Inflation Dynamics in India

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Abstract

India is a highly open economy and has been following the monetary policy of managing the quantity of money through its central bank operations. This thesis examines Indian inflation behavior by estimating different Phillips curve models related to inflation dynamics in an open economy using quarterly data over the period of 1990 to 2013. The research also compares the results with that of two other open economies, Australia and the UK. The results obtained by applying GMM estimation show that the extended open economy version of the New Hybrid Phillips curve provides the best statistical explanation of inflation dynamics for both GDP deflator inflation and CPI inflation as inflation measure. The results also demonstrate that Indian firms follow both backward looking and forward looking behavior. In addition, both the real marginal cost and exchange rate pass-through play an important role in inflation dynamics. However, India is less forward looking in price setting behavior compared to the UK and Australia although price rigidity is substantially higher in both countries. The estimated results imply that on average Indian firms keep price unchanged for 9-10 months and half of the Indian firms reset their prices in any period.

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Introduction

The main purpose of macroeconomic policies is to suggest mechanisms for robust and sustainable economic growth. Maintaining low inflation is such an important aspect of sustainability. In developing economies, inflation is determined by multiple interconnected factors. Giving a momentum to the economy generally requires expansionary monetary policy that results higher inflation. On the other hand, inflation reduction requires a tight monetary policy, which comes with a cost of slumping economy of less investment with high unemployment, and reduced output. Therefore, policymakers need proper guidelines to set the appropriate monetary policies triggering the need to understand the short run inflation dynamics over the last decade, both from policy analysis and academic points of view.

Over the last decades, both monetary policy and the economic performance of India have experienced an extensive progress. Due to rapid economic growth, the purchasing power of Indian citizens has also increased. This has contributed towards the increased rate of inflation (Figure 1). The Indian economy is highly open to the rest of the world. It is evident that price levels in India remained highly responsive to changes in the global economy. For example, when global inflation increased by 15%, on average India experienced a very high of 85% increase in domestic inflation (Rummel, 2012). While most of the developed economies have set a target of keeping inflation to around 2%, India is experiencing an inflation level around 9% (figure 1). Rummel (2012) shows that monetary policy devoted to reducing inflation by 1% point should reduce output by 1.1% to 1.8%. Thus, understanding of the nature of short run inflation dynamics is central to Indian macroeconomic events in order to control the threat of inflation and to establish macroeconomic stability via monetary policy. In response to this challenge, a great deal of research attention has been directed towards the Phillips curve specification and

significant advances have emerged in modelling inflation dynamics both from theoretical and empirical point of views.

The integrating nature of the Indian economy to the world economy rationalizes the applicability of the micro-founded new hybrid type Phillips curve approach to adjust the firm's prices. The hybrid Phillips curve provides information about the percentage of firms, which are able to adjust their prices at each period as well as the degree of backward and forward looking behavior. An advantage of the hybrid Phillips curve settings is that, when the price rigidity is higher a movement in real marginal cost does not affect inflation substantially. As a result, disinflation may involve costly output reductions. In addition, Phillips curve analysis influences policy matters about the persistency of inflation, sacrifice ratio, role of future expected inflation and slope of the long-run curve. Therefore, a representative Phillips curve analysis of inflation dynamics can successfully guide policy makers to implement proper monetary policies.

This thesis examines the nature of inflation dynamics of India through estimating different versions of Phillips curve ranging from the traditional Phillips curve to the new hybrid Phillips curve. Among the different versions of the Phillips curve, an open economy extension of the hybrid Phillips curve provides a robust explanation of short run inflation dynamics for most of the developed open economies. This led me to replicate the theoretical hybrid Phillips curve model of developed economies to test on Indian data in order to present some useful insights into the Indian inflation dynamics. In this application, I am employing the imported price of goods and services both as final consumption goods and as an intermediate production good via the marginal cost and the exchange rate pass-through in the sense that the latter plays an important role in credible monetary policy. The rationale behind this is that, if exchange rate pass-through

bears low effects then monetary authority can take steps to carry out that particular level of targeted inflation.

This research covers the literature gap of inflation dynamics for Indian economy in two ways. Firstly, this research estimates the hybrid version of the Phillips curve for open economy with the extension of imported price as intermediate goods and at the same time the results will be compared with that of developed economies where as earlier literature are available for the new Keynesian Phillips curve separately for India. Secondly, since CPI inflation can be considered as the combined effect of domestic and foreign price inflation (foreign inflation can be measured through terms of trade), CPI inflation is also used as the dependent structure of the specified model along with GDP deflator inflation. This research checks for both robustness of degree of price adjusting nature and implied duration.

Generalized Method of Moments (GMM) with instrumental variables has been employed to quarterly data ranging from 1990Q1 to 12013Q4 to estimate the model parameters to overcome the endogeneity problem and to get heteroskedasticity and autocorrelation corrected estimates. The same models have also been used for two different developed economies namely the United Kingdom (a big open economy), and to Australia (a small open economy). India being a developing country, its nature of inflation dynamics will be compared with that of developed economies of the United Kingdom and Australia to compare the ratio of forward looking and backward looking firms to set the prices for the product for the next period. In particular, this thesis aims to answer the objectives: firstly, what fraction of Indian firms are forward looking and backward looking in setting their prices? Secondly, how does the nature of Indian inflation dynamics differ from developed economics specifically from Australia and the United Kingdom?

Results of the present research findings yield a substantial difference in the degree of the forward looking and the backward looking behavior of India with that of the United Kingdom and fairly difference with that of Australia. In the same line, the implied duration of price stickiness is also different across the countries. Results demonstrate that half of the Indian firms are forward looking and half of them are backward looking in setting their prices, while two-third of the UK firms are forward looking in their nature. In addition, the average price duration is higher for UK compared with India, which is, again, higher than Australia. Furthermore, results indicate that short run inflation dynamics is directly linked to the real marginal costs as well as the real exchange rate. For India, estimated results show that 10% appreciation in Indian Rupee against US Dollar reduces 0.2% to 0.5% point inflation for current quarter.

The rest of the thesis is organized in three chapters. After the introduction the first chapter observes the relevant academic literature that have used different models of the Phillips curve analysis and the impact of different components that go through the macroeconomic activities. The second chapter describes the data sources and the methodology of the formation of the Phillips curve analysis. This chapter includes the formulations of the models starting from the traditional Phillips curve to the recent developed hybrid Phillips curve which includes the exchange rate volatility and the impact of import prices. Chapter thee discusses the empirical findings in the light of economic activities after estimating the models. Finally, a conclusion and some policy recommendations have been discussed at the end.

Chapter One: Literature review

This chapter provides a brief review of some of the prominent existing works related to macroeconomic policy formulations on inflation dynamics. An immense body of literature is available on inflation dynamics since it is one of the crucial issues in macroeconomic activities. The size of the literature on this topic is vast; such that to perform Meta analysis, Daniskova & Fidrmuc (2012) had to review 200 studies about the New Keynesian Phillips Curve. My review includes those studies that are most relevant to the present study on short run inflation dynamics in India applying the New Hybrid Philips curve (NHPC).

The Philips Curve remains the reference of discussion on inflation and has led to further developments in the field. Phillips (1958) first demonstrated the inverse relationship between unemployment and inflation and later the curve itself was named after him. In 1959, he produced the second version of the Phillips curve which includes wage instead of unit labor cost. The Phillips curve that contains price as dependent variable was not firstly introduced by Phillips; rather the credit goes to Samuelson and Solow (1960). Different versions of Phillips curve have been developed so far, for instance the New Keynesian Phillips curve (NKPC) and the New Hybrid Phillips curve (NHPC). Both the NKPC and NHPC have been estimated by many authors including Chadha et. al. (1992), Fuhrer and Moore (1995), Fuhrer (1997), Roberts (1997, 1998), Gali and Gatler (1999), Kara and Nelson (2003), Lendvai (2005), Mishkin (2007), Gabriel (2010), Ball & Mazumder (2011), Oinonen (2013) and Bhattacharya (2013).

The new Keynesian approach came in the 1980's as an effort to provide micro-foundations for key Keynesian concepts such as the inefficiency of aggregate fluctuations, nominal price stickiness and the Non-neutrality of money (Woodford, 1999). According to Taylor (1980), in every period a particular fraction of firms set new prices for a particular future

period. The pricing decision of the firm changes explicitly from a monopolistic competitor's profit maximization problem, which is subject to the constraint of time-dependent price adjustment. Today, the new Keynesian framework has emerged as the fundamentals for the analysis of monetary policy and its implications for inflation, macroeconomic fluctuations and welfare. It constitutes the theoretical underpinning for the inflation stability-oriented strategies adopted by the majority of central banks in the industrialized world (Rummel, 2012).

The New Hybrid Phillips Curve frame-work which is of importance for our study can be expressed as a function of expected future inflation, lag inflation and real marginal cost because although all firms adjust their prices in each period, some of them are unable to re-optimize their prices in that period; as a result, lagged inflation rates are used to index their prices (Christiano et al., 2001). Gali and Gertler (2000), for example, when dealing with apparent inertia in inflation, extended the basic Calvo model to combine the forward looking and backward looking fraction of firms in setting the prices; because NKPC cannot explain full inflation inertia.

