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Modeling the dynamics of inflation in India

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Abstract

In mainstream macroeconomics today inflation is related to the 'output gap', defined as the deviation of output from its 'natural' level. This view of inflation has been adopted by the leading central banks, including India's, underpinning the move to 'inflation targeting' as the sole objective of monetary policy. We present an alternative model of inflation based on features that would be considered typical of the Indian economy and a specific understanding of what drives the inflationary process here. We then test both the models across data from India over different periods and at differing frequencies. The exercise is conclusive, and bears significance for what will constitute an appropriate anti-inflationary policy.

Keywords: Inflation in India, New Keynesian Phillips Curve, Structuralist macroeconomics

JEL Classification: E31, E52

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1. **Introduction**

In mainstream macroeconomics today[2] inflation is modelled in terms of the New Keynesian Phillips Curve (NKPC). It provides the theoretical underpinning to 'inflation targeting', now adopted by most of the leading central banks of the world. In this model inflation reflects a level of output higher than the potential or 'natural' level, a gap that may be eliminated by appropriate movement of the interest rate controlled by the central bank. For this reason it would not be inappropriate to term it 'the output gap model' of inflation as we do, mainly for ease of reference, here. Since 2016 India has, by an act of parliament, adopted inflation targeting as the sole objective of monetary policy. In the report of the committee of the Reserve Bank of India that recommended the move the output gap model is presented as the inflation model appropriate for India[3]. In this paper we present an alternative model of inflation, one that we believe is based on a superior understanding of the dynamics of inflation in the Indian economy. We term this a 'structuralist' model of inflation. Then we test both these models for different sample periods, data frequencies, definitions of inflation and measures of the output gap. From the econometric point of view the ensuing results are decisive and hence relevant to the design of macroeconomic policy in India.

II. **Alternative explanations of inflation**

We first outline an alternative to the output gap model which we term 'structuralist' and then set out a simple model of it. A structuralist model of inflation is part of the body of literature referred to a structuralist macroeconomics[4]. When it originated in Latin America in the 1950s its claim for attention was at least partly based on the assertion that it reflects the structure of a developing economy which mainstream models in economics do not[5]. Inflation in this tradition is structural in that it is the outcome of industrialisation in economies that face a bottleneck in their agricultural sector. The precise nature of the bottleneck matters less than the persistent disequilibrium that it generates in the agricultural goods market. This 'structural' disequilibrium contributes initially to an agricultural-goods price inflation which is generalised across the economy via wage bargaining and cost-plus pricing in industry[6]. As the theory underlying this view of inflation has been reviewed[7] in the literature, we proceed directly to a model of our own. The model is developed with a view to generating an inflation equation that may be estimated econometrically.

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[2] See, for instance, Romer (2018).
[3] See RBI (2014).
[4] See Taylor (1984).
[5] See Palma (1987).
[6] Kaldor (1971, 1976) describes this process. The condition for non-inflationary growth in a developing economy had already been identified by Kalecki (1955, 1971).
[7] See Basu (2003).

II.i **A structuralist model of inflation**

The level of industrial production X_i is determined by the demand for it. Thus

$$X_i = f(S_a, \theta) + G \qquad (1)$$

with $f'_{S_a} > 0$ and $f'_{\theta} > 0$ where S_a is the supply of agricultural good, $\theta = \frac{P_a}{P_i}$, the relative price in the economy and G is the government spending on manufactured goods.

The price of the industrial good P_i is set by firms as mark-up over average prime cost. Thus

$$P_i = [\gamma W + e\tau P_m](1+r) \qquad (2)$$

where W and P_m are the nominal wage per worker and the price per unit of the imported material input and γ and τ are, respectively labour and imported materials requirement per unit of output. r is the percentage mark-up over cost and e is the nominal exchange rate.

Market demand D_a for the agriculture good, which comprises food, may be written as:

$$D_a = g(X_i, \theta) \qquad (3)$$

where $g'_{X_i} > 0$ and g'_{θ} as usual.

Equilibrium in the market for the agricultural good implies

$$D_a = S_a \qquad (4)$$

From the last two equations we can solve for the relative price

$$\theta = h(X_{i,} S_a) \qquad (5)$$

with $h'_{X_i} > 0$ and $h'_{S_a} < 0$.

Now the general price level P may be written as the weighted average of the two sectoral prices

$$P = \alpha P_a + (1-\alpha) P_i \qquad (6)$$

where α is the share of agricultural production in the total output of the economy.

Wage determination in the industrial sector may be represented as follows

$$W_t = \omega P_{t-1} \qquad (7)$$

where *W* is the nominal wage rate per worker, *P* is the general price level and ω represents firms' indexation formula relating the nominal wage to the price level.

The wage equation may then be written as

$$W_t = \omega[\alpha(P_a)_{t-1} + (1-\alpha)(P_i)_{t-1}] \qquad (8)$$

Some operations on the above equation yield the following expression for the inflation rate π

$$\pi_t = [\left(\frac{1}{P_{t-1}}\right)(1+r)\{\alpha\theta_t + (1-\alpha)\}(\gamma W_t + \tau e P_{m,t})] - 1 \qquad (9)$$

To get an explicit expression for relative price from (5) we first write

$$\beta X_i = S_a \frac{P_a}{P_i}$$

where βX_i is the demand for food, S_a supply of food and β is the share of industrial income spent on food.

Now θ, which equals $\frac{P_a}{P_i}$, can be expressed as follows

$$\theta = \beta \frac{X_i}{S_a}$$

Replacing θ in equation (9), the expression for inflation becomes

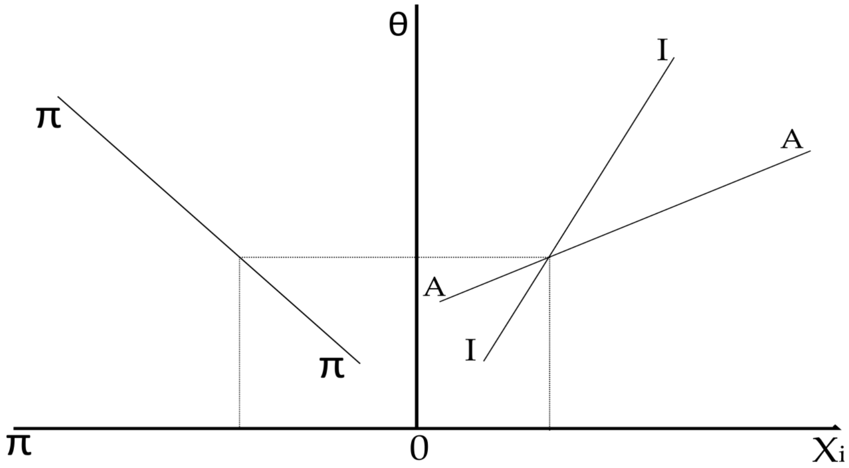
$$\pi_t = [\left(\frac{1}{P_{t-1}}\right)(1+r)\{\alpha\left(\beta\frac{X_i}{S_a}\right)_t + (1-\alpha)\}(\gamma W_t + \tau e P_{m,t})] - 1 \qquad (10)$$

Note that the inflation rate is driven by the sectoral balance, $\left(\frac{X_i}{S_a}\right)$, and the price of oil, which is entirely imported. Wages matter, but only in a reactive way as they respond to changes in the price level brought about by inflation.

