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Article

Inflation dynamics in India: A structural view

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Abstract:
The recent unprecedented global inflation has focussed attention on the supply side inflation dynamics. The Indian inflation episodes, however, have been largely associated with supply shortages and, on average, remained elevated through the last four decades, with different policy phases generating, at best, mixed results. This paper explores the Indian inflation dynamics through a structural paradigm, analysing factors such as sectoral growth imbalances and administered prices. The structural factors are observed to explain a significant part of the inflation, thus suggesting the need for government action on logistics management in the short term and structural reforms in the long run.

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I think we now understand better, how little we understand about inflation.

(Jerome Powell, 2022)

At the European Central Bank (ECB) Central Banking Forum in 2022, the discussions on monetary policy amongst the major central banks (CBs) of the world were centred around the current runaway inflation and how the CBs can handle the same. The forum admitted that supply shocks make the current scenario completely different from the relatively low inflation environment of the previous four decades amongst the developed countries (DCs). The failure of the standard models as tools for policy was also highlighted. And, despite the resolve to bring down inflation irrespective of what it takes, the limitations of CB policies in addressing supply side inflation were clearly admitted (Powell, 2022).

Price stability is important to avoid disincentives to savers, adverse redistributive effects on the lower income sections, and uncompetitive exchange rate effects. The hyper-inflation scenarios witnessed in the past have also made all the CBs wary of any general hike in price levels and have triggered prompt reaction. However, it may be pointed out that most of the high inflation scenarios witnessed in India were driven by supply side effects (please see section 1.4 below). But

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the policy orientation has been along the lines of the same models and framework that served the DCs well in their low inflation scenario for four decades but that are now being questioned (Powell, 2022). It is perhaps high time that the policy orientation in India shifts from demand management to supply management and that solutions should be sought and highlighted even if they are out of reach of the traditional monetary policy purview. With this backdrop, this paper proposes to examine the Indian inflation dynamics in the context of structural issues and the policy implications therefrom. The rest of the paper is structured as follows. Section 1 addresses the inflation dynamics in terms of Inflation measurements, long-term trends, and some observations thereon; the monetary policy context vis à vis the inflation goal and the theoretical underpinnings of the policy are also briefly examined. Section 2 discusses the structural and other issues in understanding the nature of inflation. Section 3 provides the empirical modelling and data. Section 4 discusses the empirical results and policy implications. Section 5 concludes.

1. Inflation dynamics in India and the policy context

1.1. Inflation measurements

The main indices followed to gauge inflation in India are the Wholesale Price Index (WPI) announced by the Office of the Economic Adviser, Ministry of Commerce and Industry, and the Consumer Price Index (CPI) announced for the rural, urban, and combined series by the Central Statistical Organisation. The new CPI combined is available since 2012. In addition, the Labour Bureau announces the CPI for industrial workers (CPI-IW) separately. Of these, the WPI is broader-based and includes over 700 individual commodities, including intermediate commodities over 4 main categories and 55 sub-categories. The CPI focuses on consumer goods and services and has about 465 individual commodities over 6 categories. The widely followed practice is to compare the year-on-year (YoY) percentage changes announced every month.

Within the overall indices, the sub-categories of interest for the WPI are the food articles (WPI-FA), fuel, and manufacturing; for the CPI, they are the overall index and CPI-Food. The weightages and the base year of the indices are changed over time. In order to address the difficulties posed by the differences in the base years and the weightages, percentage changes are used to gauge the variables. In particular, the combined CPI announced since 2012 has very similar weightages to the CPI-IW of 2001 and, accordingly, CPI-IW could be used for longer-term comparisons (RBI, 2014b). Prior to the adoption of flexible inflation targeting (FIT), the WPI was the preferred metric to gauge inflation. The FIT framework, stipulating a CPI target of 4% (with a flexible band of +/– 2%) was adopted in the first bi-monthly *Monetary Policy Statement* of the Reserve Bank of India (RBI) in April 2014 (RBI, 2014a). This was formally legislated in 2016.

1.2. The trends in the indices

Using backward splicing and the YoY percentage changes on the monthly data, indices of different base years were combined to produce continuous series. In addition, the annual data has been compiled as averages over the monthly data in each year. To highlight the linkages between the measures, graphical representations of the important categories of inflation are provided in figures 1-3. (i) Most inflation measures have averaged on the higher side of the FIT target for the last several decades. (ii) There is a very close correlation between CPI-IW-Food and WPI-FA (with a correlation coefficient of 0.9) and between CPI-IW and CPI-IW-Food (with a correlation

coefficient of 0.95). A large part of this can be explained by the fact that food items occupy about 46% weightage in the CPI-IW (and also in the new combined CPI that is the target of FIT). (iii) The correlation between the overall WPI and the CPI-IW is not as strong as the two relations mentioned above (with a correlation coefficient of 0.5). This dynamic could be important, as WPI consists of many manufacturing items while CPI-IW is dominated by food items. (iv) In the post-reform period, barring the two major episodes of the 2008 crisis and the recent pandemic-cum-Ukraine crisis, WPI on the whole has been relatively on the lower side. For example, the WPI averaged 4.5% between 1997 and 2021, while the CPI-IW averaged 6.7% in the same period. (v) CPI-based inflation had been relatively higher and more persistent.