As far as the Indian economy is concerned, many authors have done its analysis by applying different types of Phillips curve from different points of view. Srinivasan et.al. (2006) applies Ordinary Least Square (OLS) to find the effect of supply shocks on the inflation in India using an augmented Phillips curve. Their conclusion is that the supply shocks have only a temporary effect on both headline inflation and core inflation. Moreover, the study further concludes that core inflation is the main component for Indian monetary policy. Paul (2009) uses the output gap and inflation data taking into consideration of the supply and policy shock and hence shows that the Phillips curve relation exists for the Indian manufacturing sector. Singh et.al (2011) and Mazumder (2011) also supported this claim.

However, the Indian economy is also suitably using the forward looking and backward looking Phillips curve framework while the forward-looking Phillips curve is more appropriate than the backward looking Phillips curve (Dua and Gaur, 2010). The Lucas critique which undermines the use of Philips curve for open economy is deemed inappropriate for Indian economy (Mazumder, 2011). Moreover, for Chowdhury & Sarker (2014), the Hybrid New Keynesian Phillips Curve is not stable for India. Sahadudhen I (2012) claims that GDP and broad money have positive effects on inflation while inflation is negatively affected by exchange rate and interest rates. The author has used the co-integration and Vector Error Correction model on Indian quarterly data. So, it is seen that, NHPC can be used in case of open economy like India.

Rummel (2012) uses an augmented version of the canonical three-equation NK model. The finding is that aggregate demand reacts to interest rate changes with a lag of at least three quarters. He also shows that exchange-rate pass-through to domestic inflation is low. As a result inflation gets the most important focus in monetary policy. Rakesh Kumar (2013) explores the Indian inflation dynamics by employing the Restricted Vector Autoregressive technique. He depicts that inflation has the cointegrating relationship with other macro economic variables and the Index of industrial production has a negative effect on inflation. The author also claims that the moral suasion factor is an important factor in controlling Indian inflation.

Sahu (2013) uses hybrid NKPC for agricultural and industrial output gap to represent the sectoral characteristics of both sectors of the Indian economy. The author employed the GMM technique in a regression type model to express inflation using hybrid NKPC. But the author did not report about the forward looking and backward looking behavior of the Indian firms. He also employs the agriculture and industrial output gaps separately in the model.

However, most of the available studies about Indian inflation dynamics are devoted towards the application of NKPC or the Hybrid Phillips curve. What is missing is extending the open economy to hybrid Philips curve. In the present study, I am using the open economy extension of the hybrid Phillips curve towards the Indian economy to compare the price adjusting nature of Indian firms with that of Australia and the United Kingdom. I am employing real unit labor cost as the driving variable rather than detrended GDP in contrast to Shahu (2013). Unlike previous studies, I am using both GDP deflator inflation and CPI inflation as dependent structures.

Chapter Two: Econometric Techniques in Phillips Curve Modeling

The fundamental distinction between the traditional Phillips curve and the hybrid Phillips curve lies in the formulation of underlying inflation. The traditional Phillips curve is based on the lagged inflation while the hybrid Phillips curve is based on both lagged inflation and future expected inflation. Expected future inflation, being an endogenous variable, is correlated with error term, which makes OLS inappropriate. Moore and Schuh (1995) stipulate that GMM provides strongly consistent, and asymptotically normally distributed estimators which also involve minimum assumptions regarding the exogenous variables. Since GMM can correct for unknown forms of autocorrelation and heteroskedasticity, it emerges to be better than Two Stage Least Squares (TSLS). GMM also been used by many other authors like Gali and Gatler (1999), Fuhrer and Olivei (2004) and Nason and Smith (2008) etc. The following chapter discusses the econometric issues involved in the formulations of different Phillips curve models and estimation techniques.

2.1 Data and Variables

In this thesis for assessing inflation dynamics I am using the quarterly data series for India, the United Kingdom and Australia. The sample period is from 1990Q1 to 2013Q4. For the analysis, the variables considered are nominal GDP, Real GDP, GDP deflator, nominal exchange rate, real exchange rate, unit labor cost, unemployment rate, total employment, monthly wage, short run interest rate, interest rate spread, price of imported goods, consumer price index and Core inflation[1]. Data are seasonally adjusted where necessary. Most of the variables for UK and

[1] The seasonally adjusted constant price gross domestic price measured in local currency is termed as GDPSA. The nominal exchange rate (USD) is defined as the period average of national currency per US Dollar. The unemployment rate measures the number of people actively looking for a job as a percentage of the labor force. The unit labor cost describes the ratio of real wage

Australia are readily available in the International Financial Statistics database of International Monetary Fund and St Luis FRED data. For India, data have been collected from various sources namely: the Ministry of Statistics and Programme Implementation, the Ministry of Labor and Employment, the Labor Bureau, International Labor Organization (ILO), the International Financial Statistics database of International Monetary fund and St. Luis FRED data. Most of the variables are expressed in logarithms. The Hodrick-Prescott filter approach has been employed to get gap series.

2.2 The traditional Phillips Curves

In the traditional Phillips-curve model, it is assumed that the current inflation depends on lagged inflation, unemployment gap and some other relative prices. According to Gruen et.al. (1999) the traditional Phillips curve analysis can be summarized through the following equations:

$$\Delta_k p_t = \beta_1 \Delta_k ulc_t + \beta_2 \Delta_k pm + \beta_3 DEM_t - \beta_4 (p_{t-k} - \omega ulc_{t-k} - (1-\omega) pm_{t-k}) \quad \text{..... (1)}$$

$$\Delta_k ulc_t = \lambda \pi_t^e + \psi DEM_t + \varepsilon_t \quad \text{..... (2)}$$

$$\pi_t^e = (1-\delta)\Delta_k p_{t-1} + \delta \pi_t^* + \varepsilon_t \quad \text{..... (3)}$$

Where, p_t = log consumer price level excluding interest rates and volatile items and its rate of change is the underlying inflation rate, ulc_t = log unit labor costs , defined as the ratio of real wages per person to the per person output, pm_t = log price of import goods and services and DEM_t = some demand pressure variables.

to labor productivity per worker. Real exchange rate is defined as nominal exchange rate times the ratio of US price index to the domestic consumer price index. The consumer prices index considers all items. Interest rate spread is the difference between long run interest rate (10 years bond) and short run interest rate.

In equation (1) the term $(p_{t-k} - \omega ulc_{t-k} - (1-\omega) pm_{t-k})$ ensures that in the steady state the price level is a mark-up on unit labor costs and import prices. Equation (2) describes the evolution of unit labor costs. Equation (3) describes the inflation expectations in terms of forward looking (π_t^*) and backward looking ($\Delta_k p_{t-1}$) components.

If equation (2) and (3) are substituted in equation (1) the resulting equation describes the relationship between price inflation and change in import price, expected inflation, demand pressure, lagged unit labor cost and import prices of goods and services. This type of Phillips curve is known as P-curve. Thus, to derive P-Curve, let me first substitute equation (2) in equation (1) and then equation (3) in the resulting equation. Since I am dealing with quarterly data, let me set K=4 (Pitchford, 1999) and for simplicity suggested by Phillips let me set $\beta_2=\beta_4=0$. The resulting equation becomes

$$\Delta_4 p_t = \beta_1(\lambda \pi_t^e + \psi DEM_t) + 0 + \beta_3 DEM + 0 + \varepsilon_t$$

$$\Rightarrow \Delta_4 p_t = \phi \pi_e^t + \gamma DEM + \varepsilon_t \qquad [\text{Setting } \phi = \beta_1 \lambda \text{ and } \gamma = \beta_1 \psi]$$

In this setting let me assume that there exist a trade-off between inflation and unemployment even in the long run. This assumption leads to set ϕ=1. In addition, it is rationale to assume that Demand Pressure variable (DEM) can be replaced by the difference between Unemployment rate (denoted by U_t) and Non Acceleration Inflation Rate of Substitution (NAIRU denoted by U_t^*). Then the above equation becomes

$$\Delta_4 p_t = \pi_e^t + \gamma(U_t - U_t^*) + \varepsilon_t \qquad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

$$\Rightarrow \Delta_4 p_t = (1-\delta)\Delta_k p_{t-1} + \delta \pi_t^* + \gamma(U_t - U_t^*) + \varepsilon_t \qquad [\text{Using equation (3)}]$$

$$\Rightarrow \Delta_4 p_t - \Delta_4 p_{t-1} = \delta\pi_t^* - \delta\Delta_4 p_{t-1} + \gamma(U_t - U_t^*) + \varepsilon_t \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

Where, P_t is the price level, $P_{t-1}$is the first lagged price level, π_t^* is expected inflation, U_t is inflation and U_t^* is NAIRU (Non-Accelerating Inflation Rate of Unemployment). As NAIRU is unobservable, it is treated as a parameter to be estimated. The estimation therefore becomes nonlinear.