Comparative statics:

A diagrammatic representation of the model appears in Figure 1. It shows the inflation rate associated with equilibrium in the goods market(s).

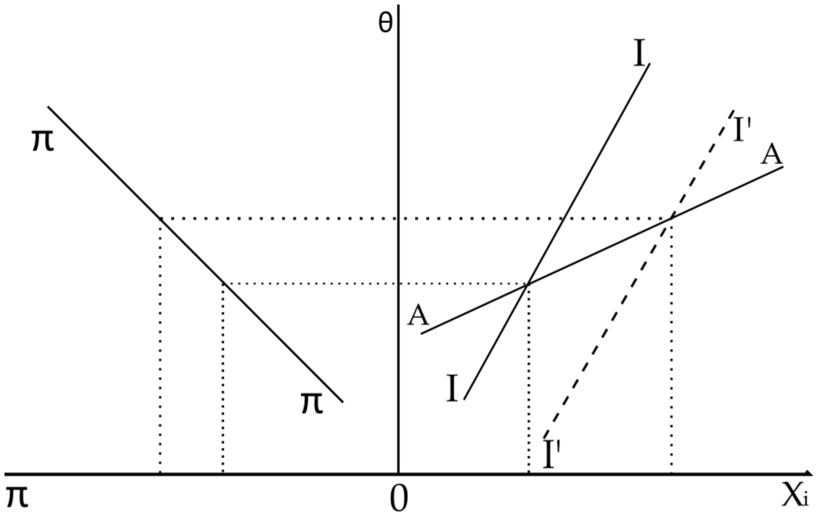
Figure 1
Equilibrium



In Figure 1, the lines 'AA' and 'II' represent equilibrium in the agricultural goods and industrial goods markets, respectively. Consideration of stability guided the choice of the slopes as drawn. The positions of the two lines would be altered according to shifts in exogenous factors stemming from either the supply- or the demand side.

We explore two comparative statics. Figure 2 depicts the effect of an increase in public investment amounting to an aggregate demand shock. It results in a higher industrial output but also higher inflation, as the relative price has risen in the face of fixed agricultural supply.

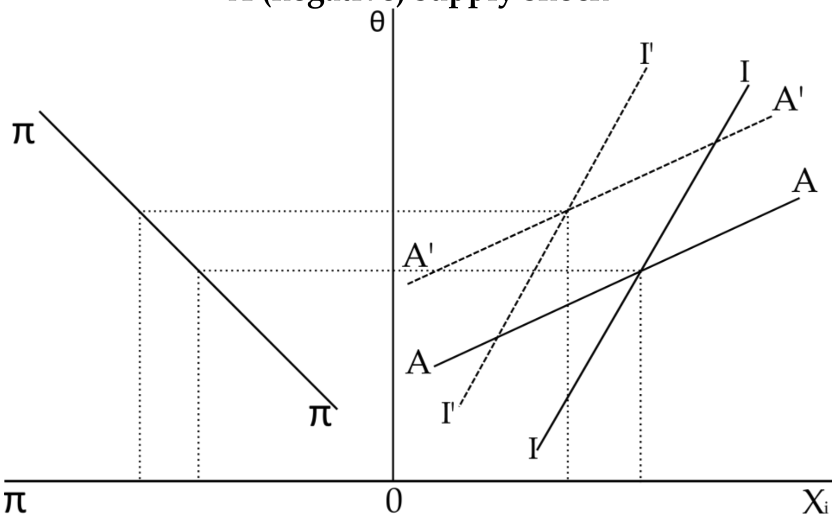
Figure 2
A (positive) demand shock



Finally, in Figure 3 we can see the impact of a supply shock, in this case an agricultural contraction. It results in lower industrial output and higher inflation as the relative price of agriculture increases. This case is important as it challenges the Phillips Curve representation according to which output invariably goes with higher inflation.

In our model inflation can rise both with an expansion and contraction of the economy, depending upon the nature of the shock. It points to the fallacy of concluding that the economy is 'overheating' by merely observing the inflation rate.

Figure 3
A (negative) supply shock



II.ii **The output gap model**

We have already outlined the output gap model. We now present it in a form accessible to econometric estimation. The model of inflation dynamics underlying inflation targeting is based on the concept of the 'output gap'. Thus, inflation in this model reflects a deviation of output from its natural level, a relationship captured by the New Keynesian Phillips Curve. More than one version exist of inflation dynamics in the New Keynesian framework. However, Roberts (1995) has shown that the notable ones " ... have a common formulation that is similar to the expectations-augmented Phillips Curve of Friedman and Phelps." And this formulation is

$$\Delta p_t = \beta E_t \Delta p_{t+1} + c_0 \ + \gamma y_t \qquad (11)$$

where Δp_t stands for the inflation rate, $E_t p_{t+1}$ is the expectation of inflation in the next period, y is the output gap, and β and ϒ are positive constants.

Fuhrer et al (2009) refer to (11) as "the now-canonical version of the New Keynesian Phillips Curve". A particular feature of this view of inflation dynamics may be noted, which is that under rational expectations, inflation depends upon the stream of future output gaps. This can be seen by iterating Equation (11) forward, which yields

$$\Delta p_t = c_0 \ + \ \gamma \sum_0^{\infty} \beta^k \, E_t\{y_{t+k)}\}.$$

Inflation is determined by forward-looking firms adjusting prices on the basis of their expectations. There is no 'intrinsic' inertia to inflation.

Motivated by the discovery of inertia in econometric estimates of inflation, Gali and Gertler (1999) (henceforth G-G) had augmented the NKPC allowing for a sub-set of firms to use "a backward-looking rule of thumb to set prices". The resulting model is termed 'the hybrid' New Keynesian Phillips Curve and is specified as follows:

$$\Delta p_t = \beta^a E_t \Delta p_{t+1} + \beta^b \Delta p_{t-1} + \ c_0 \ + \gamma y_t. \qquad (12)$$

This has given rise to an interest in the relative magnitudes of β^a and β^b representing the presence of forward-looking and backward looking elements, respectively, among firms. It may also be noted that the report of the Reserve Bank of India (2014) that recommended the adoption of inflation targeting in India had presented an inflation model similar to that in (11) above, claiming that its origins lie in the "New Keynesian research programme".

