MEASURING CORE INFLATION BY USING THE STRCUTURAL VAR APPROACH[1]

Abstract:

The aim of this paper is to estimate the core inflation for India and Pakistan using structural Vector-Autoregression (VAR) approach. We analyse the effect of aggregate supply and demand shocks on output and inflation. The supply shocks are important in the developing countries, like India and Pakistan. Given the fact that the respective central banks focus on the objective of price stability, we study the concept of core inflation. We discuss the Structural VAR approach for the estimation of core inflation. Our identification method is based on the work of Blanchard & Quah (1989) and Quah & Vahey (1995). Using the concept of vertical long-run Phillips curve we impose the restriction that the demand shocks have no long run effect on output. We define the core inflation as the persistent component of measured inflation that has no medium to long run effect on output. We estimate the impulse response functions to demand and supply shocks. We estimate the core inflation from June1994 to December 2004 using the monthly data. We conclude that the estimations of core inflation based on a forward-looking approach can be useful for monetary policy.

JEL Classification: C32, C53, E31.
Key words: Core inflation, structural Vector autoregresions.

[1] Abdul ALEEM CEPN J110, Université Paris 13.
E-mail : abdulaleem75@yahoo.co.uk
Ph. 0033149403530

1. Introduction:

The concept of inflation is very important in the macroeconomic equilibrium. The costs of inflation on the economy are significant. A high rate of inflation exerts negative influence on the macroeconomic equilibrium. Inflation attenuates the volume of investment through the "accumulation or investment channel". It reduces also the efficiency of the factors of production through "efficiency channel". Inflation impairs the confidence of domestic and foreign investor about the future direction of monetary policy. A lower and sustainable level of inflation brings in return a sustainable growth in future. A permanent decrease in the rate of inflation by a percentage point yields a rise of the steady state level of per capita income by 0.5% - 2% (Andrés J. et al 1997). Likewise, a high and more variable inflation reduces the strength of the price movements to guide the economic activity. This reasoning compels a central bank to follow a policy of keeping the inflation at low levels.

The identification of relative prices makes the consumers and the producers to take appropriate economic decisions. However, the underlying inflation contains transitory as well as permanent components. The transitory components create noise in price variations. Therefore, these components are not important from the point of view of monetary policy. The central bank can control only the core inflation. The supply side factors are outside the control of central bank. The consumer price index CPI contains the transient disturbances that are unrelated to pure inflationary process.

Since the beginning of 1990s, the research on core inflation got much importance for different reasons. Many central banks adopted the policy of price stability. More importantly, the policy of inflation targeting in different industrialised countries led these countries to focus on different core inflation measures.

The aim of this paper is to estimate the core inflation for India and Pakistan by employing the structural VARs approach. The paper is organised as follows:

In section two, we begin by examining the effects of aggregate supply and demand shocks on output and inflation. Here, we discuss also different factors that cause aggregate supply and demand shocks. In section three, we briefly analyse the evolution of inflation and the central banks' policies of the respective countries in controlling the inflation. Here, we conclude that the supply shocks are important in inflationary expectations in India and Pakistan. Furthermore, money supply is a dominant factor of inflation in both the two countries. Since the beginning of 1990s, the central banks of these countries are focusing on the objective of price stability.

In the fourth section, we study the concept of core inflation and its estimation. We analyse theoretically different measures of core inflation. We discuss the Structural VARs approach for the estimation of core inflation. Our identification method is based on the work of Blanchard & Quah (1989) and Quah & Vahey (1995). Using the concept of vertical long-run Phillips curve we impose the restriction that the demand shocks have no long run effect on output. We define the core inflation as the persistent component of inflation that has no medium to long run effect on output. We estimate the impulse response functions and the variance decompositions of inflation and industrial production to demand and supply shocks. We estimate the core inflation from June1994 to December 2004 using the monthly data. Finally, we conclude in section 5. Details about the choice of an appropriated measure of inflation are discussed in Appendix.

2. Effects of supply and demand shocks on inflation and output:

Any exogenous change in supply or demand curve is termed as the supply shock or demand shock, respectively. We will study here the long run and short run effects of demand and supply shocks on inflation and output.

2.1 Aggregate supply shocks:

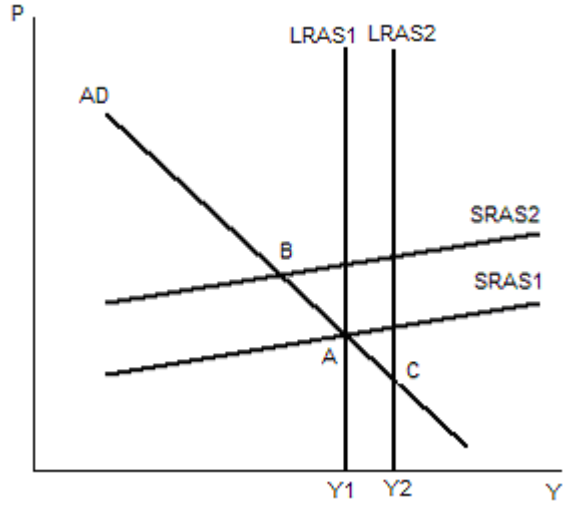
A *supply shock* is an event that suddenly changes the price of a commodity or service caused by a sudden change in the supply of a commodity or service due to changes in the cost of that commodity or service. These changes in the cost of that commodity or services are not related to prior changes in gross domestic product (GDP). As the supply shocks directly affect the prices, they are also termed as the price shocks.

In short run a negative supply shock results in a reduction of output and an increase in prices. A decline of food supply due to unfavourable climatic conditions results in a decrease in food supply and an increase in food prices. On the other hand, a positive supply shock results in an increase in output and decline in prices. Supply shocks can have temporary as well as permanent effects on prices. The impact of supply shocks on prices depends also on the expected rate of inflation. The expected rate of inflation does not respond on one period change in actual inflation. Rather it depends on whether the people take the supply shocks as temporary or permanent.

(a) Short run and long run effects of a supply shock on prices and output:

An adverse supply shock shifts the short run aggregate supply curve upwards causing the output to fall and the price level to raise in short run as explained at point B in figure 1. After some time, both the output and prices come back to their initial levels at point A.

Figure 1: Short run and long run effects of a supply shock on inflation and GDP:

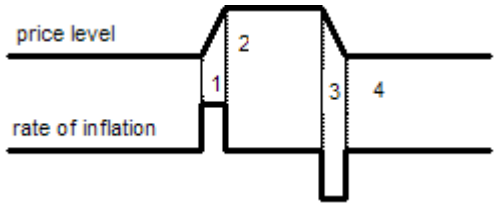


In long run, the level of output is expressed by the natural level of output. The natural level of output is determined by supply side variables, such as the technology, labour supply and the capital stock. A favourable supply shock will shift the long run aggregate supply curve to the right to the long run aggregate supply curve (LRAS2 in figure 1). However, in long run it is only the price level that is affected by the supply shocks. The rate of inflation in long run remains unaffected by the supply shocks. The effect of a supply shock on the rate of inflation is further discussed as follows:

(b) Effect of permanent and temporary supply shocks on inflation:

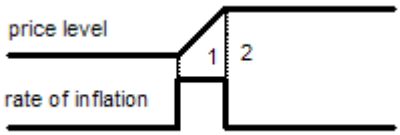
A *temporary supply shock* leads to an increase in price index in the first period. The rate of inflation increases. In the second period, the price index remains constant and the inflation rate becomes zero. In the third period the price index declines resulting in a decrease in inflation rate. In the fourth period the price index becomes constant and inflation rate comes again to zero (figure 2).

Figure 2: Effect of a temporary supply shock on the rate of inflation



However, a *permanent supply shock* increases the price index in the first period. The rate of inflation increases. In the second period the price index becomes constant and the inflation rate comes to zero. A permanent supply shock increases the price level in long run (figure 3).

Figure 3: Effect of a permanent supply shock on the rate of inflation



Source: Robert J. Gorden (1993)

3.2 Aggregate demand shocks:

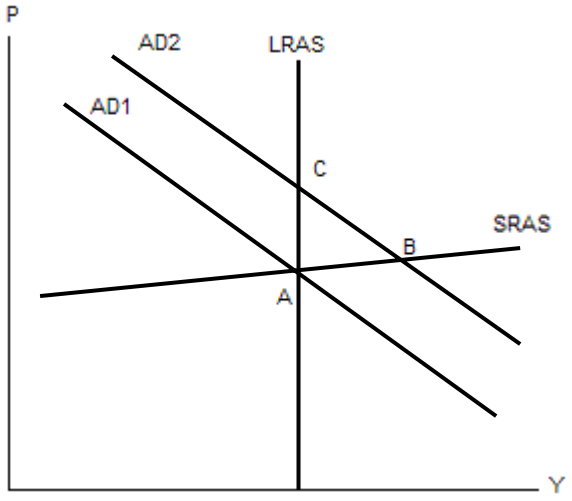
Demand shocks are related to prior changes in GDP. In short run a demand shock changes the output but the prices remain same. Whereas in long run a demand shock affects the prices but not the output.

The aggregate demand such as an increase in money supply decreases the interest rate in short run. Investment and output increase. The price stickiness in short run makes the monetary and

fiscal policies useful in order to stabilise the economy in short run (figure 4). However, in long run nominal interest rates increase. The output comes to its initial level. Prices are flexible in long run. Thus, in long run an increase in money supply increase only the price level. In long run a monetary shock has effect neither on output nor on interest rate (figure 3). This absence of long run effect of money supply on output and on interest rate explains also the long run neutrality of money.

In short run price stickiness results an absence of immediate adjustment of prices to demand shocks and only the output changes. In long run however demand shocks affect prices fully, whereas the output remains unchanged (figure 4).

