

UNDERSTANDING THE HIGH INFLATION TREND IN INDIA

Ashima Goyal

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ABSTRACT

Stylized Indian structural features and facts on growth and inflation are consistent with an elastic aggregate supply subject to chronic and sometimes sharp cost push. A variety of tests support this against an alternative hypothesis of inelastic supply. The tests include estimating aggregate supply, imposing the estimated slope to recover demand and supply shocks from price and output time series, and analyzing price-setting behavior and the relationship between different components of headline inflation. The analysis identifies the mechanisms that propagate relative price changes into the price level. Sectoral bottlenecks and governance failures are found to manifest in an upward shift of an elastic supply curve. Despite twin deficits, there was demand contraction rather than excess demand during periods of supply shocks. This contrasts with the first best policy response, which is to shift down the supply curve in response to a temporary supply shock, avoid too large a demand contraction, and neutralize mechanisms that propagate supply shocks. Since the output gap has little effect on product or wage inflation, standard monetary tightening to anchor inflation expectations, if the first best is not followed, requires a large growth sacrifice. The combination of forward and backward looking price setting that holds for Indian firms reduces the intensity of tightening required compared to if behavior is purely forward-looking.

JEL codes: E31, E52, E62, O23

Keywords: inflation, aggregate supply slope, demand and supply shocks, sectoral bottlenecks, price-setting

ABBREVIATIONS

AD	-	Aggregate demand
AEs	-	Advanced Economies
AS	-	Aggregate Supply Curve
CAD	-	Current Account Deficit
CPI	-	Consumer Price Index
CPI AL	-	Agricultural Laborer
CPII	-	Consumer Price Inflation
CPI-IW	-	Consumer Price Index for Industrial Workers
CPI RL	-	Rural Laborer
CPI UNME	-	Urban Non-Manual Employee
CSO	-	Central Statistical Organization
ER	-	Exchange Rate
EMs	-	Emerging Markets
FD	-	Fiscal Deficit
FPL&L	-	Fuel, Power, Light and Lubricant
GDCF	-	Gross Domestic Capital Formation
G	-	Government Expenditure
GDP	-	Gross Domestic Product
GDS	-	Gross Domestic Savings
GFCF	-	Gross Fixed Capital Formation
GMM	-	Generalized Method of Moments
HP	-	Hodrick-Prescott
HSC	-	Horizontal Supply Curve
IFS	-	International Foreign Statistics
IIP	-	Index of Industrial Production
LAS	-	Long-run Aggregate Supply
MGNREGS	-	Mahatma Gandhi National Rural Employment Guarantee Scheme
MSP	-	Minimum Support Price
NX	-	Net Exports
NKE	-	New Keynesian Economics
PDS	-	Public Distribution System
PFCE	-	Private Final Consumption Expenditure
RBI	-	Reserve Bank of India
VAR	-	Vector Auto Regression
VSC	-	Vertical Supply Curve
WPI	-	Wholesale Price Index
WPII	-	WPI Inflation

I. INTRODUCTION

1. Consumer inflation in India has been high since 2007, a period when inflation fell sharply in many regions of the world due to the global slowdown. It is a puzzle why inflation persisted despite a slowdown. Measurement problems add to the puzzle. Without a fully acceptable and timely measure of aggregate consumer price inflation, analysis is forced to rely on different types of disaggregated series. These behaved very differently with persistent and high inflation in food prices, but fluctuations in manufacturing inflation following those in oil price shocks. Fluctuations and fall in growth rates accompanied widening fiscal deficits. Demand side factors normally drive persistent or core inflation but observed comovements suggest that supply side factors had a role. The paper sets out the stylized facts, and basic hypotheses distinguishing between demand and supply side causation, and then tests the hypotheses in a variety of ways, before finally drawing out policy implications.

- i) It empirically estimates the aggregate supply curve taking into account the price setting behavior of individual firms over time.
- ii) It analyzes the role of demand and supply shocks in exacerbating inflation. First, it analyzes how supply shocks affect India's twin deficits i.e. current account deficit (CAD) and fiscal deficit (FD). The paper investigates whether the deficits indicate the presence of excess demand, or do supply-side aspects affect them. To do this, it analyzes the changes in the CAD conditional on demand components, and the structure of demand as reflected in disaggregated components of imports. To address the question if deficits created excess demand in areas where the supply response was constrained, disaggregated government expenditure and inadequacies in agriculture are examined.
- iii) Sharp rise in agricultural wages over the past few years has been a major contributor to inflation. Cost-push leads to a second round of price rise. Using disaggregated data from the States, the paper examines the structure of this rise and its implications for future inflation. To what extent does the wage rise indicate labor markets are tight? If not, then what other factors raise wages?
- iv) In the case where supply is elastic but subject to cost shocks, demand tightening through policies can anchor inflationary expectations and prevent a wage-price spiral that shifts up costs. However, at the same time it results in a large sacrifice of output. The paper explores policies that can reform propagation mechanisms, so demand can support an elastic aggregate supply, reducing both inflation as well as the growth sacrifice.

2. The combination of context, analysis and rigorous testing suggests answers to the puzzle of persistent high Indian inflation in a period of global slowdown. The analytical framework the tests support is used to outline policy to address the problem of high and sticky inflation without imposing a large output sacrifice.

3. The structure of the paper is as follows. Following a brief introduction, Section II presents and analyzes stylized facts of inflation. Section III sets up alternate aggregate demand and supply based explanations of inflation, qualified by sectoral aspects. Section IV presents econometric tests of these alternate hypotheses, and Section V draws out policy implications, before Section VI concludes. An appendix has details of the econometric methodologies implemented.

II. INFLATION AND GROWTH: STYLIZED FACTS

4. Before drawing out some stylized facts on recent Indian inflation and growth, this section first discusses measurement issues, to justify the indices used.

III. CONCLUDING OBSERVATIONS

A. Indian Consumer and Wholesale Price Indices

5. This sub section analyzes the relationship between selected indices and their sub-components. The many different types of inflation indices used in India are the wholesale price index (WPI), consumer price index (CPI) and the annual implicit national income deflator. The last is broad-based—it includes services. But it is available only at an annual frequency with a lag of over a year.

6. Most advanced economies had begun to use the CPI by the 1970s, since it is a measure of the cost of living. But in India the CPI was available only at monthly frequencies, with a two-month lag. The WPI, which traces price change in commodities in wholesale markets, however, was available weekly with a lag of only two weeks for provisional index and ten weeks for the final index. Since there were problems in getting weekly data from firms, its availability was changed to monthly in 2009, while primary articles continued to be reported at weekly frequency. These also began to be reported at a monthly frequency from 2011, since their weekly reporting was leading to too much focus on food inflation.

7. Moreover, the commodity coverage in WPI is wider than that in CPI. The WPI is a Laspeyres index (current prices divided by base-year prices with base-year wholesale market transactions as fixed weights). The 1993–1994 WPI series had 435 commodities in its commodity basket. Table 1 gives the broad weighting structure and its changes over time. The WPI does not cover non-commodity producing sectors like services and other non-tradable goods. It was revised with base 2004–2005 from 2010, with the unorganized manufacturing sector, which contributes about 35 percent of the total manufactured sector output, given expanded representation, and the items covered increased to 676 with the number of quotations at 5482¹. As measured in India it is not a producer price, but the quoted price of bulk transactions at a primary stage, which could be ex-factory gate for manufactured goods, but also includes some administered prices.

Table 1: Weights of WPI Series for all India Level

Major Groups	Base 1993–1994	Base 2004–2005
Primary Articles	22.025	20
Fuel, Power, Light and Lubricant	14.226	14.9
Manufactured Products	63.749	65

8. Consumer price indices should ideally give the change in retail prices of the goods and services on which a homogeneous group of consumers spend the major part of their income. Indian heterogeneity meant multiple CPI series covering different economic groups were required². The

¹ See OEA (Office of the Economic Advisor), 2008.

² Four series available in the period were the CPI UNME (Urban Non-Manual Employee), CPI AL (Agricultural Laborer), CPI RL (Rural Laborer) and CPI IW (Industrial Worker). The Central Statistical Organisation (CSO) publishes the first

consumer price index for industrial workers (CPI-IW) was compiled using retail prices collected from 261 markets in 76 centres. The items in the consumption basket in different centres varied from 120 to 160. Since January 2006, the revised CPI-IW series on the new base-period of 2001 gave a higher weight to services. Table 2 shows the weight of the six main commodity groups in the CPI-IW series. In 2011 it was further revised and expanded with base 2010, and in an attempt to develop a unified index, CPI (Urban Non-Manual Employee) was replaced by CPI (urban), CPI (rural) and CPI (combined). These series reflect the higher weight of services in the consumption basket, but their behavior has yet to be validated over time.

Table 2: Weights of CPI Series for All India Level

Group and Subgroup	Base 1982 (CPI-IW)	Base 2001 (CPI-IW)	Base 2010 (CPI-combined)
Food, Beverages and Tobacco	60.15	48.46	47.13
Fuel and Light	6.28	6.43	5.48
Housing	8.67	15.27	16.41
Clothing and Footwear	8.54	6.58	7.03
Miscellaneous	16.36	23.26	23.95

9. In the period of analysis, while centre specific CPI had to be aggregated to get an all-India index, WPI was already computed on an all-India basis. Moreover, services with administered prices and headline items such as food prices have a large weight in the CPI (Table 2). Because of all these reasons WPI was used as the preferred monetary policy measure.

10. WPI inflation (WPPI) averaged at around 5 percent per annum after 2000. Only the component 'Fuel, Power, Light and Lubricant (FPL&L)' had an inflation rate of 10 per annum from 2000 to 2007, showing higher pass-through of international oil prices to domestic inflation since oil prices were partially de-administered. FPL&L inflation was the key driver of headline inflation after 2000. CPI-IW inflation averaged around 7.67 percent from 1980 to 2009 (December). It decelerated after 2000, coming down from 8.6 percent in late 1990s to 4.4 percent in the period 2000 to 2005, but rose again to above 7 percent. Since food group inflation had the highest weight in the CPI-IW inflation basket, its high volatility drove that of CPI-IW inflation (Goyal and Tripathi, 2011).

B. Recent Behavior of Inflation

11. Our focus is on Indian inflation of the 2006–2012 period³. Figure 1a plots inflation in the WPI and in the consumer price index (CPI-IW). It shows a sharp dip in WPPI in 2009, but consumer price inflation rose to double digits in this period and by 2010 WPPI was back at ten percent. It stayed at that level until early 2012 when it fell to about seven percent and was sticky at that level even as consumer price inflation recovered to ten percent after a brief dip. Figure 1b shows the 2009 dip in WPPI largely followed that in fuel and power. Even as WPPI in food and in primary articles peaked that in manufactured products fell with inflation in fuel and power before recovering with it. The indices in Figure 1b are three month moving averages that show momentum and smooth out very short-run fluctuations.

(http://mospi.nic.in/mospi_new/upload/t4.pdf), and the Department of Labor (<http://labourbureau.nic.in/indexes.htm>) published the others.

³ Updated from Goyal (2012).

12. The component WPI non-food manufacturing is free of volatile headline components and therefore may more clearly reflect demand pressures or the pricing power of firms. The Reserve Bank of India (RBI) uses inflation in this as an indicator of excess demand. Food articles have a weight of about 50 percent in the CPI (Table 2). So Figure 1c graphs inflation in WPI non-food manufacturing and in CPI-IW food products. The pattern is similar to that in Figure 1a, except that inflation levels are generally lower in WPI non-food manufacturing compared to WPI, and higher in CPI-IW food products compared to CPI-IW. So headline components such as oil and food raised both aggregate CPI and WPI inflation.