Figure 1 – *Annual average inflation, CPI-IW vs CPI-IW-Food*

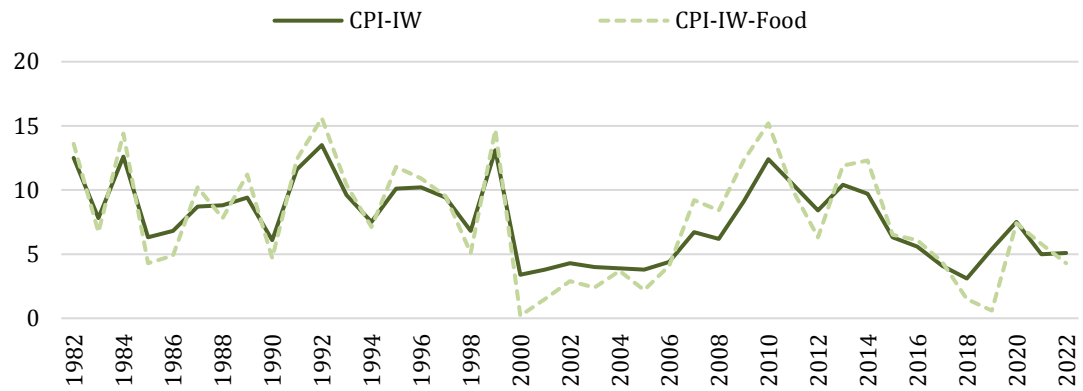


Figure 2 – *Annual average inflation, CPI-IW vs WPI-FA*

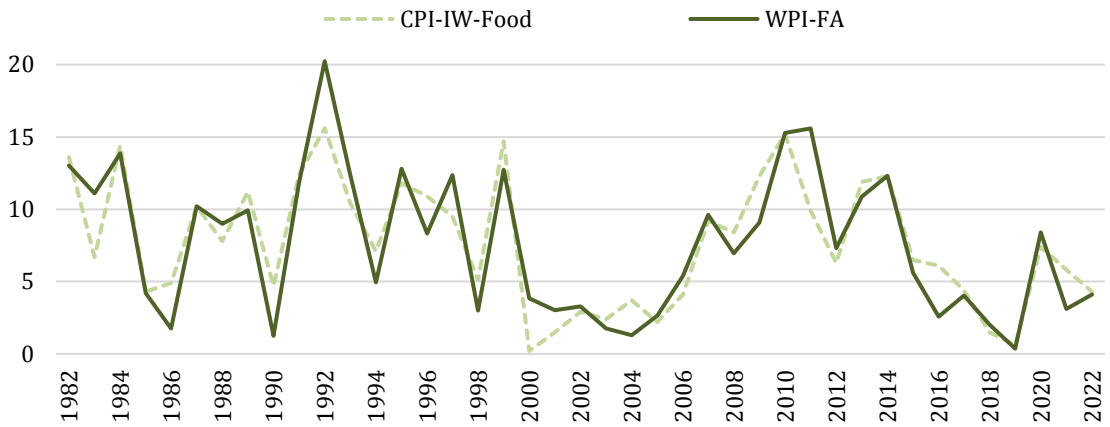
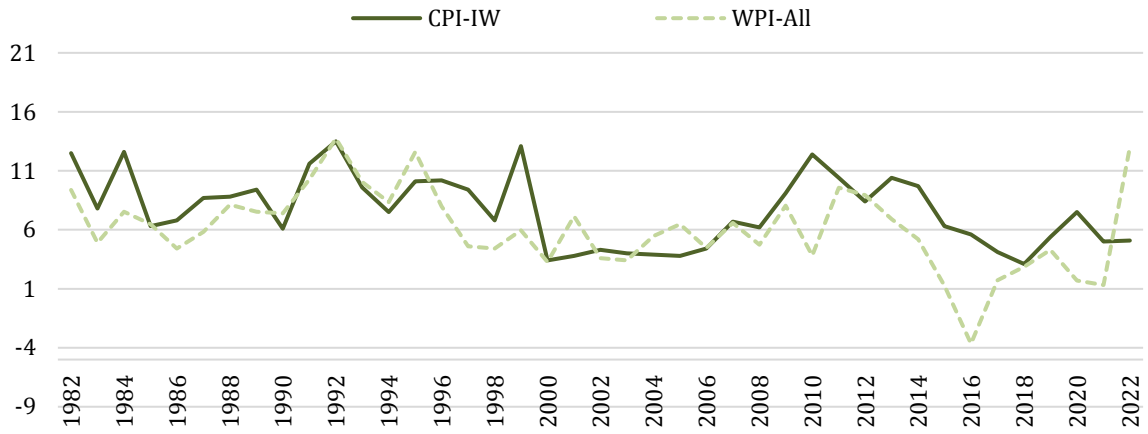


Figure 3 – *Annual average inflation, CPI-IW vs WPI All*



Source: the *Hand Book of Statistics,* tables 227, 228 and 235, Reserve Bank of India.

1.3. Monetary policy context and inflation persistence

Related literature in the Indian context has extensively covered various periods of inflation. Most of the academic and policy research has tended to look at inflation in the context of monetary policy. Accordingly, we provide a brief timeline of the monetary policy phases and the incidence of inflation.

So far, four phases of monetary policy have been seen in India. First, the policy of the pre-reform period (1947-1991) was largely an inward-looking controlled economy with credit rationing and administered prices and interest rates. Second, from 1985 until 1998, a policy of monetary targeting was adopted, with broad money (M3) as the target, based on the empirical evidence of a stable demand function for money (Rangarajan, 1997), substantiating the exogeneity hypothesis of the money supply. This framework produced "a mixed result," with the target achieved in 4 out of 13 years; however, "there was no perceptible improvement in the inflation rate" (Mohanty and Mitra, 1999). This can be seen in the fact that the WPI averaged 8.3% from 1980-1981 to 1998-1999 (ending in March), while the CPI-IW averaged 9.6% in the same period. The general consensus for that period was that the inflationary pressures were created by excessive fiscal deficits and the monetizing of the same (Prasad and Khundrakpam, 2003; Khundrakpam, 2008; Gulati and Saini, 2013). And the compulsions of the political economy forced compromise solutions (Goyal, 2014). Increasing globalisation and greater capital inflows, coupled with the development of financial markets, have shifted the policy emphasis from quantitative adjustments to price adjustments. Accordingly, new operating instruments of open market operations (OMO) and the repo rate have been given more emphasis as policy tools. And, despite the "reasonable stability of the money demand function" (Mohanty and Mitra, 1999), a single target of broad money was found inadequate for the RBI to respond to the rapid developments in the financial and global markets. Thus, a shift was made in the monetary policy framework

towards a multi-indicator approach. This approach was generally seen as successful in containing inflation and promoting growth until about 2008-09 (RBI, 2014b).

While inflation was subdued from 1999-2000 to 2005-2006 (with a WPI average of 4.8% and a CPI-IW of 3.9%), the next eight years (from 2006-2007 to 2013-2014) again witnessed high inflation (with a WPI average of 6.7% and a CPI-IW of 9.2%). The inflation of 2007-2014 attracted a lot of attention from academics and the policy makers alike and, accordingly, a number of studies have looked closely at this period. The debates and discussions of this period seem to have culminated in the RBI shifting its monetary policy framework to that of FIT. Subsequent to the adoption of FIT, the inflation measures had dipped below long-term averages, before spiking up again on the supply issues triggered by the Covid-19 and the Russia-Ukraine war.

1.4. Inflation: causal factors

Some of the themes that have been explored in the context of Indian inflation dynamics, particularly after 2006, are as follows. Goyal (2014) classifies supply shocks as dominating the inflation while demand shocks dominated output. The vulnerability of inflation to supply shocks was highlighted by several authors, such as Gokarn (2010a), Bandara (2013), Chand (2010), Nair and Eapen (2012), and SBI (2022). While food inflation was admitted as the dominating aspect of overall inflation, it is interesting to note that the reasons attributed to the same included cost-push factors and wage inflation through Mahatma Gandhi National Rural Employment Guarantee Act (MNREGA) (Bhattacharya and Gupta, 2015), higher rural demand (Mohanty, 2010, 2011), and changing income, consumption factors, and protein demand (Gokarn, 2010b). However, in a disaggregated analysis of 12 commodities, Nair and Eapen (2012) found little evidence to support the popular view of a secular shift in consumption patterns towards high-value agricultural products. The role of administered prices was also mentioned as contributing to inflation, though very few studies seem to have formally used this as an explanatory variable. We discuss this topic in more detail in section 2.

1.5. Theoretical underpinnings of the policy

The mainstream macroeconomics has accepted the paradigm of the New Keynesian Phillips Curve (NKPC) framework. This is the foundation for the popular dynamic stochastic general equilibrium (DSGE) model, "[…] which is the workhorse model for the analysis of monetary policy at major central banks" (RBI, 2014b). These models are based on rational expectations, optimising behaviour, clearing markets, and nominal rigidities that allow the non-neutrality of monetary policy. In the simple version, it consists of three basic relationships: (i) a Phillips Curve linking inflation positively to the output gap (actual output less potential output) and rational (forward looking) inflation expectations, (ii) an investment-saving (IS) relation that links the output gap to its own expected forward value and negatively to the interest rate gap (the nominal rate less the expected inflation rate less the natural rate of interest), and (iii) a monetary policy reaction rule (Taylor, 1993) that specifies the short-term nominal interest rate as a function of the output gap and the inflation gap (inflation expectation less targeted inflation) and an exogenous policy shock. This substitutes for the erstwhile LM curve. Given this framework, inflation targeting can be achieved by minimising a quadratic loss function that is equal to a summation of future values of the output gap and inflation. In the case of strict inflation targeting, the output gap variable will have a zero weight and, in the case of flexible inflation targeting, the output gap will have a non-zero weight (RBI, 2014b).

