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Impact of Imported Intermediate Goods on Inflation Dynamics: Evidence from India

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India is a highly open economy having large amount of trade with the rest of the world. This paper examines the role of imported intermediate goods on Indian inflation behaviour by estimating open economy version of Phillips curve model using quarterly data over the period of 1990 to 2013. The results obtained by applying GMM estimation show that imported intermediate goods play an important role in inflation dynamics via both real marginal cost and exchange rate pass-through. The results are valid when GDP deflator as well as CPI inflation is used as inflation measure.

Keywords: GMM Estimation, Imported Intermediate Goods, Inflation Dynamics, Open Economy, Phillips Curve

JEL Classification: C51, E52

I. INTRODUCTION

Maintaining low inflation is an important macroeconomic policy aspect of robust and sustainable economic growth. In developing economies, inflation is determined by multiple interconnected factors. One of them is rapid respondents of domestic price towards the world price. 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 per cent, on average India experienced a very high of 85 per cent increase in domestic inflation (Rummel 2012).

Over the last decades, the economic performances 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). While most of the developed economies have set a target of keeping inflation to around 2 per cent, India is experiencing an inflation level around 9 per cent (Figure 1). Rummel (2012) shows that monetary policy devoted to reducing inflation by 1 per cent point should reduce output by 1.1 per cent to 1.8 per cent. Therefore, for India, inflation is a complicated issue as well.

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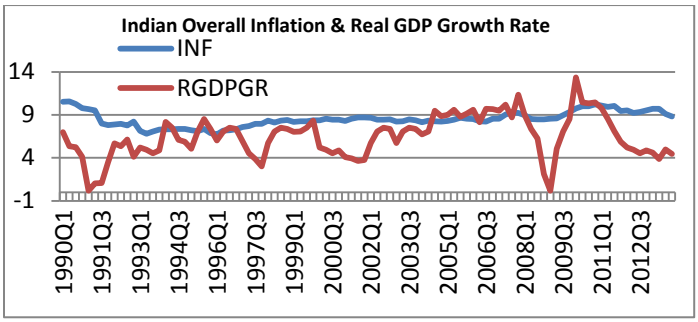
Figure 1: **Inflation and Economic Growth of India**



The integrating nature of the Indian economy to the world economy rationalises the applicability of the micro-founded new hybrid type Phillips curve approach to examine the role of imported intermediate production goods on inflation. In this application, the imported price of goods and services both as final consumption goods and as an intermediate production good has been used 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.

The new Keynesian approach came in the 1980s 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 Lucas critique, which undermines the use of Philips curve for open economy, is deemed inappropriate for Indian economy (Mazumder 2011). Sahadudhen (2012) claimed 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.

Applying Ordinary Least Square (OLS) on augmented Phillips curve, Srinivasan *et al.*(2006) find that the supply shocks have only a temporary effect on both headline inflation and core inflation. Moreover, the study 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.

This research covers the literature gap of inflation dynamics in two ways. First, this research extending the hybrid version of the Phillips curve for open economy towards imported intermediate goods to assess its role on inflation. Second, 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), in this paper CPI inflation is also used as the dependent structure of the specified model along with GDP deflator inflation. In this application, the real unit labour cost has been used as the driving variable rather than detrended GDP in contrast to Shahu (2013).

II. ECONOMETRIC MODELLING AND ESTIMATION TECHNIQUE

The New Hybrid Phillips Curve (NHPC) framework can be expressed as a function of expected future inflation (π_{t+1}), lag inflation (π_{t-1}) and real marginal cost (mc) 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). The NHPC expressed by equation 1 is developed by extending the basic Calvo model by Gali and Gatler (2000) so that backward looking rule of thumb is allowed to a fraction of firms.

$$\pi_t = \lambda S_t + \gamma_f E_t\{\pi_{t+1}\} + \gamma_b \pi_{t-1} + \varepsilon_t \tag{1}$$

where $\lambda = \frac{(1-\omega)(1-\theta)(1-\beta\theta)}{\phi}$, $\phi = \theta + \omega[1-\theta(1-\beta)]$ $\gamma_f = \frac{\beta\theta}{\phi}$, $\gamma_b = \frac{\omega}{\phi}$, ω is the fraction of "backward looking" firms, θ is the frequency of price adjustment, β is the subjective discount factor and S_t is the labour income share. 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. 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 NHPC can be used to describe such situation mere adequately that includes unit labour cost as marginal cost instead of labour income share. In this setting, it is assumed that the fraction of firms that are unable to set price freely can adjust the price partly to cope with the current inflation. This modified version of NHPC is a hybrid of the basic New Keynesian Phillips Curve since it considers both forward looking and backward looking inflation components.