The NKPC *per se* does not lend itself to an understanding of the inflationary process that it is meant to represent. For this we present an outline of the G-G model already referred to. G-G show that the NKPC can be derived from pricing behaviour in a market of identical firms supplying a differentiated product and setting price as a fixed mark up over marginal cost. The notable features of their model are price rigidity and rational expectations. Each period only a random fraction 'θ' of the firms reset their price while (1-θ) of the firms keep their prices unchanged. Now, the aggregate price level evolves as follows:

$$p_t = (1-\theta)p_{t-1} + \theta p^* \qquad (13)$$

where the aggregate price level p is a convex combination of the lagged price level and the optimal reset price p_t^*, all variables expressed as a deviation from a zero-inflation steady state.

Now let mc_t^n be a firm's nominal marginal cost at time t (again as a deviation from its steady state level) and let β denote a subjective discount factor. Then it can be shown that the optimal reset price is:

$$p_t^* = (1 - \beta\theta) \sum_{k=0}^{\infty} (\beta\theta)^k E_t \{mc_{t+k}^n\}. \tag{14}$$

Let $\pi_t = (p_t - p_{t-1})$ denote the inflation rate and mc the deviation of the firm's real marginal cost from its steady state value. Combining (13) and (14) G-G derive an inflation equation of the form

$$\pi_t = \lambda mc_t + \beta E\{\pi_{t+1}\} \tag{15}$$

This they describe as the New Keynesian Phillips Curve. Estimating it would require a measure of the real marginal cost. G-G suggest two routes.

First, specifying $mc_t = kx_t$

where x is the 'output gap' and k is the output elasticity of real marginal cost (15) may be re-written as:

$$\pi_t = \lambda k x_t + \beta E\{\pi_{t+1}\} \tag{16}$$

The second route would be to assume Cobb-Douglas production technology which implies that real marginal cost is the ratio of the share of labour *(S)* to the elasticity of output with respect to labour.

Now, the NKPC may be written as

$$\pi_t = \lambda s_t + \beta E\{\pi_{t+1}\} \tag{17}$$

where s is the labour share in value added.

III. Recent studies of inflation in India

In a recent article Srinivasan, Mahambare and Ramachandran (2017) (henceforth Srinivasan et al) cite some recent studies on inflation in India. It appears that by now the output-gap model is the maintained hypothesis in studies of inflation dynamics in India. We review the two most recent among these.

The paper by Srinivasan et al is meant as a "Critique of the Structuralist Approach" but does contain estimates of a New Keynesian Phillips Curve. The results presented by these authors is not favourable to the output gap model. In the regression results they present the output gap term is negative in the overwhelming majority of cases and not statistically significant even once. A methodological point may be added to this. The Phillips Curve represented in the regressions presented by Srinivasan et al has only lagged output gap terms. It is odd to exclude the current output gap from the regression. All theoretical representations of the Phillips Curve are centred on the current output gap. In some versions of the theory, such as in Gali and Gertler (1999), firms are forward-looking to the extent of leaving no room for the past in determining inflation. Even if on an ad hoc basis lags are to be introduced, there is no case for leaving out the current output gap from the Phillips Curve. In the context of our paper, however, it is the conclusion drawn by Srinivasan et al that is of greater significance. The authors include the relative price of agriculture as a measure of supply shocks. The coefficient on this term is reported as alternating in sign across the four terms (current plus three lags) that are included in the regression. As the hypothesis that the four coefficients on these terms sum to zero cannot be rejected, the authors conclude that supply shocks have no permanent impact on inflation which, in their view, invalidates the structuralist model. We reject this view for the following reason. While there may be a statistical rationale for testing whether coefficients on the distributed lag of a variable sum to zero, there is no economic logic whatsoever in entertaining a negative coefficient on the relative price of agriculture when its expected sign is positive. Secondly, in the structuralist view a shift in the relative price of agriculture is inflationary both directly and indirectly. The coefficients on the relative price terms capture only a direct impact. Via its indirect effects, such as through wage determination, the impact of a rise in the relative price are propagated across the economy and the original impact cannot be easily extracted.

A paper by Ball, Chari and Mishra (2016) fits a Phillips Curve to core inflation. They report a positive and statistically significant coefficient of the output gap.[8] When the measure of inflation is headline inflation this coefficient is found to be not significant at the five percent level. The measure of core inflation that the authors use is not the traditional one, i.e., 'inflation less the change in food and energy prices' but the 'weighted median inflation across industries'. We note that while this may well yield a series that is less volatile than the traditional measure of core inflation, which was based on an understanding on what may legitimately be expected to be within the central bank's control, it's economic meaning is scanty. Secondly, Ball et al themselves provide a reason why we should be sceptical of too rigid a distinction between core and headline inflation. And this is that price setters base their expectations of inflation on past levels of headline inflation, so that movements in headline inflation are passed into future core inflation via expectations. For these three reasons then, that their measure of core inflation is atheoretical, that they themselves

[8] In the light of our preceding comment on the method adopted by Srinivasan et al it may be said that Ball et al adopt the standard procedure, i.e., they use the current dated output and not lags of the same in a regression of the Phillips Curve.

attribute a connection between headline and core inflation, and that the output gap is not significant when they estimate a Phillips Curve using headline inflation as the measure of inflation, we do not consider their results as affirming of the validity of the output gap model.

It is at times made out that according to the structuralist view inflation results from supply shocks in the agricultural sector[9]. While of course negative supply shocks in this sector would be inflationary in the structuralist model, the model itself is based on a supply-side barrier to non-inflationary growth; it is not reliant on negative supply shocks. Where non-agricultural growth strains agricultural supplies, leading to a rise in agricultural prices, inflation ensues, even without a downward spike in agricultural output. A specific example of this is shown in the comparative statics of our model, where greater public investment, given agricultural supplies, raises the inflation. Now it would be inadvisable to go looking for supply shocks as the originator of inflation. What is at stake in the structuralist model is the sectoral balance, and not the level of agricultural output *per se*[10].

Finally, a word would be in order on the inclusion of the price of agricultural goods in a regression for core inflation, ostensibly as a control. Empirically speaking if core inflation is a measure of inflation excluding the price of agricultural goods there is little economic logic in including it in the regression. Secondly, when agricultural prices do enter into the determination of core inflation, and the regressions reported in Srinivasan et al (Table 2) show this to be the case, it is no longer possible to claim that core inflation can be controlled by the central bank and our interest in it, as opposed to headline inflation, would cease to exist. Lastly, the putative role of output gap and relative price of agriculture, respectively, stem from orthogonal views of inflation. In the output gap model inflation reflects an aggregate imbalance leading output to exceed potential while in the structuralist model inflation reflects sectoral disequilibrium which triggers a relative price adjustment.