Figure 4: Short run and long run effects of demand shock on inflation and GDP:



3.1 Historical review of inflation in India and Pakistan:

3.1.1 Inflation analysis in India:

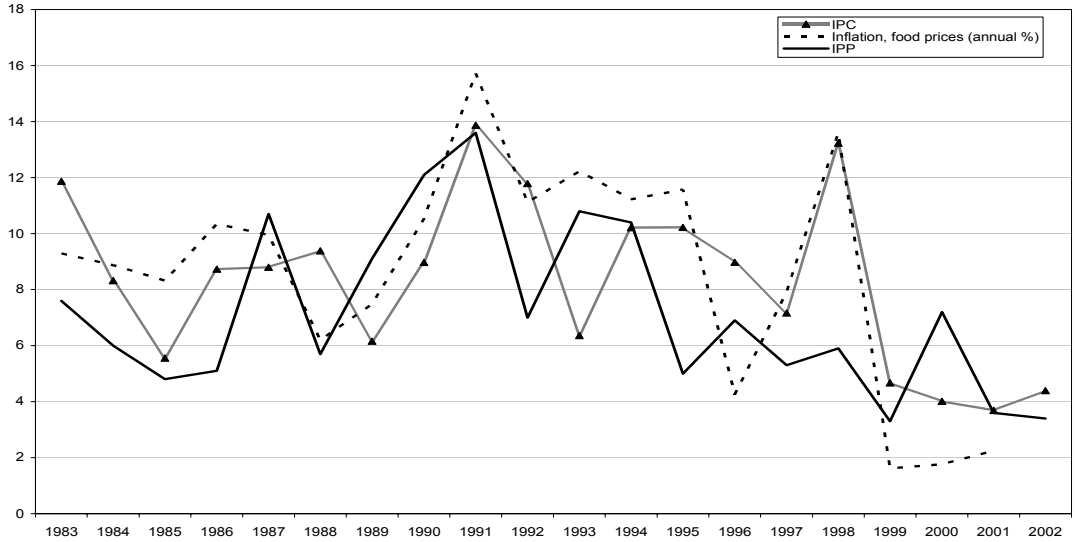
The stability of domestic prices is important not only for maintaining the external competitivity but also for maintaining the stability of money. Economic development depends indirectly on price stability. Monetary policy performs an important role in the stabilisation of prices. The evolution of inflation as illustrated by the Wholesale Price Index (WPI) is characterised by a volatile evolution of inflation till the end of 1990s not only because of the supply shocks (the volatility of food prices and the oil and energy prices) but also because of the demand shocks. Therefore, the price stabilisation[2] in medium term and the provision of credit in the productive sectors of economy to stimulate growth remained the principal objectives of the Reserve Bank of India (RBI) since the mid of 1980s. Furthermore, the price stability remained the most important objective during the 1990s, as recommended by the consultative committee for the transparency of monetary policy (RBI 1998-99). The RBI made its objective not only the reduction of the rate of inflation but also its stabilisation (A

[2] Generally, price stabilisation defined as an absence of a sharp increase in the general price level (inflation) and a permanent decrease in the general price level (deflation).

decline of the deviation with respect to its targeted level)[3]. The focus on the objective of price stability is likewise manifested in the annual report of RBI, recommending that the central bank should concentrate on the price stabilisation because the price stability accelerates the economic growth in the long run and that the real growth will be endangered if the inflation crosses its limits.

In India, aggregate supply chocks remained more important than demand shock in inflation variations since 1970s. Supply chocks explained 25% of short run variations in inflation, whereas demand shocks explained only 10% of short term variations in inflation (IMF 2003). Food price inflation remained important and volatile, especially in the beginning of 1990s (Table 2).

Figure 5: India: Food price inflation, consumer price index and wholesale price index (annual percentages) during 1983-2002.



Source: Hand book of statistics on Indian economy, RBI.

According to the Reserve Bank of India (RBI), the short term volatility of inflation was often influenced by important variations in the supply of agricultural production and the energy prices[4]. These variations in agricultural production were characterised by negative growth due to unfavourable climate.

During 1970s, inflation in India remained around 9%. During this period supply shocks remained an important factor in the variations of inflation. During 1980s, average inflation reduced to around 8%. A sharp increase of budget deficit from 3.8% in 1970s to 6.8% in 1980s strongly contributed to an increase in inflation. Reserve Bank of India financed around 32% of this deficit. Thus, fast growth of monetary aggregates for deficit financing equally explains the variations of inflation during this period. In the beginning of 1990s, inflation increased sharply due to an increase in agricultural prices and also due to monetisation of

[3] Chakravarty committee proposed a tolerable rate of inflation (the threshold rate of inflation) in the short term monetary policy. The committee proposed the rate of inflation of 4% as the tolerable rate of inflation for the Indian economy. Furthermore, the committee proposed an approach of monetary targeting the monetary policy of the RBI.

[4] Report on money and finance, Reserve Bank of India (2001-2002)

budget deficit accumulated during 1980s. In 1990-91, budget deficit and current account deficit brought about the balance of payment crisis. During 1993-95, important capital inflows put inflationary pressures on the economy. In 1994-95, WPI increased due to an increase in manufactured goods prices and the agricultural prices as well. In 1995-97, manufactured goods prices declined sharply from 12.3% to 3.1%. This decline of manufactured prices put important effects on WPI, resulting in a decrease of 8.2%. Annual inflation rate reduced from 6.9% in 1996 to 4.8% in 1997.

Table 2: India: Contribution of principal groups to Wholesale price inflation (on an average basis) Base year 1981-82=100

	1980/81-1989/90	1990/91-1998/99	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03
Primary products	33.2	36.6	23.7	56.3	8.7	10	53.4	21.6
Fuel and energy	12.6	13	29.1	7.3	41.4	62.9	47.1	33.9
Manufactured Products	54.2	49.7	47.6	36.2	49.9	27.6	0.0	44.3
Total products	100	100	100	100	100	100	100	100

Source: Annual reports of Reserve Bank of India, various years.

In 1998-99, WPI increased significantly due to a significant rise in the prices of primary products. This decrease in the agricultural output was due to unfavourable climatic conditions. During this period the agricultural product prices increased by 73.7% (annual report of the RBI 1998-99). During this period food price inflation and CPI peeked to the record level of 13.6% and 13.2% respectively since 1991. In 2000-01, a sharp increase in the fuel and energy prices led to an increase of 7.2% in WPI. This increase in the prices of fuel and energy products was due to a policy of liberalisation of the prices of these products but with irregular intervals.

Table 3: India: WPI and its components during 1983-2002

	1983-1990	1990-93	1994-2002
Average			
WPI	6.75	10,6	5,91
Primary sector	6.39	12,4	6,98
Fuel and energy	7.23	13,8	10,61
Manufactured products	5.68	9,6	2,84
Standard Deviation			
WPI	2.65	2,7	3,3
Primary sector	4.56	7,0	5,4
Fuel and energy	2.5	3,9	8,1
Manufactured products	2.53	2,0	3,74

Source: Tim Callen et Chang Dongkoo, (1999) IMF; own estimations

It is clear from table 3 that primary product prices and fuel & energy components have larger standard deviation than overall WPI. During 1983-2002, the primary product prices and the fuel and energy prices showed the variations almost three times than the overall WPI variations.

From 2002 to 2004, the CPI and WPI showed a stabilisation which was attributed on one side to an increase in the foreign exchange reserves and the reserves of agricultural products and on the other side to multiple indicators approach and to operations focusing on the liquidity adjustments in the functioning of monetary policy of the RBI.

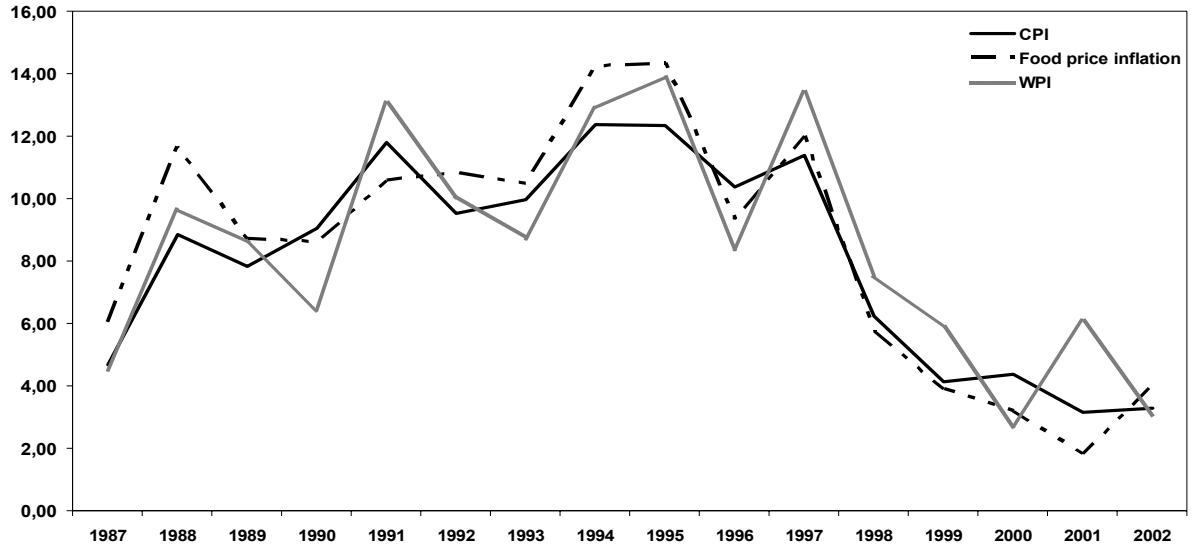
An overview of figure 5 and of Table 2 and 3 leads us to the conclusion that the RBI well controlled the inflation level during 1994-2002. The average WPI decreased from 10.6% in 1990-93 to 5.91% in 1994-2002, close to the level put by the RBI. Primary sector average inflation decreased from 12.4% to 6.98%. During this period, the policy of sufficient reserves of agricultural output significantly reduced the supply side chocks related to agricultural output. However, the standard deviation increased during the last period describing more volatility of WPI from average level with respect to precedent periods. The manufactured products showed the average and the standard deviation on normal levels during all the period.