Figure 1a: Inflation in WPI and CPI-IW

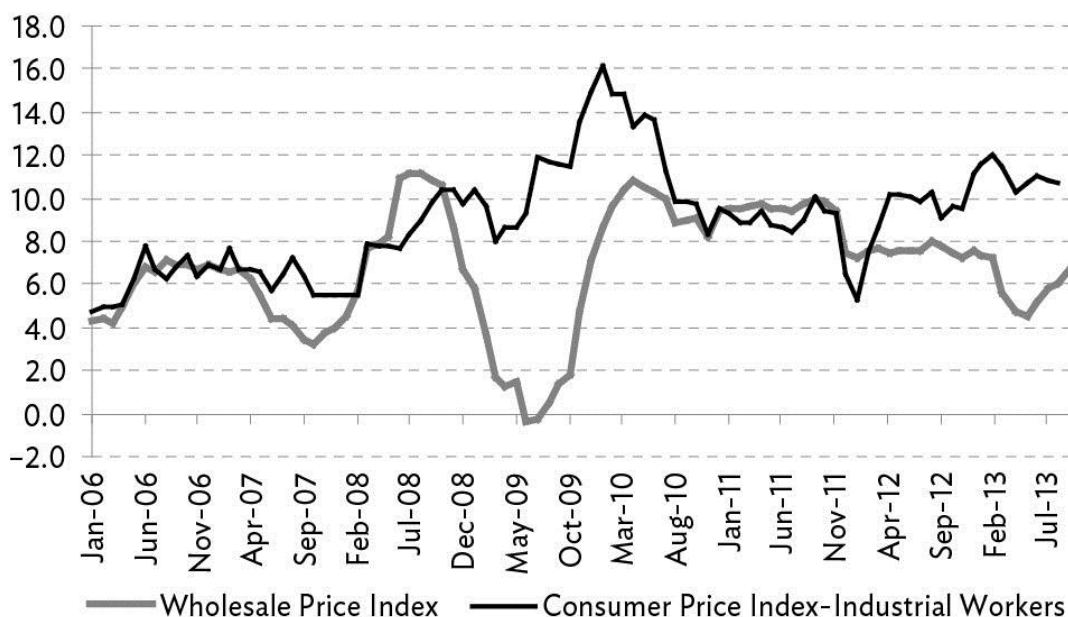


Figure 1b: Inflation in the Components of WPI; Three Month Moving Averages

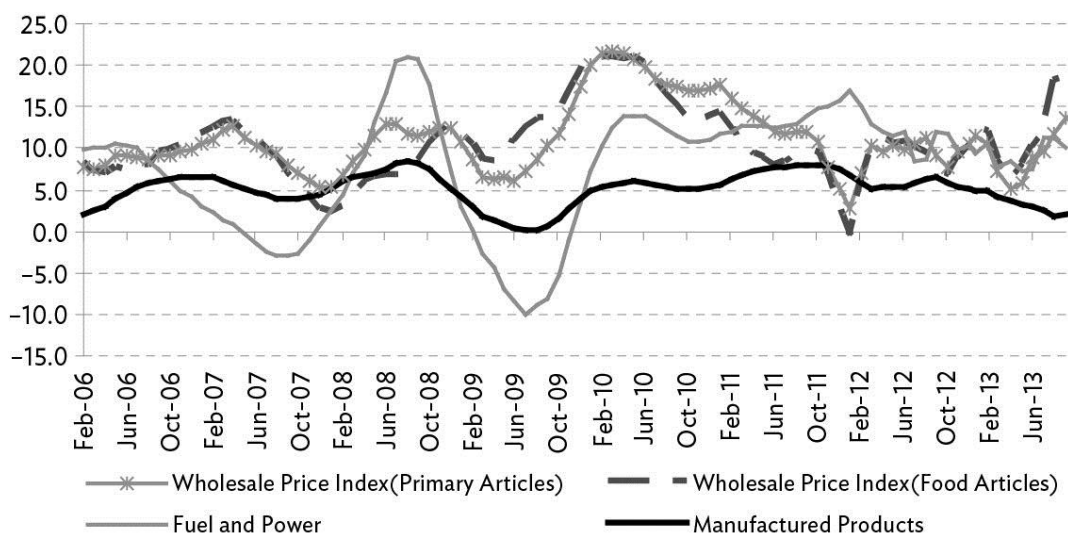


Figure 1c: Inflation of CPI_IW (Food) and WPI (Non-food Manufacturing)

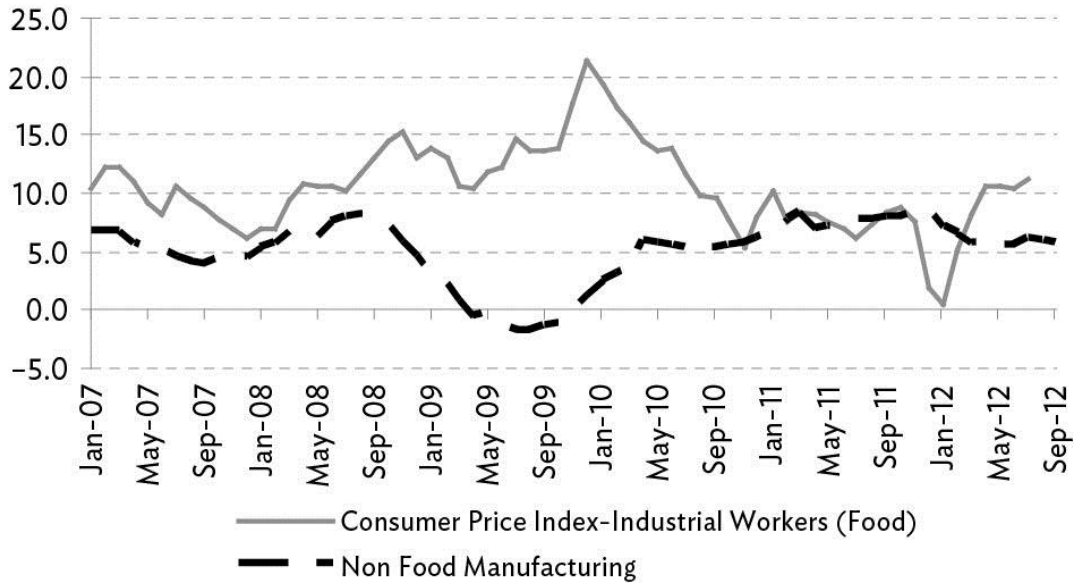
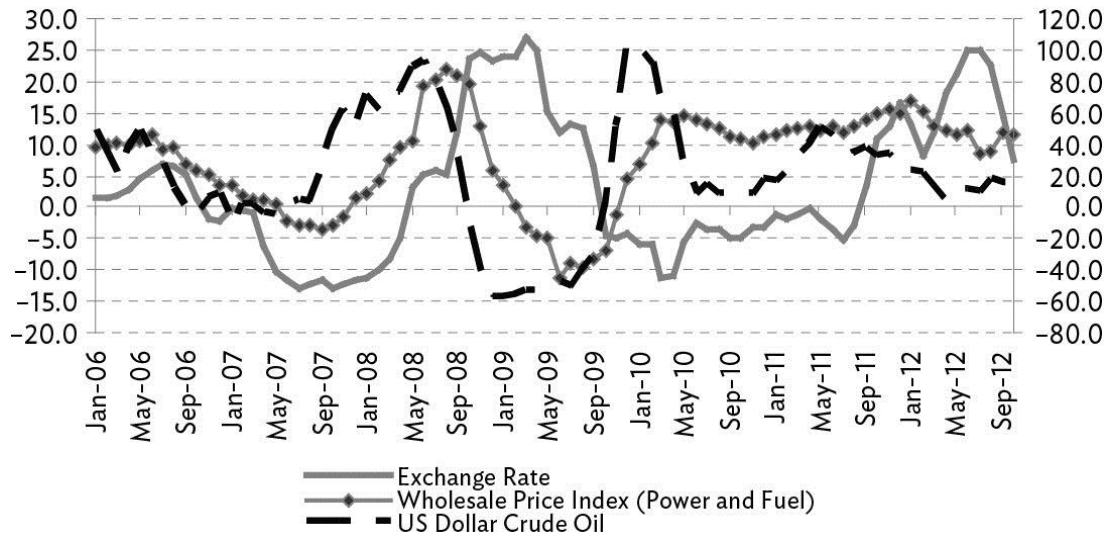


Figure 1d: Domestic and International Fuel Inflation and Changes in the Rupee Value (appreciation)



13. Figure 1d shows the external headline components. Pass through of variations in dollar crude inflation to Indian WPI (fuel and power) was quite large over 2006–2010 although Indian fuel inflation lagged and smoothed international inflation. But Indian fuel inflation remained sticky after mid 2010 although international crude prices fluctuated and softened. Although the administered component of WPI fuel had shrunk, the absence of pass through of commodity price softening in 2012 was partly due to sharp rupee depreciation in this period.

C. Growth and Monetary Aggregates

14. Growth dipped in 2008–2009 (Figure 2) following monetary tightening peaking in the summer of 2008 (the repo rate reached 9 percent) and remained at around 6 percent, 3 percent below peak growth rates for three quarters. CPI inflation continued in double digits over this period while WPII briefly plunged following the crash in oil prices. Growth cycles were pronounced especially in manufacturing and in Gross Fixed Capital Formation (GFCF) (Figure 2). Growth rates in Bank Credit and in Reserve Money had a similar cyclical structure, while Broad Money growth slowed through the entire period (Figure 3). On a first viewing, the impact of monetary tightening fell more on industry and investment growth than on inflation.

Figure 2: Rates of Growth in Output and Investment

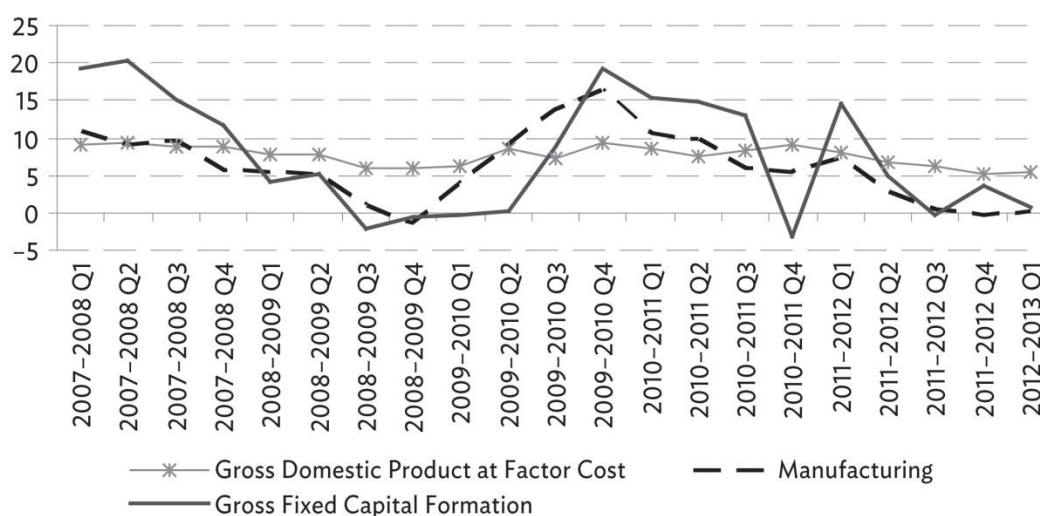
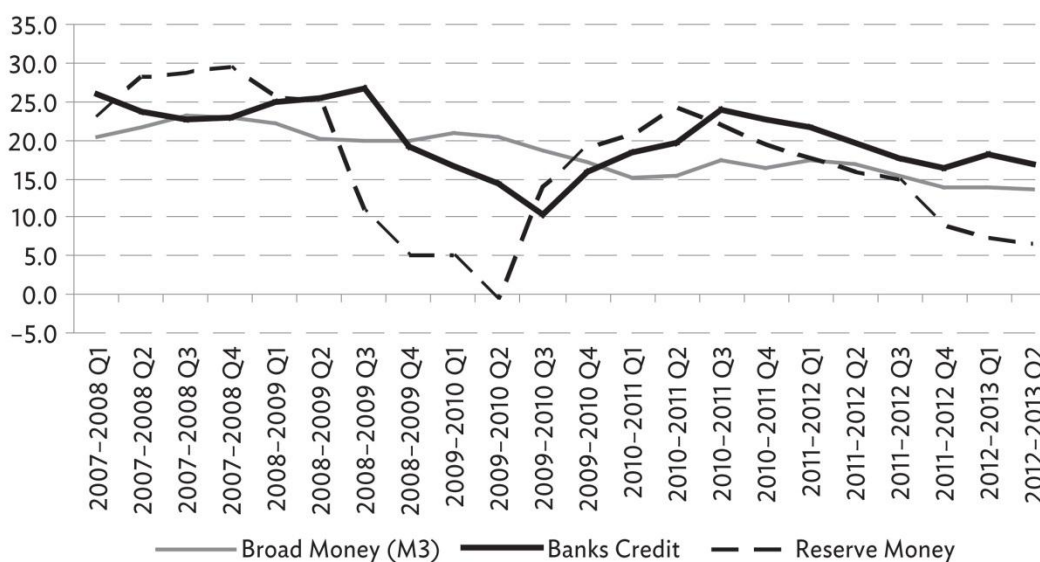
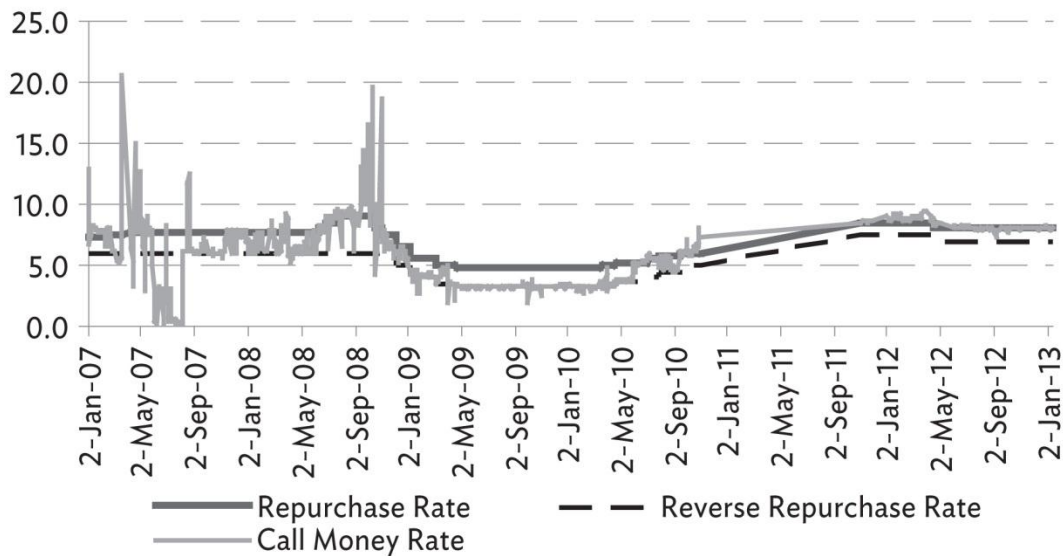