Research on inflation in India has also come from the Reserve Bank of India, naturally, and the IMF[11]. Since the formal adoption of inflation targeting in 2016, this has explicitly focused on the output gap model. Some of it has claimed a role for the output gap. In particular, Patra and Kapur (2010) report an impact lagged four quarters. However, as we have already indicated in our comment on Srinivasan et al, the NKPC explicitly specifies a current-dated relationship between inflation and the output gap (see Gali and Gertler, 1999). In keeping with the spirit of the NKPC, according to which inflation is driven by the current real marginal cost, assumed to be proportional to the current output gap, Guimaraes and Papi (2016) estimate an inflation equation for India with the current dated output gap. Of their findings they emphasise the importance of expectations, modelled as both forward and backward

[9] See Srinivasan et al (2017).
[10] See Equation 1.10.
[11] See Patra and Kapur (2010) and Guimaraes and Papi (2016).

looking. However, but the output gap is not statistically significant in any of the regressions reported (see Tables 1.2 to 1.4).

Our reading of the literature on inflation in India is that efforts to fit the output gap model to the data have not been particularly successful. The results reported point to more instances when the model is rejected than when it is not. Successful instances are confined to the use of core inflation as the dependent variable, leaving one researcher to aptly term the exercise of fitting the output gap model to the data as being "in search of the Phillips Curve for India"[12]. It appears that core inflation is a construct meant purely to evaluate the performance of the central bank; its position in economic theory is dubious. Moreover, in India economic policy does not recognise this measure of inflation. The measure used by the RBI is headline inflation measured by the rate of change of the consumer price index (CPI).

IV. **Data, estimation and results**

IV.1 Data

The main source of the data we use here is the CSO's National Account Statistics, available from the EPW Research Foundation India Time Series database. This has been used to compute the GDP deflator and the output gap, and the labour share. The Consumer Price Index (CPI) for industrial workers is taken from publications of the Labour Bureau, Ministry of Labour and Employment, Govt. of India. Wage data is from the Annual Survey of Industries (ASI) and the oil price – the wholesale price of mineral oils – published by the Ministry of Commerce and Industry, again from the EPW Research Foundation's India Time Series Database.

The annual data is for the period 1971-72 to 2015-16, except in the case of the labour share, where it is for the period 1980-81 to 2015-16. And, the quarterly data is for the period 1996-97(Q1)-2017-18(Q3).

IV.2 Estimation strategy

The variables were first tested for their time series properties, with the level variables entered in their logarithms. Inflation and output gap were found to be I(0), while relative price, wages, oil price and the sectoral balance were found to be I(1). Quarterly data were also tested for seasonal stability, which is found to be the case. Therefore, in the econometric estimation I(1) series were entered as log differences, giving us their growth rates. The details of the testing for unit root and seasonal stability are reported in the Appendix 1.

As the output gap, expected inflation, wages, relative price, oil price and sectoral balance could be endogenous, all models were estimated by OLS and GMM-IV. The instruments used are the lagged values of the potentially endogenous variables. For the annual data lags from 2 to 5 were considered while for the quarterly data lags from

[12] See Paul (2009).

2 to 8 were considered. In order to avoid the problem of "too many instruments", only lags having reasonable degree of correlation with variable instrumented were used.[13]

IV.3 Results

We now turn to the estimation. Our preferred measure of inflation is the GDP deflator as both the output gap and structuralist models are based explicitly on an understanding of how prices are determined. The GDP deflator is used by Gali and Gertler (1999) on grounds that it is a broad measure of inflation, a view with which we agree. However, central banks the world over target consumer price inflation. Accordingly, we also use the consumer price index as part of the excercise. A note is also in order regarding the measure of the output gap in this study. We follow the mainstream practice of using the Hodrick-Prescott filter to arrive at detrended output which is treated as the output gap. However, the H-P filer has come under criticism (Hamilton 2017). Therefore, we also use an alternative measure of the output gap as the difference between actual output and its trend value ascertained by fitting a trend regression to log of GDP data incorporating structural breaks. It is this variable that appears as 'cycle' in the results reported below. Clarification is also required on the definition of the variable defined "Expected Inflation". Under the rational expectation assumption, expected inflation is proxied by the one period forward inflation and instrumental variable estimation is adopted. Summary measures of these variables are given in the Appendix Tables A7 and Table A8.

We commence by estimating the output-gap model using quarterly data. In the estimate of Equation (11), presented in Table 1, the coefficient on the output gap is not statistically significant at the 5-percent level. This is so whether we use the output gap as derived from the H-P filter or the 'deviation from trend' of current output. The expectations terms do not fare much better. As interest has adhered to the question of the relative roles of future and past inflation, it may be noted that neither the forward nor the past inflation term is significant. There is no evidence for the claim that "forward-looking behaviour remains predominant" (Gali and Gertler, p.213) in determining inflation dynamics in India. So far then none of the variables that make up the NKPC have statistically significant coefficients.

Table 1 Output gap model

(GDP deflator – OLS - quarterly data)

Past inflation	0.136	0.0851	0.133	0.0847
	(1.23)	(1.04)	(1.20)	(1.03)
Expected inflation	0.111	0.101	0.106	0.100
	(1.02)	(1.14)	(0.97)	(1.13)

[13] For instance, in the case of output gap in quarterly series, the instruments chosen were 2nd, 4th, 6th and 8th lags, the respective correlation coefficients being -0.84, -0.94, 0.86, and 0.93. (see Roodman, 2009; Murray, 2006 and Reed,2015)

Output Gap	0.0524	0.00787		
	(0.95)	(0.18)		
Oil price		0.0943**		0.0942**
		(4.60)		(4.58)
Cycle			0.0517	0.00726
			(1.00)	(0.17)
q1	0.0368**	0.0297**	0.0330**	0.0291**
	(5.20)	(6.05)	(6.15)	(6.43)
q2	0.0239**	0.0163**	0.0184**	0.0155**
	(3.28)	(2.97)	(4.90)	(4.82)
q3	0.0179**	0.0147**	0.0174**	0.0146**
	(3.83)	(3.17)	(3.76)	(3.16)
Constant	-0.0101	-0.00611	-0.00754	-0.00573
	(-1.97)	(-1.67)	(-1.74)	(-1.61)
Observations	84	84	84	84
Adjusted R^2	0.402	0.534	0.404	0.534

Note: (1) t statistics in parentheses, (2) ** and * respectively indicates significant at 1 and 5 percent level.

Having first estimated the model by OLS we proceeded to estimate it by GMM(IV). The results are presented in Table 2.