However, the consensus framework has been sometimes questioned on its assumptions and application to the emerging markets. Nevertheless, the paradigm still thrives, possibly on account of its "cognitive capture" of NKPC over the entire stream of academia, mainstream economists, advisors to the government, journal publications, citations, etc., that seems to entrench this paradigm and ignore "heterodox perspectives" (Nachane, 2018). In particular, the theory based on expectations has been criticised for being a "bits and pieces" approach and a "bootstrap theory" being a "week reed" (Goodhart, 2021); also, for being "reified" into a "reality that everyone knows" but with minimal direct evidence with no examination of alternatives (Rudd, 2021). After the global financial crisis (GFC) of 2008-2009, the policy of inflation targeting by the DCs came under criticism. Its success seems to have come through a structural dynamic of cheap labour (Goodhart, 2021) and a "benign economic environment" (Beckworth, 2014). The GFC turned the attention to the broader financial stability that includes price stability, asset price inflation, and macro prudential norms. Other authors have pointed out that the inflation targeting may have actually worked in the opposite direction, of providing overall financial stability (Beckworth, 2014; Christiano et al., 2007). In the Indian context also, a year before adopting the FIT regime, the RBI had highlighted the need to expand the policy mandate from price stability to multiple objectives, including financial stability, price stability, and sovereign debt sustainability (RBI, 2013).

With respect to emerging markets, the framework poses further issues as it has evolved out of the developed markets with a focus on aggregate demand, initially the shortage of it and need for government action to push for the same and, later, the inadmissibility of stretching demand beyond a natural full employment level. By and large, the supply side has been taken as given and something that would adjust. A refreshing admission to this effect has come in the recent past from the high circles of central banking (ECB Central Banking Forum, 2022; Powell, 2022). Ironically, despite a long history of structural rigidities, the Indian monetary policy has sworn by the same framework and perhaps not given sufficient importance to the structural aspects that needed to be addressed to achieve a low inflation environment. Given the foregoing, this paper attempts, in the next section, to look more closely at the structural issues in the context of the Indian economy.

2. The structural issues in the economy

2.1. Sectoral imbalances

In the context of development economics, it had been recognised that inflation dynamics can be quite different in the developing countries as compared to the developed countries (Basu, 2003). Kalecki (1995) observed that, in the process of development, if agricultural supplies are inelastic, inflationary pressures will build up and hence there is need for the agriculture and industry to grow in a balanced manner. Similarly, Kaldor (1976) recognised the importance of the balanced growth between sectors as important for non-inflationary growth. He suggested that the terms of trade for the primary sector need to be favourable, as commodity markets were seen as price sensitive while industrial prices are administered and hence not market clearing in nature.

In the light of the overwhelming evidence of supply-side nature of inflation in India, Balakrishnan and Parameswaran (2019) question the interpretation of high inflation as a direct measure of overheating of the economy. It is not necessary for the supply to provide a negative shock in order to trigger inflationary pressures, but an imbalance or sub-optimal growth in agriculture can also act as trigger. In a situation of structural imbalance, there could be inflation

with or without economic expansion, based on the type of shock. They empirically concluded that "NKPC is a poor predictor of Inflation in India" and that a structural model with relative prices and outputs explains the Indian inflation better.

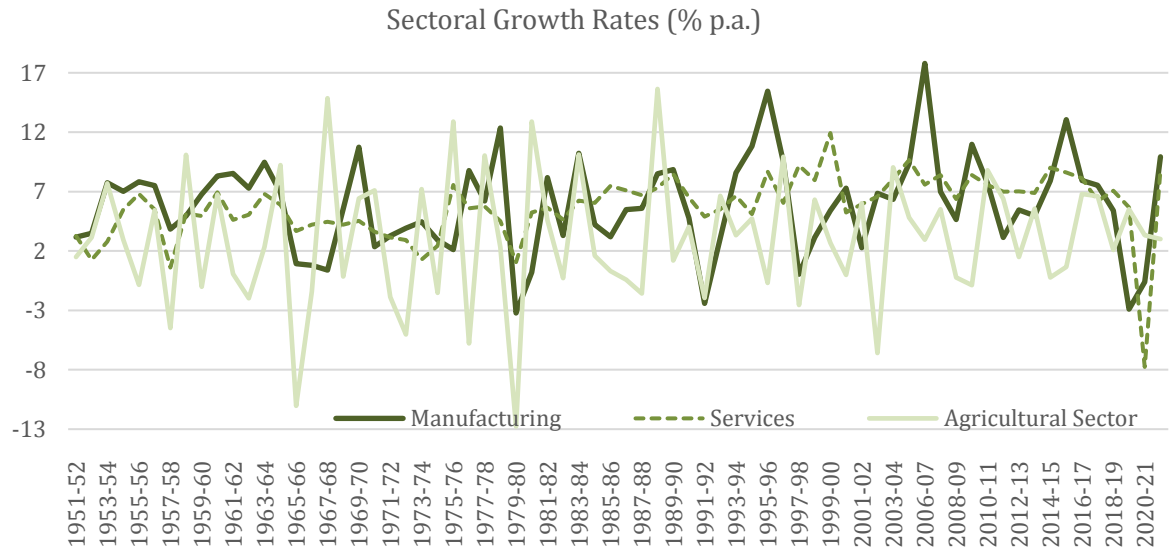
Table 1 presents the long-term growth rates of the main sectors in the Indian economy. The periods are grouped corresponding to the respective monetary policy regimes. The annual percentage growth rates for the whole period, which are helpful for understanding the clear trend, are also presented in figure 4.

Table 1 – *Long-term sectoral average growth rates (% per annum)*

Period	Agriculture	Manufacturing	Services	GDP
1951-1952 to 1984-1985	2.7	5.3	4.5	3.9
1985-1986 to 1998-1999	3.2	6.0	7.0	5.6
1999-2000 to 2013-2014	3.2	6.8	7.6	6.4
2014-2015 to 2021-2022	3.5	6.0	5.7	5.3
Whole period: 1951-1952 to 2021-2022	3.0	5.9	5.7	4.9

Source: the *Hand Book of Statistics*; table 3, Reserve Bank of India.

Figure 4 – *Sectoral annual growth rates (% per annum)*



Source: the *Hand Book of Statistics*, Reserve Bank of India.

It is clear that the "Hindu rate of growth" of 3% persisted in agriculture over the decades, though manufacturing and services have shifted their trajectory after the 80s. The volatility in the agricultural sector (including forestry and fisheries) is very high as compared to that of the manufacturing and services sector, highlighting the former sector's dependence on the vagaries of the monsoon. Since 1991-1992 there have been eight occasions where agricultural growth has been negative and a couple of more occasions where it was marginally positive. That means that, on average, we have a drop in agricultural output at least once in three years. In the period where inflation attracted a lot of attention, viz., 2002-2003 to 2015-2016, the manufacturing and services sector grew at an average of 8.1% and 7.8% per annum (p.a.), while the agricultural sector grew at 2.9% p.a. with four years of negative growth and one year of marginally positive growth. Thus, the supply shock was for 5 out of 14 years. The situation is worse when growth is considered in the Agricultural Production Index alone; this shows 13 occasions of negative growth since 1991-1992 and 7 years of negative growth between 2002-2003 to 2015-2016. As a complement to these growth differentials, we look at long-term average inflation differentials between the food sector and others in table 2. The periods are grouped together as per the high- vs the low-inflation years.