Figure 3: Rates of Growth in Money and Credit



15. Macroeconomic stimulus as part of the global coordinated postcrisis response led to a growth recovery peaking at around 9 percent in the summer of 2010. But growth slowed after that as a sharp monetary tightening cycle commenced from March 2010 and difficulties in obtaining clearances delayed infrastructure projects. The repo was raised from a low of 4.75 (the reverse repo of 3.25 was the effective rate since liquidity was slack) to a peak of 8.5 by October 2011 (Figure 4). Industry slowed from summer 2010, and for 2011–2012 gross domestic product (GDP) growth was only 6.5. It fell to 5.3, even below the 2008 level, in 2012 but inflation remained sticky. So the RBI cut the CRR. The repo rate was cut 50 basis points in April 2012 and 25 basis points in January 2013 but money supply and credit growth remained below targets, and the ratio of GFCF to GDP fell. The government struggled to reduce deficits that had doubled after the 2008 fiscal stimulus. WPI core inflation began to fall only from January 2013, two years after monetary tightening and industrial slowdown began. Moreover, the fall in WPII coincided again with softening global oil prices.

Figure 4: Policy Rates



16. Thus the experience was one of demand tightening reducing growth but not inflation, even as multiple supply shocks affected inflation.

IV. SOURCES OF INFLATION: AGGREGATE DEMAND AND SUPPLY

17. An aggregate supply curve (AS), elastic in output gap and inflation space, but subject to upward shocks (Figure 5(a)) is consistent with the outcomes enumerated in the earlier section⁴. A reduction in aggregate demand (AD) along such an AS leads to the large output sacrifice with little impact on inflation, as was the Indian experience in 2008 and in 2011. The alternative framework is inelastic supply, as in Figure 5b. With this, reduction in demand would affect inflation more than it would affect output.

⁴ IMF (2013) finds reduced responsiveness of inflation to economic slack, or a flatter slope of the AS, in advanced economies (AEs) in recent years, due partly to the better anchoring of inflation expectations. In EMs the reasons are likely to be different, including the greater impact of non-cyclical factors on wages.

18. The two frameworks also have implications for the definition of core or persistent inflation. If Figure 5(a) was valid, permanent supply shocks would generate persistent inflation. If Figure 5(b) held factors raising demand would be responsible. Formal tests to distinguish between the two hypotheses are reported in Section IV. Even if the AS slope lay somewhere between the two extremes it could be closer to one or the other. However, aggregate hypotheses alone are inadequate in the analysis of Indian inflation, since sectoral factors are also important. We examine these in the next two sub-sections.

Figure 5a: Elastic Supply

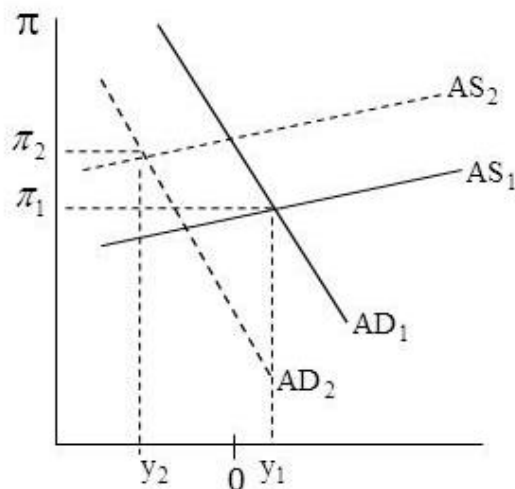
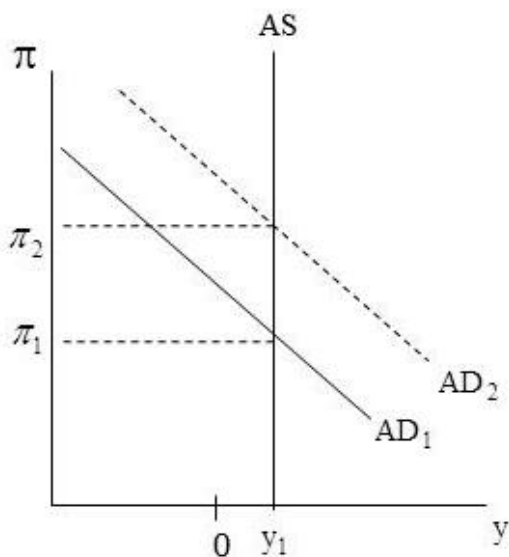


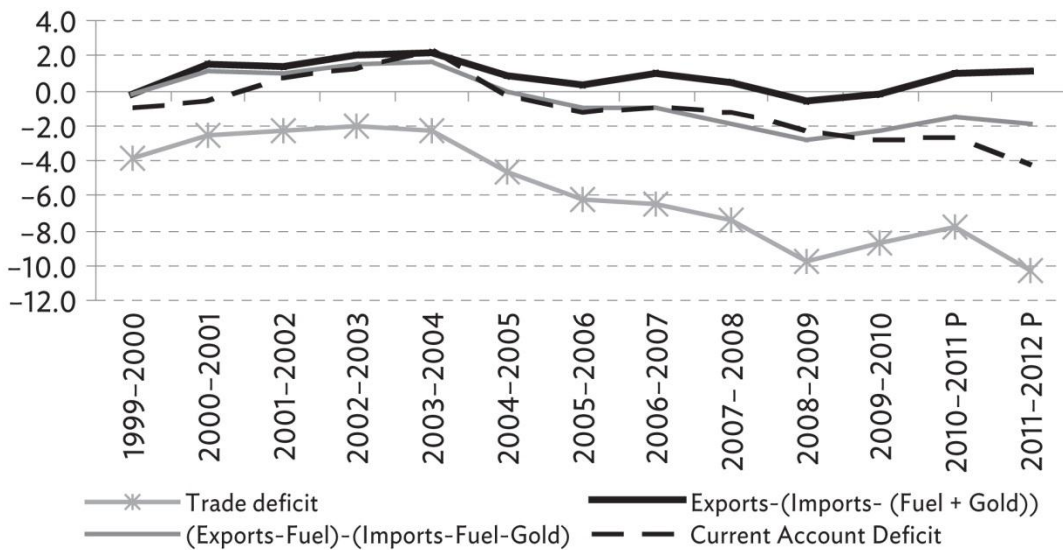
Figure 5b: Inelastic Supply



A. The Trade and Current Account Deficit of the Balance of Payments

19. The existence of twin deficits, fiscal as well as a current account deficit (CAD), in the period suggests there was generalized excess demand. However, even as the CAD widened in 2011–2012 (Figure 6) India’s GDP growth rate fell to 6.5 percent, compared to 8.4 per cent in the previous year. Growth in aggregate demand categories like consumption and fixed investment also fell. Imports of specific commodities such as crude oil and gold drove the deficit. If imports of oil and gold are subtracted from the trade deficit, it becomes a trade surplus (Figure 6). If petroleum products exports are also subtracted from exports a trade deficit of about 2 percent appears (Figure 6). All of India’s oil imports were not for domestic consumption since a large refining industry had developed.

Figure 6: Trade Deficit Adjusted for Oil and Gold and Current Account Deficit



Note: X = Exports; M = Imports; O = Oil; G = Gold.

20. The existence of twin deficits, fiscal as well as a current account deficit (CAD), in the period suggests there was generalized excess demand. However, even as the CAD widened in 2011–2012 (Figure 6) India’s GDP growth rate fell to 6.5 percent, compared to 8.4 per cent in the previous year. Growth in aggregate demand categories like consumption and fixed investment also fell. Imports of specific commodities such as crude oil and gold drove the deficit. If imports of oil and gold are subtracted from the trade deficit, it becomes a trade surplus (Figure 6). If petroleum products exports are also subtracted from exports a trade deficit of about 2 percent appears (Figure 6). All of India’s oil imports were not for domestic consumption since a large refining industry had developed.

21. An analysis of cyclical properties also suggests the trade surplus (net exports, NX) is procyclical in India rather than countercyclical as it would be if it was driven by domestic demand. Correlation of NX normalized by output with output (NX/Y with Y) is positive. NX/Y tends to fall in periods of low growth, associated with low domestic demand, rather than falling when rising growth and domestic demand raise imports. This is unlike most emerging markets (EMs) where net exports fall as output, consumption, and imports rise, so NX tends to be counter-cyclical. In the latter case, correlation of NX/Y with Y (output) would be high negative. Overconsumption, which can also be due

to low policy credibility and the associated belief that good times may not last, leads to widening EM trade deficits (NM, net imports or minus net exports, $-NX$) and CADs in such times. In developed countries, NX exhibits no strong relationship with income fluctuations. Consumption smoothing tends to make NX acyclical or mildly procyclical. So correlation of NX/Y with Y tends to be low negative for developed countries.

22. Estimated autocorrelation—or degree of comovement in NX/Y with Y , using quarterly data for 13 developed economies was -0.17 . The average value for 13 emerging, excluding South Asian, economies was -0.51 . For India, the autocorrelation estimated using annual data⁵ for the postliberalization era—calendar years 1980–2007—was 0.14. The South Asian region, excluding India, tends to have even more strongly procyclical correlations.

23. The NX can be procyclical if growth is export driven, for example, services export, so NX rises with output. As exports rise, they raise income and raise NX . On the other hand, a sudden collapse of export markets, due to a global shock, reduces income and decreases NX . Alternatively, if a contractionary rise in oil prices raises the import bill, NX would fall even as growth fell. If oil shocks raise costs, and as a result growth falls, NX would fall along with falling growth.

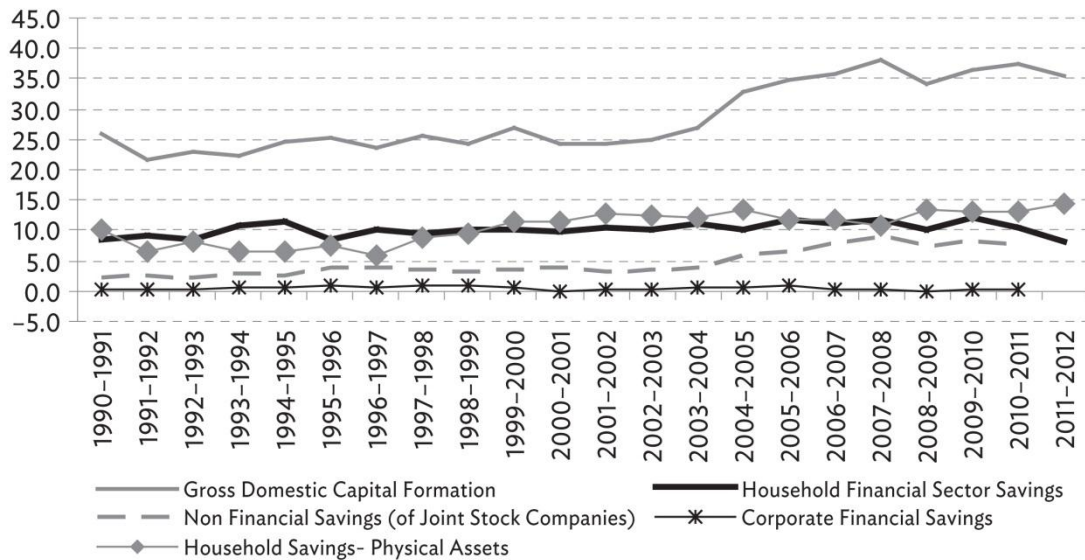
24. In the period after the financial crisis there was both a collapse in export markets and a rapid resumption in oil price hikes along with a widening CAD. As income fall, especially firm profits, so do savings. The CAD must equal $I-S$ by definition. Although investment is falling in slowdowns, savings can fall even more, widening the CAD. If oil shocks raise inflation, and this is sustained as over 2007–2013, low real interest rates and the absence of inflation hedges can especially lower financial savings. The latter finance investment that requires traded goods imports, while physical savings, such as in real estate and construction, are invested more in non-traded goods. So a fall in financial savings may widen the trade and current account deficit even more than a fall in aggregate domestic savings that occurred through a reduction in physical savings. Measurement practice in India implies physical savings are the same as investment in the unorganized sector. Household physical investment is measured as a residual, after deducting the shares of the corporate sector and of government. So the estimates of physical savings in the household sector are identical to those of physical investment. It follows if the rest of investment exceeds financial savings foreign savings must finance it.