Similarly, the W-curve (Gruen et.al. 1999) can be derived if I substitute unit labor cost (ULC_t) in place of consumer price level (p_t). It is also suggested (e.g. Johnson et. al 1974) to use fourth order moving average of Unemployment rate ($MA_4(U_t)$) instead of unemployment rate (U_t). Then equation (4) can be written as

$$\Delta_4 ULC_t = \pi_e^t + \gamma(MA_4(U_t) - U_t^*) + \varepsilon_t$$

$$\Rightarrow \Delta_4 ULC_t = (1-\delta)\Delta_k p_{t-1} + \delta\pi_t^* + \gamma(MA_4(U_t) - U_t^*) + \varepsilon_t$$

$$\Rightarrow \Delta_4 ULC_t - \Delta_4 p_{t-1} = \delta\pi_t^* - \delta\Delta_4 p_{t-1} + \gamma(MA_4(U_t) - U_t^*) + \varepsilon_t \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

Gruen et al. (1999) included the import price inflation and changes in unemployment rate which leads the following augmented model

$$\Delta_4 P_t - \Delta_4 P_{t-1} = a + \delta(\pi_t^* - \Delta_4 P_{t-1}) + \gamma U_t + d\Delta U_{t-1} + \alpha_1(\Delta_4\, pm_{t-1} - \Delta_4\, pm_{t-2}) + \alpha_2(\Delta P_{t-1} - \Delta P_{t-4}) + \varepsilon_t$$

$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$ (7)

Where, pm_t is the import price. This is now a linear model.

Many studies have showed that the slope of the Phillips curve has been changed and the curve becomes flattened. This means that inflation is becoming less responsive to unemployment and less responsive to other shocks as well. This reduced sensitivity shifted the idea to examine the role of other variables in inflation dynamics through the Phillips curve mechanism.

A set of Phillips curves involving some external shocks can be extended from the traditional Phillips curve termed as classical Phillips curve for open economies which can be described by the following set of models (Balakrishnan and lopez-Salido, 2002; Kara and Nelson, 2003)

$$\Delta q_{t-1} = \alpha_{11} + \beta_{11}\pi_{t-1} + \beta_{12}OPEN_{t-1} + \beta_{13}ULC_{t-1} + \varepsilon_{1t}$$

$$\Delta RPM_{t-1} = \alpha_{21} + \beta_{21}\pi_{t-1} + \beta_{22}OPEN_{t-1} + \beta_{23}ULC_{t-1} + \varepsilon_{2t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ (8)$$

$$\Delta TOT_{t-1} = \alpha_{31} + \beta_{31}\pi_{t-1} + \beta_{32}OPEN_{t-1} + \beta_{33}ULC_{t-1} + \varepsilon_{3t}$$

Where, Δq_{t-1} = Changes in the real exchange rate, ΔRPM_{t-1} = Change in real import price, ΔTOT_{t-1} = Change in terms of trade, π_{t-1} = First lagged inflation rate and $OPEN_{t-1}$ = First lagged of openness index and openness index is defined by the ratio of sum of export and import price to GDP.

2.3 Derivation of the New Phillips curve

It is usual that firms use their market power to set the price of the product above its marginal cost to make it profitable even if the set price is not optimal. Under Calvo (1983) pricing in any time period a fraction of firms have fixed probability (1-θ) of adjusting the price at that period, as a result other fraction of firm will keep the price unchanged with probability θ. If the firms are identical and they have a conventional constant price elasticity of demand for its product, then the price level can be expressed as

$$p_t = \theta p_{t-1} + (1-\theta)p_t^*$$

Where, p_t = the aggregate price level, P_{t-1}= the lagged price level and p_t^* = the new reset (optimal) price level assumed same for all ne setter firm. All these variables are expressed as a percent deviation from a zero inflation steady state.

If inflation rate at time t denoted by $\pi_t = p_t - p_{t-1}$ and mc_t be the deviation of the firm's real marginal cost from its steady state value in percentage then inflation can be expressed as

$$\pi_t = \lambda mc_t + \beta E_t\{\pi_{t+1}\} + \varepsilon_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

Where, $\lambda = \frac{(1-\theta)(1-\beta\theta)}{\theta}$; θ being the frequency of price adjustment and β is the subjective discount factor. In this expression the fraction of firms keeping price fixed is independent of time elapsed from last revised price, thus the average duration of a set price can be calculated by $\frac{1}{1-\theta}$ that is on average firms do not change their price for $\frac{1}{1-\theta}$ quarters. Another parameter β measures the subjective discount factor so that firm can choose price to maximize expected discounted profits at time t.

However, this NKPC expressed by equation (8) is not free from criticism; the most prominent one is that real marginal costs are usually unobservable. To overcome this denigration, the output gap defined as the deviation from its trend can be used as a proxy for real marginal costs in the empirical Phillips curve. Let y_t denote the log of output, y_t^* be the log of output level then the output gap can be defined by $xt = y_t - y_t^*$. As a result marginal cost is the product of output gap and output elasticity of marginal cost i.e. $mc_t = \kappa x_t$. Thus, this relation results the Phillips curve –like relation in terms of output gap, output elasticity of marginal cost and expected inflation, described in the following equation

$$\pi_t = \lambda\kappa x_t + \beta E_t\{\pi_{t+1}\} + \varepsilon_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (10)$$

According to Gali and Gatler (1999) if $S_t = \frac{W_t N_t}{P_t Y_t}$ is the labor income share or equivalently real unit labor costs where, W_t =wage, N_t = labor, P_t = price Y_t = output and if s_t be the percent deviation measure of S_t from the steady state then $mc_t = s_t$ which leads to the inflation equation

$$\pi_t = \lambda s_t + \beta E_t\{\pi_{t+1}\} + \varepsilon_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (11)$$

Where again $\lambda = \frac{(1-\theta)(1-\beta\theta)}{\theta}$, θ is the proportion of non-adjusting firms, β is the subjective discount factor, π is inflation (D4LPGDP), S is the labor share gap (SHGAP).

Since the expectation term is correlated with the error term, OLS is biased and inconsistent. To obtain estimates for the structural parameter, a non-linear estimation technique should be used. Galí and Gertler set up the GMM moment conditions in two alternative ways.

In the first set of moment conditions, the original equation is multiplied by θ thoroughly which gives

$E_t\{(\theta\pi_t - (1-\theta)(1-\beta\theta)S_t - \beta\theta\pi_{t+1})Z_t\} = 0$; Where, Z_t is the set of instruments.

The second set of moment conditions:

$E_t\{(\pi_t - \frac{(1-\theta)(1-\beta\theta)}{\theta}S_t - \beta\pi_{t+1})Z_t\} = 0$; Where, Z_t is the same instrument used in the first set of moment conditions.

2.4 The New Hybrid Phillips-Curve

This version of Phillips curve is admired due to its ability to deal with apparent inertia in inflation. This version was developed by extending the basic Calvo model by Gali & Gatler (2000) so that backward looking rule of thumb is allowed to a fraction of Firms.

$$\pi_t = \lambda S_t + \gamma_f E_t\{\pi_{t+1}\} + \gamma_b \pi_{t-1} + \varepsilon_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (12)$$

Where, $\lambda = \frac{(1-\omega)(1-\theta)(1-\beta\theta)}{\phi}$, $\phi = \theta + \omega[1-\theta(1-\beta)]$ $\gamma_f = \frac{\beta\theta}{\phi}$, $\gamma_b = \frac{\omega}{\phi}$ and ω is the fraction of "backward looking" firms. However, for plausible values of θ and ω the sum of γ_f and γ_b becomes reasonably close to unity which indicates β is reasonably close to unity.

Substituting in these expressions of parameters into the equation yields

$$\pi_t = \frac{(1-\omega)(1-\theta)(1-\beta\theta)}{\phi} S_t + \frac{\beta\theta}{\phi} E_t\{\pi_{t+1}\} + \frac{\omega}{\phi}\pi_{t-1} + \varepsilon_t$$

By multiplying through by ϕ the model becomes

$$\phi\pi_t = (1-\omega)(1-\theta)(1-\beta\theta)S_t + \beta\theta E_t\{\pi_{t+1}\} + \omega\pi_{t-1} + \varepsilon_t$$

Lastly, replace ϕ as a function of model parameters:

$$\theta + \omega[1-\theta(1-\beta)]\pi_t = (1-\omega)(1-\theta)(1-\beta\theta)S_t + \beta\theta E_t\{\pi_{t+1}\} + \omega\pi_{t-1} + \varepsilon_t$$

For this structural form the moment condition is:

$$E_t\{([\theta + \omega[1-\theta(1-\beta)]]\pi_t - (1-\omega)(1-\theta)(1-\beta\theta)S_t - \beta\theta E_t\{\pi_{t+1}\} - \omega\pi_{t-1})Z_t\} = 0$$

However, the moment condition for the reduced form is:

$$E_t\{\pi_t - \lambda S_t - \gamma_f \pi_{t+1} - \gamma_b \pi_{t-1})Z_t\} = 0$$

The instrument set includes second and third lags of dependent specification (i.e. lags of D4LPGDP or D4LCPI), detrended labor share, interest rate spread, first difference of nominal

exchange rate, two additional lags of unit labor cost, two additional lag of imported price, two additional lag of seasonally adjusted unemployment rate, labor share gap, first difference of major trading partners wage rate, first difference of major trading partner GDP and first difference of major trading partners commodity price index first difference of major trading partners short run interest rate and first difference of major trading partner long run interest rate.. The constant term is included in the instrument set to ensure the zero mean of the model error term.

