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Change in Inflation Dynamics with the Level of Economic Development: A Comparative Study for Open Economy

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Abstract

This study compares the inflation behavior of India, Australia and the United Kingdom 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 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 both the real marginal cost and exchange rate pass-through play an important role in inflation dynamics. In addition, firms of these countries follow both backward looking and forward looking behavior. However, India is less forward looking in price setting behavior compared to the UK and Australia although price rigidity is substantially higher.

Keywords

Inflation Dynamics, Open Economy, Philips Curve, GMM Estimation, Real Marginal Cost, Exchange Rate

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1. 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. 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.

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. The hybrid Phillips curve analysis for inflation dynamics provides information about the percentage of firms, which are able to adjust their prices at each period as well as the as other features of traditional Phillips curve analysis. In consequence, 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 (Fuhrer and Moore (1995), Fuhrer (1997), Roberts (1997, 1998), Gali and Gatler (1999), Kara and Nelson (2003), Lendvai (2005), Mishkin (2007), Gabriel (2010), Rummel (2012) etc.). Although Indian is a developing economy, suitably using the hybrid Phillips curve framework rationalized by its integrating nature to the world economy. Paul (2009) shows that the Phillips curve relation exists for the Indian manufacturing sector. Singh et. al (2011) and Mazumder (2011) also supported this claim.

The Lucas critique, which undermines the use of Philips curve for open economy, is deemed inappropriate for Indian economy (Mazumder, 2011). Sahadudhen (2012) claims that

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GDP and broad money have positive effects on inflation while inflation is negatively affected by exchange rate and interest rates. Rummel (2012) finds that aggregate demand reacts to interest rate changes with a lag of at least three quarters. Kumar (2013) depicts that inflation has the cointegrating relationship with other macroeconomic variables. Sahu (2013) uses hybrid new Kynesian Phillips curve for agricultural and industrial output gap to represent the sectoral characteristics of both sectors of the Indian economy. These studies support the application of open economy version of hybrid Phillips curve analysis for India.

In the present study, 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 have been used. 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 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. 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) and the results will be compared. 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.

2. Data and Variables

The quarterly data series for India, the United Kingdom and Australia over the period 1990Q1 to 2013Q4 have been used. 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. Data for UK and 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 has been used to get gap series.

1The 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 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.

3. Econometric Techniques in Phillips Curve Modeling

3.1. 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, which can be described as

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

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. This type of Phillips curve is known as P-curve. Similarly, in the W-curve (Gruen et. al. 1999) unit labor cost (ULC_t) is used 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). The resulting model is

$$\Delta_4 ULC_t - \Delta_4 p_{t-1} = \delta\pi_t^* - \delta\Delta_4 p_{t-1} + \gamma(MA_4(U_t) - U_t^*) + \varepsilon_t \quad (2)$$

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

$$\begin{aligned}\Delta_4 P_t - \Delta_4 P_{t-1} &= a + \delta(\pi_t^* - \Delta_4 P_{t-1}) + \gamma U_t + d\Delta U_{t-1} \\ &+ \alpha_1(\Delta_4 pm_{t-1} - \Delta_4 pm_{t-2}) + \alpha_2(\Delta P_{t-1} - \Delta P_{t-4}) + \varepsilon_t\end{aligned} \quad (3)$$

Where, pm_t is the import price. This is now a linear model and OLS can safely be used to estimate the parameters. Many studies have showed that inflation is becoming less responsive to unemployment and 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.

3.2. The New Phillips Curve

Under Calvo (1983) pricing 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:

$$\pi_t = \lambda mc_t + \beta E_t\{\pi_{t+1}\} + \varepsilon_t \quad (4)$$

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.

