly focus on numerical and statistical constancy of the estimated equation. The one step recursive residual are recorded with band of 2SE in graph 4.1 . The model standard error is almost constant over time and almost all the estimated recursive residuals are inside the 2SE band.

Fig 4.2



The recursive chow break point test for 1973-1983,1974-1984.......,2004 is recorded in the graph 4.7*****. From the figure it is very much clear that we don't have evidence for structural breaks. So the coefficients are statistically and numerically constant. This stability shows that in spite of institutional and economic structural changes the inflationary process remain constant over time.

The dynamics of the above model are very simple. The current oil prices and the lag of marginal cost has positive effect where as mark up has a negative effect on the on the CPI inflation.

Different diagnostic tests are applied on equation (4.12) against different alternatives. JB test shows that there is no evidence against normality. White Heteroskedasticity shows that there is no evidence of heteroskedasticity in above equation. Similarly other diagonastic tests reported above show that ECM is well specified.

ECM provides us an environment in which we can steady the short run and long run effects of exogenous variables on endogenous variables.

The long run multiplier effect of ulc and ip on cpi inflation is 1.17% and 7% respectively. The static Long run solution is

$$p_s = 0.125ulc \;|\; 0.367pet \;|\; 0.50ip \;|\; 0.764tax \qquad (4.13)$$

If variables grow with (same) constant rate say (g) we get the following dynamic long run equation

$$p_d = 0.125ulc + 0.367pet + 0.50ip + 0.764tax - 6.70g \qquad (4.14)$$

The equation (4.14) generalizes equation (4.13).

Fig 4.3

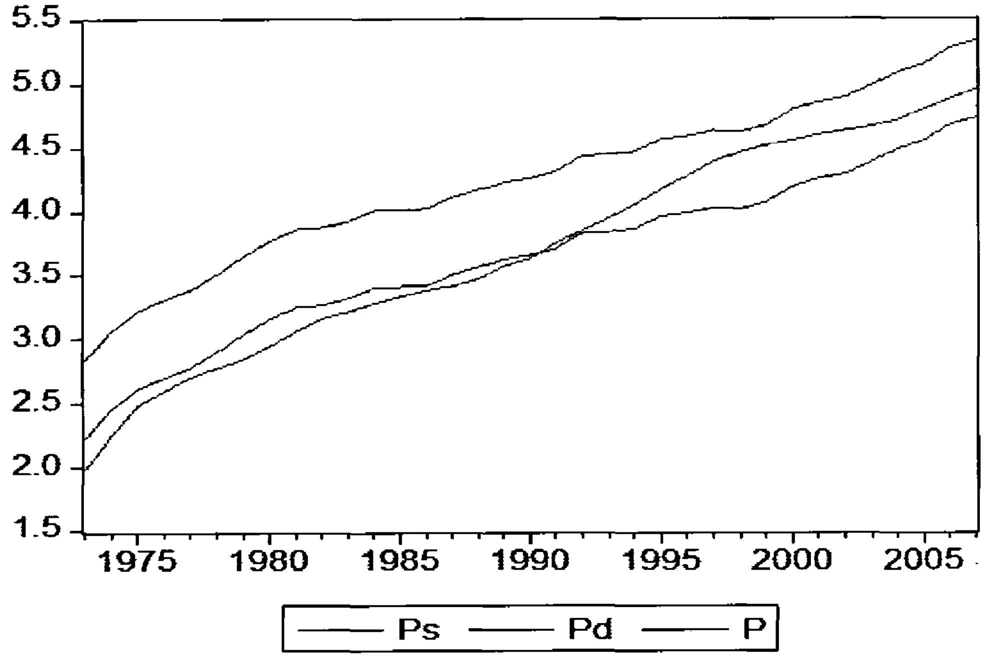


Figure 3.5 shows graph of log of consumer price index, their static and dynamic equilibrium. Static and dynamic equilibriums are calculated from equations (4.13) and (4.14). The static price equation remains above p and Pd. This result is obvious because we assumed zero inflation rate in calculation of Ps where as we observe positive inflation annually. P and Pd have almost born similar path.

4.8 Dynamic Properties of the Model

Equation (4.12) can be rewritten as

$$p_t = 0.43\, p_{t+1} + 0.54\, p_{t-1} + 0.007pet_t + 0.0007pet_{t-1} + 0.0024ulc_{t-1} + 0.009ip_{t-1} + 0.014tax_{t-1} + 0.003mc_{t-1} + \upsilon_t \qquad (4.15)$$

One can observe the short run effects of Xt on Yt. For example the short run effect of pet on p can be given by the coefficient of pet_t and pet_{t-1}.These are given as 0.007 and 0.0009respectively.