3.1.2 Inflation analysis in Pakistan:

In Pakistan during 1980s and 1990s, monetary policy focused on the credit plan for public and private sector. During this period, Pakistani rupee was continuously devalued against the US dollar. The State Bank of Pakistan (SBP) used the reserve money and net domestic assets as intermediate targets of monetary policy.

In 1989, the SBP started the financial sector reforms with a liberalisation of interest rate, a decrease in the framework of credit and improvement in the surveillance of banking sector. Currently, the SBP is targeting the short term interest rates (6 month Treasury bill rate). The objective of the state bank of Pakistan is the price stability and the acceleration of economic growth.

Figure 6: Pakistan: Consumer price index (CPI), food price inflation and Wholesale price index (WPI) during 1987-2002



Source: World development indicators, World Bank; International financial statistics, IMF.

Table 4 shows a decline in the average rate of inflation and its standard deviation as well in the end of 1990s. Here, the standard deviations of the three groups at different periods explain their price volatility relative to the overall CPI. It is clear from the table 4 that primary products and the fuel and energy components have much larger standard deviations than the overall level of CPI. Fuel and energy prices during the period 1994-2002 show six times high variations than the overall CPI variations in Pakistan. The presence of transitory noise makes difficult the measurement of inflation.

Table 4: Pakistan: CPI and its components during 1983-2002

	1989-93	1994-98	1999-03
Average			
CPI	14,54	9,83	3,84
Food products	14,95	10,46	3,43
Fuel and energy	15,15	10,02	5,11
Others	13,65	9,10	3,71
Standard Deviation			
CPI	11,74	2,99	0,62
Food products	13,04	4,18	1,53
Fuel and energy	11,05	5,71	3,93
Others	10,54	3,31	1,13

4. Core inflation:

As we discussed that the central banks of the two countries under consideration have their focus on price stability since the beginning of 1990s. Given the fact that supply side variables are also important in inflationary evolutions in emerging and developing countries, most of the empirical research, especially that related to the countries under consideration, has also showed the dominant effects of monetary growth on inflation. In this scenario, a question arises about the type of inflation that the central bank should follow. Whether the central bank should focus on the observed rate of inflation or it should concentrate on the trend rate of inflation. Clearly, the central bank should focus on the trend rate of inflation or in other words "the core inflation". Core inflation is an important concept from the point of view of central bank in the conduct of monetary policy.

a) Role of Monetary policy in controlling the inflation: The rationale for focusing on core inflation

The observed rate of inflation might not be origin of monetary factor, especially when we are considering the short term horizon. The **supply shocks**, especially in case of developing countries, often containing only the short term effects on prices do not correspond to the demand of overall economy This increase does not constitute the underlying monetary inflation. During a bad weather, a shortage in the food raises the food prices. A rise in the food prices increases temporarily the price indices. This increase in price indices is caused by pure supply factors. The inflation having such types of short term effects of supply shocks can not be controlled by the central bank. Thus, the objective of monetary authorities can be achieved by separating the inflation into the long term variations and the short term variations. This separation of inflation into persistent and temporary components helps to have a more stable level of inflation. The estimation of a permanent component of inflation in the form of core inflation gives correct inflation forecasts and its relationship with monetary aggregates. The analysis of core inflation gets more importance if the central bank follows the evolution of monetary aggregates.

In long run the inflation is influenced mostly by monetary factors[5]. Thus, monetary policy performs an important role in controlling the inflation. A credible monetary policy reduces the inflationary expectations and increases the economic growth. Thus, any decline in the credibility of monetary policy will cause a rise in inflationary expectations.

Monetary policy decisions have long and variable transmission lags. It can not offset the temporary shocks to inflation. So, for its successfulness the monetary policy should focus on the persistent component of inflation. When the central bank considers the part of inflation influenced by the monetary shocks, its decision to control the core inflation will be capable of producing its desired effects on the economy. It will accommodate a forward looking monetary policy. In order to control inflation, the central bank should have enormous information about it, especially the forecasts of inflation and the estimates of the response of inflation to changes in the monetary policy instrument.

[5] We will discuss this issue in the section 8 of core inflation. However, some supply shocks have permanent effects prices even in long run.

In an environment of price stability the exact information about the price trends is important for a central bank. The commonly used indicator for the analysis of price trends is the consumer price index (CPI). But the use of CPI as an indicator of inflation can pose problems for well functioning of monetary policy because CPI is subject to certain disturbances irrelevant to pure inflationary shocks. So, if a central bank focuses on price stability, it should consider the estimates of inflation that measure the effect of the decrease in the purchasing power of money. In other words, it is not the cost of living but the monetary inflation that is of concern for the central bankers. A given change in base money affects all the prices equiproportionately. 'A central bank ought to target a price index whose rate of increase corresponds to the inflation that generates the costs that the central bank is seeking to avoid by focusing on an inflation-control objective[6]'. Generally, the core inflation is considered as a permanent component of price index related to the monetary growth. The policy of core inflation minimises the noisy components created by short-lived shocks. Thus, it attenuates the risks of these shocks of entering into inflationary expectations.

b) A good indicator of current and future trends in inflation:

The monthly variations of inflation contain noisy components and thus it is not easy to explain these variations. If the central bank uses the core inflation as a target, it will shift the public's focus on the trend level of inflation. This shift of the public's focus is the mainspring of anchoring the inflation expectations which will be incorporated afterwards into wage contracts. That is why central banks in numerous countries especially the industrial countries use different types of core inflation as an inflation indicator. The most commonly used measure of core inflation is the consumer price index excluding the fresh agricultural products.

c) **Defining core inflation:**

Eckstein (1981) defined Core inflation as 'the trend increase of cost of the factor of production that originates in the long-term expectations of inflation in the minds of households and business, in the contractual arrangements which sustain the wage-price momentum and in the tax system'. Thus, core inflation is a steady-state long run concept and a trend increase of the aggregate price level. We can classify different concepts of core inflation in two main groups. According to first group, the core inflation is "a persistent component of measured inflation that has no medium to long term impact on output". The persistent component is tied to the excess demand for goods and services, the changes in the unit labour cost and the monetary policy. This group focuses on the behavioural definition the core inflation and its estimation is backed by the economic theory. This group estimates core inflation by using the univariate techniques of smoothing inflation and multivariate approaches, such as Structural Vector Auto-Regression (SVARs) approaches. The second group defines the core inflation as "a sustained increase in the general price level excluding certain items thought to create noise in the course of general price level". The transient items creating noise in the inflation signals are usually the changes in relative prices whose effects on aggregate price level do not cancel out. These transient changes are the measurement errors, unusual climate conditions, the price controls, the exchange rate changes and one-off change in indirect taxes etc. This group estimates the core inflation by using the statistical methods. These statistical methods are the zero weight approaches and the approaches using

[6] Wynne M. 1999

robust estimators such as weighted median or trimmed means. We briefly discuss these approaches in the section 4.1.

In our analysis of core inflation, we take the idea of Quah & Vahey (1995). We define the core inflation as "that component of measured inflation that has no medium to long run impact on real output". This long run and persistent component of price index is highly correlated to monetary growth. In an economy, the expectation based price setters have highly smoothed price paths, relative to the realisation based price setters. Considering the price stability in a medium to long run context, we can decompose the aggregate inflation rate in core inflation and non-core inflation:

$$\Pi_t = \Pi^{Core}{}_t + \Pi^{SR}{}_t$$

Where,

Π_t = aggregate inflation rate in period t.
$\Pi^{Core}{}_t$ = Core inflation rate
$\Pi^{SR}{}_t$ = Short-term or cyclical inflation.

$\Pi^{SR}{}_t$ comprises on the short term disturbances to inflation. We will focus with more details on the definition of the core inflation in the next section in our identification scheme.

d) Official measures of core inflation in India and Pakistan:

The state bank of Pakistan uses non-food non-oil inflation measure (NFNO) as core inflation. Tahir S. (2003) estimated the core inflation by using the trimmed means method. She trimmed 20% values on both sides of the price distribution for estimating the core inflation. The Indian central bank (Reserve bank of India) has no official measures of core inflation. However, the policy of lowering and stabilising the inflation by the central banks in these countries is of high importance.

4.1 Approaches for the estimation of core inflation:

In the following sections, we provide a brief account of different generalised and persistent measures of core inflation.

(a) **Generalised measures of core inflation:**

The generalised measures of core inflation comprise of the cross-sectional and panel methods. The *cross-sectional methods* measure the core inflation by using the weighting approaches which comprise of ex food and energy or zero weighting approaches, trimmed means, and weighted median etc. These are disaggregated methods which use the distribution of inflation at a particular point in time. Panel methods comprise of the dynamic factor index.

i) Method of ex-food and energy:

'Ex-food and energy approach' is the most commonly used approach. Some central banks exclude also certain other unwanted categories showing one-off changes, for example interest rate on mortgage, subsidies or levies by the government etc. The logic is that these

are noisy components and they provide no information about the long term trend or core inflation.

ii) Method of trimmed means:

The method of *trimmed mean* removes the extreme movements during a particular time period by trimming the tails of the distribution of price shocks. The trimmed means approach splits off the core inflation changes from asynchronous disturbances on the grounds that asynchronous disturbances give no signal to long term inflation. Bryan & Cecchetti (1993) employed the model of Ball & Mankive (1992), in which the relative price rigidity and menu costs compel certain firms not to change their prices of this sector. Only those sectors change their prices who have the menu costs less than the change in price ($|\varepsilon_i| > menu\ cost$). Thus, according to the trimmed mean method:

$$\Pi_i = \Pi^{core} + \varepsilon_i$$

With Π_i is the rate of inflation of i^{th} sector, Π^{core} is the core inflation, and ε_i are the asynchronous disturbances.