Table 2 Output Gap Model
(GDP deflator – GMM - quarterly data)

Past inflation	0.0840	-0.00106	0.102	-0.0361
	(0.98)	(-0.01)	(1.50)	(-0.20)
Expected inflation	-0.492	-1.199	-0.270	-1.364
	(-0.48)	(-0.53)	(-0.39)	(-0.64)
Output Gap	0.0800	0.0866		
	(1.70)	(0.94)		
Cycle			0.0641*	0.0676
			(1.97)	(0.80)
Oil Price		0.0978**		0.0945**
		(5.37)		(5.55)
	(0.04)	(-0.35)	(0.33)	(-0.45)
q1	0.0320**	0.0205	0.0289**	0.0124
	(3.29)	(1.00)	(3.33)	(0.51)
q2	0.0205*	0.00941	0.0143	-0.00140
	(2.37)	(0.48)	(1.69)	(-0.05)
q3	0.00130	-0.0234	0.00700	-0.0283
	(0.04)	(-0.35)	(0.33)	(-0.45)
Constant	0.00391	0.0245	0.00206	0.0333
	(0.15)	(0.42)	(0.11)	(0.58)
Observations	82	82	82	82
Hansen's J(χ^2)	0.851	0.389	0.892	1.270

P-value	(0.654)	(0.533)	(0.640)	(0.260)

Note: (1) t statistics in parentheses, except for Hansen's J, for which p-values are reported. (2) ** and * respectively indicates significant at 1 and 5 percent level.

No difference in the status of the NKPC as an explanation of the inflation dynamics in India may be observed. The output gap is not statistically significant however it has been measured. We discount the case of its significance in a sole regression when the 'cycle' is substituted for the 'output gap' – see Table 2 – for the term is no longer significant once the change in the price of oil is included. The coefficients on the two inflation terms, intended to capture expectations, are of the wrong sign.

We now proceed to repeat the exercise using CPI inflation as the dependent variable. OLS estimates are reported in Table 3.

Table 3 Output gap model
(CPI Inflation - OLS - Quarterly Data)

Past inflation	0.275	0.293*	0.272	0.289*
	(1.94)	(2.02)	(1.95)	(2.03)
Expected inflation	0.309*	0.315*	0.303*	0.310*
	(2.10)	(2.12)	(2.06)	(2.08)
Output Gap	0.0508	0.0401		
	(0.96)	(0.75)		
Oil price		0.0200		0.0189
		(1.37)		(1.30)
Cycle			0.0496	0.0392
			(1.02)	(0.79)
q1	0.0175**	0.0163**	0.0140**	0.0136*
	(3.30)	(2.98)	(2.75)	(2.61)
q2	0.0341**	0.0323**	0.0287**	0.0281**
	(6.85)	(6.38)	(6.87)	(6.63)
q3	0.0180**	0.0171**	0.0176**	0.0169**
	(3.40)	(3.18)	(3.27)	(3.09)
Constant	-0.0112**	-0.0109**	-0.00872*	-0.00891*
	(-3.07)	(-2.96)	(-2.08)	(-2.11)
Observations	84	84	84	84
Adjusted R^2	0.477	0.476	0.478	0.477

Note: (1) t statistics in parentheses, (2) ** and * respectively indicates significant at 1 and 5 percent level.

When the regressions in Table 3 are replicated through GMM-IV estimation the results were as they appear in Table 4.

Table 4 Output gap model
(CPI Inflation - GMM-IV- Quarterly data)

Past inflation	0.121**	0.166**	0.103*	0.179**
	(4.32)	(6.88)	(2.15)	(4.45)
Expected inflation	0.948**	0.854**	0.969**	0.858**
	(7.01)	(6.05)	(9.06)	(7.93)
Output gap	0.0285	-0.00481		
	(1.75)	(-0.31)		
Cycle			0.0227	-0.0157
			(1.14)	(-1.02)
Oil price		0.0380**		0.0407**
		(5.77)		(5.98)
q1	0.00720	0.00603	0.00523	0.00630
	(1.93)	(1.41)	(1.77)	(1.94)
q2	0.0331**	0.0291**	0.0306**	0.0293**
	(10.71)	(8.78)	(17.11)	(14.51)
q3	0.0335**	0.0311**	0.0352**	0.0306**
	(13.13)	(14.80)	(10.23)	(11.40)
Constant	-0.0196**	-0.0175**	-0.0189**	-0.0179**
	(-11.36)	(-12.04)	(-13.54)	(-13.48)
Observations	78	78	78	78
Hansen's J (χ^2)	0.119	0.174	1.125	0.831
P-value	0.942	0.917	0.570	0.660

Note: (1) t statistics in parentheses, except for Hansen's J, for which the p-value is reported. (2) ** and * respectively indicates significant at 1 and 5 percent level.

A difference in the estimates when inflation is measured by the rate of change in the CPI must be noted. Now both forward and past inflation are found to be significant. There is even some evidence of the former predominating, though only slightly. However, the significance of all this is not evident as the output gap remains not significant statistically.

The exercise thus far, being based on quarterly data, was repeated with annual data. The results are presented in Tables 5 and 6 which contain OLS and GMM estimates, respectively.

Table 5 Output Gap model

(GDP deflator – OLS - annual data)

Output gap	-0.473*	-0.355		
	(-2.10)	(-1.74)		
Past inflation	0.275	0.149	0.238	0.110
	(1.23)	(0.68)	(1.08)	(0.52)
Expected inflation	0.299	0.406*	0.296	0.414**
	(1.66)	(2.63)	(1.60)	(2.71)
Oil price		0.104		0.112*

		(1.79)		(2.07)
Cycle			-0.483*	-0.414*
			(-2.54)	(-2.58)
Constant	0.0296*	0.0212	0.0330*	0.0231
	(2.19)	(1.65)	(2.45)	(1.84)
Observations	44	44	44	44
Adjusted R^2	0.220	0.283	0.240	0.321

Note: (1) t statistics in parentheses, (2) ** and * respectively indicates significant at 1 and 5 percent level.

Table 6 Output gap model

(GDP deflator - GMM-IV - annual data)

Output gap	-0.463	-0.727		
	(-0.49)	(-0.50)		
Expected inflation	0.659	1.329	0.651	0.660
	(0.80)	(1.00)	(1.43)	(1.67)
Past inflation	0.264	0.0310	0.230	0.0689
	(0.95)	(0.11)	(0.83)	(0.23)
Oil price		0.198		0.153
		(1.58)		(1.59)
Cycle			-0.419	-0.122
			(-0.65)	(-0.33)
Constant	0.00473	-0.0467	0.00869	0.00527
	(0.09)	(-0.50)	(0.47)	(0.26)
Observations	44	44	44	44
Hansen's J (χ^2)	1.76	1.22	1.46	1.72
	(0.62)	(0.54)	(0.69)	(0.63)

Note: (1) t statistics in parentheses, except for Hansen's J, for which the p-value is reported. (2) ** and * respectively indicates significant at 1 and 5 percent level.

Note that so far the results using annual data are not very different from those obtained from the use of quarterly data. The coefficients on the output gap and the deviation of output from trend are not found to be positive and significant as predicted by the model. Having estimated the model with inflation measured by the GDP deflator we replace the dependent variable with inflation measured by the rate of change of the consumer price index (CPI). The results are in Tables 7 and 8.