According to Patra and Kapur (2010), foreign commodity price and changes in exchange rate are significant determinants of short run inflation instability. Also, from Ito and Sato (2008) exchange rate pass-through play a significant role in domestic inflation in the light of enlarged globalisation. Therefore, the above NHPC 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 is 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

$$\pi_t = \gamma_b \pi_{t-1} + \gamma_f E_t \pi_{t+1} - s\gamma_f (E_t \Delta q_{t+1} - \Delta q_t) + s\gamma_b (\Delta q_t - \Delta q_{t-1}) + \lambda mc_t + \varepsilon_t \quad (2)$$

This expression describes current inflation (π_t) 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 and 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 labour 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

$$\pi_t = \gamma_b \pi_{t-1} + \gamma_f E_t \pi_{t+1} + \lambda^l mc_t + \lambda^m rer_t + \varepsilon_t \quad (3)$$

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

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

The model is 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. To apply Generalized Method of Moments (GMM), the moment conditions take two specifications. Specification (1)

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

Specification (2)

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

The corresponding orthogonality condition for the reduced form model is

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

All these specifications of orthogonality conditions require the instrument set that includes second and third lags of dependent specification, detrended labour share, interest rate spread, first difference of nominal exchange rate, two additional lags of unit labour cost, two additional lag of imported price, two additional lag of seasonally adjusted unemployment rate and labour share gap. The instrument set also includes first difference of major trading partners' commodity price index, GDP, short run interest rate and long run interest rate. The constant term is included in the instrument set to ensure the zero mean of the model error term. India's major trading partners are 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 and Russia.

III. DATA AND METHODOLOGY

For assessing the impact of imported intermediate goods on inflation dynamics, the quarterly data series of India over the period of 1990 to 2013 have been used. For the analysis, the variables considered are nominal GDP, real GDP, GDP deflator, nominal exchange rate, real exchange rate, unit labour cost, unemployment rate, total employment, monthly wage, short run interest rate, interest rate spread (difference between short run and long run interest rate), price of imported goods, consumer price index and core inflation. Data are seasonally

adjusted. Data have been collected from various sources, namely the Ministry of Statistics and Programme Implementation, the Ministry of Labour and Employment, the Labour Bureau, International Labour 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.

Following Moore and Schuh (1995), Gali and Gatler (1999), Fuhrer and Olivei (2004) and Nason and Smith (2008), the Generalised 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 structural and reduced form parameters of the model.

IV. RESULTS AND DISCUSSIONS

The model has been fitted for the whole sample period from 1990Q1 to 2013Q4. Then following different authors (e.g. Ivashina and Scharfstein 2010, Campello, Graham and Harvey 2009) the data have been divided into two periods considering the Lehmann Brother's Collapse in September 2008 to incorporate the effect of 2008 financial crises into the model . For each of the three periods, two alternative specifications of dependent structure have been used, namely GDP deflator inflation and CPI Inflation; both are in seasonally differenced (i.e. summer-to-summer, winter- to- winter, etc. represented by D4).

Table I and Table II present 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 1 using the mentioned instrument set. The model considers the imported goods as the final consumption goods. In this estimation process, unit labour cost has been used as the rear marginal cost rather than labour share gap. In this specification, the orthogonality conditions for over identification restrictions are strictly satisfied.

As Table I and Table II indicate, in most cases the restrictions of the inflation coefficients summing to unity are not rejected. Similarly, the lambda restriction receives expected positive sign and is statistically significant i.e. the real unit labour costs play a 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. Both reduced and structural forms provide the same measure of forward looking and backward looking fraction, which is an indication of consistent estimates i.e. open economy hybrid curve is suitable to describe Indian inflation dynamics. The result supports that around half of the Indians' firms are still following backward looking behaviour. However, price stability is rather higher; on average prices are fixed around 9 to 10 months. It is also evident from the results that the unit labour costs appear as significant determinant at 5% level only for full sample. This indicates that as the economy is increasing the behaviour is changing with time in terms of labour income share. For this reason, the extended model has been used to assess the effect of imported intermediate goods on inflation behaviour.

TABLE I
ESTIMATED RESULTS 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)
Full Sample	D4PGDP	0.47*** (0.06)	0.52*** (0.05)	0.02*** (0.007)	2.3	11.2	0.67	0.83	0.36
	D4CPI	0.48*** (0.04)	0.51*** (0.04)	0.007*** (0.01)	2.4	8.1	0.83	0.004	0.94
Pre Crisis 2008	D4PGDP	0.48*** (0.06)	0.51*** (0.07)	0.02 (0.009)	2.3	6.8	0.91	0.08	0.77
	D4CPI	0.47*** (0.04)	0.53*** (0.04)	0.006 (0.01)	2.5	6.6	0.82	0.87	0.35
Post Crisis 2008	D4PGDP	0.48*** (0.03)	0.52*** (0.03)	0.04** (0.02)	2.3	7.1	0.89	0.11	0.73
	D4CPI	0.48*** (0.03)	0.53*** (0.03)	0.01 (0.02)	2.2	6.9	0.85	2.11	0.14