In this method, individual price indices are ordered according to their variations and then we give zero weight to extreme variations (a certain percentage of the indices on both sides). Generally, in the trimmed mean method, we remove 16% extreme variations in prices (8% of the smallest and 8% of the largest changes in prices) while taking into account relative weighting of price index and estimating the average of rest distribution. Bryan & alii (1997) observed that 'a trimmed means is more efficient estimator of core inflation' if the tails of the distribution are fat and they defined 'the core inflation as the long run centred moving average of CPI'. According to them, this method can improve the core inflation estimates because the inflation data generally expose high kurtosis relative to the normal distribution. The weighted trimmed mean is calculated by the following formula:

$$\pi_\alpha = (1/(1-2\alpha/100))\sum w_i\pi_i \quad \text{i} = \text{f}\,(\text{I}_\alpha)$$

Here, $\pi_i = \{\pi_1, \pi_2, \ldots\ldots \pi_n\}$ are the sectoral inflations measured in terms of the CPI. Each sectoral inflation has the respective weights $w_i = \{w_1, w_2 \ldots w_n\}$. Their cumulative weight is $W_i = \sum w_i$, such that $I_\alpha = \{\alpha/100 < W_i < 1-(\alpha/100)\}$. As this method is static, so there is no need to revise it while adding new data.

The optimal value of trim is determined by using the root mean square error (RMSE).

$$RMSE = \sqrt{\sum_{t=1}^{n} (\pi_t^{\alpha} - \pi_t^{trend})^2 / n}$$

α is the trimming ratio. π^{α} is the inflation measured in terms of log difference of CPI. π^{trend} is the trend rate of inflation. Generally, the 12 months or 36 months centred moving averages is considered as the trend rate of inflation. n is the number of samples. According to RMSE criteria, the optimal value of trim corresponds to the minimum value of RMSE.

Thus, the α% trimmed mean is obtained by trimming α% in every queue of the distribution.

The extreme variations are also removed by trimming the values further than 1.5% standard deviation from the average. Trimming in this way allows the values trimmed to be dependent on the tightness of the distribution.

iii) Method of weighted median:

The method of *weighted median* gives an estimation of core inflation by considering the median distribution of price variations according to the importance of distribution. Each movement is weighted according to its weights in the basket of good during the time period under consideration. The used of weighted median is motivated by the point that the price movements in different components of CPI are often skewed. Bryan & Cecchetti (1993) analysed three limited influence estimators namely, the CPI ex food and energy, 15% trimmed means and the median. They found the median to be closely related to money growth and that this median provides more precise estimates of future inflation. The weighted median is calculated as follows:

Weighted median = [(50% - CW1) * (MM1) + (CW2 – 50%) * (MM2)] / (CW2 – CW1)

CW1 = Cumulative weight of first value in the median
CW2 = Cumulative weight of second value in the median
MM1 = Monthly movement of first value in the median
MM2 = Monthly movement of second value in the median.

Drawbacks of exclusion based measures:

A specific increase in the price of a good may increase the general price level, so a negative point of the method of Bryan & Cechetti and almost all the exclusion based methods is that the exclusion of a certain good may result in the loss of some important information. In the context of India and Pakistan and in general for all the developing economies, where both the food and energy prices are heavily weighted, the ex-food and energy approach is undesirable because any exclusion of these subgroups will lead to a significant loss of information and probably will result in the biased estimate of core inflation. These approaches are rather subjective. These are not corrected for the correlation between inflation and economic cycle. Further, these approaches are not backed by any economic theory rather they depend only on the statistical criteria. Finally, in case of the trimmed means the optimal value to be trimmed changes if we increase the number of groups.

vi) Panel method for core inflation:

Dynamic factor index model developed by Stock & Watson (1988) takes into account the cross-sectional and time series properties of individual price changes for estimating core inflation.

4.1.1 Persistent measure of core inflation:

These approaches comprise of the univariate time series smoothing statistical techniques and multiviate modelling approaches.

1) Univariate Time-series smoothing techniques:

Smoothing the trend of the rate of inflation by either the *moving averages method* (one year or three years (centred) moving averages) or by some *Autoregressive integrated moving averages models (ARIMA)* are the time series approaches for the estimation of core inflation. The use of these smoothing techniques reduces the volatility of inflation. Some more sophisticated techniques such as the Hodrick-Prescott filter and the Kalman filter are also used to smooth the trend of the rate of inflation.

However, these techniques assume certain features of inflation that are again not well supported by the economic theory. These approaches lower the timeliness of information on core inflation if we use 6 months or 12 month monthly data. Furthermore, these approaches only remove the temporary shocks as long as these shocks exhibit regular seasonality or magnitude. In reality, there are some asynchronous shocks in the price indices that do not belong to seasonality and the time series smoothing techniques do not capture these asynchronous shocks.

2) Multivariate modelling approaches:

Multivariate approaches decompose the actual inflation into core inflation and non core inflation by using the method of *structural Vector Auto Regression* proposed by Quah and Vahey (1995). Fase & Folkertsma (1998), Clause (1997), Jacquinot (1998), Mialou (2002) used the same methodology for measuring the core inflation for other countries. Multivariate approaches also decompose the actual inflation into core and non core inflation by *the common trends approach* used by Blix (1997).

Multivariate approaches relate the practical measurement of inflation to its theoretical definition. Quah & Vahey (1995) assume long run output neutrality and define core inflation having no long run effects on real output. They associate the aggregate supply shocks to short term inflation. According to them, the supply shocks may have permanent effects on the price levels, but not on the rate of inflation. They take the core inflation as a more persistent monetary phenomenon than the aggregate measured inflation under the assumption of long run neutrality of money and the vertical Phillips curve.

However, the approach of Quah & Vahey (1995) treats all the transient shocks identically. In order to improve the results, Clause (1997), Bjornland (1997) and Gartner & Wehinger (1998) added one more restriction by using the oil prices and the short term nominal interest rates.

4.2 Criteria for the choice of an approach for the estimation of core inflation:

There are six criteria for the choice of an approach for the estimation core inflation[7].

1) The approach should adequately represent the concept of price stability the central bankers look for. This estimate of core inflation will reflect only the persistent component that matters to the central bank.
2) The approach should be forward looking.
3) The approach should have some theoretical basis. It should make sense on economy theory.
4) The approach should be understandable by the public. According to this criterion, only the ex food and energy approach can be understandable by public.
5) Historical decomposition should not change over time.
6) The approach should be computable in real time.

4.3 The Structural VARs approach and estimation of core inflation:

In this section we analyse thoroughly the structural Vector Auto-regression approach and the estimation of core inflation using this approach.

4.3.1 Rationale for the Structural VAR approach:

We employ the structural Vector Auto-regression approach for estimating the core inflation. The interest for structural VARs is based on the criticism by Sims (1980) describing that the economic theory does not precise sufficiently the large structural models. Our focus is on forward looking assessment of inflation. Thus, the structural VAR approaches are preferable to other approaches because the structural VAR approaches are forward looking[8] and based on monetary theory. There is a general agreement upon the long term neutrality of inflation on production[9]. Long term neutrality of inflation implies that the inflation has no effects on output in long run. By imposing this long run restriction, the structural VAR approach removes the conceptual mismatch between current methods of estimation of inflation and the economic theory. The economic foundation and forward looking properties of Structural VAR approach make this approach superior to other approaches for the estimation of core inflation.

The Structural VAR approach uses the concept of log run vertical Phillips curve. This concept is also equivalent to the long run vertical aggregate supply curve[10] where there exists a long run dichotomy between the price and output. In long run an aggregate supply shock has no effect on inflation (figure 3).

To our best knowledge there is not yet any work done on core inflation for the countries under consideration by employing this approach. The actual inflation is divided into two parts; the core inflation and the cyclical or short term inflation. According to the vertical long run Phillips curve, the core inflation is the part of inflation that has no long run effect on

[7] Roger (1998) ; Wynne (1999).
[8] Wynne (1999).
[9] Quah & Vahey (1995); Jacquinot (1999).
[10] Blix (1997).

production. The other part is short term inflation. Accordingly the core inflation shows the long term long run dichotomy between the real and nominal variables. Long run vertical Phillips curve tells us that in long run the output is affected only by the supply shocks and the inflations is affected only by the demand shocks.

We consider the bivariate VAR model, composed on Gross Domestic Product (GDP) and Consumer price index (CPI), on the lines proposed by Blanchard & Quah (1989) and Quah & Vahey (1995). We suppose that there are only two shocks on the economy, i.e., the supply shock (ε_s) having permanent effects on output and aggregate prices and the demand shock (ε_d) having no long run effects on output but permanent effects on aggregate prices. Further, we impose two restrictions on these structural shocks. The first restriction is that these shocks are uncorrelated at all leads and lags. The second restriction is that the demand shocks have no long run effect on output. We can write it in the functional form as follows:

$y = f(\varepsilon_s)$
$p = f(\varepsilon_s, \varepsilon_d)$

4.3.2 Structural VAR method:

VAR model of order P is as follows:

$$A(L)X(t) = \varepsilon_t \qquad (1)$$

Where

$Var(\varepsilon) = \Sigma_\varepsilon$ and $A(L) = \sum_{j=0}^{p} A(j)L^j$

$A(L)$ is invertible. L is lag operator. Structural shocks $\varepsilon_t = (\varepsilon_1, \varepsilon_2, ...\varepsilon_n)_t$ are serially uncorrelated. They are pair wise orthogonal. Their variances are normalised to one. Their variance covariance matrix is an identity matrix (I).

The matrix X follows a stationary process. So, we can write their moving average representation as follows:

$$X(t) = B(0)\varepsilon(t) + B(1)\varepsilon(t-1) + ... \qquad (2)$$

or

$$X(t) = B(L)\varepsilon_t = \sum_{j=0}^{\infty} B(j)\varepsilon(t-j) \qquad (3)$$

Where,

$B(L) = A^{-1}(L)$

Bivariate moving average form with 'y' standing for output and 'p' for inflation (i.e., $X(t)= [\Delta y \quad \Delta p]'$) is written as follows:

$$\left.\begin{aligned} \Delta y_t &= \sum_{j=0}^{\infty} B_{11}(j)\varepsilon_{1,t} + \sum_{j=0}^{\infty} B_{12}(j)\varepsilon_{2,t} \\ \Delta p_t &= \sum_{j=0}^{\infty} B_{21}(j)\varepsilon_{1,t} + \sum_{j=0}^{\infty} B_{22}(j)\varepsilon_{2,t} \end{aligned}\right\} \qquad (4)$$

The term $\sum_{j=0}^{\infty} B_{12}(j)$ explains the long run effect of ε_2 on the level of y.