25. In line with our analysis, 2011–2012, the year of CAD rising to 4.2 per cent of GDP, saw both a sharp rise in oil prices and fall in growth. As against this, the CAD was only 1.3 per cent in 2007–2008, a year of high consumption, investment and output growth. Figure 7 shows that Gross Domestic Capital Formation (GDCF) softened in the period the CAD widened. The CAD is also the difference between GDCF and Gross Domestic Savings (GDS). In 2011–2012 the CAD rose by 1.5 percentage points of GDP, from 2.7 per cent the previous year. Investment fell from 36.8 to 35 percent, or by 1.8 percentage points, while GDS fell more from 34 to 30.8 or by 3.2. The largest fall in a savings component was in household financial savings from 10.4 to 8 per cent, or by 2.4 percentage points. This, together with fall in corporate saving of 0.7, itself almost entirely accounts for both the widening in the CAD and the fall in investment. Household physical savings actually increased by 1.2 almost compensating for the fall in public sector saving of 1.3; both largely impact non-traded goods. Physical savings, invested in real estate, are regarded as a better inflation hedge.

⁵ The data are smoothed using the Hodrick-Prescott (HP) filter to remove short-run fluctuations. For quarterly series 1600 is used as the smoothing parameter. Since yearly data are observed only one-fourth as often as quarterly data, the value used is $1600/4^4 = 6.25$. Critical correlations were also calculated with unfiltered data and with 100 as the smoothing parameter with similar results. More details and other correlations are available in Goyal (2011a).

26. A countercyclical CAD in India’s case suggests that external supply shocks rather than domestic excess demand were the drivers. Supply side shocks are to be expected in economies that are still agriculture dependent, have severe infrastructure bottlenecks, and are dependent on oil imports. To the extent oil imports rise in booms they tend to make NX countercyclical, but the other factors could be dominating.

Figure 7: Investment and Components of Saving as a Ratio to GDP



27. So a CAD may not indicate excess demand but rather reflect supply shocks. If policy magnifies shocks instead of smoothing them, it could make NX even more procyclical. Low domestic pass through of international oil prices makes import demand inelastic, and inflation encourages physical savings. Growth of deposits also falls, as tightening reduces money and credit growth. Deposits are a major component of financial savings. These sectoral effects widen the CAD. As oil shocks raise net imports and inflation, domestic savings are diverted towards non-traded goods, raising the need for foreign savings.

B. Disaggregated Government Expenditure

28. A disaggregated analysis of government expenditure, sourced from budget documents, shows a rise in consumption transfers in the period. The ratio of revenue expenditure to total expenditure rose, as did ratios of transfers to States, of subsidies and of expenditure on social services to total expenditure, while development expenditure ratios fell (Figure 8). Figure 9 shows the peaks in public investment and capital outlays, as a percentage of GDP at market prices, reached in 1986-1987, were never recovered. Infrastructure spending was supposed to substitute, but delays due to problems in policy consistency and in clearances, raised costs of supply even as demand fell.

29. Since food constitutes a large share in the budget of lower income groups, consumption transfers would translate into demand for food. If restrictions and distortions in the agricultural sector prevent an adequate supply response, even over a longer period, food inflation would remain high, while monetary tightening would squeeze demand for industry, as in the Indian experience.

Figure 8: Government Expenditure Components

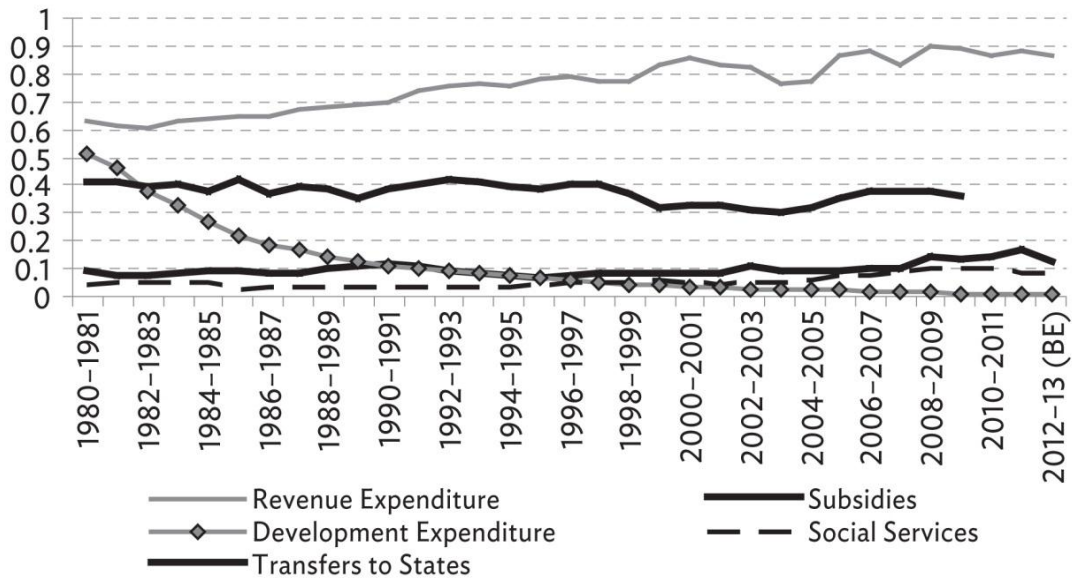
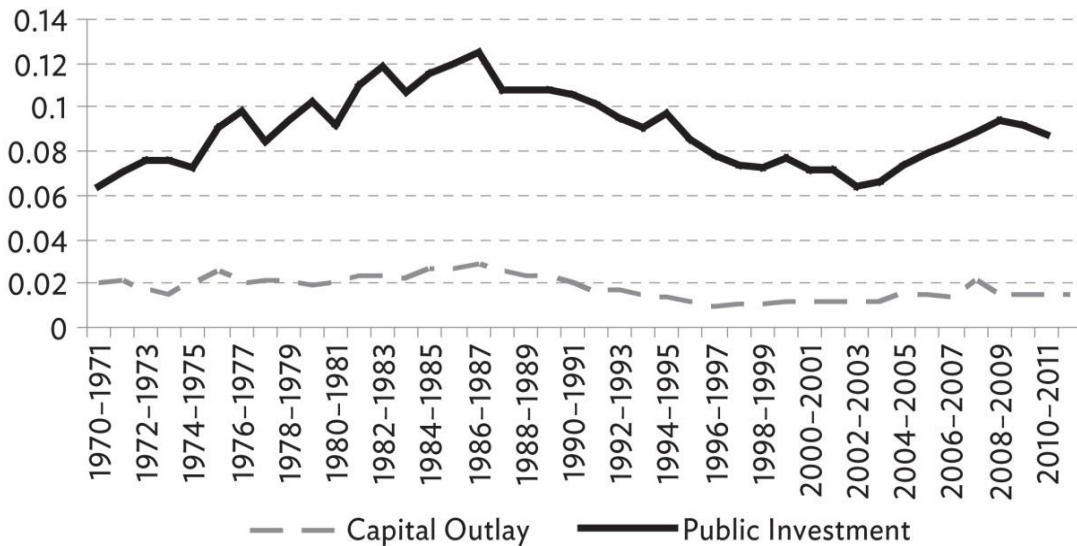


Figure 9: Public Investment Ratios



30. If a fall in the FD reduces growth but not the CAD, it implies government expenditure creates demand largely for non-tradable goods, not for imported goods. If so, a fall can reduce growth and soften domestic inflation but not improve the CAD. This is precisely what happened when the Government, pushed by fears of rating downgrades, made a serious effort to reduce the FD, in the last quarter of 2012. Growth in government consumption fell to 1.9 per cent from 8 per cent in the preceding quarter, while that for community, social and personal services as a whole fell from 7.5 to 5.4 per cent, inflation softened somewhat but the CAD rose to 6.7, its highest value ever, in that quarter. Thus sectoral issues contribute to the interplay between demand and supply factors in India.

V. ECONOMETRIC TESTS

31. In order to distinguish between the two demand and supply hypotheses we first estimate the elasticity of the Indian aggregate supply curve, and the shocks it is subject to⁶. Second, imposing the estimated elasticity restriction on aggregate supply, it is possible to extract measures of demand and supply shocks from time series of inflation and output growth. This gives further evidence on the relative impact of aggregate supply and demand shocks on inflation. Third, direct and indirect tests are conducted of the different components of headline inflation such as oil and food price shocks, their aggravation through changes in the exchange rate, their propagation through changes in wages and other mechanisms. These were the supply shocks and some of the factors that caused their persistence. Finally, changes in demand during periods of supply shocks are measured to test if there was excess demand during these periods. These tests and their results are given in the subsections below, while methodological details are given in appendices.

A. Aggregate Supply Curve

32. Traditional Phillips curves have wages that rise as unemployment falls. Translated into an AS curve, this implies an upward slope or prices that rise with capacity utilization or with the output gap or with above steady-state output growth, which are alternative measures of cyclical changes. The modern New Keynesian Economics (NKE) approach,⁷ has led to a large literature on estimation of aggregate supply, from a micro-foundation of firms' price setting. Work on India remains limited,⁸ but repeated cost shocks make it especially important to understand the effect of firms' price setting on inflation.

33. When a firm experiences a shock to its desired relative price, it resets price only when the change is large enough to cover menu costs of the process of change. That is, firms respond to large shocks and not to small shocks. If the distribution of relative prices is skewed to the right, many firms want to raise prices by a large amount while fewer firms want to reduce prices—so aggregate price will rise. Thus the skewness of the price distribution, derived from disaggregated price indices, gives a measure of aggregate supply shocks (AsymX).

34. The disaggregated Indian WPI shows a positive skew, which is especially large in periods of supply shocks. The asymmetry of the relative price distribution is used to proxy supply shocks in estimations of the AS curve. Moreover, prices rise more easily than they fall—average price increase over time is greater than average price decrease. While price increase is around 10 percent, price decrease is less than 5 percent. Therefore an aggregate inflation of about 5 percent is required to accommodate relative price changes.

35. First, a hybrid NKE Phillips curve with backward (the lagged inflation term) and forward (π_{t+t}) looking behavior is estimated. In addition to these terms, current inflation is a function of marginal cost. In this approach, a price which is varied is set as function of the expected future marginal cost. This variable, when directly measured, is found to work better in empirical estimations than its usual proxy, the output gap. Marginal cost is closer to the firm's actual decision variable. A

⁶ This section will draw on Goyal (2012b); Goyal (2012a); Goyal and Arora (2012); Goyal and Tripathi (2011); Goyal and Pujari (2005); Tripathi and Goyal (2011).

⁷ See, for example, Galí and Gertler (2000).

⁸ See Dua and Gaur (2010); Goyal (2008); Paul (2009); Singh, Kanakraj and Sridevi (2011).

proportionate relationship is assumed between the output gap and marginal cost. A cost shock, then, is anything that disturbs this relationship. Such deviations can occur due to changes in mark-ups as costs of intermediate inputs rise.

36. In the generalized method of moments (GMM) estimation, real industry level average unit cost, or labor's share of income, is used as a measure of real marginal cost. Since GMM is a generalization of the instrument variable estimator, it can estimate forward-looking behavior by instrumenting expectations under the assumption of orthogonal errors, thus taking care of possible endogeneity issues in single equation estimation. It can also adjust for non-normality in data, for heteroscedasticity and for autocorrelation.

$$\pi_t = \underset{(0.046)}{0.69} E_t \{ \pi_{t+1} \} + \underset{(0.05)}{0.28} mc_t + \underset{(0.06)}{0.29} \pi_{t-1} + e_t$$

37. J test for over-identification 0.218 (0.896) (the null hypothesis is that the model is "valid"); p-values are in brackets. Sum of coefficients on both lagged and lead inflation does not differ significantly from unity. The coefficients are functions of three model parameters as shown below.

$$\pi_t = \alpha_t E_t \{ \pi_{t+1} \} + \gamma mc_t + \alpha_b \pi_{t-1} + e_t$$

where:

$$\varphi = \theta + \omega [1 - \theta(1 - \beta)]$$

$$\alpha_t = \beta \theta \varphi^{-1}$$

$$\alpha_b = \omega \varphi^{-1}$$

$$\gamma = (1 - \omega)(1 - \theta)(1 - \beta \theta) \varphi^{-1}$$

where θ measures the degree of price stickiness; ω measures the degree of backwardness in price setting and β is the discount factor. The estimations imply parameter θ is about 0.516, that is, about half of Indian firms reset their prices in any period. The parameter ω is about 0.34, that is, 34 percent of the prices setting industries are backward looking. The estimated value of parameter β was 0.96.