Note: D4PGDP is seasonally differenced GDP deflator inflation and D4CPI is the seasonally differenced CPI Inflation. GMM estimates with HAC weighting matrix and 2-lag Newey-West method. Std. errors are in bracket; ***,** and * indicate 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 II

ESTIMATED RESULT OF NEW HYBRID PHILLIPS CURVE; STRUCTURAL FORM

Specification		B	Θ	Ω	γ_f	γ_b	J-stat [p(J)]	H_0: β=1 [Pr χ^2]	H_0: λ=0 [Pr χ^2]	Implied duration
Full	D4PGDP	0.94***	0.68***	0.74***	0.46	0.52	10.76	0.57	1.26	3.12
Sample		(0.08)	(0.08)	(0.12)			[0.70]	[0.44]	[0.26]	
	D4CPI	0.99***	0.66***	0.69***	0.48	0.51	8.49	0.05	2.18	2.94
		(0.03)	(0.06)	(0.11)			[0.90]	[0.81]	[0.13]	
Pre	D4PGDP	0.97***	0.68***	0.73***	0.47	0.52	7.17	0.02	1.90	3.12
Crisis		(0.17)	(0.15)	(0.13)			[0.92]	[0.87]	[0.16]	
2008	D4CPI	1.01***	0.70***	0.61***	0.49	0.5	10.0	0.17	0.91	3.33
		(0.03)	(0.06)	(0.11)			[0.81]	[0.67]	[0.34]	
Post	D4PGDP	0.92***	0.57***	0.47***	0.51	0.49	9.38	1.45	3.58*	2.32
Crisis		(0.07)	(0.05)	(0.07)			[0.74]	[0.22]	[0.06]	
2008	D4CPI	0.92***	0.58***	0.53***	0.49	0.51	9.32	7.1***	29.4***	2.38
		(0.03)	(0.03)	(0.05)			[0.81]	[0.007]	[0.000]	

Note: Estimation method and instrument set are the 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 * indicate significance at 1%, 5% and 10% respectively. Std. errors are in parentheses. 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 1/(1-θ) measures the average duration of one price.

Table III presents the results of the open economy hybrid version of the Phillips curve, which is augmented to control for foreign inflation and exchange rate pass-through represented by equation 3. 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 III, 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 is performing well. In addition, the null hypothesis H_0: β=1 is not rejected in all cases; this statistically ensures that the sum of coefficients of the 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.

TABLE III

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]
Full Sample	D4PGDP	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]
	D4CPI	0.37*** (0.07)	0.63*** (0.07)	0.02*** (0.002)	0.02*** (0.01)	2.4	5.9 [0.87]	0.42 [0.51]
Pre Crisis 2008	D4PGDP	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]
	D4CPI	0.46*** (0.05)	0.54*** (0.05)	0.01*** (0.009)	0.06*** (0.02)	2.5	6.1 [0.86]	0.31 [0.57]
Post Crisis 2008	D4PGDP	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]
	D4CPI	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]

Note: GMM estimates with HAC weighting matrix and 2-lag Newey-West method. In the case of CPI specification instrument set includes D4LCPI instead of D4LPGDP. Std. errors are in parentheses; ***,** and * indicate 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.

The results (λ^l) estimates indicate that short run inflation dynamics is directly linked to the real marginal costs, which are highly statistically significant in all cases. This indicates that this extended hybrid model is performing better when imported intermediate goods are included compare to the model that only includes imported goods as final consumption goods. The estimated coefficient is ranging between 0.02 and 0.07, suggesting that for a 10% substitution of imported intermediate goods by domestic sources (if possible), domestic inflation can be reduced by 0.2% to 0.7% point for current period if the forward and backward fractions remain the same. In other words, imported intermediate goods are costlier than domestic sources via the exchange rate pass-through. As a result, for persistence reduction in inflation, it is needed to ensure the optimum use of domestic sources as well as the domestic currency should maintain strong position. The real exchange rate (λ^m) takes the expected sign and becomes

statistically significant. Results suggest that a 10% appreciation in Indian Rupee against the US Dollar is able to reduce inflation by 0.2% to 0.5% point for the current quarter. Even the performance is better for post crises period than earlier period. However, results also indicate that financial crisis shock in 2008 did not affect the Indian economy much and economic performance was stable.

V. CONCLUSION AND POLICY RECOMMENDATIONS

In this paper, the hybrid Phillips curve has been augmented by incorporating the effect of imported goods price towards the open economy extension of the model. The model can successfully describe the Indian inflation dynamics. In one hand, the discount factor 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. Therefore, the findings of this research suggest that the monetary authority should anchor inflation expectation more rigidly and the labour 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. 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. Overall, the estimated results suggest that the imported intermediate production goods play statistically and economically significant role in Indian inflation dynamics.

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