In equation (4.12) we observe that the coefficient on the error correction term and the contemporaneous variable are very small so adjustment to disequilibrium would be very gradual

For example suppose import prices increases permanently by 10% in a given year. One can observe that in above equation import prices does not appear in the current year so it will not effect the present value of CPI but in next year it will increase the CPI by 0.09%.

In each following year, the disequilibrium is reduced by gradually smaller increments until the full 5%increase in the CPI is achieved. The long run multiplier measures the magnitude of the total effect of a shock. This information is useful but in addition it is often valuable to recognize how many years it takes for some fraction of the total effect of a shock to disperse or how much of the shock has dissolute after some number of periods. The two statistics, mean and median of the lag distribution of regressors give information about the adjustment pattern of the disequilibrium. After giving shock to a regressor, the median lag statistic can calculate the first lag, r, at which almost half of the adjustment on the way to long-run equilibrium has occurred. Mean lags statistic provides the average amount of time for a shock to dissipate. For more information see Suzanna De Boef-2005. The median lag length can be calculated by computing m for successive values of r and sum the value of r, till m >0.5:

$$\mu = \frac{\sum_{r=0}^{R} \omega_r}{\sum_{r=0}^{\infty} \omega_r} \qquad 4.16$$

where

$w_r = \frac{B(L)}{A(L+1)}$, B(L) and A(L) are in the standard representation.

Calculation shows that median lag length is 4 years. This means that half of the adjustment on the way to long-run equilibrium will be completed in 4 years. For developed countries like Australia the adjustment is slower. After realization of a shock it takes four years to adjust only $\frac{3}{4}$ percent portion[32].

The mean lag length for ADL(1,1,1) can be calculated by following formula

$$\mu = \frac{\sum_{r=0}^{\infty} r\omega_r}{\sum_{r=0}^{\infty} \omega_r} \qquad 4.17$$

In our case mean lag length is $3\frac{1}{3}$ years.

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32 *de Brouwer and Ericsson (1998)*

CHAPTER 5

HYPOTHESIS TESTING AND MODEL SELECTION

The econometricians of recent times are very much concern to evaluate the statistical adequacy of the empirical models. To cope up with problem they mainly focused on hypothesis testing and model selection. Verily Model selection can be referred to as a statistically discriminating between the rival models. It provides us a metric to choose the statistically best model among the several available competing models. On other hand, hypothesis testing tend to test whether or not empirically evaluated model is true rather than to choose the best of the several models. This subsection is attributed to focus on hypothesis and model selection when the models or hypotheses under discussion are non-nested in the sense that one cannot obtain the individual model from the rest of the competing models by imposing restrictions on the parameters or by limiting process. Non nested models occur naturally in econometric analysis when the same economic phenomenon is being explained by rival economic theories. Our final model in (4.12) and its rival theories discussed in the chapter 3 or the best example of non nested models.

Model selection and Hypothesis testing are different string of assessment of the model. Model selection starts with given set of models say S with the aim of selecting one of the models for particular purpose from S with a precise loss function keeping in mind. It considers each model in set S symmetrically. In spirit it is a part of decision making. On the other hand hypothesis testing treats null and alternative hypothesis asymmetrically i.e. it attributes different status to null and alternative models. So hypothesis testing may or may not end with the definite models. It means that it is possible to reject both the models under consideration.

Though both approaches are worth pursuing for model evaluation but clearly depend upon the primary objective of the research. If the research objective is decision making, model selection is more appropriate and if it is dealing inferential problems then hypothesis testing is more appropriate. This subsection is addressing the hypothesis testing which involve non nested models.

Since hypothesis testing is asymmetric so the choice of null is very important. In nested models while general to specific modeling processing the most parsimonious model is selected as the null hypothesis. But in case of non nested models we do not have any natural null.[33] If we go through the literature, it provides evidence that almost all researcher selected the model of type in (4.12) as a null model[34].

It is crucial to highlight the distinction between the joint and paired hypotheses testing. Let M_0 is a null model and M_i □ S, i= 1,2,3...m-1 be the alternative models. Testing H_0 against single M_i is a paired test and testing H_0 against set of M_i's is a joint test.