Table 2 – *Annual averages of inflation components*

Years	CPI-IW total	CPI-IW food	CPI-IW non-food	WPI total	WPI food	WPI manufactured
1982-1983 to 1998-1999	9.3	9.5	9.1	7.7	9.4	7.2
1999-2000 to 2006-2007	5.0	4.1	6.0	5.2	4.8	3.9
2007-2008 to 2015-2016	8.7	9.9	7.7	5.0	9.5	3.9
2016-2017 to 2022-2023	5.2	4.3	5.8	4.9	4.2	3.9
1982-1983 to 2022-2023	7.5	7.4	7.5	6.1	7.5	5.3

Source: the *Hand Book of Statistics,* Reserve Bank of India.

Prima facie, it appears that the high inflation episodes were all characterized by the stronger influence of food inflation. As mentioned above, the differential sectoral growth rates seem to contribute to this phenomenon. In periods of negative growth rates in agriculture, this imbalance becomes much more prominent. Essentially then, in such periods the issue becomes whether the economy has excess demand or a shortage of supply. Viewed from the perspective of excess demand, the suggestion was to keep the monetary policy stance tight for a considerable length of time (Anand et al., 2014). Similarly, citing the role of expectations, inflation targeting and "aggressive and pre-emptive policy action" were recommended (Patra et al., 2014). A structural argument, on the other hand, would focus on bridging the shortages as the principal theme of policy rather than curtailing demand and incomes.

2.2. The role of administered prices

Another major structural issue that needs to be examined is the role of administered prices, viz., minimum support prices (MSP) for agriculture and domestic oil prices for the non-food sector. In the food sector, the twin objectives of food security and safeguarding farmers' interests had been attempted in India through the mechanisms of the Public Distribution System (PDS) and MSP. The MSP that started in the mid-sixties has been progressively extended to, currently, 23 commodities, including some cash crops. Since MSP is a guarantee from the government, it sets a floor to the free-market price. Thus, wherever the Government procures from the farmers at MSP, it can be presumed that, the free-market price is below the support price. It would be important to note the reverse causality as well, since the MSP recommendation is done by the Commission on Agricultural Cost and Pricing (CACP), keeping in view various factors including costs, demand/supply conditions, and global issues. (CACP, 2023). A high inflation in the previous period is therefore likely to create an upward pressure on MSP. From the above, it appears that MSP and inflation can feed on each other.

The association of MSP with inflation has been acknowledged/reported in some studies, such as Parikh et al., (2003), Mohanty (2010), Mishra and Roy (2012), RBI (2014b), and Bhattacharya and Gupta (2015). Chinoy and others noted that the rationalisation attempted in the MSP between 2014 and 2016 was an important factor in the CPI disinflation seen in that period (Chinoy et al., 2016).

In order to consider the impact of MSP, we create an index of the MSP food-grains and non-food grains and total, using WPI weights of the crops that are covered by MSP (see the appendix for further details). The percentage changes in this index along with the CPI-IW changes are presented in table 3.

Table 3 – *Average annual percentage change in MSP Index and CPI-IW*

	MSP annual percentage change			**CPI-IW**
	Food crops	**Cash crops**	**All**	
1990-1991 to 1999-2000	10.2	9.1	9.8	9.5
2000-2001 to 2005-2006	3.0	4.2	3.4	4.0
2006-2007 to 2013-2014	11.3	11.8	11.4	9.2
2014-2015 to 2021-2022	5.1	5.1	5.1	5.3

Source: based on data from the Reserve Bank of India.

2.3. MSP: impact on inflation

Prima facie, it appears that most of the periods of high inflation were accompanied by high percentage changes in MSP. The impact of such price intervention works in multiple ways. *One*, the crops for which the terms of trade seem more favourable are produced in excess. The excess

production does not lead to a downward pressure on prices, as the government maintains buffer stocks. *Two*, the land area allocation to other crops, such as nutri-cereals and soya goes down and relative supply shortages emerge in such crops. *Three*, the excess buffer stocks maintained and the spoilages act as a drag on the exchequer. *Four,* and more importantly, in the Indian polity, it is almost impossible to reverse a subsidy or an intervention, even if it was originally intended as a short-term measure. In order to manage the distortion, further tweaking of and/or further interventions become necessary. It may be noted that concerns that MSP will be withdrawn and demands that MSP should be legalised have dominated the agitation against recent farmers' laws, even though the farm laws did not talk of MSP. There has also been further demand to increase the MSP by adding imputed rental value for owned land, although it is considered neither logical nor feasible to include this (Chand, 2018).

While the logic of protecting farmer incomes from the vagaries of the market place is a noble objective, it has been pointed out that the MSP benefits accrue mainly to large farmers (Parikh et al., 2003; Rakshit, 2003; Kishore and Jha, 2021). In addition, the practice of MSP has been considered instrumental in misallocation of agricultural resources in as much as there is excess crop allocation and excess production of a few crops, notably rice, wheat, and sugar. Excess allocation to these crops also raises the issues of soil degradation, as these are fertilizer- and water-intensive crops. In addition, there are environmental concerns about pollution from N2O emissions of urea usage (Nair, 2021) and carbon emissions from stubble burning (Puri, 2022).

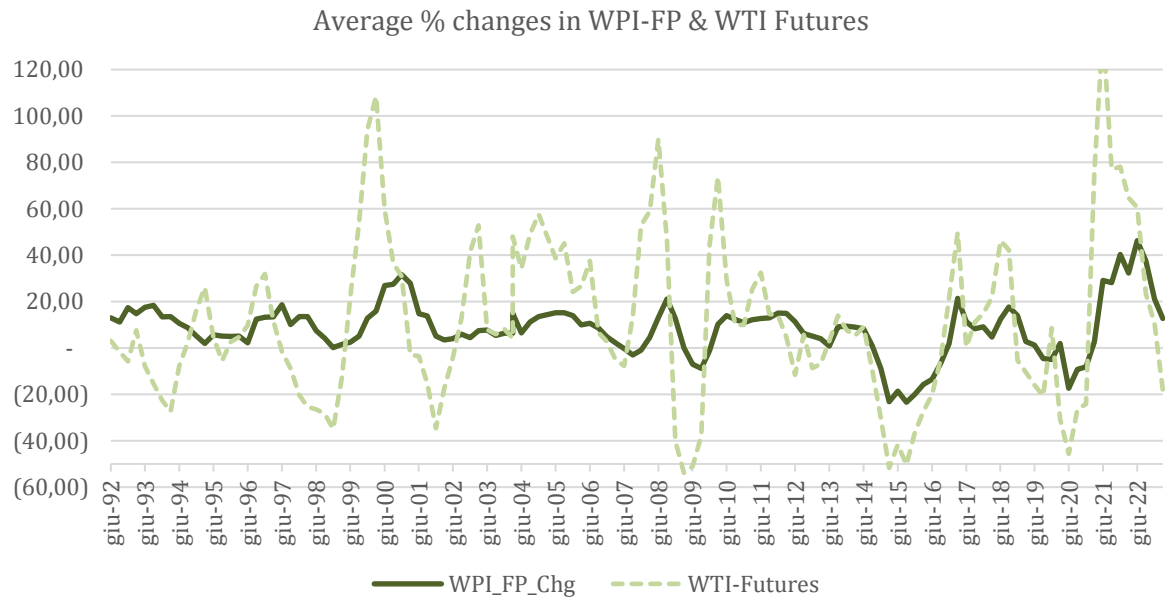
2.4. Exchange rates and oil prices: the impact on inflation