Reduced form of VAR is as follows:

$$C(L)X(t) = e_t \qquad (5)$$

e_t = Reduced form innovations. $e_t = (e_1, e_2, ..., e_n)_t'$

$$C(L) = \sum_{j=0}^{\infty} C(j)L^j \qquad (6)$$

C(L) is invertible. We assume *C(0)= I.* $Var(e_t) = \Omega$

By inverting C(L) we can write the reduced form Wold Vector Moving Average representation of X_t as follows:

$$X(t) = C(L)^{-1} e_t \qquad (7a)$$

$$X(t) = D(L)e_t \qquad (7b)$$

With $D(L) = C(L)^{-1}$ and

$$D(L) = \sum_{j=0}^{\infty} D(j)L^j \qquad (8)$$

Equations 3 and 7 (a) imply that the reduced form innovations are linear combination of structural shocks. That is,

$$e_t = A_0^{-1}\varepsilon_t \qquad (9)$$

With, $A_0^{-1} = B_0$. Multiplying both sides of equation 9 by its transpose and considering that,

$Var(\varepsilon) = \Sigma_\varepsilon$ and $Var(e) = \Omega$

$$\Omega = B(0)\Sigma_\varepsilon B(0)' \qquad (10)$$

We further assume that $\Sigma_{\varepsilon} = I$. Thus,

$$\Omega = B(0)B(0)' \qquad (11)$$

From equations 3, 7 and 9, we get:

$$B(1) = C(1)B(0) \qquad (12)$$

Thus, from equations 9 & 12, we can recover ε, since the matrix B(0) is unique.

4.3.3 Identification of shocks:

Our aim is to estimate the matrix B(0) by the process of identification of shocks. Matrix B_0 will help us to determine the unobservable structural shocks from the observable reduced form shocks. Since, there are n^2 unknowns in our equation. Therefore, in order to exactly identify the reduced form VAR, we need to impose n^2 restrictions. In our bivariate VAR model, there are two variables (n=2), so we have to impose four restrictions. Equation 11 provides ($\frac{n(n+1)}{2}$) three restrictions (the shocks are orthogonal (equation 11)). We have to impose now one more restriction ($\frac{n(n-1)}{2}$) in order to exactly identify the VAR model. Thus the fourth restriction is provided by the long run neutrality condition (equation 14). We can rewrite equation 12 for B(0), as follows:

$$B(0) = B(1)C(1)^{-1} \qquad (13)$$

The demand shock $\varepsilon_{2,t}$ has no effect on output level (y). Thus, the long run long neutrality condition imply that the upper right entry in *B(1)* is zero. That is:

$$B_{12}(1) = \sum_{j=0}^{\infty} B_{12}(j) = 0 \qquad (14)$$

Equation 14 imply that *B(1)* is the lower triangle. Finally we can write the equation 4 in matrix form as follows:

$$\begin{bmatrix} \Delta y_t \\ \Delta p_t \end{bmatrix} = \begin{bmatrix} B_{11}(1)\,0 \\ B_{21}(1)\,B_{22}(1) \end{bmatrix} \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \end{bmatrix} \qquad (15)$$

The inflation equation is as follows:

$$\Delta p_t = B_{21}(1)\varepsilon_{1,t} + B_{22}(1)\varepsilon_{2,t} \qquad (16)$$

4.3.4 Impulse response Function:

From equation 3, $X(t) = B(L)\varepsilon_t$.

Therefore, the response of a variable $X_{i,t}$ at a time horizon 's' to a unitary shock to j^{th} component of ε_t can be written as follows :

$$\partial B_{ij,s} = \frac{\partial X_{i,t+s}}{\partial \varepsilon_{j,t}} \qquad (17)$$

$\partial B_{ij,s}$ in the above equation are the impulse response functions.

4.3.5 Historical decomposition and the estimation of core inflation:

Our intention from the historical decomposition of a series is to simulate the series for a given horizon t + s conditional on the available information in the period t, in order to analyse the share of each disturbance in the historical evolution of the series. At a time horizon s the historical decomposition of the variable X is as follows:

For Output:

$$X_{1,t+s} = \sum_{k=0}^{s-1} B_{11,k}\varepsilon_{1,t+s-k} + \sum_{k=0}^{s-1} B_{12,k}\varepsilon_{2,t+s-k} + \sum_{k=s}^{\infty} B_{1*,k}\varepsilon_{t+s-k} \qquad (21)$$

For inflation:

$$X_{2,t+s} = \sum_{k=0}^{s-1} B_{21,k}\varepsilon_{1,t+s-k} + \sum_{k=0}^{s-1} B_{22,k}\varepsilon_{2,t+s-k} + \sum_{k=s}^{\infty} B_{2*,k}\varepsilon_{t+s-k} \qquad (22)$$

From equation 19, we can differentiate between the core inflation Δp_t^{core} and the short term inflation Δp_t^{SR} as follows:

$$\Delta p_t^{core} = \sum_{k=0}^{s-1} B_{22,k}\varepsilon_{2,t+s-k} + \sum_{k=s}^{\infty} B_{2*,k}\varepsilon_{t+s-k} \qquad (23)$$

$$\Delta p_t^{SR} = \sum_{k=0}^{s-1} B_{21,k}\varepsilon_{1,t+s-k} \qquad (24)$$

4.3.6 Estimation methodology and results:

As an extended time series for monthly GDP data is not available for India and Pakistan. Therefore, we used the index of industrial production for India and the index of manufacturing production for Pakistan as a proxy for monthly GDP data. We used the whole sale price index for India and the consumer price index for Pakistan for our estimation of core

inflation. We estimated the inflation Our estimation work covers the times period from June 1994 to December 2004. We chose this period because of the data limitations.

(i) The tests for stationarity:

We performed the Augmented Dicky Fuller unit root test (See tables 5 a, b & 6 a, b). In case of Pakistan, the output was stationary, with a constant (excluding the trend) with the lag length 12. The inflation was stationary with lag length twelve excluding the trend and the constant.

Table 5 a: Pakistan: Augmented Dickey Fuller tests

Sample: 1995:09 2004:12: Lag Length: 12; Null Hypothesis: $\Delta\pi$ has a unit root

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4,47611	0,00001
Test critical values:	1% level	-2,58577	
	5% level	-1,94371	
	10% level	-1,61483	

*MacKinnon (1996) one-sided p-values.

Table 5 b: Pakistan: Augmented Dickey Fuller tests

Lag length: 12; Null Hypothesis: Δ(industrial production) has a unit root

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4,018	0,002
Test critical values:	1% level	-3,490	
	5% level	-2,887	
	10% level	-2,581	

*MacKinnon (1996) one-sided p-values.

In case of India, the output was stationary with lag length 11, including the constant. The inflation was stationary with lag length twelve, excluding the constant and the trend at 99% critical level.

Table 6 a: India: Augmented Dickey Fuller tests

Null Hypothesis: Δ(industrial production) has a unit root

Exogenous: Constant ; Lag Length: 11 (Fixed)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3,561	0,008
Test critical values:	1% level	-3,489	
	5% level	-2,887	
	10% level	-2,581	

*MacKinnon (1996) one-sided p-values.

Table 6 b: India: Augmented Dickey Fuller tests

Null Hypothesis: Δπ has a unit root
Exogenous: None; Lag Length: 12 (Fixed)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3,853	0,000
Test critical values:	1% level	-2,586	
	5% level	-1,944	
	10% level	-1,615	

*MacKinnon (1996) one-sided p-values.

(ii) **The tests of Cointegration:**

Next, we performed the tests of cointegration (table 7 & 8). The Johanson cointegration tests showed an absence of the long run cointegration relationship among Δπ and Δy in Pakistan at 95% critical level (table 7).

Table 7: Johanson cointegration test: Pakistan

Sample: 1995:04 2004:12: Test assumption: Linear deterministic trend
Δπ & Δy ; Lags interval: 1 to 7

Hypothesized No. of CE(s)	Eigenvalue	Trace statistic	0.05 Critical Value	Probability.**
None	0,05	7,92	15,49	0,47
At most 1	0,02	2,33	3,84	0,13

Trace test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

However, in case of India the cointegration test showed a long run relationship among Δπ and Δy. Therefore, we performed the test cointegration on level (i.e., for π and y). The test showed the absence of long run relationship among the two variables at 95% critical level (table 8).

Table 8: Johanson cointegration test: India

Trend assumption: Linear deterministic trend
Series: π & y; Lags interval (in first differences): 1 to 6

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0,118	15,255	15,495	0,054
At most 1	0,003	0,381	3,841	0,537

Trace test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

(iii) Determination of lag-length:

We analysed the sequential modified LR test statistics, final prediction error (FPE) criterion, Akaike (AIC) and Schwarz (SC) criteria and the Hannan-Quinn (HQ) information criterion for selecting the maximum lag length for our estimation (tables 8 & 9).

In case of India, the values for FPE, AIC and HQ criteria were maximum in absolute terms for the lag length 3. The SC value was maximum in absolute terms for the lag length 2. Finally, the LR value was maximum for the lag length 9. For a monthly data, the lag length of 3 is too small. So we used the sequential modified LR test and we took the lag length of 9.