38. Second, the hybrid PC is also estimated including the measure of supply shocks, *AsymX*. Tests showed that this variable performed better than other measures such as oil prices or dummy variables. It also captures the effect of non-oil cost shocks:

$$\pi_t = \underset{(0.06)}{0.78} E_t \{ \pi_{t+1} \} + \underset{(0.06)}{0.025} mc_t + \underset{(0.05)}{0.25} \pi_{t-1} + \underset{(0.01)}{0.027} AsymX_t + e_t$$

39. The coefficient of *AsymX* is small but significant. Including the asymmetry measure leads the coefficient on marginal cost to fall substantially. The slope or marginal cost coefficient in the previous regression may have been higher since it was capturing part of the shift in the curve due to supply shocks. Including a supply shock variable in the estimation of aggregate supply removes an omitted variable bias, which, in the presence of frequent supply shocks affects the estimation of aggregate

supply elasticity. It also shows that non-food manufacturing inflation may reflect cost shocks rather than excess demand based pricing power.

40. Supply curves estimated at the disaggregated industry level data to understand price setting at this level gave similar key results. In a disaggregated study of the effects of oil shocks on firm pricing, the coefficients on money supply growth while positive were generally much smaller than those on cost variables. There was evidence of forward looking behavior⁹.

41. The results give the elasticity of AS, and the degree of backward and forward-looking behavior. Half of Indian firms reset their prices in any period, and a little more than half are forward looking in their price setting. The estimated coefficients in this section suggest that the short-run AS is almost flat.

B. Demand and Supply Shocks

42. The stylized facts described in section II B and the estimations in III A suggest that supply is elastic in the short-run. Next, we first test the two alternative AS hypotheses in a 2 variable VAR model using long-run identifications. Second, impose the supported AS elasticity to recover the shocks from price and output time series thus estimating the relative impact of demand and supply shocks on inflation.

43. A formal time series test is applied to identify if the long-run aggregate supply (LAS) is vertical (VSC) or horizontal (HSC). If the VSC is the correct identification:

1. Impact of demand shocks on output should die down by the medium run.
2. Supply shocks should have little sustained impact on price levels.
3. Demand shocks should account for the major part of inflation.
4. Supply shocks should affect long run output.

44. If the HSC is the correct identification:

1. Impact of demand shocks on price levels should die down by the medium run.
2. Supply shocks must form the major part of inflation.
3. Demand shocks have a sustained long run impact on output levels.
4. Supply shocks should have little sustained long run impact on output.

45. On successively imposing these identifications in a two-equation structural model, using the annualized month on month rise in WPI, and the index of industrial production (IIP) as the output series, a high elasticity of long run supply could not be ruled out, because supply shocks had a large impact on inflation and demand shocks had a large and persistent effect on output levels.

46. The long-run restriction allows inflation to be decomposed into that due to short-run structural demand and supply shocks. Figure 10 reports these for the years 2010 to 2012¹⁰. A large impact of supply shocks on inflation and a large and persistent effect of demand shocks on output support an elastic LAS. The identification procedure for estimating demand and supply shocks did not impose any short run restrictions. If supply bottlenecks made the short-run AS steep, the estimation would also capture short-run effects of demand on inflation. Inflation could either be due to demand

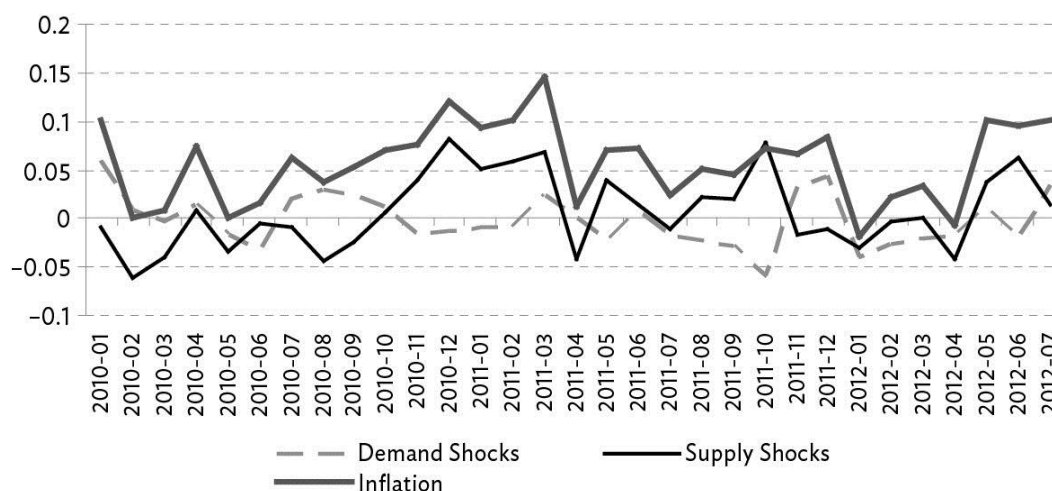
⁹ See Tripathi and Goyal (2011) and Tripathi (2012) for more details on the estimations.

¹⁰ The estimations update those in Goyal and Pujari (2005) and Goyal and Arora (2012).

shocks with a steep short run AS or to upward and leftward shifts of an elastic AS. Recent episodes and the estimation in III A suggest that supply shifts dominate inflation since the short run supply is also not inelastic.

47. Estimated demand and supply shocks (Figure 10) shows supply shocks largely caused inflation, while demand shocks were mostly negative when supply shocks raised inflation. Low agricultural growth, and the new plateau oil prices reached after the Arab spring (see Figure 1d) explain the large positive supply shocks over the end of 2010 to early 2011. The sharp exchange rate depreciation following the escalating Euro debt crisis was probably responsible for the peak in supply shocks towards the end of 2011. Periodic depreciation due to a high CAD and risk-on outflows kept supply shocks high over much of 2012, although there were periods when they reduced with softening global commodity prices. Rising wages due to inflationary expectations also contributed to supply shocks, but could not sustain them above 5 percent. By the end of the year, supply shocks were falling and demand rising although inflation remained sticky.

Figure 10: The Contribution of Demand and Supply Shocks to Inflation



48. There were multiple supply shocks, but no large and persistent second round pass-through. It is when such pass-through occurs and sustains supply shocks at above 5 per cent of inflation that output can be said to be above potential. Since prices rise more easily than they fall, positive manufacturing or core inflation from first round cost shocks alone does not imply output is above potential. Falling trend growth in a slowdown also need not imply potential growth has fallen.

49. The evidence suggests the estimated supply shocks in section IV B are due to shifts of an almost flat supply curve.

C. Testing for the Effect of Relative Prices on Aggregate Prices

50. Our estimate of aggregate supply shocks was based on a pass through of a relative price change into the price level. Some relative prices are especially critical. If a rise in food prices raises wages, it would also affect the price level. In this section we apply some indirect tests of this effect.

51. Since producer prices are inputs into final consumer prices, wholesale price inflation (WPI), as a proxy for producer prices, should cause consumer price inflation (CPI). Moreover consumer prices are a weighted average of the prices of domestic and of imported consumption goods. So there should exist a long-term equilibrium relationship between consumer and wholesale price inflation and the change in exchange rate—this is a macroeconomic identity.

52. But if producer prices are set as a mark-up on wage costs, the mark-up depends on demand pressures, and wages depend on consumer prices, the causality between wholesale and consumer price inflation could be reversed. Now CPI would cause WPI. The AS function underlies this relationship.

53. Since India's per capita income is still low, the share of food in the consumption basket is large. So, average wages may respond to food inflation more than they do to CPI. In that case, even if CPI does not cause WPI, the food component of CPI inflation (CPIIF) may do so. This would establish an important propagation mechanism leading to inflation persistence if rise in wages in turn caused a rise in food prices.

54. The restrictions on causal relationships suggested by the identity and the AS are tested using Granger causality. There is stronger evidence that CPI and food price inflation Granger causes wholesale price inflation (in the sense that past values of the first explain the second) when controls are used for other macroeconomic variables affecting the indices. That exchange rate depreciation Granger causes CPI food inflation also supports the identity. There is evidence of longer-term convergence between domestic and international prices in the major foodgrains.

55. Cointegration was used to test the underlying theoretical relationships. Since cointegration is found to exist, the short-run adjustment to equilibrium is also estimated. Long-term equilibrium relationships between consumer and wholesale price inflation and the exchange rate, from the identity and also through the AS function should exist. The two long run (cointegrating) relationships are found to hold. They are:

$$WPI_{t-1} - 1.127CPI_{t-1} - 1.045IIP_{t-1} - 1.003OIL_{t-1} - 0.838ER_{t-1}$$

$$CPI_{t-1} - 1.501WPI_{t-1} - 0.029ER_{t-1}$$

56. The first, which is the AS, implies that WPI rises with CPI, IIP, oil prices and the exchange rate. The second, which is the identity, implies that CPI is the sum of WPI and exchange rate. In estimating the adjustment to equilibrium for the CPI equation only the second CPI identity was significant, while for WPI the cointegrating equation derived from AS equation was significant. So adjustment equations are written for only the CPI and WPI variables in matrix form below, with t-values in brackets.

$$\begin{bmatrix} \Delta CPI_t \\ \Delta WPI_t \\ \Delta IIP_t \\ \Delta OIL_t \\ \Delta ER_t \end{bmatrix}$$

$$= \begin{bmatrix} -0.044(3.354) & -0.004(-0.686) \\ 0.015(-1.019) & -0.39(3.395) \\ \vdots & \vdots \end{bmatrix} \begin{bmatrix} CPI_{t-1} - 1.501 WPI_{t-1} - 0.029 ER_{t-1} \\ (NA) \quad (-6.549) \quad (-2.362) \\ -1.13 CPI_{t-1} + WPI_{t-1} - 1.045 IIP_{t-1} - 1.003 OIL_{t-1} - 0.838 ER_{t-1} \\ (-6.815) \quad (NA) \quad (-2.823) \quad (-7.029) \quad (-4.963) \end{bmatrix} +$$

$$\begin{bmatrix} -0.220(-2.118) \\ 0.211(2.589) \\ \vdots \end{bmatrix} + \begin{bmatrix} 0.379 & 0.349 & 0.022 & 0.002 & 0.014 \\ (3.79) & (-4.15) & (2.268) & (0.372) & (0.712) \\ 0.319 & 0.069 & 0.023 & 0.031 & 0.014 \\ (6.704) & (4.790) & (1.759) & (2.793) & (1.587) \\ \vdots & \vdots & \vdots & \vdots & \vdots \end{bmatrix} \begin{bmatrix} \Delta CPI_{t-1} \\ \Delta WPI_{t-1} \\ \Delta IIP_{t-1} \\ \Delta OIL_{t-1} \\ \Delta ER_{t-1} \end{bmatrix} + \begin{bmatrix} u_{1t} \\ u_{2t} \\ u_{3t} \\ u_{4t} \\ u_{5t} \end{bmatrix}$$

57. While OIL is not significant in the short run for CPI adjustment (ΔCPI), for ΔWPI , OIL, ER (exchange rate) and IIP (index of industrial production) came out to be strongly significant. Food price inflation is also cointegrated with manufacturing inflation.

58. In other estimates of NKE aggregate demand and supply curves for India also, lagged CPI inflation affects WPI inflation. Expected future CPI values significantly affect CPI inflation, but WPI inflation is backward looking (Goyal, 2008).

D. Factors Affecting Wages

59. Since a rise in wages is a major factor propagating relative price shocks into the price level we also conduct direct tests of the factors affecting wages. Indian real wages for rural unskilled male laborers were constant over April 2002 to August 2007. But after that growth was positive, with nominal wage growth exceeding that in the relevant CPI index (RBI 2012).

60. The first phase of Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS), a scheme guaranteeing 100 days of employment to each able bodied worker, was implemented on January 2, 2006, to cover 200 districts. It was extended to another 130 districts in 2007–2008, and to the whole country from April 1, 2008. Although the primary goal was insurance, labor employed was to be used to create productive assets, such as for water harvesting, which could raise agricultural productivity. It is often claimed MGNREGS raised rural unskilled wage growth above rural productivity growth. But this was also the period of high food inflation and episodes of depreciation. So it is necessary to test which of these factors had a greater impact on wage inflation.

61. State level monthly wage data, made available only recently, make it possible to try and disentangle effect of macroeconomic and policy variables on rural wages. The period 2008–2010 forms a perfect natural experiment, compensating partly for the short length of the series. It was a period of sharp rise in food prices and exchange rates due to external and therefore exogenous shocks, and was also the period of nationwide implementation of MGNREGS. We also use a longer panel running from 2005–2012, where it is possible to control for the endogeneity of macroeconomic variables.

