Inflation Targeting in India : An Interim Assessment

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Abstract

This paper provides an assessment of India's inflation-targeting regime. It shows that the Reserve Bank of India is best characterized as a flexible inflation targeter: contrary to criticism, it does not neglect changes in the output gap when setting policy rates. The paper does not find that the Reserve Bank of India became more hawkish following the transition to inflation-targeting; to the contrary, adjusting for inflation and the output gap, policy rates became lower, not higher. Some evidence suggests that inflation has become better anchored: increases in actual inflation do less to excite inflation expectations, indicative of improved anti-inflation credibility. The question is whether the shift to inflation-targeting has enhanced the credibility of monetary policy such that the Reserve Bank of India is in a position to take extraordinary action in response to the Covid-19 crisis. The paper argues that the rules and understandings governing inflation-targeting regimes come with escape clauses allowing central banks to shelve their inflation targets temporarily, under specific circumstances satisfied by the Covid-19 pandemic. The paper provides evidence that inflation-targeting central banks were able to respond more forcefully to the Covid-19 crisis, consistent with the idea that inflation expectations were better anchored, providing more policy room for maneuver.

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Inflation Targeting in India: An Interim Assessment[1]

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1. Introduction

Monetary policy in India has a checkered history. The Reserve Bank of India (RBI) has followed a variety of policy strategies over the years. Following a long period of fiscal dominance during which the central bank was expected to monetize budget deficits, the fiscal framework was reformed and strengthened in the early years of the current century, allowing the RBI to exert more independence and bring inflation down to levels characteristic of other low- and middle-income countries. This transition culminated in the inflation-targeting agreement of February 2015 and an amended RBI Act in May 2016, which gave the central bank a statutory inflation target. At this point the RBI adopted a full inflation targeting (IT) framework, emulating international best practice.

These changes being recent (the amended RBI Act recently celebrated its fourth anniversary), their consequences have been the subject of little systematic analysis. Moreover, their efficacy is now being subjected to "the mother of all stress tests" in the form of the Covid-19 pandemic. We think that four years of experience is just enough on which to base a preliminary analysis and that the challenge of the pandemic makes it even more important to extract lessons from that experience.

Some of the lessons we draw may be surprising. Contrary to conventional wisdom that the RBI should focus on core inflation and "look through" volatile and transient food-price inflation, we find that food-price inflation can de-anchor expectations and spill over into core inflation; by implication, monetary policy should respond. We show that the RBI is best characterized as a flexible inflation targeter: contrary to criticism, it does not neglect changes in the output gap when setting policy. We do not find that the RBI became more hawkish following the transition to IT; to the contrary, adjusting for inflation and the output gap, policy rates became lower, not higher. We find some evidence that inflation has become better anchored: increases in actual inflation do less to excite inflation expectations, indicative of improved anti-inflation credibility. Consistent with this conclusion, a number of inflation-related outcomes (the level and volatility of inflation, the stability of inflation expectations, the behavior of ancillary variables such as the exchange rate and equity markets) are more stable than before.

Finally, we ask whether the RBI, having gained credibility with the shift to IT, is in a position to take extraordinary steps in response to Covid-19. We argue that this is the case, and that rules like those governing modern IT regimes come with implicit escape clauses allowing central banks credibly committed to those regimes to deviate, under exceptional circumstances, without untoward consequences. Specifically, we argue that the better anchoring of inflation expectations has enhanced the scope for the RBI to respond to an exceptional shock like the Covid pandemic – a shock that is (i) independently verifiable and (ii) not of the authorities' own making – despite the fact that inflation was already running at the top of the target range and that Covid, as a negative supply shock, might be expected to raise inflation. We provide evidence that inflation targeting central banks were able to respond more forcefully to the Covid-19 crisis, consistent with the idea that inflation expectations were better anchored, giving them more policy room for maneuver.