Table 7 Output gap model

(CPI - OLS - annual data)

Output gap	-0.216	0.130		

	(-0.50)	(0.47)		
Past inflation	0.293	0.156	0.283	0.174
	(1.05)	(0.66)	(1.10)	(0.76)
Expected inflation	0.286	0.333*	0.275	0.327*
	(1.57)	(2.31)	(1.50)	(2.21)
Oil price		0.240		0.226
		(1.99)		(1.94)
Cycle			-0.287	-0.0821
			(-0.79)	(-0.36)
Constant	0.0312	0.0158	0.0329	0.0155
	(1.07)	(0.55)	(1.21)	(0.53)
Observations	43	43	43	43
Adjusted R^2	0.060	0.211	0.068	0.210

Note: (1) t statistics in parentheses, (2) ** and * respectively indicates significant at 1 and 5 percent level.

Table 8 Output gap model
(CPI inflation - GMM-IV - annual data**)**

Output gap	-0.314	0.308		
	(-0.26)	(0.33)		
Expected inflation	0.872	0.804	0.796	0.602
	(1.93)	(1.56)	(1.78)	(1.44)
Past inflation	0.483	0.267	0.435	0.218
	(1.33)	(0.79)	(1.20)	(0.68)
Oil price		0.267		0.263
		(1.29)		(1.66)
Cycle			-0.197	0.589
			(-0.16)	(0.87)
Constant	-0.0266	-0.0297	-0.0166	-0.00937
	(-0.46)	(-0.57)	(-0.28)	(-0.18)
Observations	43	43	43	43
Hansen's J (χ^2)	1.32	1.25	1.29	1.28
	(0.72)	(0.53)	(0.73)	(0.73)

Note: (1) t statistics in parentheses, except for Hansen's J, for which the p-value is reported. (2) ** and * respectively indicates significant at 1 and 5 percent level.

As may be seen in the tables, when the CPI measure of inflation is adopted and annual data is used, the finding that the output gap is not statistically significant is unchanged whether the estimation is by OLS or GMM (IV). A difference from the quarterly model is that forward inflation is significant and predominates over past inflation but as the output gap, however measured, remains insignificant we conclude that the NKPC is a poor predictor of inflation in India.

As already stated, advocates of the NKPC as a model of inflation have proposed the share of labour as a superior measure of marginal cost. Taking this into account we have re-estimated the model substituting the labour share for the output gap. The results are in Table 9.

Table 9 The NKPC with the labour share as marginal cost
(annual data - 1980-81 to 2015-16 - GDP deflator)

	OLS	OLS	GMM-IV	GMM-IV
Labour Share	0.0453	0.0484	-0.111	-0.105
	(0.34)	(0.37)	(-0.31)	(-0.32)
Past inflation	0.380**	0.366**	0.0898	0.104
	(3.10)	(2.93)	(0.23)	(0.26)
Expected inflation	0.393**	0.402**	0.828	0.814
	(3.14)	(3.22)	(1.58)	(1.50)
Oil Price		0.0242		0.0345
		(0.76)		(0.70)
Constant	-0.000975	-0.00397	0.0487	0.0436
	(-0.02)	(-0.08)	(0.39)	(0.39)
Observations	35	35	30	30
Hansen's J (χ^2)			1.58	1.62
			(0.66)	(0.65)
Adjusted R^2	0.537	0.530		

Note: (1) t statistics in parentheses, except for Hansen's J, for which the p-value is reported. (2) ** and * respectively indicates significant at 1 and 5 percent level.

Note that the labour share is not statistically significant either.

The estimates of the output-gap model using quarterly and annual data in alternate runs serve not merely a test of the model across differing data frequencies but also as a test of its validity for different time periods. Our results suggest that the output-gap model is a poor representation of inflation dynamics in India. We now proceed to an estimation of the structuralist inflation model.

Two versions of the structuralist model, representing proximate and deeper determinants, respectively, of inflation are estimated. These are defined by Equation 9 and 10, respectively, of the theoretical model in Section II. Accordingly, we use the relative price of agriculture and sectoral balance, respectively, in alternate runs. Sectoral balance is the ratio of output of non-agricultural sector to that of agricultural sector. All other independent variables are as in the model. Estimates of these equations using quarterly data are presented in Tables 10 and Table 11. It should be noted that this is at best a partial version of the structuralist model for it excludes the change in wages. Such a specification is necessitated by the fact that industrial wage data are available only at an annual frequency for the Indian economy. A point worthy of comment is that the relative price is significant in every case. However, the coefficients of all the variables other than lagged inflation are significant only when the estimation is by GMM (IV).

Table 10 Structuralist model

(GDP deflator - quarterly data)

	OLS	OLS	GMM-IV	GMM-IV
Relative price	0.222**		0.604**	
	(4.09)		(6.38)	
Sectoral balance (t)		0.0111		0.00349
		(0.56)		(0.29)
Sectoral balance (t-1)		0.0163		0.0171**
		(1.03)		(4.60)
Oil Price	0.112**	0.0987**	0.136**	0.0995**
	(5.62)	(4.81)	(10.58)	(9.00)
Past inflation	0.0928	0.0715	0.158**	0.0615
	(1.24)	(0.90)	(4.56)	(1.22)
q1	0.0229**	0.0172	0.0149**	0.0148**
	(5.44)	(1.31)	(3.68)	(3.00)
q2	0.00688*	0.00523	-0.00569	0.00525*
	(2.27)	(0.59)	(-1.51)	(2.44)
q3	0.00831**	0.00868	0.00201	0.00286
	(3.16)	(0.44)	(0.77)	(0.29)
Constant	-0.000318	0.00262	0.00345	0.00472
	(-0.15)	(0.28)	(1.95)	(1.18)
Observations	85	85	81	83
Hansen's J (χ^2)			0.911	1.474
P-value			0.634	0.479

Note: (1) *t* statistics in parentheses, except for Hansen's J, for which the p-value is reported. (2) ** and * respectively indicates significant at 1 and 5 percent level.

Table 11 Structuralist model

(CPI - quarterly data)

	OLS	GMM-IV	OLS	GMM-IV
Relative price	0.338**	0.663**		
	(6.11)	(6.46)		
Sectoral balance (t)			0.0327	0.0421**
			(1.99)	(3.23)

Sectoral balance(t-1)			0.0114	0.0161*
			(0.49)	(2.34)
Oil Price	0.0382**	0.0538**	0.0158	0.0181*
	(3.39)	(7.75)	(1.09)	(2.47)
Past inflation	0.398**	0.449**	0.381**	0.424**
	(5.88)	(14.99)	(3.13)	(5.64)
q1	0.0123**	0.00690	0.0186	0.0177**
	(3.13)	(1.47)	(0.98)	(3.94)
q2	0.0188**	0.00788	0.0239	0.0206**
	(4.89)	(1.90)	(1.59)	(4.16)
q3	0.00502	-0.00230	0.0292	0.0321**
	(1.51)	(-0.85)	(1.37)	(3.95)
Constant	-0.00217	0.00155	-0.00940	-0.00939**
	(-0.76)	(0.79)	(-0.74)	(-3.39)
Observations	85	80	85	82
Adjusted R^2	0.631	0.457		
Hansen's J (χ^2)		1.474		1.485
P-value		0.688		0.686

Note: (1) t statistics in parentheses, except for Hansen's J, for which the p-value is reported. (2) ** and * respectively indicates significant at 1 and 5 percent level.