In view of the fact that the country has been increasingly globalised, the other global factors, viz., exchange rate and capital flows, also become important in their influence on domestic inflation. Although the exchange rate is not strictly an administered one, the RBI is known to intervene in the markets regularly on the downside of the rupee to contain "volatility" and on the upside to maintain competitiveness and build reserves. Each time there has been a sharp drop in the rupee (oil crises, the Asian financial crisis, the global financial crisis, the QE taper, and trade wars are some examples), the RBI has raised interest rates in defence and/or interest rates shoot up on the liquidity drain arising out of dollar sales and capital outflows. Studies in the Indian context have observed mixed evidence of global factors on the impact on domestic inflation. Raj and others observed that import prices, exchange rate, and capital flows contributed, on an average, 20-30% of domestic inflation. The impact of imported inflation has softened significantly from the 1950s to the 1990s but has increased after 2003 (Raj et al., 2008). These factors have been found to contribute to the monetary policy responses in the Taylor rule specifications. In particular, the policy response showed a higher focus on the exchange rate in low inflation and high depreciation regimes (Kumawat and Bhanumurthy, 2018). The policy response to the exchange rate was also observed, particularly after 1999, evidently in response to higher capital flows (Hutchinson et al., 2010).

Domestic oil prices have been liberalised since 2010. However, the domestic prices do not fully reflect the global prices, particularly on the downside, as the government taxes on oil keep varying. Some studies have observed a limited role for oil and other global prices on inflation (Bhattacharya and Gupta, 2015; Chinoy et al., 2016), presumably due to the tax adjustments on the domestic oil price. In order to understand the influence of international oil prices on domestic inflation, we map in figure 5 the relative movements (y-o-y percentage p.a.) in the quarterly averages of the popular West Texas Intermediate (WTI) grade of crude oil active month future prices traded on the New York Mercantile Exchange (NYMEX) against the y-o-y quarterly average

of the domestic WPI-Fuel and Power (F&P) Index. It appears that the administered pricing in the oil sector has, by and large, cushioned the volatility in domestic fuel inflation compared to a highly volatile international oil price scenario.

Figure 5 – *Quarterly average percentage changes in WTI futures and WPI-F&P Index*



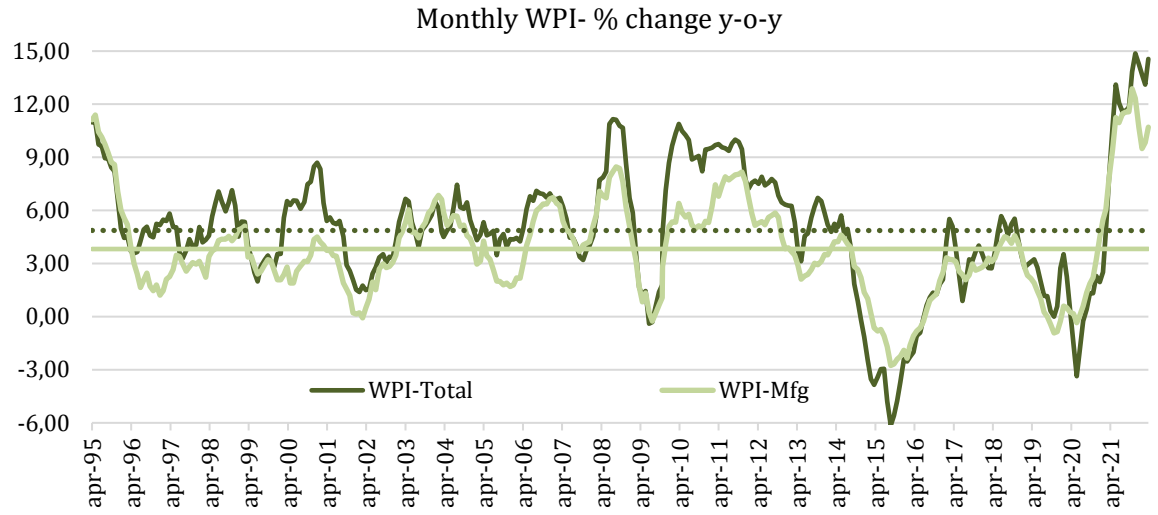
Source: Calculations are from back-spliced WPI indices over the base year 2012; data from GOI, eaindustry.nic.in, and WTI Futures from Refinitiv Eikon.

2.5. The WPI Experience: a structural positive?

Prima facie, there seems to be logic in the wholesale measure encompassing many commodities leading the retail measure. In the global boom of 2007-08 and again in the recent pandemic and the Ukraine situation, it appeared that global factors fed on to the WPI and further into the CPI. This aspect, however, needs more investigation. It is felt that, despite its relegation in importance since 2014, the WPI is still important as it has a wider base and perhaps better reflects overall economic conditions. Further, irrespective of the measure applied, WPI behaviour shows up a very important aspect of the structural issues, as follows.

Figure 6 presents a trend in manufacturing inflation of the monthly WPI (y-o-y percentage change) for the 1995-2022 period. The long-term trend in manufacturing inflation is instructive. It is easy to surmise that demand factors have not caused high inflation in the sectors that had been opened up, for the simple reason that supplies in such sectors soon caught up with the demand. This would apply to a large number of manufactured items.

Figure 6 – *Long-term trend in manufacturing inflation, WPI monthly (% change per annum)*



Source: calculations from back-spliced WPI indices over the base year 2012; data from GOI, eaindustry.nic.in.

Witness the drop in average levels of the WPI after reforms. This can be attributed, to a large extent, to the opening up of the economy to competitive pressures and supply enablers (as against the earlier era of shortages and latent inflation through rationing and controls). The WPI was falling even while the target was shifted from WPI to CPI. The WPI-Mfg averaged 1.8% from November 2012 to December 2020. For the whole period of 27 years (1995 to 2022), the WPI-Total averaged 4.9% and the WPI-Mfg averaged 3.8% compared to the WPI-Food Index of 5.9%. Barring the two occasions where the WPI was high (one, the "irrational exuberance" and widespread speculation in commodity markets leading to the GFC and, two, the shortages in the global supply chains related to the Covid pandemic), the average would have been even lower. The behaviour of the WPI thus clearly demonstrates that the problem is one of structural rigidity and not positive output gap.

Having looked at some of the important factors in understanding inflation in the Indian context, we attempt to model the long-term inflation against some of the important structural factors noted above.

3. Empirical modelling and data

Given the nature of the problem delineated, we propose looking at the empirical relation between CPI, being the policy target, and the two main structural variables, viz., agricultural production and MSP. As mentioned in section 1, since the CPI-IW has a close linkage to the CPI, the CPI-IW is taken as the measure to proxy the CPI for the long-term data. We consider two sets of data, viz., annual and quarterly, as these convey slightly different perspectives of agricultural performance, viz., production and GDP; further, the quarterly data captures the intra-year volatility of prices and interest rates. The annual data consists of the annual growth rates of the Agricultural Production Index (Agr_Ption), y-o-y changes in the MSP calculated from the annual MSP prices

announced (using WPI weights for different crops; see the appendix), the annual average CPI-IW, and the annual average of weighted average call rates (Call_rate) for the years ending March of 1982 to 2023.

For the quarterly data, we consider quarterly averages of the CPI-IW, the annual percentage change in the MSP Index applied uniformly over the four quarters of each year (MSP_Uniform), a sectoral imbalance term measured as the difference between percentage changes between the GDP/GVA of Manufacturing and Services as against the GDP/GVA of Agriculture and Allied activities (Non_agr_agr), and the quarterly average of weighted average call rates (Call_rate) for the period from June 1997 to March 2023. All data is taken from the *Hand Book of Statistics* of the RBI. As can be seen, all these variables are used in their growth terms so as to even out the effects of indexing over a long period of time under different base years and weightages. The variables have been tested for stationarity and the results are provided in tables 4 and 5.