Section 2 starts with an overview of the evolution of India's monetary policy framework, placing the shift to inflation targeting in a broader historical context. Section 3 then describes different measures of inflation for India with an eye toward determining which have the greatest utility for policy. Section 4 estimates reaction functions for the RBI that can be used to place its policy actions in international comparative perspective. It asks whether and how the reaction function changed with the shift to inflation targeting. Sections 5 and 6 then look at how the behavior of macroeconomic and financial variables, including inflation expectations and passthrough, changed if at all with the shift to IT. Section 7 looks at the RBI's response to the Covid-19 pandemic, after which Section 8 concludes.

2. India's monetary policy framework[2]

India's monetary policy framework has evolved over recent decades (for a summary see Appendix Table A1). In the first two decades following independence, there was no formal framework for monetary policy. Policy regulated credit availability with an eye toward the needs of the current five-year plan.[3] With enactment of the Banking Regulation Act in 1949, banks were required to maintain a Statutory Liquidity Ratio in the form of gold, cash and approved securities. Other policy instruments included the discount rate (bank rate), reserve requirements and open market operations.

The monetary policy framework in place from the end of the 1960s, when the major banks were nationalized, through the mid-1980s is often described as one of "credit planning," during which policy operated via Statutory Liquidity Ratio (SLR) and the Cash Reserve Ratio (CRR), a specified minimum fraction of total customer deposits that commercial banks must hold in cash or as deposits with the central bank. The SLR was used to finance the budget deficit, the CRR to neutralize the effect of deficit financing on inflation.[4] Deposits at and credit supplied by public sector banks expanded rapidly, resulting in a rapid increase in the broad money supply: the money stock increased by 17.5 percent a year during the 1970s and first half of the 1980, compared to less than 10 percent in the previous decade. Since the period featured modest economic growth (about 4 percent a year), this resulted in relatively high inflation (averaging 8.8 percent). Das (2020) contends that traditional monetary policy instruments, such as bank rate and open market operations, proved inadequate for regulating credit growth, money supply, and inflation owing to fiscal dominance.[5]

From the mid-1980s through the late 1990s, the Reserve Bank employed a "monetary targeting with feedback" framework, in which the broad money supply was set in line with projected GDP growth

[2] This section draws on Mohan and Ray (2018), Das (2020), and Hutchison et al (2013). See also Mohan and Kapur (2009) and Patra and Kapur (2012) for discussions of the evolution of monetary policy in India. Dua (2020) provides a discussion of the inflation targeting framework, and Patnaik and Pandey (2020) compare features of India's inflation targeting framework with that of other countries.
[3] Monetization of the budget deficit by the RBI increased after the second five year plan, leading to an increase in SLR to 25 percent from 20 percent.
[4] The SLR was raised from 25 percent of bank's Net Demand and Time Liabilities (NDTL) in 1969 to 37 percent by July 1985, while the CRR was raised from 3 percent of banks' NDTL in 1969 to 9 percent by 1985.
[5] Recall that the RBI was not independent and was expected to finance the budget deficit with no questions asked. As Ghate and Kletzer put it, "Fiscal dominance and financial repression have been hallmarks of Indian monetary policy for decades. The Reserve Bank of India was designated as the banker for the government and authorized to grant advances to the Government of India in the Reserve Bank of India Act of 1934. These advances became *ad hoc* 3-month Treasury Bills continuously held by the RBI in a process of automatic monetization of government debt. The RBI simply funded the public sector budget deficit through periods of rising public debt and inflation until the 1990s. In 1997, the authorization to issue such *ad hoc* Treasury Bills ended and replaced by a system of Ways and Means advances. The RBI continues in its debt management role for the Government of India. In 2006, RBI's participation in the primary market for government debt ceased, and India completed the transition to market determined yields on government bonds."

and inflation. The move to this framework coincided with financial-sector reforms and increasingly market-determined interest and exchange rates. Price stability was the central objective of monetary policy, with 5-7 percent as the target range for inflation. (This is different from saying that the central bank adopted a monetary policy strategy of inflation targeting, where such a framework involves additional elements, as described below.) Although the RBI introduced various money market instruments in the late 1980s, including commercial paper and certificates of deposit, the money market was thin and illiquid due to low volumes. Fiscal dominance in the form of significant automatic monetization of budget deficits by the central bank remained a monetary-policy fact of life.