However, this NKPC expressed by equation (4) 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. 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:

$$\pi_t = \lambda s_t + \beta E_t\{\pi_{t+1}\} + \varepsilon_t \quad (5)$$

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

3.3. The New Hybrid Phillips-Curve

This version of Phillips curve is admired due to its ability to deal with apparent inertia in inflation which was developed by extending the basic Calvo model by Gali&Gatler (1999) so that backward looking rule of thumb is allowed to a fraction of Firms and expressed as

$$\pi_t = \lambda S_t + \gamma_f E_t\{\pi_{t+1}\} + \gamma_b \pi_{t-1} + \varepsilon_t \quad (6)$$

Where, $\lambda = \frac{(1-\omega)(1-\theta)(1-\beta\theta)}{\phi}$, $\gamma_f = \frac{\beta\theta}{\phi}$, $\gamma_b = \frac{\omega}{\phi}$, $\phi = \theta + \omega[1-\theta(1-\beta)]$ 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. For this structural form the moment condition is:

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

Alternatively, moment condition for reduced form is: $E_t\{\pi_t - \lambda S_t - \gamma_f \pi_{t+1} - \gamma_b \pi_{t-1})Z_t\} = 0$.

However, this version of the Phillips curve is not completely able to capture the incidents and evaluation of the practiced monetary policy, especially when the economy is open enough. 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, 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 (McCallum and Nelson 1999)). 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

$$\pi_t = \gamma_b \pi_{t-1} + \gamma_f E_t \pi_{t+1} + \lambda^l ulc_t + \lambda^m rer_t + \varepsilon_t \quad (7)$$

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

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.

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

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

The reduced form model exhibits the condition: $E\{(\pi_t - \gamma_b\pi_{t-1} - \gamma_f\pi_{t+1} - \lambda^l ulc_t - \lambda^m rer_t)Z_t\} = 0$

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. 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.

4. Results and Discussions

4.1. The Traditional Phillips Curve

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 1 (P-curve) and equation 2 (W- curve) have been estimated. The estimated results are presented in Table 1.

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.]

Table 2. Gruenet. 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.]

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 represents the Gruen et. al. (1999) suggested model described in equation 3. 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.

4.2. The New Phillips Curve

Table 3 represents the completely forward-looking New Keynesian Phillips curve model proposed by Gali and Gatler (1999) presented in equation 5. In Table 3 over identification test results show that null hypothesis of well specified model cannot be rejected. 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.

Table 3. Estimation results of Gali&Gatler's (2003) New-Keynesian Phillips Curve model.

	First specification						Second Specification				
		θ	β	DW	P(J)	H_0: β=1 [Pr χ2]	θ	β	DW	P(J)	H_0: β=1 [Pr χ2]
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. 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.]

Table 4. Estimated result of reduced form New Hybrid Phillips Curve.

	Specification		γ_f	γ_b	λ	DW	J-stat	Pr(J)	H0: β=1	Pr(χ2)
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: 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.]

Using the results from Table 3, 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.

4.3. The New Hybrid Phillips Curve for Open Economy

Firstly, the model has been estimated for the whole sample

period from 1990Q1 to 2013Q4. Then the sample period has been divided into two time periods (considering the Lehmann Brother's Collapse in September 2008) which constitutes pre crisis period (1990Q1 to 2008Q2 for India while 1990Q1 to 2008Q3 for other countries) and reaming period as post crisis, since in India the financial year starts from April instead of January. For each of the three periods, both dependent structures, namely, GDP deflator inflation and CPI Inflation have been used; both are in seasonally differenced (i.e. summer-to-summer, winter- to- winter etc.).

Table 4 and Table 5 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 6 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.

Table 5. Estimated result of New Hybrid Phillips Curve; structural form.

Specification			β	θ	ω	γ_f	γ_b	DW	J-stat [p(J)]	H0: β=1 [Pr χ2]	H0: λ=0 [Pr χ2]]	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: 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. Duration measures the average duration of one price.]

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. 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 6. 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)]	H0: β=1 [Pr ^{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: Std. errors are in parentheses; ***,** and* indicates significance at 1%, 5% and 10% respectively..]

Table 6 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 7. 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 6, 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 models 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. Furthermore, the average price duration is higher for UK than India than Australia. Furthermore, λ^l the 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 domestic currency against the US Dollar is able to reduce inflation by 0.2% to 0.5% points for India for the current quarter, while these effects are lower for other two countries. Even the performance is better for post crises period than earlier period.

5. Conclusion

Among the models, the open economy version successfully describes the Indian inflation dynamics as well as other two developed economies. Results of the present research findings yield a substantial difference in the degree of the forward looking and the backward looking behavior of India, a developing and big open economy, with that of the United Kingdom, a developed and big open economy and fairly difference with that of Australia, a developed and small open economy. 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 unswervingly associated to the real marginal costs as well as the real exchange rate. Therefore, it is possible to say that inflation dynamics is not directly linked with the development level of economy rather associated with monetary operations like exchange rate pas through and real marginal cost.