Table 4 – *Unit root tests (annual data)*

	Augmented Dickey-Fuller (ADF)		**Phillips-Perron (PP)**	
Variable	**Level**	**First difference**	**Level**	**First difference**
	Intercept and trend	**Intercept and trend**	**Intercept and trend**	**Intercept and trend**
CPI_IW	–4.23***	–9.47***	–4.32***	–10.28***
Agr_Ption	–8.16***	–7.28***	–11.59***	–34.42***
MSP	–3.70**	–6.39***	–3.65**	–16.74***
Call rate	–3.84**	–5.95***	–3.77**	–11.50***
WPI_total	–3.68**	–8.40***	–3.71**	–8.81***

Note: The figures are the associated t-statistic of the coefficients; *** and ** represent 1% and 5% level of significance.

Table 5 – *Unit root tests (quarterly data)*

	Augmented Dickey-Fuller (ADF)		**Phillips-Perron (PP)**	
Variable	**Level**	**First difference**	**Level**	**First difference**
	Intercept and trend	**Intercept and trend**	**Intercept and trend**	**Intercept and trend**
CPI_IW	–2.89	–6.36***	–2.86	–15.11***
Non_agr_agr	–4.71***	–9.91***	–3.95***	–21.86***
MSP_Uniform	–2.62	–9.95***	–2.86	–9.95***
Call rate	–4.81***	–9.51***	5.10***	–14.19***

Note: The figures are the associated t-statistic of the coefficients; *** and ** represent 1% and 5% level of significance.

For the annual data, all the variables were found I(0) at the 1% or 5% level. For the quarterly data, call rates and the Non_agr_agr (the sectoral imbalance) were stationary at I(0) at the 1% level, while the MSP_Uniform and CPI-IW were I(1).

4. Empirical model, results and discussion

4.1. Model based on annual data

For the annual data, we attempt to model the CPI-IW, agricultural production, MSP and call rates. In order to model the empirical relation between the various time series variables, the vector auto regression (VAR) framework was initially considered, as each of the variables can potentially have lagged effects on the other variables. The lag-length was chosen to be 1, in view of the annual nature of the data and based on AIC and HQ criteria provided in table 6.

Table 6 – *Lag length criteria*

Lag	Log L	LR	FPE	AIC	SC	HQ
0	–433.4339	NA	64928.80	22.43251	22.60313	22.4937
1	–400.8870	56.74859*	27948.35*	21.58395*	22.43705	21.8900*
2	–390.1120	16.57681	37580.90	21.85190	23.38749	22.4028
3	–374.7856	20.43525	41808.48	21.88644	24.10452	22.6822

Note: LR: LR test statistic; FPE: final prediction error; AIC: Akaike information criterion; SC: Shwarz information criterion; HW: Hannan-Quinn information criterion.

The VAR results showed that only in the CPI_IW equation were the coefficients of explanatory variables significant. Further, Agr_ption and MSP were seen granger causing the CPI-IW while the CPI_IW did not granger cause any of the variables. In view of this, a single equation using the ordinary least squares method was considered to model the CPI_IW, as follows:

$$CPI\_IW_t = \alpha + \beta_1 CPI\_IW_{t-1} + \beta_2 \text{Agr\_Ption}_{t-lag} + \beta_3 \text{MSP}_{t-lag} + \beta_4 \text{Callrate}_{t-lag} + \mu_t \qquad (1)$$

We model the CPI_IW as dependent on its own lag (expected sign positive, showing persistence), MSP of the same period (as the same are announced before the cropping season) and its one lag (both expected signs positive), Call_rates of the same period (expected sign positive, as monetary authorities could react to changes in the CPI-IW in the same year) and one lag (expected sign negative in line with the expectations and interest rate transmission hypotheses), and Agr_Ption with lag 1, as it is expected that the impact of the variations of agricultural output would be seen with a lag, given the buffer stocks (expected sign negative). The regression results based on annual data are presented in table 7.

Table 7 – *Regression results of annual data*

Variable	Coefficient	t-statistic
CPI_IW (–1)	0.2314	1.6912*
MSP	0.0934	0.9981
MSP (–1)	0.2283	2.6068**
AGR_PTION (–1)	–0.1425	–2.4539**
CALL_RATE	0.3438	2.6446**
CALL_RATE (–1)	–0.1682	–1.1864
C	2.2880	2.1709**
Adjusted R-squared		0.48
Log likelihood		–84.75
F-statistic (prob)	7.14 (0)	
Durbin-Watson stat		2.03

Note: ***, ** and * represent 1%, 5% and 10% level of significance.

The coefficients for the structural variables of Agr_Ption (–1) and MSP (–1) exhibited expected signs and are statistically significant. Although MSP of the same period also had the correct sign, it was not statistically significant. The Wald test for MSP and its first lag showed that they are jointly also statistically significant. It is notable that the call rate was not statistically significant, although for the contemporaneous variable it had the expected positive sign. The CPI-IW's on lag was also statistically significant at 10% level. These results suggest that such inertial inflation is stemming from structural factors that could not be tamed via demand management. The model satisfied the diagnostic checks for residual auto-correlation, heteroskedasticity, and stability, including Ramsey reset test and the CUSUM squares test (results available on request).

4.2. Model based on quarterly data

In order to delineate the structural impact, if any, after the reform period, we attempt to model a similar specification based on quarterly data, starting from the quarter ending June 1997 to March 2023. Quarterly average growth rates of the CPI_IW, Non_agr_agr, MSP_Uniform, and quarterly average Call_rates were used as the variables, as explained in section 4, above.

As shown above, the imbalance term (Non_agr_agr) and Call_rate were I(0), while the CPI_IW and MSP_Uniform were I(1). Accordingly, we employ the ARDL (auto-regressive distributed lag) model developed by Pesaran et al. (1996, 2001) for the long-run relationships based on quarterly data, in view of its ability to generate unbiased estimates of the long run even when a few of the regressors are endogenous and it does not require all variables in the same order of integration, i.e., I(0) or I(1). The ARDL procedure consists of two stages. First, the long-term relationship is estimated as follows:

$$\alpha(L,p)y_t = A_0 + \sum_{i=1}^{k} \beta_i\,(L,q)X_{it} + \mu_t \qquad (2)$$

where: A_0 is a constant; y_t is the target variable, viz., CPI-IW; X_{it}, is the vector of regressor variables, viz., Non_agr_agr, Call_rates, and MSP_Uniform; and $\alpha(L,p)$ and $\beta(L,q)$ are polynomials of order p and q of the lag operator L; μ is the error term. The long-run relationship is tested with the F-Bounds test, for the joint significance of all the explanatory variables. If a relation is observed by rejecting the null of no long term relation, the short-term error correction term is estimated, specifying the speed of correction, as follows:

$$\Delta y_t = \Delta\alpha_0 + \sum_{j=1}^{p} a_j \Delta y_{t-j} + \sum_{i=1}^{k}\sum_{j=1}^{q} \beta_{ij} \Delta X_{i,t-j} - \gamma EC_{t-1} + \mu \quad (3)$$

and $EC_t = y_t - \hat{a} - \sum_{i=1}^{k} \hat{b}_i X_{it}$, where Δ is the first difference operator, a_j, and β_{ij} are the short-run dynamic coefficients, and γ measures the speed of adjustment.