As the economy was further liberalized, the practice of automatic debt monetization through the central bank's purchases of treasury bills was eliminated.[6] This allowed the RBI to adopt a multiple indicators approach as of April 1998. In addition to taking into account trends in growth and inflation, the central bank now took into consideration additional macroeconomic variables such as credit growth, the exchange rate, the trade balance, unemployment, and the stance of fiscal policy. The decade that followed was also marked by greater fiscal discipline, enforced starting in 2003 through a newly enacted Fiscal Responsibility and Budget Management (FRBM) Act, which prohibited the RBI from purchasing government securities on the primary market, and by continued financial sector liberalization and interest rate deregulation.

As a result of these changes, interest rates gradually became the main instrument of monetary policy. From the late 1990s through the early 2000s, bank rate was used to signal the policy stance. In April 1999, the RBI introduced an Interim Liquidity Adjustment Facility (ILAF) under which liquidity was injected at bank rate and withdrawn at the reverse repo rate (the rate at which RBI borrows from the banks). By November 2004, this had developed into a full-fledged liquidity adjustment facility (LAF) in which the repo rate (the rate at which the banks borrow from the RBI) provided the upper bound of the policy interest rate corridor, while the reverse repo rate provided the lower bound. If liquidity was ample, the operative rate was the reverse repo rate; when it was scarce, it was the repo rate. From 2011, a revised corridor was redefined as a fixed width of 200 basis points. The repo rate was placed in the middle, with the reverse repo rate 100 basis points below it and a Marginal Standing Facility rate 100 basis points above it (at which commercial banks could borrow overnight up to one percent of their net demand and time liabilities to meet liquidity shocks).

Further changes were introduced in September 2014 to coincide with the move to formal inflation targeting.[7] An expert committee (Patel Committee Report, RBI, 2014) had recommended that the RBI should manage liquidity by offering term repos of different tenors. This led to ending unlimited accommodation of liquidity needs at the fixed LAF repo rate; providing most central bank liquidity

[6] There were two kinds of treasury bills: "ordinary treasury bills" were placed with banks and retails investors at market rates as per a weekly schedule of borrowing, and "ad hoc bills" could be placed only with the RBI, at below market rates when required. Ad hoc connotes that there was no schedule for issuance. In 1994 the RBI and the government signed an agreement specifying limits on the automatic monetization of budget deficits. In March 1997, another agreement was then signed under which ad hoc treasury bills were replaced by Ways and Means Advances, through which the government could borrow from the RBI subject to limits. It was agreed that these advances would not be a regular source of deficit financing but only cover day-to-day mismatches in receipts and payments of the government. Note that as part of Covid-19 policy response, the borrowing limits under Ways and Means Advances were increased for both central and state governments, and the number of consecutive days for which government could be overdrawn was also increased.

[7] See Patra et al (2016).

through term repo auctions; fine tuning operations through repo/reverse repo auctions of maturities ranging from intra-day to 28 days; allowing market participants to hold central bank liquidity for a longer period; and progressively reducing the SLR.

The government and RBI then signed an inflation-targeting agreement in February 2015 and amended the RBI Act in May 2016.[8] The inflation target was set by the government in consultation with the Reserve Bank.[9] Accordingly, the government announced via the Official Gazette that 4 percent Consumer Price Index (CPI) inflation would be the target from August 5, 2016, with an upper tolerance limit of 6 percent and a lower limit of 2 percent. It further announced that the government would constitute a six member Monetary Policy Committee (MPC) including three ex officio members from the RBI: the Governor of the Bank (who would also be its Chairperson); the Deputy Governor in charge of Monetary Policy; and one officer to be nominated by its Central Board. The other three members would be appointed by the government. Members would hold office for four years and could not be reappointed.