62. We regress the State panel as well as average wages on variables such as nominal depreciation, food price inflation, aggregate demand variables and their lags. The first two sets of regressions

reported in Table 3 are from the shorter panel, and the last column from the longer panel. Column 2, Table 3 reports the results of regressing wage inflation for all the States on the set of macrovariables— industrial growth, inflation and depreciation. Column 3, Table 2 reports the results of regressing average wage inflation across all States on the set of macrovariables¹¹. The longer panel allowed more lagged variables to be included. Only the significant variables for the fixed effects panel are reported in Column 4. It has the advantage of more variation in output, but also more endogeneity. The R^2 is also low.

Table 3: Determinants of Wage Inflation in the States

Variables	2	3	4
	Wages	Average Wages	Wages (2005–2012)
Lag WPI (food) inflation	0.531 (2.57)	0.240 (2.95)	-0.60 (-3.44)
Lag exchange rate depreciation	0.170 (3.41)	1.04 (15.93)	0.18 (2.33)
Lag CPI inflation	0.649 (2.49)		
Lag IIP growth			0.13 (3.81)
CPI inflation			1.27 (10.56)
Exchange rate depreciation (y-o-y)			0.07 (2.36)
IIP growth (y-o-y)			0.06 (4.24)
R square	0.445	0.512	-0.04

Notes:

1. The regressions in columns 2 and 3 are with the short monthly panel 2008–2010. Correlation between errors and regressors were found to be 0. Pesaran's test of cross sectional independence = 1.676, Prob = 0.0936.
2. Column 3 is a fixed effects regression with the longer panel 2005–2012.
3. t statistics are given in brackets.

63. While the output growth variable was not significant in the shorter panel, both food inflation and exchange rate depreciation had highly significant positive effect on average and individual State wage inflation. The coefficient of IIP is significant in the last regression reported but is low compared to the others. Thus it was cost of living factors, in particular food inflation, that pushed up wages more than demand factors did.

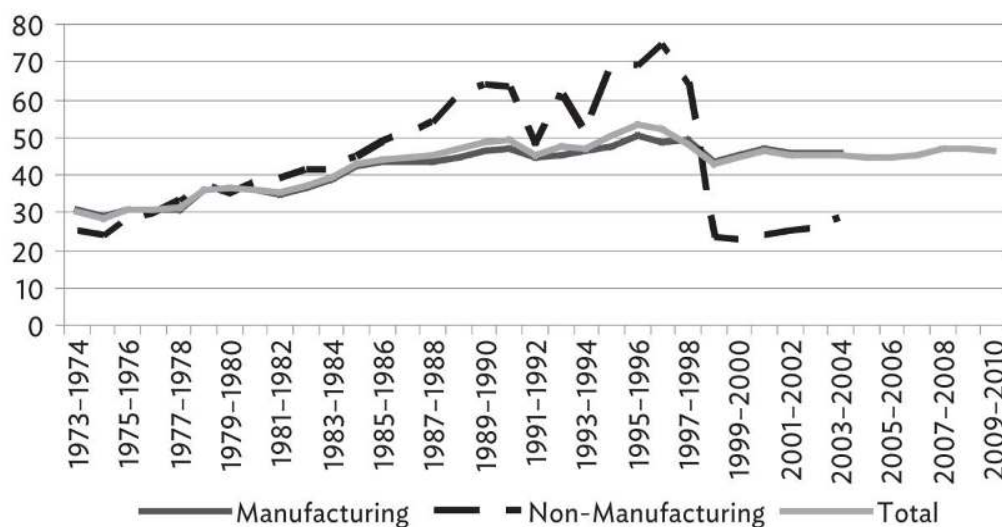
64. There was a large dispersion of wages across States and over time—State specific factors were also at play. States with high wage inflation were: Andhra Pradesh, Haryana, Odisha, Punjab and Tamil Nadu. The States with low wage inflation were Gujarat, Himachal Pradesh, Rajasthan, Madhya Pradesh and West Bengal. Rajasthan, Chhatisgarh, Andhra Pradesh and Madhya Pradesh were the States that on average performed better than other states over 2008–2010 in terms of universal coverage of the rural population under the MGNREGS. But the States with the highest wage levels in this period were Haryana, Punjab and Kerala in that order. The States that effectively implemented MGNREGS had neither the highest wage levels nor, with the exception of Andhra Pradesh, had the highest rates of wage growth. The average daily MGNREGS wage paid in 2009–2010 was INR 90.2 but was INR 150.9 in Haryana. In 2009 the notified daily MGNREGS wage was raised to INR 100 in most States, but was indexed to the CPI for agricultural labor only on April 1, 2012. During our data period there was no

¹¹ Wherever heteroskedasticity was found, the Prais-Winsten regression was used for robust errors. Pesaran CD (cross-sectional dependence) test was used to test whether the residuals are correlated across entities. Cross-sectional dependence can lead to bias in tests results (also called contemporaneous correlation), but the null hypothesis that residuals are not correlated was accepted.

indexation. That States with effective MGNREGS implementation did not have the highest wages implies macrovariables affected average wages more than MGNREGS and other State level factors.

65. The large response of rural wages to inflation, and therefore of informal wages that are linked to rural wages, is however a new feature. This will be intensified with the indexation of the MGNREGS wage. Figure 11, based on ASI data, shows that in the downturn following peak interest rates after the East Asian crisis, manufacturing real wages did not fall—these were indexed to inflation. But nonmanufacturing real wages which may not have been so indexed fell. India's large informal labor probably bore the brunt of a slowdown as lower employment reduced their pricing power. A growth sacrifice to contain inflation used to work by reducing employment and wages more in the informal sector.

Figure 11: Real Wages Per Worker Per Year (CPI(IW))
(in '000s)



66. But informal wages are also now being partially indexed through MGNREGS, so employment growth will fall but sticky real wages will keep up cost pressures. In 2012 MGNREGS wages exceeded State minimum wages in 21 States. They now set a floor to wages in many informal sector activities, and reduce indexation lags. The multiple supply shocks identified in section IV B suggest, however, that indexation is still not complete enough to trigger a wage response exceeding productivity sufficient to sustain upward shifts of the supply curve. Food price inflation is still the most important trigger for wage increases.

E. Governance Failures

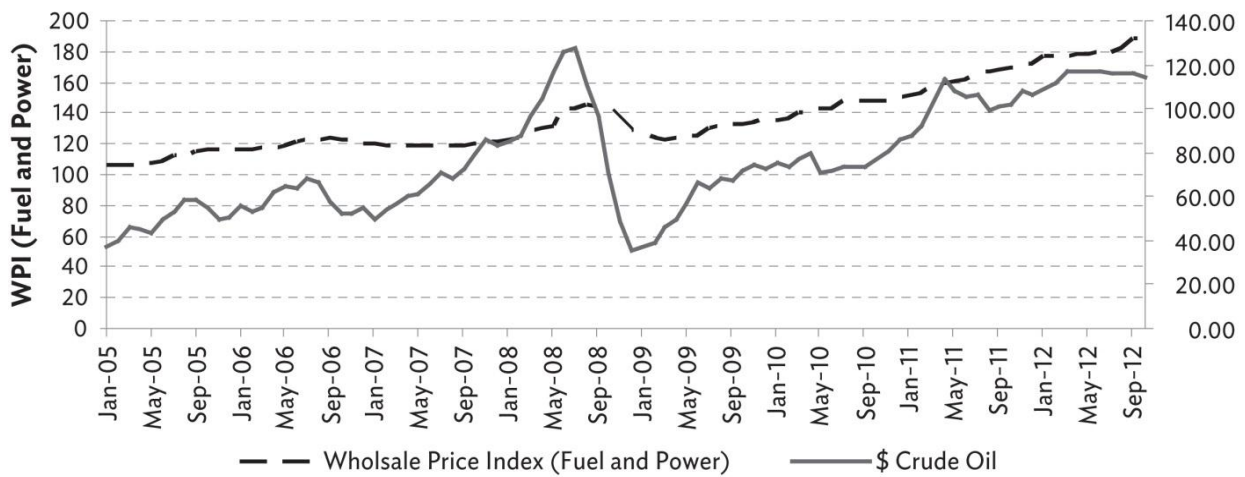
67. In addition to the propagation mechanisms identified above, governance failures also impart an upward bias to prices, forming another set of mechanisms to propagate supply shocks. While some administered prices are frozen others, where there are active lobbies, are raised too much. The minimum support price (MSP) given to farmers tends to impart an upward bias to food prices. The distance from international prices is used to force a rise in domestic prices. One reason for low inflation over 2003-2007 was low global food prices—so Indian MSPs were not raised. In 2007 as the gap

between domestic and international foodgrain prices rose sharply, farmers’ lobbying secured steep rises over the next few years.

68. Farmers benefit from stable prices—a sharp price rise induces oversupply in the next season, and reduces farm revenue. Raising producer prices steeply yet attempting to protect the consumer through the public distribution system (PDS), is a source of corruption, apart from the distortions in movement of foodgrains and monopoly marketing channels created to ease government procurement. All of these disrupt supply chains and raise costs. If procurement prices become true support prices and government foodgrain stocks fall, food security can be more effective through a combination of food coupons or conditional cash transfers in urban areas, and PDS in rural areas where markets are thin.

69. World commodity prices rise and fall sharply. In India since they are administered they do not rise as sharply, but they also never fall—so over time the cumulative rise can be higher. Figure 12 shows Indian fuel prices are less volatile than international, but unlike for the latter, trend upwards. Inflation is higher over time. Such a system of price setting can convert a temporary supply shock into a persistent shock. In recent periods domestic prices also fluctuated as exchange rate fluctuations raised non-administered oil price components (Figure 1d). Moreover, since administered prices become a political decision, it is difficult to change them. Thus despite steep cost escalation passenger fares have not been raised in Indian railways since 2003. Freight rates have been raised, since this is an indirect charge the voter does not perceive. So the voter pays less for train travel but more for every good she consumes as transport costs rise. Indirect costs are even higher—Indian rail lost freight to subsidized environmentally polluting diesel trucks with much higher social costs.

Figure 12: Indian and International Oil Prices



70. This is just an example of how poor public service delivery raises costs. Unreliable public power leads to high cost and polluting use of private diesel-based generators. Large consumption subsidies and tax breaks reduce government spending on essential infrastructure, creating bottlenecks that raise costs. Potential expansion in capacity is lost. Wastage and ineffective expenditure adds to these costs.

71. Many populist policies give short-term benefits but raise hidden or indirect costs. This holds even for policies that prevent prices from rising. Examples are price caps that freeze key prices and user

charges. These distort relative prices and therefore the allocation of resources. Both producers and consumers get wrong signals. Distortions in fertilizer and diesel prices have destroyed the environment and created serious health costs. Subsidized diesel has created a black market in adulterating petrol. Free electricity and over-irrigation has harmed the water table, and soil fertility—again raising costs of production.

72. If user charges are not raised when costs of production are going up, for example due to oil shocks, normally the quality of the service is reduced. This partly explains the poor quality of many public services, which again creates indirect costs (Goyal 1999). Thus although the initial shift in the domestic supply curve is moderated, it is converted into a chronic upward creep.

VI. POLICY IMPLICATIONS

73. The analysis above suggests the first best policy is supply-side action to shift down the AS, to the extent possible, in response to supply shocks, or at least to prevent its further rise. In the absence of this, monetary-fiscal demand-side tightening may have to be used to anchor inflationary expectations but would require a large growth sacrifice. Unfortunately, such tightening, together with the conversion of temporary supply shocks into rising chronic inflation through upward shifts of the AS curve, is the most common policy combination implemented during past inflationary periods.

74. Growth sacrifice is high since a flat AS curve implies output gap or cyclical variables have little effect on goods inflation. Their effect on wage inflation was also found to be low (Section IV.D). The estimated effect of food prices and the exchange rate on rural wages was much larger. The estimated coefficients in Table 4 suggest, in the presence of food inflation, a very high output contraction would be required to reduce wage growth. A reduction in food price inflation itself would be more effective. The factors affecting wages are largely those that shift the AS work.

Table 4: Monetary and Fiscal Policy and Outcomes in High Inflation and other Years
(Average annual rates)

Years	Monetary Shock	Fiscal Shock	Policy Shock	Credit Shock	Demand Shock	Real GDL Growth	WPH Inflation
1972-1975	-0.4	-0.4	-0.8	-0.6	0.4	1.8	18.5
1975-1979	0.7	1.0	1.8	0.	0.3	5.8	1.6
1979-1981	0.4	-0.6	-0.3	-1.3	-3.1	1.0	17.7
1981-1990	0.3	0.4	0.7	0.1	-0.6	5.6	8.0
1990-1992	-0.4	-0.9	-1.3	-0.6	-13	4.0	11.4
1992-1994	1.3	0.1	1.4	1.7	0.3	5.7	8.4
1994-1995	0.6	-0.6	0.1	-0.9	1.8	6.4	12.6
1995-2008	0.1	-0.1	0.	0.1	0.6	7.0	5.2
2008-2009	0.5 (-1.1)	1.4	1.9 (0.3)	-0.7	-0.7	6.7	8.1
2009-2010	0.0	0.2	0.2	-1.2	1.3	8.4	3.8
2010-2012	-1.8 (-0.5)	-0.5	-2.3 (-1)	-0.8	-2.4	7.7	9.4

Notes: From 2001 the rise in the repo rate rather than fall in reserve money is used as the measure of monetary tightening. The terms in brackets shows policy shocks using change in reserve money. Figure in bold indicate the years in which inflation was in double digits; WPI = Wholesale Price Index; GDP = Gross Domestic Product.