We expect a positive sign for the coefficients of the variables MSP_Uniform and Non_agr_agr. The call rates could exhibit a positive sign in the initial lags, as the policy reacts to inflation; however, with subsequent lags it is expected to be negative, as the demand adjustments are expected to counteract the price changes. For estimating the lags, the order of 7, 3, 4, 8 (for the CPI_IW, Non_agr_agr, MSP_Uniform, and Call_rate) was chosen based on AIC criteria. We observe that, as with the annual data, the quarterly data shows that MSP and imbalance terms granger cause the CPI-IW, while the the CPI_IW granger causes the imbalance term. The results of the estimated ARDL (7, 3, 4, 8) are shown in table 8.[1]

Table 8 – *Long-term results of the ARDL model with quarterly data*

Dependent variable: CPI-IW		
Variable	**Coefficient**	**t-stat**
CPI-IW	—	—
MSP_Uniform	0.61	4.80***
Non_agr_agr	0.28	2.35**
Call_rate	–0.91	–2.47**
R-squared	0.91	
Durbin Watson	1.99	
F-Bounds test	10.25***	

Note: *** and ** represent 1% and 5% level of significance.

The Wald tests confirm joint significance of Non_agr_agr and MSP_Uniform coefficients at the 1% level. With respect to Call_rates, the joint significance of the coefficients is just above the 5%

[1] In view of the RBI interventions in the exchange rate, government interventions in oil prices, and our emphasis on domestic structural variables, we have not considered the international variables in the model presented. However, we also ran an alternate model, including the variables of exchange rate and international oil prices, viz., USD/INR and CLc1, measured in terms of percentage change year-on-year, on the monthly data, averaged over the quarters, so as to be consistent with the other variables. Although the adjusted R^2 improves marginally from 0.89 to 0.90, the coefficients themselves are not statistically significant (except for the CLc1 change variable at the 10% level in the 8th lag, with a very low coefficient). The results of the alternate model are available on request.

level. However, the Wald test for the coefficients for the first five terms of Call_rates is not statistically significant. Only the lags of 5-8 quarters are jointly significant. This is in line with the mainstream explanation of interest rates effecting the CPI only indirectly and after significant lags. Based on the significant F-statistic, we reject the null (of no relationship). Accordingly, the error correction is estimated with the results shown in table 9.

Table 9 – *Short-term coefficients from the error correction estimation*

Dependent variable: Δ CPI-IW		
Variable	**Coefficient**	**t-stat**
Constant	1.76	6.19****
Δ CPI-IW		
Δ CPI-IW (–1)	–0.01	–0.12
Δ CPI-IW (–2)	0.16	1.97*
Δ CPI-IW (–3)	0.05	0.77
Δ CPI-IW (–4)	–0.39	–5.84***
Δ CPI-IW (–5)	0.1	1.46
Δ CPI-IW (–6)	0.18	2.57***
Δ MSP Uniform	0.01	0.32
Δ MSP Uniform (–1)	–0.08	–1.62
Δ MSP Uniform (–2)	–0.13	–2.72***
Δ MSP Uniform (–3)	–0.08	–1.62
Δ Non_agr_agr	0.03	2.09**
Δ Non_agr_agr(–1)	–0.01	0.12
Δ Non_agr_agr(–2)	–0.05	–3.18***
Δ Call_rate	–0.06	–0.54
Δ Call_rate (–1)	0.26	2.16**
Δ Call_rate (–2)	0.1	0.76
Δ Call_rate (–3)	–0.01	–0.11
Δ Call_rate (–4)	0.26	2.42**
Δ Call_rate (–5)	0.24	2.82***
Δ Call_rate (–6)	0.29	3.61***
Δ Call_rate (–7)	0.17	2.20**
ECT (–1)		–0.25***
R-squared	0.65	
F-statistic	10.25***	

Note: ***; **, and * represent 1%, 5%, and 10% level of significance.

The short-term cointegrating equation was therefore estimated to be:

$$D(CPI\_IW)=1.76-0.25*(CPI\_IW(-1)-(0.61*MSP\_UNIFORM(-1)+0.28*NON\_AGR\_AGR(-1)-0.91*CALL\_RATE(-1))) \quad (4)$$

The model satisfied various diagnostic checks for residual auto-correlation, heteroskedasticity, and stability, including the Ramsey reset test and the CUSUM square test. These, along with the model fit vs actuals and residuals, are provided in table A1 in the appendix.

Based on the coefficients, the sensitivity of the CPI-IW to MSP and imbalance terms can be estimated. For example, an increase in the MSP Index to 8% (with the initial CPI-IW at 5% and the imbalance term at 4%) would lead to a spike in the CPI-IW of 65 basis points. With an unchanged imbalance, the call rates need to be raised to about 9% to counter that effect. In addition, as mentioned above, the joint Wald test of the initial five terms of call rates is not statistically significant. Any inflation control through interest rate management would then mean a large adjustment that would work perhaps with significant delay.

4.3. Policy implications: excess demand or supply shortage?

From the above analysis it appears that the structural variables under discussion have a significant explanatory power for the consumer inflation. The fall in the CPI after the adoption of FIT could very well be explained by the fall in commodity prices and by a structural model rather than the NKPC model (Balakrishnan and Parameswaran, 2021). As pointed out earlier, the WPI was already falling and in negative territory, even at the time of FIT adoption. By adopting a framework ill-suited to the economy, inflation had been described as an excess demand situation rather than a supply shortage situation. This is considered very important, as the solutions that are offered are tailored accordingly. Interest rate management seems to work only with significant lag and, going by the sensitivity noted above, the growth sacrifice it entails could shrink incomes of the most vulnerable unorganised sector and squeeze their demand to subsistence level.

4.4. Agricultural reforms

The fact that supply side issues dominate inflation is acknowledged, even in mainstream macroeconomics, but it is largely side-stepped as something that is not in the control of central banks. In fact, the prescription from IMF or RBI economists has been to keep the monetary policy aggressive (Patra et al., 2014) and tighter for a longer period (Anand et al., 2014), possibly to compensate the slow effect of interest rates on the overall economy. This appears to be the policy stance as well, despite monetary policy having a limited impact on the CPI even if non-food inflation is controlled through interest rates (Mishra and Roy, 2012).

The structural theme needs to be made the central agenda in the drive to rein in inflation. A beginning may have been made in this direction, going by a few recent statements from official circles in this regard on food inflation and farm reforms (Subramanian and Sharma, 2022), and on interest rate management alone being ineffective for controlling inflation (Sitaraman, 2022). Recently, we have also seen renewed efforts to manage short-term logistics through buffer stocks and external trade.

In spite of the government's short-term supply management efforts from time to time, it is imperative to correct the structural imbalance to address the problem in the long term. Clearly, Indian agriculture has not witnessed the kind of reforms that were done in 1991 in the manufacturing and services sectors. In all major crops, Indian productivity is significantly below the leading nations in the respective crops and even below the world averages (GOI, 2022, pp. 236-237). The low productivity and unsustainable input-intensive practices have been well documented (see Chand, 2019, and RBI Bulletin, 2022). The MSP system should act as a temporary support for crops that need encouragement because of shortages and higher value rather than for the politically expedient ones, where there is already excess production. There is an urgent need for crop diversification away from water- and fertilizer-intensive crops and traditional cereals such as sugar, rice, and wheat to higher nutritional cereals, pulses, and oilseeds. The subsidy mechanism and the price incentives need to work in this direction. Further, there is need to expose the sector to competitive pressures and private investments to improve efficiency. Accordingly, there is a need for effective food management strategy, investments in storage of buffer stocks, involvement of the private sector, and technology-led growth (Chand, 2010). In short, for "a second green revolution focussed on the agriculture-water-energy nexus, making agriculture more climate-resistant and environmentally sustainable" (RBI Bulletin, 2022).