Based on seminal work of Cox (1961) non nested hypothesis testing has three common approaches

1) Cox type tests: Modified log likelihood ratio test

[33] For details see Non nesting hypothesis testing by M.Hashem et al (1999)
[34] Modeling inflation in Australia by Gorden de Brower (1998).

2) The comprehensive model approach: In this strategy an artificial general model is built such that it contains the non nested models as a special case
3) Encompassing tests: In these tests we try to inquire whether the null model is competent enough of predicting the characteristics of the alternative model.

5.1 a) Cox type tests

Since Pesaran (1974) who first used the Cox principle in econometrics, lot of tests has been developed to test the null model against the single or multiple alternative non nested regression models. These tests are referred to paired and joint tests respectively. We briefly explain this approach in following sub section

5.1 a1) A few paired and Joint tests for model Selection

Here we try to examine H0 model (presented in 4.12) against Hi , i=1...m alternative models (developed in chapter 3). In mathematical specification we can write it as

$$H0: y = \beta' X + \vartheta_0, \qquad \vartheta_0 \sim N(0, \quad \sigma_0^2 I) \qquad 5.1$$

$$Hi: y = \alpha'_i Z_i + \mu_0, \qquad \mu_0 \sim N(0, \sigma_j^2 I) \quad ; i = 1,2 \ldots m \qquad 5.2$$

Here Y is dependent variable. In our case it is CPI inflation. X and Z represents the matrices of regressors and β and α represents the corresponding vectors of parameters. $H0$ is a null and Hi are designated the alternative models.

$Hi's$ are assumed to be non-nested in the way that there is at least one column among regressor matrix that cannot be presented as a linear combination of the rest of the columns of the others.

To compare with rival regression models, test has been anticipated for four probable classifications[35].

(1) A paired Cox-type test

(2) A paired Wald test

(3) A joint Cox-type test and

(4) A joint Wald test.

Consider the general regression. R must be a regressor matrix which includes explanatory regressors from all alternative models.

$$y = X\gamma_0 + R\vartheta + \epsilon \qquad 5.3$$

Let Q=[X R]. It is supposed that Q is full rank matrix. Here to test $H0$ is simply testing $\vartheta = 0$;

with the test statistic

$$\varphi = \hat{\sigma}_{\varphi}^{-2} y' M_0 R [R' M_0 R]^{-1} R' M_0 y \qquad 5.4$$

Where

$$\hat{\sigma}_{\varphi}^{-2} = \frac{y'}{t}(I - Q(Q'Q)^{-1}Q')y \qquad 5.5$$

$$M_0 = I - X(X'X)^{-1}X' \qquad 5.6$$

Under H0:

$$\varphi \sim \chi^2(\rho(R))$$

[35] For more details see Naorayex. Dastoor

Where $\rho(R)$ is equal to the rank of R which intern equal to the number of elements in ϑ.

For different values of R, we get different following tests as special cases.

1) A paired Cox-type test(J-test)

$$R = Z(Z'Z)^{-1}Z'y$$

2) A paired Wald test

$$R = \bar{Z}$$

Where $\bar{Z}$ contains only the columns independent of the columns of X.

(3) A joint Cox-type test

$$R = \hat{G}$$

Where $\hat{G}$ is (n, m) matrix whose ith column is equal to

$$R = Z_i(Z_i'Z_1)^{-1}Z_i'y$$

(4) A joint Wald test.

Here R contains p linearly independent columns from X of all the alternative models.

1) A paired Cox-type test(J-test)

Here we first apply the paired Cox-type test one by one to choose the model between the estimated theories based empirical models reported in equation (3.20), equation (3.23) and equation (3.24) and the estimated model in (4.12). The corresponding results are as follows:

1) (4.12) against (3.20)

$\chi^2(1.66,5) = 0.89.$

2) (4.12) against (3.23)

$\chi^2(1.74,2) = 0.41.$

(4.12) against (3.24)

3) $\chi^2(1.85,3) = 0.60$

A paired Cox-type test (J-test) shows that we can statistically choose (4.12) against the non nested competing models (3.20), (3.23) and (3.24). A paired Wald test reports almost similar statistical results.

2) A joint Cox Type tests

3) Now we try to apply the joint Cox type test to select the model between (4.12) and the rest of the models i.e. (3.20), (3.23) and (3.24). The result is as follows

$\chi^2(2.19,9) = 0.98$

The results again support (4.12) against (3.20), (3.23) and (3.24). It does not mean that we are rejecting the other models we are just in process of model evaluation.