Table 9: India: Information criteria

Lag	LR	FPE	AIC	SC	HQ
2	**47,30**	**1,59E-08**	**-12,28**	**-12,04***	**-12,18**
3	**12,05**	**1,52e-08***	**-12,32***	**-11,99**	**-12,19***
4	**1,77**	**1,61E-08**	**-12,27**	**-11,84**	**-12,09**
5	**4,27**	**1,66E-08**	**-12,24**	**-11,71**	**-12,03**
7	**2,64**	**1,74E-08**	**-12,19**	**-11,47**	**-11,90**
9	**13,13***	**1,67E-08**	**-12,24**	**-11,32**	**-11,87**
10	**2,20**	**1,75E-08**	**-12,19**	**-11,18**	**-11,78**
11	**3,42**	**1,82E-08**	**-12,16**	**-11,05**	**-11,71**

For Pakistan, the values of sequential modified LR test, the FPE and the AIC criteria were maximum in absolute terms for the lag length 7. The SC and HQ criteria gave the maximum for the lag length 2 (see the table 8). Again, for a monthly data the lag length of 2 is too small. Therefore, we selected the lag length of 7.

Table 10: Pakistan: Information criteria

Lag	LR	FPE	AIC	SC	HQ
2	**29,20**	**1,28E-07**	**-10,20**	**-9,96***	**-10,10***
3	**4,88**	**1,31E-07**	**-10,17**	**-9,84**	**-10,04**
4	**5,37**	**1,33E-07**	**-10,16**	**-9,72**	**-9,98**
5	**8,56**	**1,32E-07**	**-10,17**	**-9,64**	**-9,95**
7	**17,1***	**1,23e-07***	**-10,24***	**-9,51**	**-9,94**
8	**1,84**	**1,30E-07**	**-10,19**	**-9,37**	**-9,85**
9	**4,11**	**1,34E-07**	**-10,16**	**-9,24**	**-9,79**
10	**3,42**	**1,39E-07**	**-10,13**	**-9,11**	**-9,71**
11	**6,97**	**1,38E-07**	**-10,13**	**-9,02**	**-9,68**

Estimation of matrices:

Our estimates of the coefficients of the variance-covariance matrix of regression residuals are as follows:

Table 12: Estimates of Var-Cov matrix

	$\Omega_{1,1}$	$\Omega_{2,1}$	$\Omega_{2,2}$
India	3.709	0.026	0.253
Pakistan	44.66	-0.125	0.211

The matrix C in our Wold moving average estimation of the reduced form VAR is given as follows (equation 5):

Table 13: Estimates of matrix *C*

	$C_{1,1}$	$C_{1,2}$	$C_{2,1}$	$C_{2,2}$
India	2.669	4.059	-0.083	5.295
Pakistan	2.949	6.456	-0.052	4.438

In the equation (7 (a)) $X(t) = C(1)^{-1}e_t$ and from equation 9 $e_t = A_0^{-1}\varepsilon_t$. So, $X = C^{-1}B\mathcal{E}$. We estimate the matrix $BC(1)^{-1}$ as follows. In the matrix *DB*, we set the figure above the principal diagonal equal to zero. This is manifested by the second term ($(DB)_{1,2} = 0$) on the first row in the table below.

Table 14: Estimates of matrix BC^{-1}

	$(BC^{-1})_{1,1}$	$(BC^{-1})_{1,2}$	$(BC^{-1})_{2,1}$	$(BC^{-1})_{2,2}$
India	0.715	0.000	-0.005	0.094
Pakistan	2.229	0.000	0.012	0.102

Finally, by using the orthogonalisation scheme of Blanchard & Quah, we got the following B matrix. Matrix $B(0) = A_0^{-1}$ shows the significant effects of $\boldsymbol{\varepsilon}_1$ on output and of $\boldsymbol{\varepsilon}_2$ on inflation.

Table 15: Estimates of matrix B(0)

	$B(0)_{1,1}$	$B(0)_{1,2}$	$B(0)_{2,1}$	$B(0)_{2,2}$
India	1.888	0.380	-0.086	0.496
Pakistan	6.650	0.661	-0.064	0.454

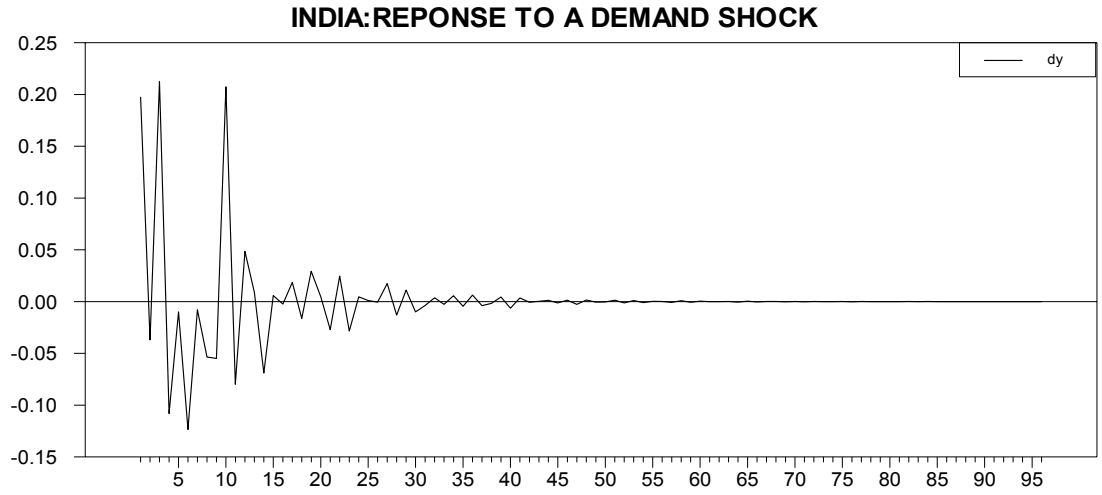
4.3.7 Validation of the identification scheme:

Before estimating the core inflation with the structural VAR approach, we validate our identification scheme by estimating the impulse response functions and the historical decomposition of variance.

(i) Responses to shocks:

The series of Figures from 7 to 14 shows the accumulated impulse responses of industrial production and inflation to demand and supply shocks. We scaled the responses of each variable in terms of standard deviations. The vertical axis shows the standard deviations and the horizontal axis shows the months. The impulse response of industrial production to a positive demand shock in India is cumulated to zero at the end of four years. In case of Pakistan, this response is cumulated to zero at the end of third year (Figure 13). The impulse response of inflation to a demand shock is positive, both in India and Pakistan.

Figures 7 & 8: India: Accumulated impulse responses to a demand shock



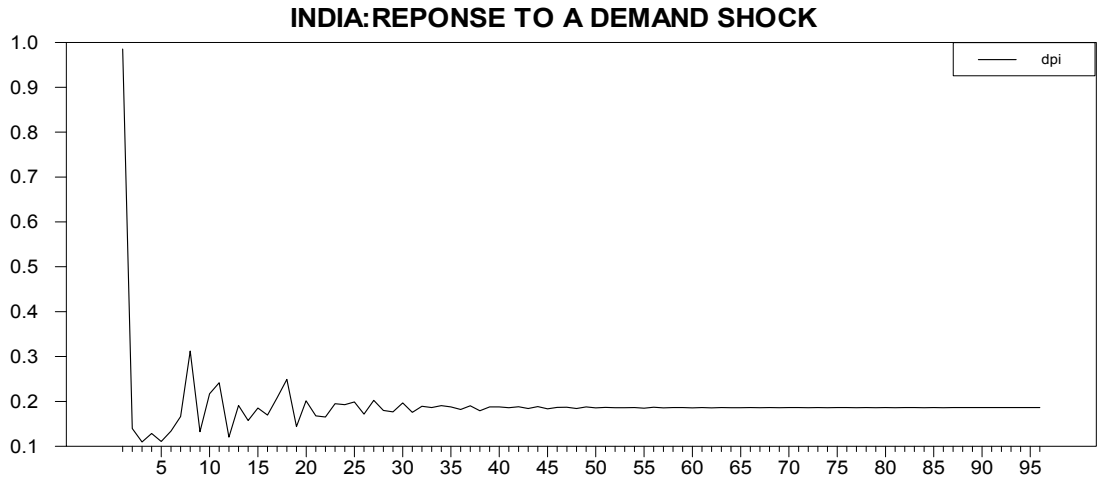
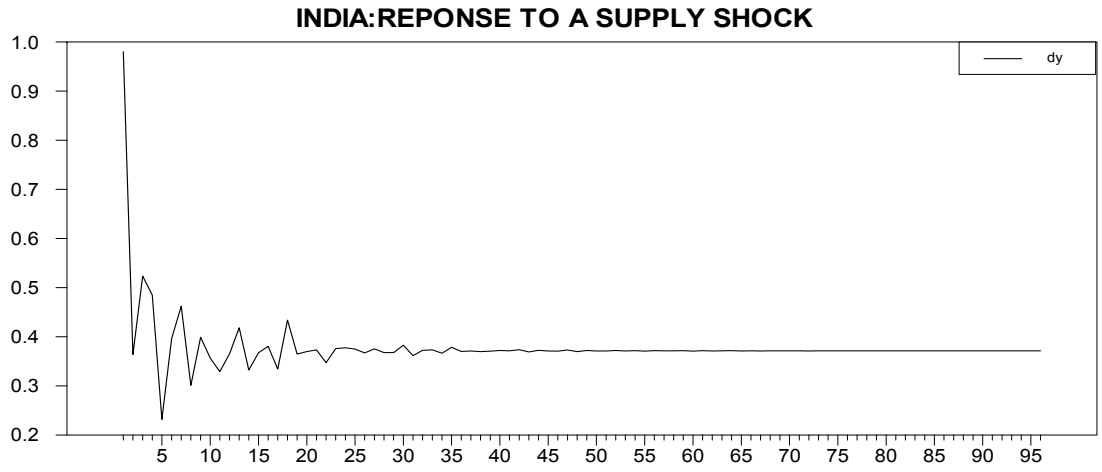