These results show the structuralist model to be well determined statistically when quarterly data is used. The price of oil and the relative price of agriculture are invariably statistically significant. Also, the explanatory power of the regressions is higher than that of the output gap model, as indicated by the R^2. However, the sectoral balance term is significant only when the model is estimated by GMM-IV.

Table 12 Structuralist model
(GDP deflator - annual data)

	OLS	OLS	GMM-IV
Past inflation	0.289	0.229	-0.0394
	(1.69)	(1.78)	(-0.27)
Oil Price	0.134**	0.125**	0.113*
	(3.46)	(4.42)	(2.55)
Wages	0.135	0.136	0.392**
	(1.49)	(1.53)	(2.72)
Relative price	0.460**	0.551**	0.480**
	(4.45)	(6.07)	(3.22)
Time trend		-0.00127**	-0.00139**
		(-4.44)	(-4.41)
Constant	0.0211*	0.0810**	0.0836**
	(2.14)	(4.89)	(3.62)
Observations	45	45	41

Adjusted R^2	0.462	0.658	0.451
Hansen's J (χ^2)			1.843
P-value			0.99

Note: (1) t statistics in parentheses, except for Hansen's J, for which the p-value is reported. (2) ** and * respectively indicates significant at 1 and 5 percent level.

Table 13 Structuralist model
(GDP deflator - annual data)

	OLS	OLS	GMM-IV	GMM-IV
Past Inflation	0.170	0.150	0.161	0.138
	(0.62)	(0.53)	(0.78)	(0.72)
Oil Price	0.0974	0.0923	0.0946*	0.0872**
	(1.87)	(2.01)	(2.05)	(2.65)
Wages	0.165	0.166	0.362	0.358*
	(1.06)	(1.07)	(1.94)	(2.07)
Sectoral Balance(t)	0.109	0.0729	0.236*	0.167*
	(0.90)	(0.73)	(2.04)	(2.17)
Sectoral Balance(t-1)	0.0585		0.134	
	(0.65)		(1.73)	
Time trend			-0.00118**	-0.00102**
			(-5.23)	(-6.38)
Constant	0.0285*	0.0335**	0.0574**	0.0599**
	(2.44)	(3.08)	(3.97)	(4.86)
Observations	45	45	40	40
Adjusted R^2	0.130	0.146		
Hansen's J (χ^2)			1.813	1.795
P-value			0.98	0.99

Note: (1) t statistics in parentheses, except for Hansen's J, for which the p-value is reported. (2) ** and * respectively indicates significant at 1 and 5 percent level.

Table 14 Structuralist Model
(CPI - annual data)

	OLS	OLS	GMM-IV	GMM-IV
Past inflation	0.169	-0.0394	0.0702	0.0284
	(0.88)	(-0.23)	(0.63)	(0.14)
Oil price	0.226*	0.180	0.0772	0.0423
	(2.34)	(1.57)	(0.86)	(0.43)
Wages	0.439*	0.448	0.528*	0.0911
	(2.05)	(1.91)	(2.04)	(0.22)
Relative price	0.521**		0.456**	
	(2.94)		(2.78)	

Sectoral balance (t)		-0.187		-0.00128
		(-1.21)		(-0.01)
Time trend		0.000360		
		(0.47)		
Constant	-0.00583	0.00892	0.00212	0.0525
	(-0.19)	(0.18)	(0.08)	(1.33)
Observations	44	44	41	41
Hansen's J (χ^2)			1.81 (0.99)	1.79 (0.97)
Adjusted R^2	0.359	0.239	0.191	-0.036

Note: (1) t statistics in parentheses, except for Hansen's J, for which the p-value is reported. (2) ** and * respectively indicates significant at 1 and 5 percent level.

A feature emerging from our estimation is that the two versions of the structuralist model do not perform equally well. In particular, while the relative price of agriculture is invariably significant, the sectoral-balance variable is not significant for CPI inflation. And even when this is statistically significant its coefficient is low. This is in keeping with the economic model in which the relative price is a proximate determinant of inflation dynamics and the sectoral balance is more distant. This relationship is evident if we study Equations 9 and 10 of the model. To back our claim for the suitability of Equation 9 as a representation of the structuralist model of inflation we present in Table 15 an estimate of an econometric model of the relative price of agriculture. Note that the sectoral balance is a strong determinant of the relative price, as seen in the magnitude of the coefficient.

Table 15 Determinants of the relative price
(annual data)

	OLS	GMM-IV
Sectoral balance (t)	0.345*	0.512*
	(2.10)	(2.19)
Relative price (t-1)	0.354	0.409*
	(1.71)	(2.30)
Oil price(t)	-0.132*	-0.124
	(-2.39)	(-1.56)
Constant	0.00678	-0.000348
	(0.59)	(-0.03)
Observations	45	45
Hansen's J (χ^2)		1.87 (0.99)
Adjusted R^2	0.275	

Note: (1) t statistics in parentheses, except for Hansen's J, for which the p-value is reported. (2) ** and * respectively indicates significant at 1 and 5 percent level.

If we are to put forward our best econometric estimate it would be the GMM-IV estimates reported in Table 12. This is the full structuralist model; the quarterly estimates do not contain wages. All the independent variables that appear in the theoretical model of Section II are statistically significant in this estimate.

Our estimated results show the structuralist model to be well determined statistically which is not the case with the output-gap model. This leaves the former as the sole empirically valid representation of inflation dynamics in India. While there are several studies[14] that show the poor performance of the output gap model in India ours is the only one to propose and demonstrate that there exists a theoretically founded and empirically validated alternative model of inflation for its economy.

V. Conclusion

In this paper we presented a model of inflation in the tradition of structuralist macroeconomics. When estimated for India, this turned out to be fairly well determined econometrically. By comparison inflation dynamics cannot be accounted for by the output gap model, the basis of monetary policy in India. The output gap model provides the rationale for inflation targeting, believed to work through the central bank's success in anchoring inflationary expectations. The estimates presented here reveal both the insignificance of the output gap and only a limited influence of expected inflation on inflation dynamics. These results call for a review the efficacy of monetary policy for controlling inflation in India. We would like to state that our findings on the unimportance of forward-looking expectations on inflation and the failure of the New Keynesian Phillips Curve to provide an empirical description of the inflation process do not reflect some developing economy pathology. Indeed they are in line with what has also been found to be the case for the US economy[15]. To conclude, by now we have evidence that as far as the dynamics of inflation in India are concerned, the structuralist model dominates the alternatives proposed over the past three decades, namely the monetarist model of inflation[16] popular in the 1980s and the output gap model underlying inflation targeting today. This suggests that inflation control in India must address the agricultural supply constraint.