5.1 b) Encompassing property of the model

The model given in (4.12) looks sound on statistical and theoretical grounds. Now a natural question comes in mind that how this model perform against the alternative models present in literature. In simple words we mean that whether model in (4.12) encompass non nested models discussed in chapter 3.The encompassing feature of the model needs very special attention because it shows the ability to explain the results of alternative empirical models in literature. This characteristic becomes particularly significant when the other models have a great deal diverse economic and policy repercussion.

Literature provides several tests statistics to check various kinds of encompassing but approach of Mizon (1986) appears to be the most popular. We will therefore also use the same approach in this study. We briefly explain this approach in following sub section:

We can test the parametric encompassing of $H0$ against the single alternative Hi by different formulas e.g. Wald test, F-test, Godfrey's T_x test, Generalize likelihood ratio encompassing test and The Davidson and MacKinnon's J test etc[36]. The brief discussion is as follows

1) For complete parametric encompassing Wald statistic is given as

$$\eta = y'M_x\bar{Z}(\bar{Z}'M_x\bar{Z})^{-1}\bar{Z}'M_xy \qquad 5.7$$

Where

$$M_x = I - X(X'X)^{-1}X' \qquad 5.8$$

$$\varphi \sim \chi^2(p) \qquad 5.9$$

Where p is the number of parameter in β.

2) $$F - test = \frac{(t-k-p)\hat{c}_*'Z'M_xZ\hat{c}_*'}{tp\hat{\sigma}_\varepsilon^2} \qquad 5.10$$

$$\hat{c}_* = (\bar{Z}'M_x\bar{Z})^{-1}\bar{Z}'M_xy \qquad 5.11$$

and

$$t\hat{\sigma}^2 = y'M_xy - \hat{c}_*'\bar{Z}'M_x\bar{Z}\hat{c}_* \qquad 5.12$$

[36] For details read " Tests of Non-Nested Regression Models by Godfrey(1983)

Mizon (1986) prove that parametric encompassing Wald statistic is asymptotically equivalent to Godfrey's T_x test, Generalize likelihood ratio encompassing test and The Davidson and MacKinnon's J test and η/p is asymptotically equivalent to F-test.

To check the parameter encompassing we will use complete parametric encompassing Wald statistic for non nested models.

The results of parametric Wald test reveals that model (4.12) encompasses (3.20), (3.23) and (3.24):$\chi^2(0.17,5) = 0.99$, $\chi^2(0.21,1) = 0.64$, $\chi^2(0.26,2) = 0.88$. Put somewhat differently, for example, money growth, output gap, output growth or P* inflation are not important in explaining CPI inflation directly. There may have other channels through which these variables effect the CPI inflation but this is out of the scope of my research. Similarly one can easily check that (4.12) is not encompass by (3.20), (3.23) or (3.24). *For example if the null is (3.23) encompasses (4.12) then* $\chi^2(14.12,2) = 0.0009$.

At more abstract stage, (4.12) can be used to test a range of other models. For example the New Keynesian Philips Curve, Purchasing power parity and wage price models etc. These models are nested in (4.12) and their validity can be tested using conventional F test. For example if we want to check whether (4.12) encompasses New Keynesian Philips Curve we would impose restrictions simultaneously on the coefficients of Δpet and error correction term and set them equal to zero. The p-value of F-test is 0.06 which leads to rejection of H0 (New Keynesian Philips Curve) at one percent significance level, it means at least one of the additional terms in the model contributes extra information about the response.

5.2) Forecasting

Using the strategy discuss in 3.5.1 and 3.5.2 , the root mean square error of static and dynamic forecast for the models develop in chapter 3 and chapter 4 are reported as

Table 5.1 RMSE

Models	RMSE -Static	RMSE-Dynamic
Structural equation	0.46	0.6
QTM	1.6	0.13
P-star	0.174	0.172
BVAR	0.15	0.13
Markup model	0.13	0.13

From the table it is evident that markup model outperform all structural models in static forecast. BVAR model has lowest RMSE in dynamic forecast horizon which is equal to the static RMSE of markup model.