Appendix: Major Trading Partners List

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

References

[1] Christiano, L. J., Eichenbaum, M. and Evans, C.(2001). Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy, Northwestern University, 2001.

[2] Fuhrer, J C, Moore, G R and Schuh, S (1995). Estimating the Linear-Quadratic inventory model: maximum Likelihood versus Generalized Method of Moments, Journal of Monetary Economics 35:115–158.

[3] Dua, p., Gaur, U., 2010. "Determination of inflation in an open economy Phillips ccurve framework: The case of developed and developing Asian Countries." *Macroeconomics and Finance in Emerging Market Economies* 3(1): 33-51.

[4] Gali, J, Gertler, M., 1999. "Inflation Dynamics: A structural econometric analysis." *Journal of Monetary Economics* 44: 195-222.

[5] Gali, J., Gertler, M., Lopez-Salido, J.D., 2005. "Robustness of the Estimates of the Hybrid New Keynesian Phillips Curve." *NBER Working Paper Series* 1-15.

[6] Gali, J., Gertler, M., Lopez-Salido, J.D., 2001. "European inflation dynamics." *European Economic Review* 45 (7): 1237-1270.

[7] Gruen, D., Pagan, A. Thompson, C., 1999. "The Phillips ccurve in Australia." *Journal of Monetary Economics* 44: 223-258.

[8] Ito, T. and K. Sato (2008). "Exchange Rate Changes and Inflation in Post-Crisis Asian Economics: VAR Analysis of Exchange Rate Pass-Through" Journal of Money, Banking and Credit 40 (7): 1407-38.

[9] Jeffrey C. Fuhrer J.C. and Olivei G.P. (2004). Estimating Forward-Looking Euler Equations with GMM and Maximum Likelihood Estimators: An Optimal Instruments Approach, Federal Reserve Bank of Boston, USA.

[10] Kara, A., Nelson, E., 2003. "The Exchange Rate and Inflation in the UK." *Journal of Political Economy* 50, no. 5: 585-608.

[11] Kumar, R., 2013. "A Study of Inflation Dynamics in India: A Cointegrated Autoregressive Approach." *Journal of Humanities and Social Science* 8 (1): 65-72.

[12] McCallum, B. and Nelson, E. (1999). 'An optimizing IS-LM specification for monetary policy and business cycle analysis', Journal of Money, Credit and Banking, 31: 296–316.

[13] Mazumder, S., 2011. "The stability of the Phillips curve in India: Does the Lucas ctitique apply?" *Journal of Asian Economics* 22: 528-539.

[14] Nason, J. M., and Smith, G. W. (2008). "Identifying the New Keynesian Phillips Curve," Journal of Applied Econometrics, 23 (5), 525–551.

[15] Patra, M, and Kapur, M. (2010). A Monetary Policy Model without Money for India, IMF Working Paper 10/183 (Washington: International Monetary Fund).

[16] Paul, B. P., 2009. "In search of the Phillips curve for India." *Journal of Asian Economics* 20: 479-488.

[17] Rotemberg, J. J., and Woodford, M. (1999). The Cyclical Behavior of Prices and Costs. In Handbook of Macroeconomics., ed. John B. Taylor and Michael Woodford,1051–135. Elsevier.

[18] Rummel, O., 2012. "Money Transmission Channels, Liquidity Conditions and Determinants of Inflation: Estimating the new Keynesian Phillips curve in a monetary model for India." *Bank of England* 1-39.

[19] Sahadudhen I., 2012. "A cointegration and Error Correction Approach to the Determinants of inflation in India." *International Journal of Economic Research* 3(1): 105-112.

[20] Sahu, J. P., 2013. "Inflation Dynamics in India: A hybrid New Keynesian Phillips Curve Approach." *Economics Bulletin* 33(4): 2634-2647.

[21] Singh, S. Julian Park, J. and Brown J.L. (2011). The economic sustainability of cropping systems in Indian Punjab: A farmers' perspective, The University of Reading, UK.

[22] Taylor J.B. (1980). Aggegate Dynamics and Staggered Contracts. The journal of Political Economy, 88(1): 1-23.