However, this version of the Phillips curve is not completely able to capture the incidents and evaluation of the practiced monetary policy in the region, especially when the economy is open enough. A new Hybrid Phillips curve can be used to describe such situation mere adequately that can be expressed as

$$\pi_t = \gamma_b \pi_{t-1} + \gamma_f E_t \pi_{t+1} + \lambda mc_t + \varepsilon_t \quad \text{..... (13)}$$

In this setting it is assumes that the fraction of firms that are unable to set price freely can adjust the price partly to cope up with the current inflation. This modified version of NKPC is a hybrid of the basic NKPC since it considers both forward looking and backward looking inflation components.

According to Patra & Kapur (2010), foreign commodity price and changes in exchange rate are significant determinants of short run inflation instability. Also from Ito & Sato (2008) exchange rate pass- through play a significant role in domestic inflation in the light of enlarged globalization. Therefore, the above hybrid Phillips curve (equation 13) should be augmented by foreign commodity price inflation and real exchange rate variables. If imported goods are considered as the final consumption good, then the effect of foreign inflation rate is included in

the import price. As a result the overall inflation rate at time t are comprised of domestic and imported goods inflation i.e. $\pi_t = (1-s)\pi_t^d + s(\pi_t^f + \Delta e_t)$; where π_t^f is the inflation rate of imported prices in foreign currency, Δe_t is the depreciation rate of the domestic currency and s is the share of imported prices in the inflation rate of the general price level. Similarly defining the real exchange rate $q_t = p_t^f + p_t^d + e_t$ and Δq_t as the rate of change of the real exchange rate and if the restriction $\gamma_b + \gamma_f = 1$ is imposed then the Phillips curve expression takes the form

$$\pi_t = \gamma_b \pi_{t-1} + \gamma_f E_t \pi_{t+1} - s\gamma_f (E_t \Delta q_{t+1} - \Delta q_t) + s\gamma_b (\Delta q_t - \Delta q_{t-1}) + \lambda mc_t + \varepsilon_t \quad \text{..... (14)}$$

This expression describes current inflation as the combination of current and future expected change of real depreciation rate. The corresponding orthogonality condition can be described as

$$E_t\{(\pi_t - \gamma_b \pi_{t-1} - \gamma_f E_t \pi_{t+1} + s\gamma_f (E_t \Delta q_{t+1} - \Delta q_t) - s\gamma_b (\Delta q_t - \Delta q_{t-1}) + \lambda mc_t) z_t\} = 0$$

Alternatively, according to McCallum Nelson (1999) to model imported goods as intermediate production goods while the final consumption goods are produced as domestic product, the hybrid Phillips curve expression contains nominal level real exchange rate instead of difference in real exchange rate. At this setting the real marginal cost can be expressed as: $mc_t = \alpha ulc_t + (1-\alpha) q_t$; where, ulc_t is the real unit labor cost , q_t stands for the real cost of unit imported good and α comes from Cobb-Douglas production technology where variables are expressed in deviation from steady state. As a result, in this situation the Hybrid Phillips curve takes the expression

$$\pi_t = \gamma_b \pi_{t-1} + \gamma_f E_t \pi_{t+1} + \lambda^l ulc_t + \lambda^m rer_t + \varepsilon_t \quad \text{..... (15)}$$

Where, $\gamma_f = \frac{\beta\theta}{\phi}$, $\gamma_b = \frac{\omega}{\phi}$, $\phi = \theta + \omega[1-\theta(1-\beta)]$, $\lambda^l = \frac{\alpha(1-\omega)(1-\theta)(1-\beta\theta)}{\phi}$ and

$\lambda^m = \frac{(1-\alpha)(1-\omega)(1-\theta)(1-\beta\theta)}{\phi}$

As earlier, the model is also restricted to the sum of lagged and expected future inflation rate is sufficiently close to unity i.e. when β=1, then $\gamma_f + \gamma_b = 1$ that ensures the hybrid form of model. The moment conditions take two specifications

Specification (1)

$$E_t\{(\phi\pi_t - \beta\theta\pi_{t+1} - \omega\pi_{t-1} - \alpha(1-\omega)(1-\theta)(1-\beta\theta)ulc_t - (1-\alpha)(1-\omega)(1-\theta)(1-\beta\theta)rer_t)z_t\} = 0$$

Specification (2)

$$E_t\{(\pi_t - \phi^{-1}\beta\theta\pi_{t+1} - \phi^{-1}\omega\pi_{t-1} - \phi^{-1}\alpha(1-\omega)(1-\theta)(1-\beta\theta)ulc_t - \phi^{-1}(1-\alpha)(1-\omega)(1-\theta)(1-\beta\theta)rer_t)z_t\} = 0$$

The corresponding orthogonality condition for the reduced form model is

$$E\{(\pi_t - \gamma_b\pi_{t-1} - \gamma_f\pi_{t+1} - \lambda^l ulc_t - \lambda^m rer_t)Z_t\} = 0$$

All these specifications of orthogonality conditions requires the instrument set that includes second and third lags of dependent specification (i.e. lags of D4LPGDP or D4LCPI), detrended labor share, interest rate spread, first difference of nominal exchange rate, two additional lags of unit labor cost, two additional lag of imported price, two additional lag of seasonally adjusted unemployment rate, labor share gap, first difference of major trading partners commodity price index, first difference of major trading partner GDP, first difference of major trading partners short run interest rate and first difference of major trading partner long run

interest rate. The constant term is included in the instrument set to ensure the zero mean of the model error term.

Generalized Method of Moments Using Heteroskedasticity and Autocorrelation Consistent (HAC) weighting matrix with 2-lag Newey-West correction method and iterating weights, N-step iterative and user specified bandwidth of 2.00 have been used to estimate the parameters.

Chapter Three: Results and Discussions

In this chapter, I estimate the econometric models using generalized method of moments (GMM) so that the appropriate orthogonality conditions are satisfied. I estimate the model parameters using both reduced form and structural form. In light of estimated parameters, this chapter discusses about the degree of forward-looking and backward looking behavior of firms, price stickiness, discount factors and the implied durations of prices. All models are estimated using GDP deflator and CPI inflation. This chapter also provides information about the statistical properties of the estimated parameters.

3.1 The traditional Phillips curve

The traditional Phillips curve includes the current price, lagged price, expected inflation and Non-Accelerating Inflation Rate of Unemployment. Using the difference between quarterly interest rate and short run interest rate of major trading partner as the proxy for inflation expectation the traditional Phillips curves expressed by equation 5 (P-curve) and equation 6 (W-curve) have been estimated. The estimated results are presented in Table1.

Table 1: Estimate for the P-Curve and the W-Curve

	P- curve			W-curve		
	India	Australia	UK	India	Australia	UK
δ	0.13* (0.05)	0.07*(0.23)	0.11*(0.04)	1.64* (0.36)	0.45(0.19)	0.99*(0.001)
γ	-0.13(0.10)	-0.21(0.12)	-0.003 (0.34)	-1.17 (0.66)	-0.001(0.16)	-0.002(0.9)
U*	4.97* (1.61)	5.21*(0.78)	6.7*(2.3)	-0.79 (4.08)	5.97 ()	6.7()
DW	1.56	1.53	1.48	0.39	0.30	0.20
R^2	0.10	0.18	0.10	0.24	0.41	0.71

*[OLS estimates. Std. errors are in bracket, * indicates significance at 5%. DW is 1st order residual autocorrelation.]*

In Table 1 both the P- curve and the W-curve results show that model fit is poor although coefficients have expected sign in most cases. Non Accelerated Inflation Rate of Unemployment (U*) is close for all three countries. However, as the results indicate, the relationship is not

stable. Although the residuals are not severely auto correlated in the P-curve, they are severely positively correlated in the W-curve. Overall, the results are not reasonably satisfactory to describe inflation.

Table 2: Gruen et. al. (1999) suggested model

	PSE	URATESA	URATESA(-1)	DD4LPM(-1)	PPP	DW	R^2
India	0.13* (0.05)	-0.04(0.09)	0.12(0.10)	0.023**(0.013)	0.31* (0.07)	1.81	0.29
Australia	0.16*(0.04)	0.025(0.04)	-0.34 (0.25)	0.01** (0.001)	0.43*(0.08)	2.51	0.43
UK	0.18*(0.04)	0.21(3.08)	0.23 (0.14)	0.02** (0.007)	0.23* (0.04)	1.67	0.41

*[OLS estimates. Std. errors are in bracket, * indicates significance at 5%. URATE(-1) and DD4LPM(-1) indicate first lag of unemployment rate and differenced in seasonally differenced 1st order lag of import price respectively.]*

Table 2 represents the Gruen et. al. (1999) suggested model described in equation 7. The fit of the model is moderately inspiring compared to p-curve and w-curve. Residual auto correlations are mild. However, LM test indicates serial correlation in the residuals. Recursive graphs show stable estimates (Figure 3).