5.3 Forecast encompassing test statistics

We employed QPS test based on Diebold and Mariano (1995) (DM)-type approach. This test is design for non nested models. The QPS test statistics is as follows[37]

[37] For more detail see "Forecast Encompassing Tests and Probability Forecasts by Clements 2007".

$$QPS = \frac{n\bar{d}}{\sqrt{\sum_{\tau=1-h}^{h-1} \sum_{t=\tau+1}^{n} (d_t - \bar{d})}} \qquad 5.11$$

Where $d_t = (e_{1t} - \bar{e_1})[(e_{1t} - \bar{e_1}) - (e_{2t} - \bar{e_2})$

QPS has a student t-distribution with n-1 degree of freedom. It has a null that markup model forecast encompasses the forecast of X model.

Table 5.2

Models	DM test (p-value)
Structural equation	0.68
QTM	0.21
P-star	0.793

Table 5.2 shows that markup model forecasts encompass the forecasts of structural model, QTM model and P-star model.

In addition to theories discussed and estimated in chapter 3 for explaining inflation, there are other regression models for inflation. The results of these models are briefly discussed in chapter 2. These models show that depreciation of rupee, seigniorage (ΔM/GDP), bond finance government expenditure (dept/M2), money depth (M2/GDP) , exchange rate depreciation , government instability are inflationary. Since we claim that our final model encompass the most of the existing literature so we try to incorporate these variables in our model and will try to check whether it improve anything to our model or not. We add depreciation of rupee in our main model as ad hoc variable in equation (4.12) the results are given as under

$$\Delta p_t = 0.752\ (\Delta p_{t+1}) + 0.0109\Delta pet_t + 0.0051mc_{t-1} - 0.036[p_{t-1} - 0.125ulc_{t-1} - 0.367pet_{t-1} - 0.50ip_{t-1} - 0.764tax_{t-1}) - 0.15dep + \upsilon_t$$

Regression results are as follows

Variable	Coefficient	Std. Error	t-Statistic	Prob.
INF(1)	0.752883	0.150948	4.987690	0.0000
Δpet	0.010938	0.006336	1.726246	0.0957
mc(-1)	0.005138	0.001781	2.884655	0.0076
e(-1)	-0.036374	0.024319	-1.495690	0.1463
DEPRECIATION	-0.157631	0.485375	-0.324762	0.7479

If we compare this equation with equation (4.12) we see that depreciation has brought almost zero changes into the magnitudes of the coefficients of the other variables. t-stat shows that it is individually insignificant. It worsens the forecast root mean square error. New FRMSE is 0.1776. Owing to this dramatic poor performance we can confidently exclude this variable. If we add money depth instead of depreciation of rupee new estimated equation would be

$$\Delta p_t = 0.76(\Delta p_{t+1}) + 0.01\Delta pet_t + 0.005mc_{t-1} - 0.04[p_{t-1} - 0.125ulc_{t-1} - 0.367pet_{t-1} - 0.50ip_{t-1} - 0.764tax_{t-1}) - 0.23money.depth + \upsilon_t$$

We find the similar results. No significant difference in the coefficient of equation (4.12). The p value of t-state for the coefficient is 0.59 which shows that it is insignificant. New FRMSE is 0.19. On the same grounds we can reject the variable. It is not improving anything in the model. If we add bond finance government expenditure (dept/M2) to equation (4.12) it deteriorates the forecast performance. It is also a statistically insignificant variable. To check their collective performance we applied Wald statistics on these three coefficients and find that they are collectively not important. Similarly we tested many other variables for example seigniorage (ΔM/GDP) etc , they have not improved any good to the model however when we added the variable for political instability[38] we found it statistically significant and it improves the forecasting performance of the model. New FRMSE of the model is 0.12. So our final model now becomes

$$\Delta p_t = 0.6(\Delta p_{t+1}) + 0.011\Delta pet_t + 0.0047mc_{t-1}$$
$$0.055(p_{t-1} \quad 0.125ulc_{t-1} \quad 0.367pet_{t-1} \quad 0.50ip_{t-1}$$
$$- 0.754tax_{t-1}) + 0.01polity + \upsilon_t$$

Results show that inflation is positively associated with political instability in Pakistan.