Figure 9 & 10: India: Accumulated impulse responses to a supply shock



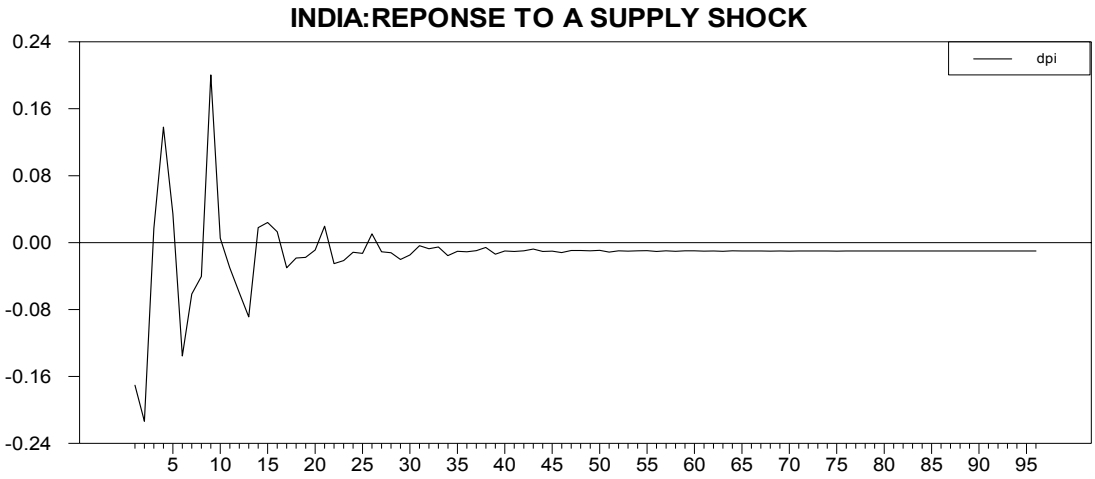
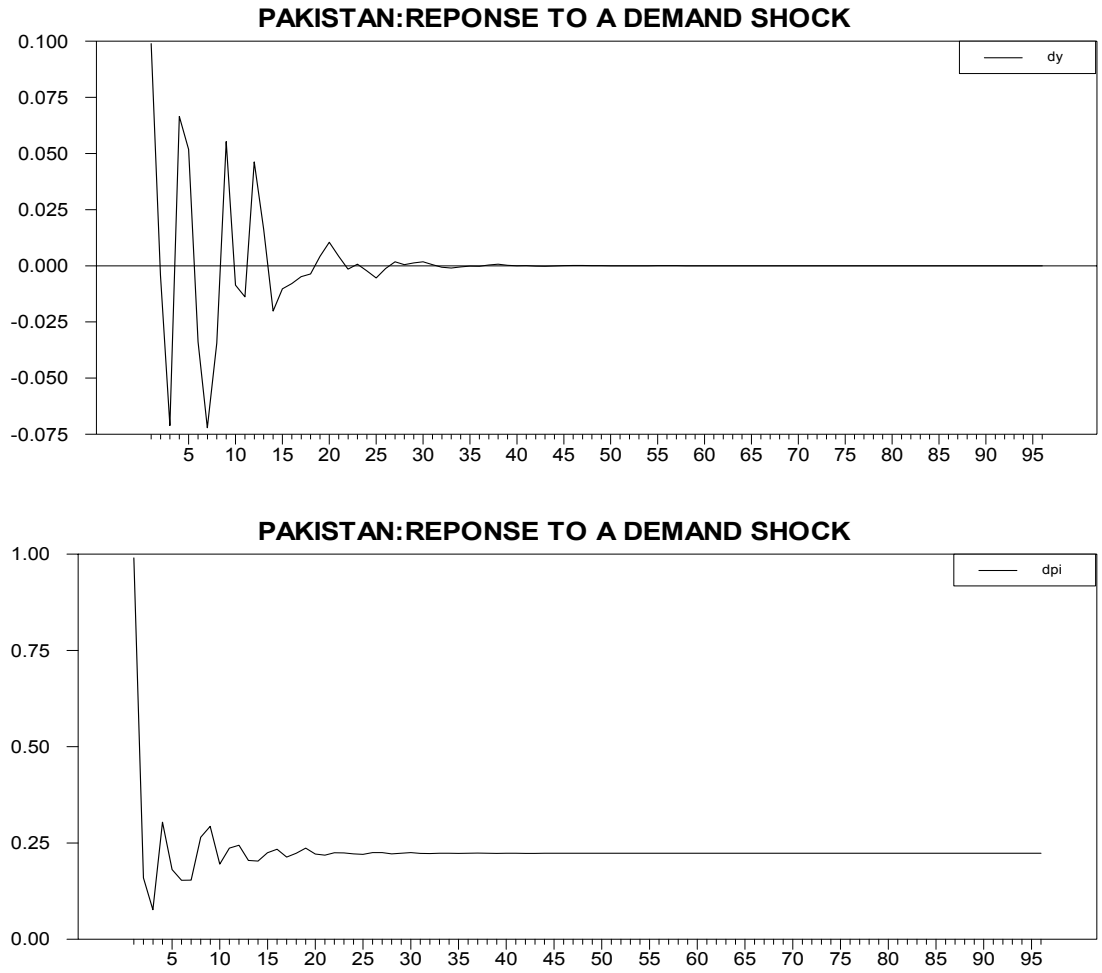


Figure 11 & 12: Pakistan: Accumulated impulse responses to a supply shock

Figure 13 & 14: Pakistan: Accumulated impulse responses to a demand shock



The impulse response of industrial production to a supply shock is positive, in both countries. The accumulated impulse response of inflation to a supply shock is negative and is insignificant in case of India. The accumulated impulse response of inflation to a supply shock is positive in case of Pakistan. However, this effect is insignificant. Our results of accumulated impulse response are similar to those of the effects of a supply shock on observed inflation in other empirical studies on European countries (Jacquinot (1998) for United Kingdom and Gartner Christine et al (1998) for Italy).

We imposed the long term restriction that the demand shocks have no long run impact on industrial production. The resulted impulse responses functions validate our identification scheme and they fulfil the restrictions imposed in our model.

(ii) Variance decompositions:

We have estimated the part of the variance of each series for the countries under consideration due to the demand shock. Our estimates of the variance decomposition verify our identification scheme (i.e., the demand shock has not significant effects on output) for the two countries over the times horizon of ten years.

Table 11: Decomposition of Variance for Series Δy and Δπ
Percentage of variance explained by a demand shock $\varepsilon_{d,t}$

	India			Pakistan	
Horizon (months)	Δy	Δπ	Horizon (months)	Δy	Δπ
1	2.909	97.091	1	1.947	98.053
2	1.802	98.198	2	8.499	91.501
3	4.742	95.258	3	8.839	91.161
4	5.526	94.474	4	9.737	90.263
6	7.573	92.427	6	10.043	89.957
8	7.778	92.222	8	10.364	89.636
12	12.079	87.921	12	11.767	88.233
18	12.639	87.361	18	11.802	88.198
24	12.667	87.333	24	11.809	88.191
36	12.705	87.295	48	11.811	88.189
48	12.708	87.292	60	11.811	88.189
120	12.708	87.292	120	11.811	88.189

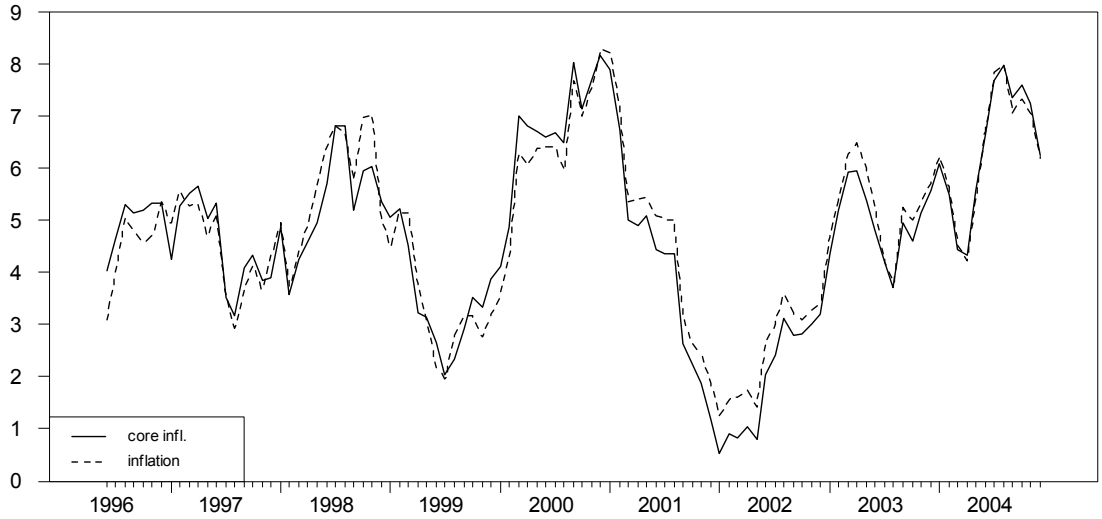
For India the variance decomposition for the industrial production due to the demand shock ranges to around 12.7% at the end of tenth year, whereas for the inflation this effect reaches to 87.3% (table 9).

In case of Pakistan, the variance decomposition of industrial production due to a demand shock reaches to 11.8% approximately at the end of tenth year and the variance decomposition for the inflation reaches to 88.2% (table 11).