[14] See Paul (2009) and Hatekar, Kulkarni and Sharma (2011)
[15] See Fuhrer (1997) and Rudd and Whelan (2007), respectively.
[16] See Balakrishnan (1994).

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Appendix 1

A1. Testing for unit root and seasonal stability

Unit root properties of the time series were tested using the Augmented Dickey-Fuller (ADF) test, the Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) test, and the Zivot and Andrews test. The Zivot-Andrews test is used because a trend stationary series with a break in the trend can be wrongly diagnosed as an I(1) process by both the ADF and KPSS tests. This test allows for an unknown break in trend and intercept when testing for a unit root. The lag length for the ADF test was selected on the basis of the Bayesian Information Criteria (BIC) and lag length in KPSS test was fixed at 1, as the simulation results reported in Kwiatkowski, Phillips, Schmidt, and Shin (1992), showed that for a sample size similar to ours, a lag length of one provides correct size of the test.

In the case of quarterly data, we also test for a seasonal unit root or seasonal stability using the tests developed in Canova and Hansen (1995) and Hylleberg, Engle, Granger, and Yoo (1990), respectively known in the literature as the Canova-Hansen test and HEGY test.

Table A1

Unit Root test: Annual level

Variable	ADF	KPSS	Zivot-Andrews	Remark
Relative Price	-0.837 (-3.50)	0.3976 (0.146)	-2.75 (-5.08)	I(1)
Wage	-1.56 (-3.50)	0.363 (0.146)	-3.849 (-5.08)	I(1)
Oil Price	-3.19 (-3.50)	0.181 (0.146)	-4.34 (-5.08)	I(1)
Sectoral Balance	-1.04 (-3.50)	0.548 (0.146)	-6.75 (-5.08)	I(1)
Inflation	-3.73 (-2.93)	0.43 (0.463)		I(0)

Note: Critical values at 5 percent level are given in parenthesis. The null hypothesis in ADF and Zivot and Andrews tests is I(1) and alternative is I(0). In the KPSS test the null hypothesis I(0) and alternative I(1). In all the cases, alternative hypothesis is trend stationarity, except in inflation where the plot against time showed no trend and hence the alternative of stationarity around the mean was chosen.

Table A2

Unit Root test: Annual First-difference

Variable	ADF	KPSS	Remark
Relative Price	-4.95 (-2.93)	0.448 (0.463)	I(0)
Wage	-3.56 (-2.93)	0.136 (0.463)	I(0)
Oil Price	-4.73 (-2.93)	0.54 (0.463)	I(0)
Sectoral Balance	-6.06 (-2.93)	0.361 (0.463)	I(0)

Note: Critical values at 5 percent level are given in parenthesis. The null hypothesis in ADF test is I(1) and alternative is I(0). In the KPSS test the null hypothesis I(0) and alternative I(1). In all the cases, alternative hypothesis is stationarity around mean, as the plots revealed no trend.

Table A3

Unit Root test: quarterly level

Variable	ADF	KPSS	Zivot-Andrews	Remark
Relative Price	-2.016 (-3.45)	0.1847 (0.146)	-3.32 (-5.08)	I(1)
Oil Price	-0.894 (-3.45)	0.179 (0.146)	-4.16 (-5.08)	I(1)
Sectoral Balance	-2.586 (-3.45)	0.289 (0.146)	-5.60 (-5.08)	I(1)
Inflation	-3.41 (-2.89)	0.1332 (0.463)	--	I(0)

Note: Critical values at 5 percent level are given in parenthesis. The null hypothesis in ADF and Zivot and Andrews test is I(1) and alternative is I(0). In the KPSS test the null hypothesis I(0) and alternative I(1). In all the cases, alternative hypothesis is trend stationarity, except in inflation, where the plot against time showed no trend and hence alternative of stationarity around mean was chosen.

Table A4

Unit Root test: quarterly first -difference

Variable	ADF	KPSS	Remark
Relative Price	-9.30 (-2.89)	0.241 (0.463)	I(0)
Oil Price	-4.754 (-2.89)	0.4076 (0.463)	I(0)
Sectoral Balance	-5.749 (-2.89)	0.292 (0.463)	I(0)

Note: Critical values at 5 percent level are given in parenthesis. The null hypothesis in the ADF test is that the series is I(1) and alternative is that it is I(0). In the KPSS test the null hypothesis is that the series is I(0) and the alternative is that it is I(1). In all the cases, the alternative hypothesis is stationarity around mean, as the plots revealed no trend.

Table A5

Testing for a seasonal unit root: quarterly levels

Variable	Canova-Hansen test	HEGY Test
Inflation	0.5331 (0.517)	16.60 (0.00)
Relative Price	1.6713 (0.01)	29.82 (0.00)
Oil Price	1.66 (0.01)	85.98 (0.00)
Sectoral Balance	1.936 (0.01)	3.659 (0.465)

Note: The null hypothesis in the Canova-Hansen test is stationarity and the null hypothesis of HEGY test is unit root. In both cases joint F statistics is reported. P-values are given in parentheses. For the HEGY test the p-values are bootstrapped.

Table A6

Testing for a seasonal unit root: quarterly first differences

Variable	Canova-Hansen test	HEGY Test
Relative Price	0.6898 (0.375)	17.89 (0.00)
Oil Price	0.7606 (0.3109)	16.97 (0.00)
Sectoral Balance	1.9762 (0.01)	7.84 (0.01)

Note: The null hypothesis in the Canova-Hansen test is stationarity and the null hypothesis of HEGY test is unit root. In both cases the joint-F statistic is reported. P-values are given in parentheses and in HEGY test the p-values are bootstrapped.

Table A7

Summary of measures of variables (annual data)

Variable	Mean	Min	Max
Inflation (based on GDP deflator)	0.070974	-0.02598	0.158868
Inflation (based on CPI-IW)	0.076254	-0.07941	0.25155
Oil price growth	0.091349	-0.20209	0.610996
Wage growth (current price)	0.094843	-0.00813	0.212774

Output gap	-0.00332	-0.05697	0.044895
Growth rate of relative price	0.009486	-0.18708	0.088555
Growth rate of sectoral balance	0.036252	-0.08297	0.146069
Labour share	0.375744	0.321915	0.412559

Note: Growth rates are log changes.

Table A8

Summary Measures of variables (quarterly data)

Variable	Mean	Min	Max
Inflation (based on GDP deflator)	0.013319	-0.03749	0.061309
Inflation (based on CPI-IW)	0.016235	-0.03617	0.066052
Output Gap	1.15E-10	-0.12069	0.093238
Growth rate of oil price	0.01729	-0.27644	0.187685
Growth rate of relative price	0.004855	-0.06879	0.053253
Growth rate of sectoral balance	0.007916	-0.7001	0.362394

Note: Growth rates are log changes.