[38] As suggested by Khan et.al (2008), we used the polity 2 index for government instability. It ranges from -10 to 10 which show purely autocratic to purely democratic regimes. Data is available on Polity IV project. Link is www.systemicpeace.org/polity

CHAPTER 6

CONCLUSION

In literature we have surge of models for explaining inflation. The main objective of the study is model evaluation for inflation or a search of an acceptable model which either explains or rejects the rival models. The main strands of model evaluation are model selection and hypothesis testing. In the search of an acceptable model, we try to give due importance to both features. We started from bottom line. We empirically estimated, a parsimonious; data consistent error correction model based on extended version of Brouwer and Ericsson (1995) markup model. We extended the Brouwer and Ericsson (1995) markup model to allow for the effects of tax variable (the ratio of GDP at market prices to GDP at factor cost) on CPI inflation. The importance of the variable is noted by different researchers for example Bowdler(2004). Our final model has reasonable statistical features and has sound economic grounds. We also re-estimated a complete set of renowned theoretical and time series models for explaining CPI inflation in case of Pakistan. This gives us a launching pad for model evaluation for CPI inflation.

As we know that model selection starts with given set of models say S with the aim of selecting one of the models for particular purpose from S with a precise loss function keeping in mind. We selected forecast root mean square error as a loss function. With this loss function we can consider each model symmetrically.

To summarize the static and dynamic forecasting performance of empirically estimated theoretical and time series models we can conclude that model based on mark up theory has lowest forecast mean square error both in static and dynamic horizons. BVAR estimates have second lowest FRMSE in the list. If we inflate dynamic horizons of forecast it only magnifies FRMSE but does not alter the main findings.

We also tested many important variables mentioned in the literature for example exchange rate, political instability depreciation of rupee, bond finance government expenditure, seigniorage etc in a model based on price markup theory and found that all except political instability lessen the forecasting power of the model. So our final model with political instability has lowest root mean square error.

As we discussed earlier that second important pillar of model evaluation is hypothesis testing. It tends to test whether or not empirically evaluated model is true rather than to choose the best of the several models. There are two types of hypothesis testing, Nested and non nested hypothesis testing. We applied both of the choices, since hypothesis testing is asymmetric i.e. it attributes different status to null and alternative models, so the choice of null is very important.

In nested models while general to specific modeling processing the most parsimonious model is selected as the null hypothesis. This parsimonious model contains forward looking New Keynesian inflation model and hypothesis of purchasing power parity. In analysis we found that our model encompasses both models.

In chapter 3 and 4 we empirically re-estimated/estimated different non nested models namely model based on quantity theory of money, P-star model, structural model and markup model. As stated earlier, in hypothesis testing choice of null is very important but unfortunately, in case of non nested models we do not have any natural null (Hashem 1999). As noted by Brouwer and Ericsson (1995) and many others, we took a model based on a markup theory as a null model. Non nested hypothesis testing has three common strategies Cox (1961). 1) Cox type tests, 2) The comprehensive model approach 3) Encompassing tests. We applied all of these approaches.

Cox type tests can be categorized as paired and joint tests respectively for testing a single and multiple alternatives. Paired and Joint tests have in turn two types. Cox paired/joint tests and Wald paired/joint tests. These tests show that we can statistically choose our null against single and multiple alternatives as an acceptable model.

The comprehensive model approach is discussed in nested models.

Encompassing tests also have similar results. Model in (4.12) encompasses alternative models individually and collectively but not encompassed by them. But it does not mean that other models are false but our model is a redundant model. It is most likely that money derives inflation but the channels might be marginal cost, import prices, unit labor cost, petrol prices etc.

Unlike model selection hypothesis testing not always ends with the definite models. It means that it is possible to reject both the models under consideration. But fortunately we end up with a model that is statistically and economically sound and has a power to explain (not explained by) the moments of the other renowned model for explaining CPI inflation.

Although model in (4.12) have minimum FRMSE and has explaining power of other renowned models yet we do not claim that it reflects the true data generating process.

There are many important variables which we have not included in our model. For example impact of terrorism, structural shocks, underground economy and many more. Our emphases were on model evaluation or statistical adequacy. Whenever someone tries to develop and estimate a model he should follow the path of model evaluation. This study, expectantly, will assist how to estimate, compare and explain the existing literature.

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Appendix A

```
Y=[ ];

w= [100];

[m,n] = size (y);

if m < n

   y = y';    m = n;

end

s = repmat([w -4*w ((6*w+1)/2)], m, 1);

s(1,2) = -2*w;    s(m-1,2) = -2*w;

s(1,3) = (1+w)/2;  s(m,3) = (1+w)/2;

s(2,3) = (5*w+1)/2; s(m-1,3) = (5*w+1)/2;

M = spdiags(s, -2:0, m, m);

M = M+M';

L = M\y;

L
```