Table 3: Classical version of open economy Phillips curve; India

			constant	π_{t-1}	$open_{t-1}$	ulc_{t-1}	R^2
India	Detrended	Δq_{t-1}	0.67*(0.07)	0.37* (0.11)	0.27* (0.03)	0.22* (0.02)	0.64
		Δrpm_{t-1}	0.009 (0.25)	0.51*(0.09)	0.003 (0.03)	0.15* (0.07)	0.45
		Δtot_{t-1}	0.59* (0.15)	0.21* (0.06)	0.70* (0.05)	0.11*(0.02)	0.38
	Not detrended	Δq_{t-1}	4.09*(0.27)	0.12(0.11)	0.05*(0.01)	0.02(0.08)	0.85
		Δrpm_{t-1}	8.41*(0.33)	0.99*(0.15)	1.55*(0.02)	-0.16(0.11)	0.97
		Δtot_{t-1}	4.95*(0.22)	0.69*(0.10)	0.13*(0.01)	0.19*(0.07)	0.75

*[Note: OLS estimation with Newey-west correction for serial correlation. Lag selection for explanatory variables are based on BIC. Std. errors are in bracket, * indicates significance at 5%.]*

Table 3 displays the results for the open economy classic Phillips curve models that are presented in equation set 8 for India using different variables that are affected other than domestic economic activities. The estimations include more than one lag of inflation by the support of Swartz Information Criteria. The open economy variable is significantly affected by inflation representation, economic openness and unit labor cost. For exchange rate appreciation,

all the other relevant variables that are included seem to be significant irrespective of detrended or trended. The models are performing well with level data rather than detrended variables. However, in all models most of the explanatory variables are appearing as statistically significant.

3.2 The New Phillips curve

Table 4 represents the completely forward looking New Keynesian Phillips curve model proposed by Gali and Gatler (1999) presented in equation 11.

Table 4: Estimation results of Gali & Gatler 's (2003) New-Keynesian Phillips Curve model

		First specification					Second Specification				
		θ	B	DW	P(J)	H_0: β=1 [Pr χ^2]	θ	β	DW	P(J)	H_0: β=1 [Pr χ^2]
India	PGDP	0.15* (0.01)	0.71* (0.05)	1.7	0.13	1.54 [0.06]	0.62 (1.9)	0.97* (0.03)	1.8	0.18	0.07 [0.97]
	CPI	0.19 (0.12)	0.87* (0.05)	1.8	0.23	0.91 [0.11]	0.57 (1.3)	0.94* (0.05)	1.8	0.46	0.07 [0.96]
Australia	PGDP	0.33* (0.03)	1.04* (0.03)	1.7	0.42	0.11 [0.85]	0.79 (1.9)	0.99* (0.01)	1.6	0.32	0.009 [0.99]
	CPI	0.26* (0.03)	1.03* (0.03)	1.7	0.63	0.11 [0.85]	0.23* (0.03)	0.99* (0.03)	1.9	0.37	0.009 [0.99]
UK	PGDP	0.21* (0.03)	1.2* (0.05)	1.6	0.95	0.97 [0.32]	0.31* (0.02)	1.03* (0.02)	2.3	0.89	0.11 [0.84]
	CPI	0.27* (0.02)	1.05* (0.02)	1.7	0.97	0.17 [0.74]	0.35* (0.01)	1.01* (0.02)	1.9	0.94	0.03 [0.97]

*[Note: GMM estimates; instrument set includes D4LPGDP (-2 TO -3), SHLAB, SI, SHGAP, DLUSD, WPXC, WIQ and WIL. Std. errors are in bracket, * indicates significance at 5%. Θ is the proportion of non-adjusting firms, β is the subjective discount factor, PGDP is the seasonally differenced GDP deflator as inflation measure, CPI is the seasonal differenced consumer price index. DW indicates Durbin Watson statistic for residual autocorrelation. J-statistics is Hansen's J-statistic for over identification test. P-value of the corresponding test is presented in square brackets. H_0: β=1 column provides the value of chi-square statistics and corresponding p-value for the test of discount factor equal to unity.]*

In Table 4 over identification test results show that null hypothesis of well specified model cannot be rejected. It means that models are performing well. In other words, the orthogonality conditions are sufficiently close to zero. When the first specification of moment condition is used, the discount factor has been far away from unity for India while for Australia

this is a bit higher than unity. On the other hand, when the second specification is used, the discount factor has been very close to unity. In the case of India, most parameter estimates (θ and β in both cases) appear as statistically insignificant, although the null hypothesis of discount factor equal to unity is mostly accepted. Using the results from Table 4, the estimated value of λ, as a function of θ and β, indicates that labor share gap is indifferent to inflation irrespective of inflation measure. Overall, this pure forward looking model is not suitable to describe Indian inflation behavior.

3.3 The New Hybrid Phillips curve for Open economy

In this section the open economy version of the hybrid Phillips curve parameters have been estimated. For each country, I have estimated the same model using GMM with same set of instrument for three different time periods. Firstly, I have estimated the model for the whole sample period from 1990Q1 to 2013Q4. Then I have divided the sample period into two time periods considering the Lehmann Brother's Collapse in September 2008 to incorporate the effect of 2008 financial crises into the model. Since in India the financial year starts from April instead of January, for pre-financial crises period I have considered the period of 1990Q1 to 2008Q2 for India while 1990Q1 to 2008Q3 for other countries. Similarly, for post crises period I have used time period of 2008Q3 to 2013Q4 while for Australia and the UK the period is from 2008Q4 to 2013Q4. For each of the three periods, I have used two alternative specifications of dependent structure, namely GDP deflator inflation and CPI Inflation; both are in seasonally differenced (i.e. summer-to-summer, winter- to- winter etc.) format.

Table 5: Estimated result of reduced form New Hybrid Phillips Curve

Specification			γ_f	γ_b	λ^l	DW	J-stat	Pr(J)	H_0: β=1	Pr χ^2)
INDIA	**Full Sample**	**PGDP**	**0.47*** (0.06)**	**0.52*** (0.05)**	**0.02*** (0.007)**	**2.3**	**11.2**	**0.67**	**0.83**	**0.36**
		CPI	**0.48*** (0.04)**	**0.51*** (0.04)**	**0.007*** (0.01)**	**2.4**	**8.1**	**0.83**	**0.004**	**0.94**
	Before Crisis 2008	**PGDP**	**0.48*** (0.06)**	**0.51*** (0.07)**	**0.02*** (0.009)**	**2.3**	**6.8**	**0.91**	**0.08**	**0.77**
		CPI	**0.47*** (0.04)**	**0.53*** (0.04)**	**0.006*** (0.01)**	**2.5**	**6.6**	**0.82**	**0.87**	**0.35**
	After Crisis 2008	**PGDP**	**0.48*** (0.03)**	**0.52*** (0.03)**	**-0.04** (0.02)**	**2.3**	**7.1**	**0.89**	**0.11**	**0.73**
		CPI	**0.48*** (0.03)**	**0.53*** (0.03)**	**-0.01 (0.02)**	**2.2**	**6.9**	**0.85**	**2.11**	**0.14**
Australia	**Full Sample**	**PGDP**	**0.53*** (0.03)**	**0.47*** (0.03)**	**-0.04 (0.03)**	**2.3**	**10.7**	**0.82**	**1.69**	**0.19**
		CPI	**0.54*** (0.03)**	**0.46*** (0.03)**	**0.04** (0.02)**	**1.9**	**7.7**	**0.95**	**1.43**	**0.23**
	Before Crisis 2008	**PGDP**	**0.56*** (0.01)**	**0.46*** (0.01)**	**-0.04 (0.01)**	**2.8**	**21.9**	**0.18**	**0.36**	**0.54**
		CPI	**0.55*** (0.04)**	**0.45*** (0.04)**	**0.05*** (0.02)**	**2.9**	**5.03**	**0.97**	**0.65**	**0.42**
	After Crisis 2008	**PGDP**	**0.57*** (0.02)**	**0.40*** (0.05)**	**-0.47 (0.39)**	**1.8**	**4.2**	**0.83**	**1.61**	**0.21**
		CPI	**0.61*** (0.03)**	**0.30*** (0.04)**	**-0.10 (0.037)**	**1.4**	**3.9**	**0.86**	**18.8**	**0.00**
UK	**Full Sample**	**PGDP**	**0.56*** (0.04)**	**0.44*** (0.03)**	**0.15*** (0.03)**	**1.9**	**14.8**	**0.73**	**0.13**	**0.71**
		CPI	**0.55*** (0.04)**	**0.45*** (0.04)**	**0.018 (0.02)**	**2.3**	**9.4**	**0.92**	**0.22**	**0.63**
	Before Crisis 2008	**PGDP**	**0.62*** (0.03)**	**0.39*** (0.03)**	**0.22 (0.14)**	**2.7**	**14.25**	**0.76**	**2.64**	**0.11**
		CPI	**0.58*** (0.03)**	**0.38*** (0.04)**	**0.08*** (0.02)**	**2.5**	**8.6**	**0.94**	**3.5**	**0.06**
	After Crisis 2008	**PGDP**	**0.55*** (0.11)**	**0.38*** (0.12)**	**0.0001 (0.001)**	**1.9**	**3.91**	**0.86**	**5.4**	**0.02**
		CPI	**0.56*** (0.05)**	**0.43*** (0.04)**	**0.0008** (0.009)**	**1.5**	**3.9**	**0.86**	**27**	**0.00**