5. Summary and conclusions

We have attempted to delineate the dynamics of inflation in India. The empirical evidence had pointed out the dominance of supply side factors, in particular the food supply, through different monetary policy regimes. While the WPI has averaged much less after the reforms of the 90s, the CPI-IW had remained stubbornly high. The NKPC and the inflation targeting framework focus on the demand side, while treating supply issues as shocks (and by implication, not inherently structural). This does not appear to describe the Indian economic scenario well. The structural factors are observed to provide, qualitatively and empirically, an equally if not more important explanation for the inflationary pressures in the economy. In the context of recurring supply shortages, it is inappropriate to address inflation through a prism of excess aggregate demand, because of the welfare implications of the income sacrifices. The inflation control focus should therefore be to address these rigidities in the food sector through logistic management in the short term and structural reforms in the long run. The central bank should emphasise the limitations of such demand management and the need for development of the agricultural sector as the main focus for lasting success in taming inflation.

Appendix

MSP Index construction

The MSP prices of the 15 crops and crop categories were taken as base data. The WPI weights (base 2012) for the 15 crops aggregated 5.59127% in the WPI. This aggregate was normalised to 100. The individual weights in the WPI were then taken as a proportion of the aggregated normalised weight of 100 [e.g., rice with a weightage of 1.43052 was converted to an MSP weight of 25.58489 (1.43052/5.59127*100)].

The data of 1989-90 was chosen as the base for the MSP calculation, as MSP prices were available for all the 15 categories of crops in that year. The individual prices of 1989-90 were normalized to 100 and subsequent prices were converted to an index for each crop. (e.g., the MSP of rice for 1990-91 was 205 as compared to 185 for 1989-90. Thus, the index of MSP for rice in 1990-91 works out to 110.8108 (205/185*100). The individual index thus calculated is multiplied by the MSP weightage (23.58489) as above to constitute its weight in the overall MSP Index. Thus, for 1990-91 the contribution of rice to the aggregate MSP Index was 28.3508 (25.58489*110.8108/100). The summation of all the contributions provided the total MSP Index for that year. The year-on-year change is then captured as the percentage change in the index.
Procurement data was not used for weightages, as the administered MSP essentially sets a floor and procurement typically happens if the free-market price tends to be below the MSP. The price categories and the prices are taken from the RBI *Hand Book of Statistics*, tables 25 and 26. The indices were extended backwards until 1980-1981 by assuming repeated prices for the years in which they were not announced (so that the change in MSP would have been zero for those years for those particular commodities).

Table A1 – *Diagnostic checks – ARDL – quarterly data*

Breusch-Godfrey serial correlation LM test:			
Null hypothesis: No serial correlation at up to 1 lag			Prob
F-statistic	0.3471	Prob. F(2,68)	0.7079
Obs*R-squared	0.9703	Prob. Chi-square(1)	0.6156
Heteroskedasticity test: Breusch-Pagan-Godfrey			
Null hypothesis: Homoskedasticity			Prob
F-statistic	1.4071	Prob. F(25,70)	0.1337
Obs*R-squared	32.1077	Prob. Chi-square(25)	0.1549
Scaled explained SS	12.1433	Prob. Chi-square(25)	0.9854
Ramsey RESET test			
Omitted variables: Squares of fitted values			
	Value	df	Prob
t-statistic	1.5468	69	0.1265
F-statistic	2.3925	(1, 69)	0.1265
Likelihood ratio	3.2723	1	0.0705

Figure A1 – *CUSUM square test*

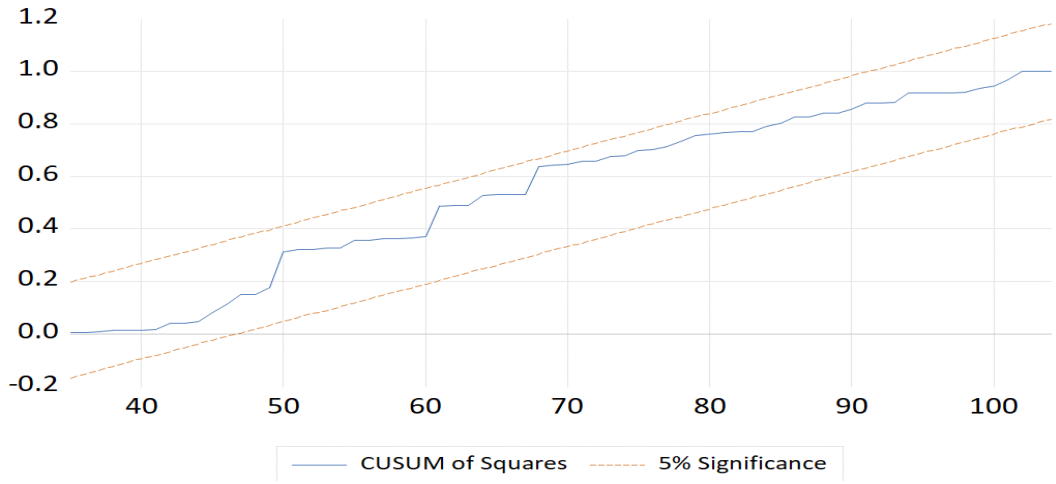
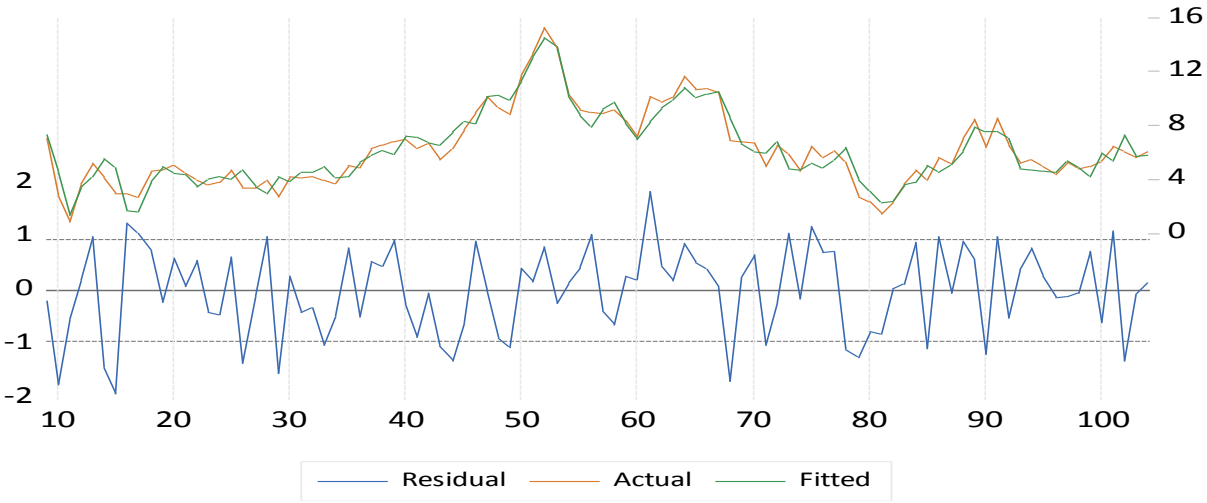


Figure A2 – *Residuals; and actual vs fitted*



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