75. Under a demand shock, to the extent firm price setting is forward looking, the Taylor Principle says policy rates should rise at least as much as core inflation. Inflation is anchored, with zero output cost, as firms do not set higher prices that would then be sticky, raising future inflation in line with expectations. There is no tradeoff between growth and inflation for a demand shock, but under a supply shock, for inflation to be reduced, growth must fall. If price-setting is backward looking there is a potential tradeoff even under demand shocks. Output can increase in the short-term since prices rise fully only later. To that extent policy tightening should be staggered also, to reduce the output sacrifice imposed. Policy demand contraction should be less than the output contraction. But the analysis below shows it generally exceeded output contraction. The maximal output sacrifice was imposed while inflation was not effectively reduced.

76. Table 4 shows the “monetary” and “fiscal” shocks and sum of the two in the “policy” variable. These shocks identify the policy induced demand shock, and also show if monetary and fiscal policies acted in concert or at cross purposes. The bold figures show the monetary and fiscal response to periods of inflation above 8 percent, which were all periods of an adverse supply shock. The table gives the average annual rates over inflationary and non-inflationary years.

77. The monetary policy shock is calculated as the change in reserve money growth before 2002 and the change in the repo rate after 2002. The fiscal policy shock is the change in the sum of Central Government revenue and capital expenditure each as a percentage of GDP. That is, period t gives the total of the two fiscal policy variables each minus their respective values in period $t-1$. A similar calculation is done for the monetary policy variable. A negative value implies policy contraction exceeded that in GDP. Policy amplified supply shocks since the contractionary impulse exceeded the fall in output. It was negative in years when the GDP growth rate fell due to a supply shock. The only shock period in which policy was countercyclical was 2008–2009 when the GFC constituted a large negative external demand shock. Monetary policy was also not procyclical over 1995–2008, as it generally was in other periods. Also monetary policy and fiscal expenditure do tend to expand and to contract together.

78. The “credit” variable does a similar calculation for broad money M3, bank credit to the commercial sector and total bank credit, the sum divided by three. Credit also contracted in periods of policy tightening, and it grew at less than the GDP ever since the GFC. Finally the “demand” shock measures changes in domestic absorption relative to GDP. It is the sum of changes in private final consumption expenditure (PFCE), government expenditure (G), Gross Domestic Capital Formation (GDCF) each as a percentage of GDP.

79. In general Table 4 shows each shock, plus the policy response, imparted a considerable negative impulse to aggregate demand, even as the supply shock pushed up costs. Demand remained positive through the first oil shock years but fell steeply in 1975–1976. It was consistently negative through the eighties, which were the years of largest fiscal deficits and RBI accommodation! Since the table measures final demand categories, perhaps large government transfers were siphoned away, maybe abroad, without reaching beneficiaries to create demand, or they raised prices of inelastically supplied non-traded goods.

80. Policy shocks were no longer negative after the mid-nineties, and demand shocks remained positive. But they became highly negative in 2011–2012, as policy contracted severely. Rates of inflation and the output sacrifice were lower under recent shocks, although policy reactions remained as severe, suggesting greater resilience and diversity due to a larger share of the private sector.

81. Once the structure of demand and supply, their respective elasticities, and frequent supply shocks are identified, implications follow, for monetary and for fiscal policy. These are divided into those applicable in the short and in the long-run. Issues of coordination between monetary and fiscal policy and anchoring wage-price expectations are also taken up¹². Policy needs to play a stabilizing role, with more nuanced and smaller yet forward-looking adjustments.

A. Temporary Shocks and Stabilization

82. Examples of temporary shocks that raise domestic prices are monsoon failures, international oil or other commodity shocks that raise border prices. Since price adjustment is asymmetric, prices rise more easily than they fall. This, together with elastic supply, implies tightening in response to a cost shock will impact output more than prices. It follows policy may allow the first round pass through of a temporary cost shock without tightening.

1. Short-term Monetary-Fiscal Coordination

83. But for such monetary forbearance coordination is required with fiscal policy. Short term supply-side fiscal moves such as reduction in excise and tariffs, freer movement of food, imports etc. can partly shift down the supply curve. The supply shock itself is extended because of delayed administrative pass-through. Instead an oil price shock should be passed through to restrain consumption. A nominal exchange rate appreciation can abort pass through for a temporary oil price shock.

84. If key relative prices that trigger propagation mechanisms are involved, policy must react quickly. Foreseeing second round effects, early but mild tightening, to at least the neutral interest rate based on expected core inflation, together with supply-side measures, could anchor inflationary expectations without a sharp reduction in demand. It can prevent inflationary wage expectations from setting in, shifting up the supply curve, and making inflation persistent.

85. If tightening is required, both fiscal and monetary policy should tighten together. If one is lax the other may be forced to tighten too sharply. Even if inflation rises above a threshold strict inflation targeting, is best avoided. Weight must also be given to the output gap.

2. Implication of Firm Wage and Price Setting

86. Our estimated firm behaviour has implications for monetary policy and the tradeoff between inflation and growth. A sharp policy response to a rise in expected future excess demand can prevent the 66 percent of forward looking firms from raising prices. Since the higher prices persist for about a year, policy that anchored inflation expectations would reduce inflation persistence. Under demand shocks this is without any cost to output since inflation is reduced by reducing future, not current, output gaps. The policy rate change itself can be moderate to the extent firms internalize future rise of rates on the changed policy path. The rate rise can, but need not, add up to inflation over the entire tightening path. Rates need not rise as much as inflation immediately.

87. However, 34 percent of firms continue to be backward looking, so there is some price inertia and lagged effects of policy rate changes. A reduced but continuing share of administered prices aggravates this. This also implies policy response to supply shocks should be moderate, the size of

¹² The arguments draw on and update Goyal (2010, 2012a).

tightening reduced, and tightening cycles must not be prolonged—since it is standard backward looking stabilization that is required. So in order to anchor inflationary expectations to prevent second round pass through, yet allow lagged adjustment to play out, while being responsive to early signs of the cycle reversing, step changes in interest rates conditional on directional changes in inflation can be effective.

88. Other effects of high interest rates also suggest moderation in their use. They tax the most dynamic interest elastic component of the economy, such as consumer durables and investment thus reducing capacity. They affect the ability to repay of indebted firms, and reduce loan quality of banks. Even if real interest rates are low, they normally coincide with supply shocks when costs rise for both firms and consumers. A staggered conditional rise in policy rates will raise real rates in response to suppressed inflation that is expected to manifest in future.

89. Strategic capital controls and signaling can also affect exchange rates separately from interest rate policy. In Indian conditions the exchange rate may have a broader reach compared to the interest rate—it affects costs in the informal sector and headline as well as core inflation. Even so large spikes in the exchange rate must also be avoided, since they affect firms who have borrowed abroad, as well as exporters, adversely.

90. Constraints on interest rates use can be mitigated somewhat by direct action on credit quantities through LAF injection and absorption of liquidity and through CRR requirements. Smoothing the effect of autonomous shocks to liquidity through capital flows and changes in government cash balances can reduce bank transaction costs and ease pass through of policy rates.

91. Short-run policies work only for a temporary shock. A permanent shock requires a productivity response. Adequate supply-side policies that anchor inflation expectations and wage responses prevent a temporary shock becoming persistent through second round effects.

B. Longer-term Response: Structural and Fiscal Reforms

92. The major supply shocks have been food and oil prices but poor governance has turned these into chronic inflation. Given the sensitivity of wages to food prices, interventions in agriculture have been increasingly inappropriate for a period of terms of trade shocks and diversifying diets. India chose to subsidize agricultural inputs, together with implicit taxes from export and marketing restrictions, a price support and procurement program incentivizing farmers and a public distribution scheme (PDS) to protect consumers. Procurement prices were raised with a rise in border prices but did not fall with them, thus imparting general cost-push, and creating large food stocks in costly and dysfunctional food support programs. Foodgrains, for which the elaborate food policy structure is designed, now account for only 25 percent of agricultural output. Price support in cereals with continuing poor infrastructure and distortion of marketing to help public procurement prevents diversification in response to changing dietary patterns. Each external commodity price shock further magnifies domestic distortions.

93. The new food security ordinance (2013) has the advantage of allowing States to choose their own delivery methods. Food coupons or cash transfers to females can provide food security to the poor while allowing them to diversify their food basket. The PDS should focus on remote rural areas where private outlets are thin allowing government food stocks shrink. Raising nominal farm prices does not guarantee favorable terms of trade, as nominal wages, industrial prices and input costs also rise with lags. Since income elasticity of demand for food is still high, more moderate nominal price

increase may incentivize better agricultural output and income growth, as happened in the eighties. Government procurement should shrink to that required for a true price support program.

94. A new approach that strengthens local institutions, reduces risk, and waste of produce, thus creating new options for farmers, is required to improve agricultural productivity. Multi-brand FDI in retail can help but will take long to fructify. Domestic changes to improve inter-state connectivity and competition in agricultural marketing could be faster, and would make FDI more effective when and if it did come in. Agricultural production and distribution are on the concurrent list. The Centre can legislate on the movement of goods and on creating a national market. But even without that, two or more States can pass a resolution on goods movement under Article 252 of the Constitution. States can be motivated by making key allocations conditional upon reforms. Once a few States start showing positive results, others will follow. Experience with recent Finance Commissions and the Jawaharlal Nehru Urban Renewal Missions show that incentives work with States, if they are not subject to political renegotiation. They should be made more formula based.

95. Since MGNREGA is a source of wage indexation and inflation propagation it must be focused on creating assets, through conditional allocations. Officials implement a clear target given to them. With asset creation as the objective, employment would be created as a by-product.

96. Formula based pricing in the oil sector could reduce political pressures that lead to lags in adjustment to external price shocks, yet deliver some smoothing and burden sharing even as regulatory capacity and competition are encouraged. Faster pass through can encourage fuel economy. That fuel prices in India rise but rarely fall is another feature that turns a temporary supply shock into a persistent one, and imposes large externalities on the economy. This could change.

97. A rise in productivity allows higher wages to be consistent with the more depreciated and competitive real exchange rate required to reduce the CAD. A rise in agricultural productivity, especially, reduces pressures for rising wages and domestic second round inflation, thus reducing real exchange rate appreciation from higher domestic inflation differentials.

98. An FD implies a government's expenditure exceeds its revenues. Large FDs in India are thought to create excess demand that drives Indian inflation. But Table 4 shows large demand compression during inflationary episodes and Figures 8 and 9 show it was the composition of government expenditure which was the problem.

99. If the composition of government spending changes towards building human capacity and improvements in public service delivery, it can deliver 'active inclusion'¹³, remove the fear of unsustainable deficits, and improve the supply response. Strengthening institutions and thickening democracy are imposing more continuous accountability. State elections are also rewarding better governance. But better systems are required. Poor coordination means multiple government agencies do not factor in each other's costs, or consider the big picture.

100. Given high private savings, relatively low government debt, and growth prospects, current deficits are manageable, provided there is a credible fiscal consolidation path. Improvements in institutions and laws such as the FRBM Act did succeed in reducing deficits, especially in the States where they were complemented with incentives.

¹³ Defined as inclusion which creates the conditions for the majority to contribute to and participate in growth (Goyal, 2012c).

101. If improvements in governance reduce cost pressures on inherently elastic supply, monetary policy can support demand. Monetary-fiscal coordination would improve reducing the cyclicalities seen in Indian growth rates.

C. International Reform

102. EMs must find non-distortionary ways to respond to spikes in food and commodity prices, but large global spikes imply international distortions, which should also be reformed. Excess liquidity creation in the West may be required to deal with their slowdown, but they must agree to reforms in financial regulations and in the global financial architecture that mitigate the spillovers to EMs from such policies. The spillovers include volatile risk-on risk-off capital flows, spikes in commodity prices and in exchange rates. EMs now have more voice in global fora such as G-20 and BIS and they must use them in a coordinated and research-based manner. One reform they could push for is standardized position limits in futures markets around the world. There is evidence that countries that imposed such limits were able to reduce short term bubbles in futures markets (Goyal and Tripathi, 2012). Convergence to common regulatory standards is necessary to prevent arbitrage. Another rise the availability of swap lines as and if required when quantitative easing tapers off.