*[Note: GMM estimates with HAC weighting matrix and 2-lag Newey- West method; instrument set includes D4LPGDP (-2 TO -3), SHLABHP, SI, DLUSD,ULCHP(-1 TO -2),LPMHP(-1 TO -2), URATE(-1 TO -2), DLWPXC DLWGDP DWIQ and DWIL. In case of CPI specification instrument set includes D4LCPI instead of D4LPGDP. Std. errors are in bracket; ***,** and* indicates significance at 1%, 5% and 10% respectively. DW indicates Durbin Watson statistic for residual autocorrelation. J-statistics is Hansen's J-statistic for over identification test. P-value of the corresponding test is presented in square brackets. H_0: β=1 column provides the value of chi-square statistics and corresponding p-value for the test of discount factor equal to unity.]*

Table 6: Estimated result of New Hybrid Phillips Curve; structural form

Specification			B	θ	ω	γ_f	γ_b	DW	J-stat [p(J)]	H_0: β=1 [Pr χ^2]	H_0: λ=0 [Pr χ^2]	Implied duration
INDIA	**Full Sample**	**PGDP**	**0.94*** (0.08)**	**0.68*** (0.08)**	**0.74*** (0.12)**	**0.46**	**0.52**	**2.3**	**10.76 [0.70]**	**0.57 [0.44]**	**1.26 [0.26]**	**3.12**
		CPI	**0.99*** (0.03)**	**0.66*** (0.06)**	**0.69*** (0.11)**	**0.48**	**0.51**	**2.4**	**8.49 [0.90]**	**0.05 [0.81]**	**2.18 [0.13]**	**2.94**
	Before Crisis 2008	**PGDP**	**0.97*** (0.17)**	**0.68*** (0.15)**	**0.73*** (0.13)**	**0.47**	**0.52**	**2.5**	**7.17 [0.92]**	**0.02 [0.87]**	**1.90 [0.16]**	**3.12**
		CPI	**1.01*** (0.03)**	**0.70*** (0.06)**	**0.61*** (0.11)**	**0.49**	**0.5**	**2.3**	**10.0 [0.81]**	**0.17 [0.67]**	**0.91 [0.34]**	**3.33**
	After Crisis 2008	**PGDP**	**0.92*** (0.07)**	**0.57*** (0.05)**	**0.47*** (0.07)**	**0.51**	**0.49**	**1.7**	**9.38 [0.74]**	**1.45 [0.22]**	**3.58* [0.06]**	**2.32**
		CPI	**0.92*** (0.03)**	**0.58*** (0.03)**	**0.53*** (0.05)**	**0.49**	**0.51**	**2.0**	**9.32 [0.81]**	**7.1*** [0.007]**	**29.4*** [0.000]**	**2.38**
Australia	**Full Sample**	**PGDP**	**1.03*** (0.04)**	**0.57*** (0.05)**	**0.42*** (0.05)**	**0.58**	**0.41**	**2.2**	**10.85 [0.82]**	**5.01 [0.03]**	**6.05 [0.02]**	**2.32**
		CPI	**1.06*** (0.03)**	**0.57*** (0.05)**	**0.45*** (0.06)**	**0.58**	**0.42**	**2.7**	**9.15 [0.91]**	**2.95 [0.08]**	**6.89*** [0.009]**	**2.32**
	Before Crisis 2008	**PGDP**	**1.03*** (0.03)**	**0.61*** (0.03)**	**0.42*** (0.11)**	**0.60**	**0.40**	**2.4**	**10.48 [0.84]**	**2.49 [0.11]**	**4.93 [0.03]**	**2.56**
		CPI	**1.04*** (0.03)**	**0.56*** (0.05)**	**0.42*** (0.07)**	**0.58**	**0.42**	**2.8**	**9.74 [0.87]**	**3.04 [0.10]**	**3.51* [0.06]**	**2.27**
	After Crisis 2008	**PGDP**	**1.03*** (0.03)**	**0.57*** (0.05)**	**0.39*** (0.01)**	**0.60**	**040**	**1.9**	**4.87 [0.85]**	**11*** [0.000]**	**41*** [0.000]**	**2.32**
		CPI	**1.03*** (0.03)**	**0.59*** (0.05)**	**0.37*** (0.01)**	**0.61**	**0.38**	**1.9**	**4.93 [0.89]**	**13*** [0.000]**	**44*** [0.000]**	**2.43**
UK	**Full Sample**	**PGDP**	**0.95*** (0.04)**	**0.75*** (0.04)**	**0.44*** (0.14)**	**0.61**	**0.35**	**2.5**	**12.12 [0.35]**	**0.94 [0.33]**	**2.36 [0.12]**	**4.00**
		CPI	**0.95*** (0.03)**	**0.78*** (0.04)**	**0.51*** (0.15)**	**0.59**	**0.40**	**2.4**	**9.48 [0.57**	**2.42 [0.12]**	**2.59 [0.11]**	**4.54**
	Before Crisis 2008	**PGDP**	**0.97*** (0.03)**	**0.78*** (0.07)**	**0.36*** (0.09)**	**0.67**	**0.32**	**2.3**	**11.06 [0.43]**	**1.29 [0.29]**	**1.76 [0.18]**	**4.54**
		CPI	**0.96 (0.03)**	**0.79*** (0.05)**	**0.42*** (0.15)**	**0.63**	**0.35**	**2.4**	**6.22 [0.85]**	**1.65 [0.19]**	**2.13 [0.14]**	**4.76**
	After Crisis 2008	**PGDP**	**0.99*** (0.02)**	**0.81*** (0.01)**	**0.32*** (0.03)**	**0.70**	**0.30**	**2.0**	**6.49 [0.83]**	**0.07 [0.79]**	**22 [0.00]**	**5.26**
		CPI	**0.98*** (0.04)**	**0.81*** (0.03)**	**0.56*** (0.14)**	**0.59**	**0.41**	**1.6**	**8.71 [0.65]**	**0.34 [0.55]**	**1.37 [0.24]**	**5.26**

*[Note: Estimation method and instrument set are same as for reduced form model. β is the discount factor, θ is the degree of price stickiness; ω is the degree of backwardness. γ_f and γ_b indicate fraction of forward and backward looking firms respectively. ***, ** and * indicates significance at 1%, 5% and 10% respectively. Std. errors are in parentheses. DW indicates Durbin Watson statistic for residual autocorrelation. J-statistics is Hansen's J-statistic for over identification test. P-value of the corresponding test is presented in square brackets. H_0: β=1 column provides the value of chi-square statistics and corresponding p-value for the test of discount factor equal to unity. Implied duration is calculated as* $\frac{1}{1-\theta}$ *measures the average duration of one price.]*

Table 5 and Table 6 represent the estimates of parameters of the open economy Hybrid Philips curve with some related statistics for reduced form model and structural form model respectively presented in equation 12 using the mentioned instrument set. In this estimation process, unit labor cost has been used as the rear marginal cost rather than labor share gap. In this specification the orthogonality conditions for over identification restrictions are strictly satisfied. In most cases the restrictions of the inflation coefficients summing to unity is not rejected. Similarly, the lambda restriction receives expected positive sign and is statistically significant i.e. the real unit labor costs play significant role for inflation. The Durbin –Watson statistic reveals that there is no severe problem of residual autocorrelation.

The estimated results from both reduced form and structural form of the hybrid specification parameters are found to be statistically significant irrespective of dependent specification. Specifically, the model empirically shows the significant nature of forward looking and backward looking nature. Here γ_f and γ_b are representing the forward looking and backward looking fraction of total firms. Both reduced and structural forms provide the same measure of γ_f and γ_b which is an indication of consistent estimates. The result supports that around half of the Indians' firms are still following backward looking behavior. However, price stability is rather higher; on average prices are fixed around 9 to 10 months. The estimated results suggest that among the three countries, the United Kingdom has the highest price stability like more than one year, while Australia is subject to reset their prices more often compare to other two countries. It is also evident from the results that the unit labor costs appear as significant for both India and the United Kingdom.

Table 7: Open economy New Hybrid Phillips curve- Imported Intermediate goods; reduced form