4.3.8 Core inflation:

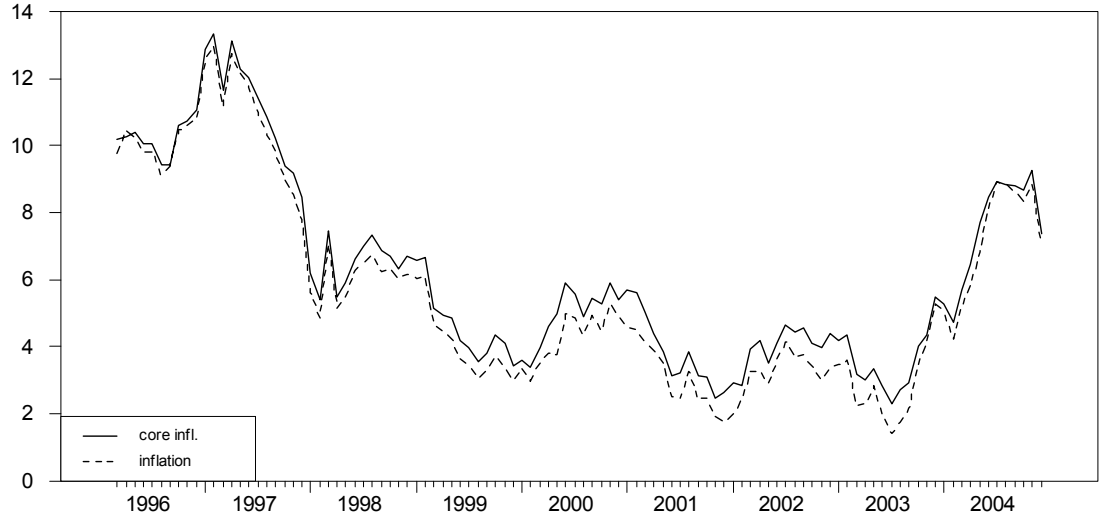
Figures 15 and 16 show the evolution of core inflation and the observed inflation in India and Pakistan. Both of the two Figures are in annual averages. From the figure 15, it is evident that in India the core inflation and the observed inflation both have closed evolution except during 2001-2002. During this period, the core inflation is less than the observed inflation. In general, we found that in long run the core inflation converges towards the observed inflation. As we discussed above that during the period of 1998-1999, the Indian economy faced a significant rise the prices of primary products. Moreover, during the period of 2000-2001, the inflation rose again due to an increase in the fuel and energy price. The core inflation takes in to account these two effects. This phenomenon is also supported by the earlier research showing that the primary product prices and the prices of fuel and energy have important effects on inflation expectations in both the countries.

Figure 15: India: core inflation and actual inflation during 1995-2004



In case of Pakistan, again the two series showed a closed evolution. However, we found that during the period of 1998-2003, the core inflation remained above the actual inflation. Here, our results are similar to that of P. Jacquinot (1998) for France, Germany and United Kingdom, where the core inflation exceeds the actual inflation during the periods of disinflation. For UK, Quah & Vaehy (1995) and Jacquinot (1998) found, during the 1990s, a significant difference between the core inflation and the actual inflation due to favourable supply shocks. In case of Pakistan, the difference between the core inflation and the actual inflation may be due to the existence of supply shocks. The rise of actual inflation during the period of 1996-1997 was due to an increase in fuel and energy prices. Given the importance of the price variations of these products in a developing economy like Pakistan, the core inflation fully captures this rise in actual inflation.

Figure 16: Pakistan: core inflation and actual inflation during 1995-2004



5. Conclusions:

We estimated the core inflation for India and Pakistan by employing the structural Vector-Autoregression (VAR) approach. We study the effect of aggregate supply and demand shocks on output and inflation. The supply shocks are important in developing countries, like India and Pakistan. Given the evidence, that the central banks in the respective countries are focusing the policy of price stability, we discuss the notion of core inflation. First of all, we study the concept of core inflation. There exist two main methods to define the core inflation. The first method is backed by the economic theory and the second method consists of statistical approaches.

We discuss the Structural VAR approach for the estimation of core inflation. Our identification method is based on the work of Blanchard & Quah (1989) and Quah & Vahey (1995). Using the concept of vertical long-run Phillips curve we impose the restriction that demand shocks have no long run effect on output. We define the core inflation as the persistent component of measured inflation that has no medium to long run effect on output. This long run component of price index is highly correlated to monetary growth. We estimate the impulse response functions to demand and supply shocks. We estimate the core inflation from June1994 to December 2004 by using the monthly data. We showed that the actual inflation remained around the core inflation during most of the period of estimation. Whereas, in case of Pakistan, we found that the core inflation remained above the actual inflation from 1998 to 2003. During the rest of the period, the actual inflation remained around the core inflation.

Finally, we conclude that the estimations of core inflation based on a forward-looking approach can be helpful for monetary policy. It will be more useful for a central bank to compare different approaches of core inflation for policy purposes.

References:

1. Amisano G. & Giannini C. (1997) "Topics in structural VAR econometrics", 2nd edition. Springer.
2. Blanchard O. & Quah D. (1989) "The dynamic effects of aggregate demand and supply disturbances", The American economic review, vol. 79, no. 4, September 1989.
3. Blix M. (1997) "Underlying inflation – A common trends approach", Economics department, Sverignes Riksbank.
4. Bryan M. & Cecchetti S. (1993) "The consumer price index as a measure of inflation", NBER working paper no. 4505.
5. ----------"Measuring core inflation", NBER working paper no. 4303.
6. Bryan M. & Cecchetti S. & Wiggins R. (1997) "Efficient inflation estimation", NBER working paper no. 6183.
7. Debelle G. (1999), "Inflation targeting and output stabilisation", Reserve Bank of Australia research discussion paper 1999-08, Economic analysis department, Reserve Bank of Australia, June 1999.
8. Eckstein Otto (1981) "Core inflation", Harvard university, Prentice Hall.
9. Enders Walter (1995) « Applied econometric time series », John Wiley & sons inc.
10. Friedman B. (2000) "Monetary policy", NBER working paper no. 8057, National Bureau of Economic Research, Cambridge, December 2000.
11. Gartner Christine & Gert D. Wehinger (1998) "Core inflation in selected European countries", Oesterreische Nationalbank working paper no. 33.
12. Gordon Robert J. (1984) "Supply shocks and monetary policy revisited", AEA papers and proceedings, 'Economic effects of the rise in energy prices', vol. 74, no. 2, pp. 38-43.
13. Gorden Robert G. (1993) "Macroeconomics", 6th edition, Harper Collins college publishers.
14. Hahn Elke (2002) « Core inflation in the Euro area: Evidence from the structural VAR approach », CFS working paper no. 2001/09, Center for financial studies at the Johann Wolgang Goefthe-Universität.
15. Haldane A. & Batini N. (1998) "Forward-looking rules for monetary policy", NBER working paper no. 6543.
16. Jacquinot P. (1999) "L'inflation sous-jacente à partir d'une approche structurelles des VAR: Une application à la France, l'Allemagne et au Royaume-Uni », document du travail, Banque de France.
17. Shapiro M. & Watson M. (1988) "Sources of business cycles fluctuations", NBER working paper no. 2589.
18. Lardic S. & Mignon V. (2002) "économétrie des séries temporelles macroéconomiques et financiers", Economica.
19. Le Bihan & Sédillot F. (1999) "Quatre indicateurs d'inflation sous-jacente: Application et interprétation", Notes d'études et de recherche numéro 69, Banque de France, décembre 1999.
20. Lucas Robert E. (1996) "Nobel lecture: monetary neutrality", Journal of political economy, vol. 104, No. 4, pp. 661-682.
21. Macklem T. "Une nouvelle mesure de l'inflation fondamentale", Reveu de la Banque du Canada, Automne 2001.
22. Mankiv Gregory N. (1997) "Macroeconomics", 3rd edition, worth publishers.

23. Mialou André (2002) « L'inflation sous-jacente en Afrique du Sud et au Gabon : Une modélisation à partir de l'approche VAR structurelle », Banque des états de l'Afrique centrale, notes d'études et de recherche no. 1, octobre 2002.
24. Mishkin Frederic S. (2004) "The economics of money, banking and financial markets", 7th edition, Addison Wesley.
25. Nessén M & Söderström (2001) "Core inflation and monetary policy", Research department, Sveriges Riksbank, Stockholm, Sweden.
26. Quah D. & Vahey P. (1995) « Measuring Core inflation », The economic journal, vol. 105, no. 432, pp. 1130-1144.
27. Rich R. & Steindel C. (2005) "A review of core inflation and an evaluation of its measures", Federal Reserve Bank of New York staff report no. 236.
28. Roger Scott (1998) "Core inflation: concepts, uses and measurement",
29. Shapiro M.D. & Watson M.W. (1988) "Sources of business cycle fluctuations", NBER working paper no. 2589.
30. Stock J. & Watson M. (1988) "A probability model of the coincident economic indicators", NBER working papers no. 2772.
31. Stock J. & Watson M. (1991) "A probability model of the coincident economic indicator", in K. Lahiri & G. Moore (eds), Leading economic indicators: new approaches and forecasting records, Cambridge university press, pp. 63-89.
32. Tahir Sadia (2003) "Core inflation measures for Pakistan", working paper no. 4, State bank of Pakistan.
33. Taillon J. (1997) "Review of the literature on core inflation", catalogue no. 62F0014MPB, No. 4, price division, statistics Canada.
34. ---------- (1999) "Core inflation: a weighted median index", catalogue no. 62F0014MPB, series no. 7, Analytical series; price division: Statistics Canada.
35. Wynne Mark A. (1999) "Core inflation: A review of some conceptual issues", European central bank.

Appendix

1. Inflation indicators:

a. Official indicator of inflation in India:

In India, consumer price index for industrial workers is the most used indicator of consumer price inflation (CPI). CPI comprises an important percentage of agricultural products (about 57%). Whereas, the wholesale price index (WPI) contains a lager basket of goods than that of CPI and it contains less percentage of agricultural products than CPI. WPI comprises 62.8% of manufactured products, 22% of agricultural products and 14.2% of energy products. In a general context, CPI well represents the cost of life in an economy, but in India the quality of CPI is often questionable. Moreover, the indices of WPI are published more frequently than those of CPI. The difference between CPI and WPI is manifested also by important divergences by the two during 1983-84 and 1995-98. That is why the RBI uses WPI in its inflation analysis. So, we will take into account the WPI in our inflation analysis for India.

b. Official indicator of inflation in Pakistan:

The consumer price index CPI is the official indicator of inflation in Pakistan. It is the weighted average of 347 items and is published every month. It is widely considered as showing the changes in the general price level in the economy.

2. Data source:

The data on CPI, WPI and industrial production is taken from the CD ROM of International financial statistics, IMF.

For the disaggregated data the data are taken from the following sources:

In the case of India the disaggregated data is taken from the Reserve bank of India data base.

In the case of Pakistan the disaggregated data is taken from the monthly statistical bulletins of the Federal bureau of Statistics of Pakistan.