VII. CONCLUSION

103. Theory, structure, estimations and recent episodes suggest Indian AS is relatively flat but subject to upward shocks—giving an important role for supply shocks in the explanation of inflation. The rise in policy rates in 2008 and in 2011 affected growth first, not inflation. If prices and wages are sticky downwards and output is elastic, it will be growth that adjusts first after a monetary shock. The paper reports econometric evidence. Low coefficients on the output gap, the IIP, and marginal costs suggest a flat AS—output gap does not have much impact on prices. The demand variable is insignificant in short-run adjustment. Including supply shocks reduced the coefficient of marginal cost. Theoretical derivation for an open EM with a dualistic labor market also supports such a structure of AS (Goyal, 2011b).

104. Underlying the slope of the AS is India's youthful demographic structure and large population transferring to higher productivity employment. New entrants to the labor force are estimated to be 12 million per year. So supply can be expected to be even more elastic in the longer-run as capacities are built. The NSSO 66th round showed double digit unemployment among the skilled in 2009–2010. Higher growth during catch-up periods implies that unemployable labor becomes employable. Structural unemployment reduces in a reversal of the process whereby cyclical unemployment becomes structural. If the unemployed lose skills after a long out of work period, a demand stimulus alone cannot reduce unemployment. In a growing economy, in the reverse process, remedial training becomes available to upskill available labor. Short-term training institutes adapting skills to requirements have mushroomed. So labor is available in response to demand. Underlying the shifts are a rise in wages and other costs, due to governance failures that aggravate exogenous shocks.

105. It follows policies that shift AD alone without reducing costs or moderating the shifts in the AS involve a large growth sacrifice, without much impact on inflation. But in the absence of such policies, the growth sacrifice becomes necessary, although it is not very effective, to moderate sticky inflation expectations and the rise in wages that itself shifts up the AS curve. The country experienced just such a slowdown in 2012. Given the sensitivity to food price inflation and aspiration effects, wages rise in response to such inflation, even without labor market tightness. Sectoral bottlenecks and poor

governance also shifts up the supply curve at all levels of output, not just at the margin. Shift rather than cyclical factors dominate inflation.

106. If policy is able to abort the propagation mechanisms pushing up the AS curve, output and employment sacrifice from supply shocks can be reduced even as inflation is kept within bounds. Oil price shocks need to be passed through more with prices allowed to rise as well as fall. Monetary policy needs to respond only to a second round pass through with early but mild tightening in response to sensitive prices such as food. The mixture of forward and backward looking price setting reduces the optimal intensity and length of monetary tightening cycles provided supply-side fiscal support is forthcoming.

APPENDIX: DATA AND METHODOLOGY

107. The methodology of the study is a combination of stylized facts and formal hypothesis testing, using time series and panel regression techniques.

A. Data

108. All the data series are seasonally adjusted using ARIMA X 12, checked for stationarity, and tested for structural breaks. The data sets used include Government expenditure and balance of payments data. The major data source is the RBI website.

109. The estimation of industry level aggregate supply uses annual data for 1990 to 2008. The data set includes prices, interest rate, fuel consumption, wages (total value = $W*N$), value of output and quantity for 35 manufacturing industries (three digit NIC code). While marginal cost proxy is calculated from ASI data, prices are taken as WPI prices at the disaggregated industry level.

110. The tests of aggregate supply identification and estimation of the SVAR use the index of industrial production (IIP) and WPI (manufacturing), since the latter is not contaminated with volatile commodity prices, and so better captures the second round effect of supply shocks such as commodity prices on manufacturing prices. Inflation is annualized inflation. Log differences of the two indices were found to be I (0). The data period is 1990: October-2012: July.

111. The causality analysis and non- structural VAR use the IIP, CPI (general index) for industrial workers, WPI (all commodities), call money rate CMR, INR/USD exchange rate, CPI (food), WPI (manufactured goods and WPI non-food manufactured goods), WPI (fuel petroleum and lubricants), WPI (primary products) and international oil prices from 1984M4 to 2010M06. Oil prices are taken as USD spot price of WTI light crude as traded on NYMEX for delivery at Cushings, Oklahoma. Oil prices were taken from International Foreign Statistics (IFS).

112. For the wage regressions the State level daily wages panel for manual agricultural labor, over the period January 2008 to December 2010, was obtained from the Economic Times, July 7, 2011. A larger data set later obtained from the original source, the Labor Bureau, Shimla, from the period 2005 onwards was also used. The balanced panel comprised 1188 data points, 18 States, and 66 months. All the variables were deseasonalized, transformed into log values, and then year on year log differences were taken to get growth rates. Annualized growth rates were used—that is January 2009 over January 2008 and so on.

B. Estimating AsymX

113. Our measure of asymmetry is a weighted average of relative price movements that are greater in absolute value than some cut off X .¹⁴ That is:

$$\text{AsymX} = \int_{-\infty}^{-X} rh(r) dr + \int_X^{\infty} rh(r) dr$$

114. Where r is an industry relative price change (an industry inflation rate minus the mean of industry inflation rates) and $h(r)$ is the density of r . The variable measures the mass in the upper tail of the distribution of price changes minus the mass in the lower tail. The tails are defined as relative price

¹⁴ The measure follows Ball and Mankiw (1994).

changes greater than X per cent or smaller than X per cent. Note that AsymX is zero for a symmetric distribution of relative price changes, positive when the right tail is larger than the left tail and negative when the left tail is larger. Moreover, for any given skewness, AsymX rises in absolute value when a larger variance magnifies the tails. Intuitively, AsymX is the change in the aggregate price level caused by price changes of industries whose relative price changes by more than X. Our AsymX series with X = 10 percent shows large fluctuations. Some of the extreme observations correspond to well-known oil shocks: for example AsymX is large and positive during the year 1974, 1980, 1990 and 2004. The variables capture the idea that large shocks have disproportionate effects since it gives full weight to price changes above 10 percent and zero weight to other price changes.

C. Estimating Demand and Supply Shocks from an SVAR Model

115. A bivariate output-price SVAR (structural vector auto regression) is used to decompose inflation rate time-series into two components, one due to AD and the other due to aggregate supply AS shocks. The long-run restrictions¹⁵ used do not restrict the short-run behaviour of the economy. There are potentially an infinite number of paths, generated by different demand and supply shocks, which the economy could follow while satisfying the restrictions. Therefore the estimated demand and supply shocks can be used to test further hypotheses, on which identification valid.

116. The identifying restriction, which is validated is a horizontal long-run AS curve, that is, an AS shock has no long-run impact on output. Dynamic properties of the estimated model turn out to be consistent with the predictions of such an AS-AD framework.

117. A two-equation small-sized VAR implies only two shocks driving the economy can be identified. So it must be feasible to aggregate multiple underlying shocks into two classes of shocks. Both shocks are assumed to be mean-zero serially uncorrelated and uncorrelated with each other¹⁶. Conditions under which such an aggregation is appropriate is if the underlying multiple shocks affect the variable of interest in the same fashion. The horizontal AS gives a natural classification into two classes of structural demand and supply shocks in line with the original reduced form shocks. The shocks, in the AD equation (1) affect the output gap directly, and are demand type shocks. Reduced form shocks, which enter the AS equation (2), affect inflation directly and so are supply-type shocks.

$$x_t = \alpha_1 x_{t+1} + \alpha_2 (i_t - \pi_{t+1}^e) + \varepsilon_{1t} \quad (1)$$

$$\pi_t = \beta_1 \pi_{t+1}^e + \beta_2 x_t + \varepsilon_{2t} \quad (2)$$

118. Where x_t is the potential gap, π_t is inflation, π_{t+1}^e is expected inflation and ε_{1t} and ε_{2t} are random shocks. So the two equation VAR is better justified under this identification. Such an HSC based identifying restriction also validates the use of a bivariate VAR.

119. Writing a variant of (1) and (2) in matrix form we have the reduced form VAR equation, $Z_t = (\Delta Y_t, I_t)$, in stationary variables, where Y_t stands for output and I_t stands for inflation. It is written as:

¹⁵ Such restrictions were first used in Blanchard and Quah (1989).

¹⁶ The covariance matrix of these two shocks is assumed to be a diagonal matrix with two rows and two columns.

$$Z_t = u + \sum_{k=1}^n \phi_k Z_{t-k} + \varepsilon_t, \quad \varepsilon_t: \text{Reduced form residuals} \quad (3)$$

$$\hat{\Omega} = (1/T) \sum_{t=1}^T \varepsilon_t \varepsilon_t' \quad (4)$$

Step 1: We convert it into Wald form, to get the structural residuals:

$$(I - \sum_{k=1}^n \phi_k B^k) Z_t = u + \varepsilon_t \quad (5)$$

$$Z_t = (I - \sum_{k=1}^n \phi_k B^k)^{-1} u + (I - \sum_{k=1}^n \phi_k B^k)^{-1} \varepsilon_t \quad (6)$$

$$Z_t = c + \psi(B) \varepsilon_t \quad (7)$$

Step 2: Identification using long run restrictions

$$Z_t = c + \Psi(1) u_t \quad (8)$$

$$\begin{pmatrix} \Delta Y_t \\ I_t \end{pmatrix} = c + \begin{pmatrix} \Psi_{11}(1) & \Psi_{12}(1) \\ \Psi_{21}(1) & \Psi_{22}(1) \end{pmatrix} \begin{pmatrix} u^y \\ u^i \end{pmatrix} \quad (9)$$

where u^y is the structural demand shock and u^i is the structural supply shock.

120. Note that $\Psi(1)$ is a long run matrix. For vertical supply curve (VSC): $\Psi_{11}(1) = 0$. In the VSC, the restriction is that demand shock does not affect output growth in the long run. However, this does not imply that demand shocks do not affect growth in the short run.

121. For horizontal supply curve (HSC): $\Psi_{21}(1) = 0$. In the HSC, the restriction is that demand shocks do not affect inflation in the long run. This, however, does not mean that demand shocks do not affect inflation in the short run.

D. Granger Causality Tests

122. Granger causality is a statistical measure of causality. One time series is said to Granger cause another if the past values of the first improve the forecasts of the other. Using both series together gives a better prediction than using only the past values of the second series. X does not granger cause Y (X~GC Y) if prediction of Y based on universe U of predictors is not better than prediction based on $U - \{X\}$ i.e. on the universe with X omitted. This is a much stiffer test than just a contemporaneous correlation between variables.

123. A systems approach to test lead-lag dynamics improves the power of statistical tests since it takes into account contemporaneous correlation of model residuals across variables. Unrestricted VAR (vector auto regression) systems are estimated to test causality, rather than structural VARs, since the aim is to test not to impose the structure. Each VAR system estimated relates inflation based on one price index to lagged values of itself and to lagged values of inflation based on another price index or

vice versa. Granger causality is also tested between various sub-components of the indices. For example, it is tested if CPI food inflation Granger causes WPI manufacturing inflation.

E. Granger Causality Tests with Controls

124. But bivariate Granger causality has to be taken with caution since it is possible, for example, that CPI inflation is correlated with some third variable that is actually causing WPI inflation to rise. Control variables allow for more careful tests. Control variables included are those that enter our structural relationships and provide information on the overall state of the economy. Specifically, the IIP index (as a proxy for output), the call money rate, and exchange rate, and log oil prices are the other variables entering our aggregate demand and supply equations. Including these variables helps identify these relationships, and ensures that the causality tests are not picking up effects due to omitted relevant variables. The control variables were tested for block exogeneity. But since that was rejected for one variable, all the variables were treated as endogenous in the estimation. The VAR systems estimated now are larger. A separate VAR system was estimated for testing Granger causality of each of the sub-indices tested. We follow the relevant procedures (Lütkepohl, 2004) to ensure the Wald statistic for zero restrictions has its usual limiting Chi-squared distribution when testing for Granger causality in a multivariate system, such as our test of $(X \sim GC Y)$ conditional on Z . The VAR systems in which causality testing was done also generated impulse responses to food price shocks after imposing the causal ordering identified.

F. Cointegration and Vector Error Correction Models (VECM)

125. Since underlying theoretical relationships imply long-run relationships between the time series, a linear combination of the variables must be stationary. A precondition for testing such cointegration is the series must be $I(1)$. All the variables, except for CMR, were $I(1)$ in levels. So we check for cointegrating relationships between them, excluding CMR. We found two cointegrating vectors, corresponding to two theoretical relationships derived. If variables are cointegrated then VECM models the long run together with short run adjustment. Moreover, Granger causality implies restrictions on the coefficients of the VECM model, which can also be tested.

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Understanding the High Inflation Trend in India

Recent Indian growth and inflation can be explained if aggregate supply is elastic but subject to upward shocks. Estimations of aggregate supply and other formal tests support such a structure. But then, reducing aggregate demand lowers growth more than inflation. The latter is best addressed at the level of the propagation mechanisms that push up the cost. Some of these, such as food price and wage inflation, sectoral bottlenecks, sharp depreciations and governance failures are examined. There is a role for monetary tightening to anchor inflation expectations that push wages up. It can be mild, however, if supported by supply-side initiatives.

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