Specification			γ_f	γ_b	λ^l	λ^m	DW	J-stat [p(J)]	H_0: β=1 [Pr χ^2]
INDIA	Full Sample	PGDP	0.45*** (0.05)	0.53*** (0.05)	0.04*** (0.009)	0.02** (0.01)	2.3	10.8 [0.62]	0.17 [0.67]
		CPI	0.37*** (0.07)	0.63*** (0.07)	0.02 (0.02)	0.02 (0.02)	2.4	5.9 [0.87]	0.42 [0.51]
	Before Crisis	PGDP	0.46*** (0.12)	0.52*** (0.01)	0.02* (0.002)	0.02* (0.004)	2.3	21 [0.10]	0.0001 [0.99]
		CPI	0.46*** (0.05)	0.54*** (0.05)	0.01 (0.009)	0.006 (0.02)	2.5	6.1 [0.86]	0.31 [0.57]
	After Crisis	PGDP	0.47*** (0.02)	0.53*** (0.02)	-0.07* (0.009)	0.05* (0.006)	2.4	7.5 [0.97]	8.11 [0.00]
		CPI	0.45*** (0.2)	0.52*** (0.02)	-0.007** (0.001)	0.04* (0.005)	2.5	7.1 [0.97]	0.57 [0.45]
AUSTRALIA	Full Sample	PGDP	0.53*** (0.02)	0.46*** (0.02)	-0.007 (0.03)	-0.17 (0.54)	2.3	10.6 [0.77]	0.88 [0.34]
		CPI	0.54*** (0.03)	0.46*** (0.03)	0.04** (0.02)	0.07 (0.03)	2.4	7.7 [0.93]	1.26 [0.26]
	Before Crisis	PGDP	0.52*** (0.03)	0.48*** (0.03)	0.01 (0.02)	-0.07 (0.36)	1.9	8.5 [0.90]	0.62 [0.43]
		CPI	0.53*** (0.03)	0.46*** (0.03)	0.04 (0.03)	0.06 (0.4)	2.9	7.5 [0.93]	1.23 [0.28]
	After Crisis	PGDP	0.67*** (0.11)	0.31*** (0.08)	-0.40** (0.16)	-4.16* (2.17)	1.9	3.8 [0.79]	0.02 [0.87]
		CPI	0.61*** (0.08)	0.39*** (0.07)	0.07*** (0.016)	3.59*** (0.49)	1.6	3.6 [0.72]	12.22 [0.00]
UK	Full Sample	PGDP	0.59*** (0.04)	0.41*** (0.04)	-0.011 (0.006)	-0.006 (0.006)	1.9	13.3 [0.57]	0.16 [0.68]
		CPI	0.56*** (0.04)	0.43*** (0.04)	0.35** (0.06)	0.002* (0.002)	2.4	9.5 [0.85]	0.42 [0.51]
	Before Crisis	PGDP	0.59*** (0.04)	0.43*** (0.04)	-0.34** (0.15)	-0.009* (0.005)	2.4	12.6 [0.62]	2.24 [0.13]
		CPI	0.54*** (0.05)	0.45*** (0.0.5)	0.05** (0.02)	0.002** (0.003)	2.4	7.6 [0.94]	2.83 [0.09]
	After Crisis	PGDP	0.66*** (0.07)	0.32*** (0.11)	0.002** (0.0005)	0.06* (0.02)	1.9	3.7 [0.81]	0.02 [0.88]
		CPI	0.65*** (0.07)	0.33*** (0.06)	-0.001* (0.0002)	-0.05** (0.011)	1.7	4.1 [0.85]	1.05 [0.31]

*[Note: GMM estimates with HAC weighting matrix and 2-lag Newey- West method; instrument set includes D4LPGDP (-2 TO -3), SHLABHP, SI, DLUSD,ULCHP(-1 TO -2),LPMHP(-1 TO -2), URATE(-1 TO -2), DLWPXC DLWGDP DWIQ and DWIL. In case of CPI specification instrument set includes D4LCPI instead of D4LPGDP. Std. errors are in parentheses; ***,** and* indicates significance at 1%, 5% and 10% respectively. DW indicates Durbin Watson statistic for residual autocorrelation. J-statistics is Hansen's J-statistic for over identification test. P-value of the corresponding test is presented in square brackets. H_0: β=1 column provides the value of chi-square statistics and corresponding p-value for the test of discount factor equal to unity.]*

Table 7 represents the results of the open economy hybrid version of the Phillips curve is augmented to control for foreign inflation and exchange rate pass through represented by the equation 15. In the augmented model the coefficients indicate forward looking fraction (γ_f), backward looking fraction (γ_b), role of real marginal cost (λ^l) and the real exchange rate (λ^m). The idea here is to model the imported goods as intermediate production goods, while all the final goods are assumed to produce domestically. In table 7, most of the parameter estimates appear statistically significant. Once again, the Durbin –Watson statistic reveals that there is no severe problem of residual autocorrelation irrespective of inflation measure and time period. In all cases, Hansen's J statistic shows that null hypothesis of well specified model is not rejected which indicated model s are performing well. In some cases of post crises period the null hypothesis H_0: β=1 is rejected; this might be due to few observations. However, in most cases the null hypothesis H_0: β=1 is not rejected; this statistically ensures that the sum of coefficients of past and expected future inflation rate is equal to unity. Therefore, γ_f and γ_b represent the degree of price stickiness (θ) and degree of backwardness (ω) in price setting respectively. As a result, these parameter estimates with its standard error from the reduced form expression can be considered as the parameter estimates (θ and ω) of structural form expression.

The results show that half of the Indian firms are forward looking and half of them are backward looking in setting their prices, while the two-third of the UK firms are forward looking in their nature. In addition, Australian firms are more forward looking in their price setting than backward looking but the forward looking fraction of firms for Australia is lower than the United Kingdom. Also, the average price duration is higher for UK than India than Australia. Furthermore, the λ^l estimates indicate that short run inflation dynamics is directly linked to the

real marginal costs, which are statistically significant as well. The real exchange rate takes the expected sign and becomes statistically significant in most cases. Results suggest that for a 10% appreciation in Indian Rupee against the US Dollar is able to reduce inflation by 0.2% to 0.5% points for the current quarter. Even the performance is better for post crises period than earlier period.

Conclusion and Policy Recommendations

In this thesis, I have estimated different Phillips curve equations ranging from traditional Phillips curve to the new hybrid Phillips curve to describe the inflation dynamics. I have compared the empirical results of Indian data with the empirical results of Australia and the United Kingdom. In contrast to earlier analysis (e.g. Sahu (2013), Rummel (2012), Kumer (2013) etc.) of inflation dynamics of India, this research has focused on the degree of forward-looking and backward-looking behavior, the Calvo probability of price changes. At the same time, this research has considering two developed economies; one is a relatively small open economy, namely Australia, while the other is a big open economy, namely United Kingdom, to compare the scenarios in the light of inflation dynamics considering India as a big developing economy.

Using the new hybrid Philips curve model, the comparison between the three countries show that Indian economy hold more backward looking farms compared with Australia and the UK; approximately half of the Indian firms are still backward looking. To overcome the Lucas critique about the Phillips curve, traditional Phillips curve has been augmented incorporating the effect of imported goods price towards the open economy extension of the model. Among the models, the open economy version successfully describes the Indian inflation dynamics as well as other two developed economies. In one hand, the discount factor in case of India is very close to unity having more backward looking farms. On the other hand, the price duration in India is rather high which means that the commodity market takes time to incorporate the available information towards price adjustment. Additionally, the real marginal cost and the real exchange rate play an important role in inflation formation. Indian Rupee exchange rate appreciation against US Dollar is able to reduce inflation although the reduction rate is not too high.

If the current inflation as well as expected future inflation is less volatile, the monetary authority can employ key interest rate to wrestle the real interest rate. The outcome of this research provides insight into the functioning of the monetary transmission mechanism of Indian economy in light of developed economies. Moreover, high real interest rate and high wages reduce the full utilization of production capacity, which yields cyclical unemployment. The findings of this research suggest that the monetary authority should anchor inflation expectation more rigidly and the labor market institutions should let wages to be determined by the market forces, letting wages be adjusted automatically. Furthermore, long-run inflation expectation being the driving force of trend inflation, monetary authority should closely observe the long run inflation so that monetary authority can raise their credibility, transparency and efficiency. Besides, the fiscal authority should formulate a prudent fiscal policy so that the monetary policy can promote both price stability and utmost sustainable employment.

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Appendix

1. Inflation and Economic growth scenario of India over the sample period

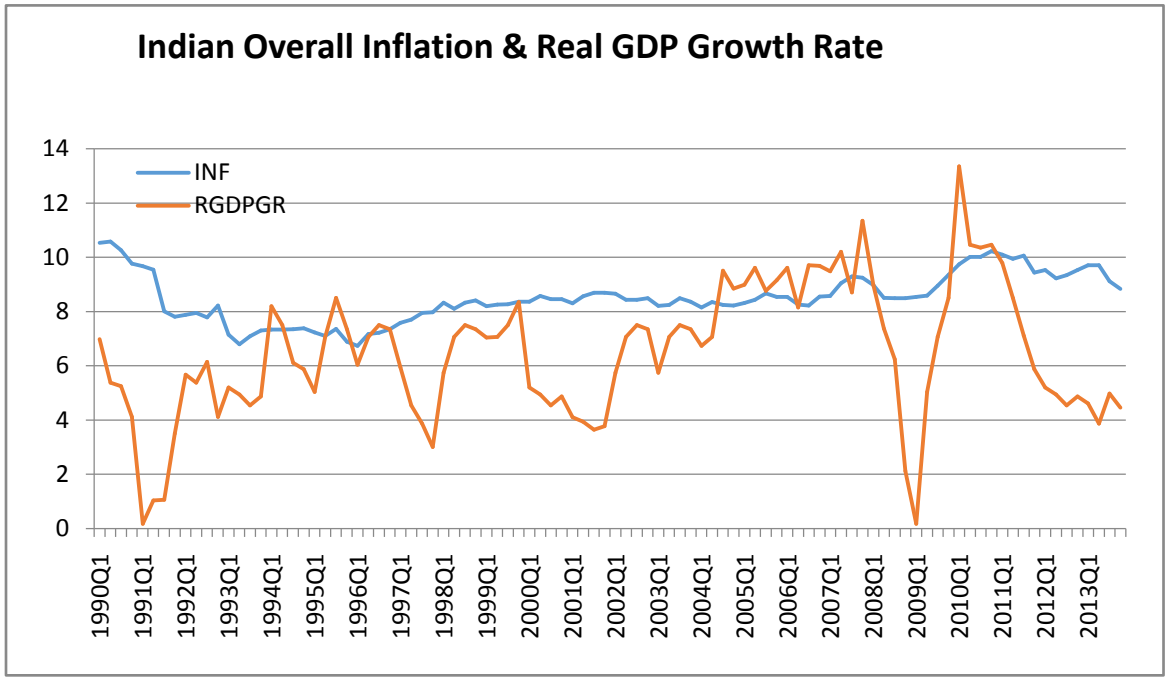

Figure 1: Graphical comparison between Indian overall Inflation and real GDP growth rate

2. H-P Series for Indian data

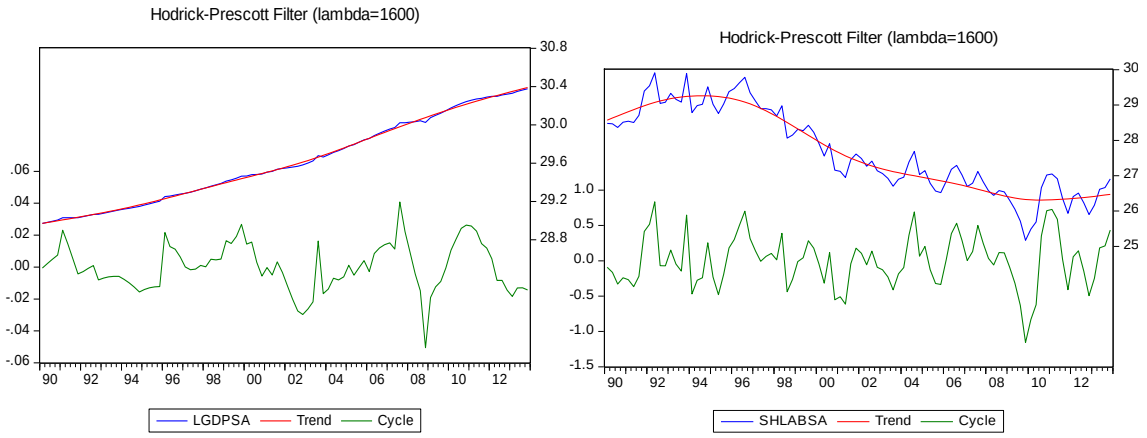

Figure2: Graphical presentation of Hodrick- Prescott Filtered detrended data series for India

3. Recursive estimates:

To check for the sensitivity of the estimated coefficients, I have conducted recursive estimates (i.e. parameters have been estimated by increasing the sample size gradually). Figure 3 shows

the point estimate of the coefficients ± standard errors of the coefficients. It is evident from the recursive graph that estimation of the coefficients seems stable.

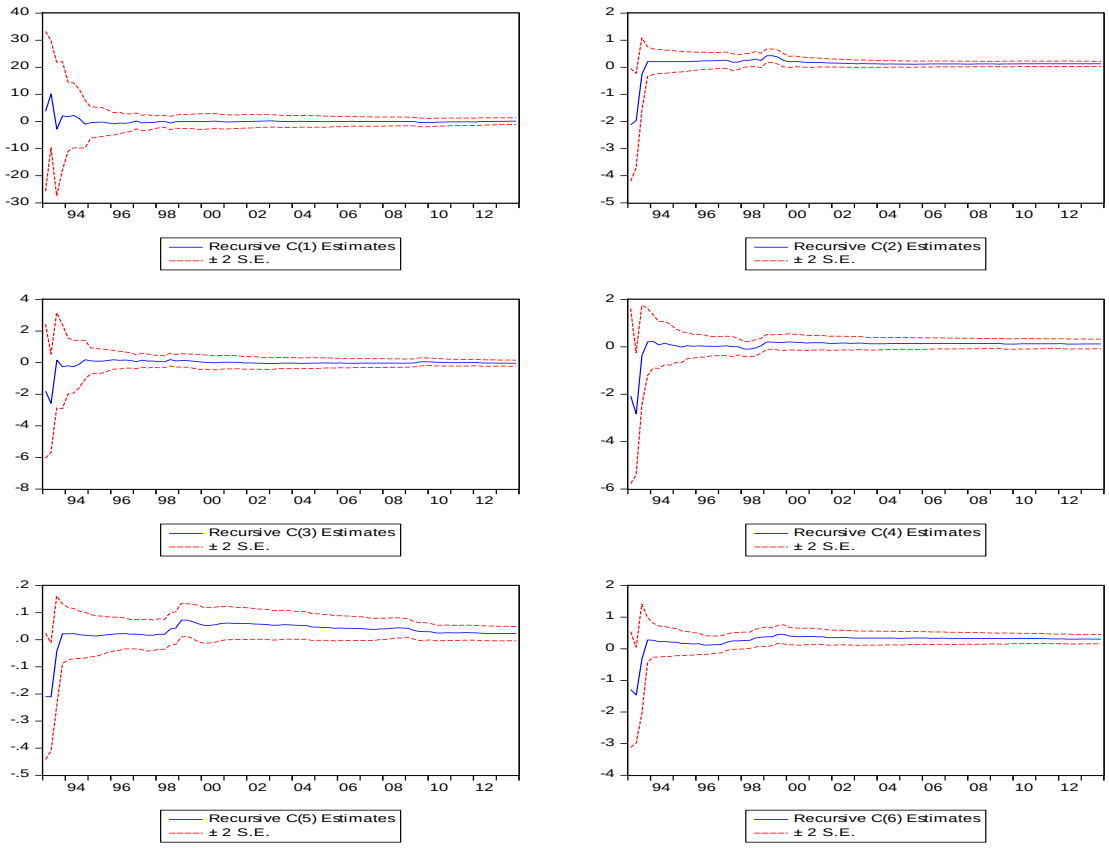

Figure3: Graphical representation of recursive estimates for India

4. Description of variables used in the analysis

Variable	Units	Series Description
POP	Person	Estimated resident population: Total
GDPSA	Local Currency, SA	Seas adjusted GDP , fixed price
URATESA	SA	Labor force survey: Unemployment rate
UESA	'000'	Labor force survey: Unemployed person
EMPSA	'000' SA	Labor force survey: Employed persons: Total
AMESA	Local currency	Average monthly earnings: All employees
PGDP	Index	GDP-Deflator
CPI	Index	CPI: All Items
IS	Interest rates, %pa	Money market: Cash rate: Interbank rate

IQ	%pa	Interest rates: Money market: bank bills: 90 days
I10	%pa	Capital market yields: Government bonds: 10 years
USD	$US/local currency	Exchange rates: Period average: United States dollar
RER	Real Exchange rate	Nominal Exchange rate x domestic CPI/ US CPI
AWE	$/week	Total earnings: All employees
ULC	Unit labor costs, SA	Real wage to labor productivity
TOT	Index SA	Terms of Trade
IMP	$	Imported Price of
BUDDEF	Local currency	Budget deficit
RGRDGR	Index	Real GDP growth Rate
WGDP	Index SA	World: GDP: MTP
WPCON	Index SA	World: Prices: MTP: Consumption deflator
WPXC	Index SA	World: MTP: Commodity price index
WIQ	%pa SA	World: Interest rates: MTP: Short-term
WIL	%pa SA	World: Interest rates: MTP: Long-term

Note: SA stands for Seasonally Adjusted, MTP: Major Trading Partners

5. Alternative Instruments

The Chaw test for structural breaks ensures the stability of the parameter estimates (figure…). Furthermore, I have used different set of instruments (appendix) to check whether estimates fluctuate substantially or not which also ensures the robustness of the parameter estimates.

Set A
Constant, D4LPGDP(-1 to -2), ULCHP(0 to -2), IMPHP(-1 to -2), DRER(-1 to -2),URATE(-1 to -2), BUDDEF(-1 to -2), RGDPGR(-1 to -2)

Set B
Constant, D4LPGDP(-1 to -4) SHLAB SI SHGAP DLWAGESA DLWPXC DLUSD DLWGDP DWIQ DWIL DLWPCON

Set C

Constant, D4LPGDP(-1 TO -8) SHLABSA SI SHGAP DLUSD

Note: L indicates logarithm, D indicates first difference, HP indicates Hodrick- Prescott filtered detrended, D4 indicates seasonally difference and lag order's are in parentheses.

6. Major Trading Partners list

India's major trading partners: Saudi Arabia, USA, Germany, Switzerland, Australia, South Korea, Japan, Singapore, Malaysia, Indonesia, Hong Kong, UK, Belgium, Italy, Thailand, Canada, Egypt, Netherlands, South Africa, Sri Lanka, China, U.A.E, Kuwait, Iran, France, Russia.

UK's major trading partners: US, Germany, France, Netherlands, Irish republic, Belgium, Italy, Spain, China, Sweden, India, Switzerland, Canada, Hong Kong , Russia, UAE, Japan, Poland, Australia, Turkey, Singapore, South Africa, Norway, Saudi Arabia, Denmark, Qatar, Czech Republic, Taiwan, Hungary.

Australia's major trading partners : China, Japan, Republic of Korea, US, India, New Zealand, Singapore, Taiwan, UK, Malaysia, Thailand, Germany, Indonesia, Hong Kong, UAE and Papua New Guinea.