The RBI was required to organize at least four meetings of the Monetary Policy Committee annually, following a schedule published in advance. [10] It was asked to publish a Monetary Policy Report, every six months, explaining the sources of inflation. It was to provide forecasts of inflation for a period between six to eighteen months; the resolution adopted by the Committee; further details, on the fourteenth day after every meeting of the MPC, including the minutes of the proceedings of the meeting; the vote of and the statement of each member of the MPC; and a document explaining steps to be taken to implement the decisions of the MPC. Finally, if the inflation target was not met, the RBI was required to submit a report detailing the reasons for failure to achieve it; remedial actions; and the estimated time-period within which the inflation target could be achieved. The agreement specified that the RBI would be deemed to have missed its target if inflation exceeded 6.0 percent or declined below 2.0 percent for three straight quarters.

3. Measures of Inflation

Inflation in India has averaged 8 percent or more since the 1980s, except in the early 2000s when it averaged 4 percent and more recently when inflation fell with the move to inflation targeting (see Table 1). Levels have exceeded average global inflation for the most part (Figure 1), while fluctuations have broadly tracked those in other low- and middle-income countries (LMI), aside from 2009-2015. Basu, Eichengreen and Gupta (2014) attribute India's relatively high inflation in this period to budget deficits and monetary policy accommodation in years that coincided with national elections.

Figure 1: Long term inflation rate (consumer prices) in India and its co-movement

Figure 1A:… with Global Inflation

Percent

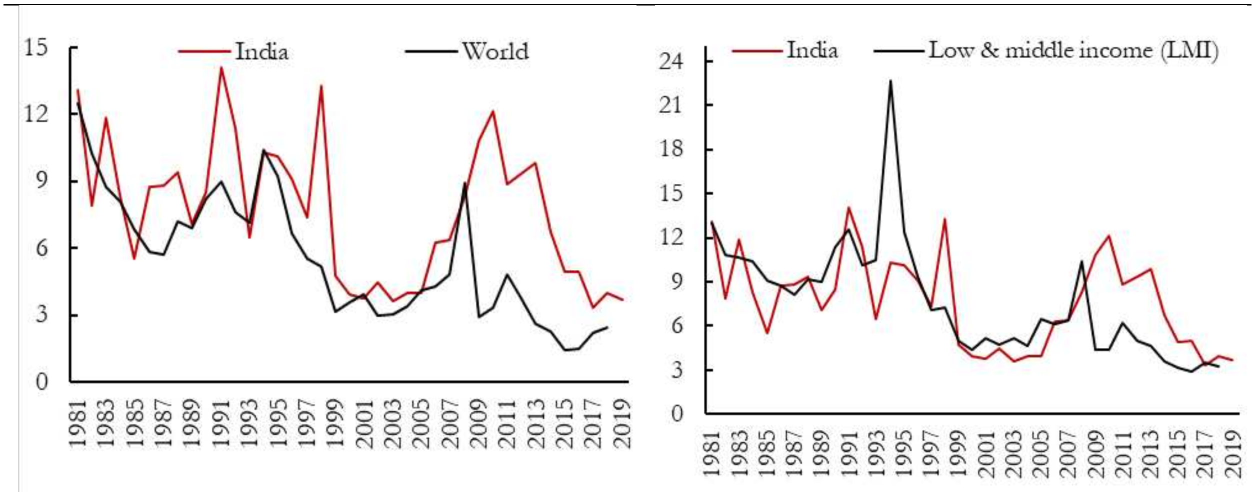
Figure 1B: …. with Low- and Middle-Income (LMI) countries

Percent

[8] For details see amendment to the Reserve Bank of India Act, 1934, Inserted by Finance Act, 2016, Chapter III F, Monetary Policy.

[9] With the possibility of revisiting it after five years.

[10] The first meeting of the MPC was held on October 3 and 4, 2016.



Source: WDI, Author's Calculations

Table 1: Average inflation rates in India, the World, and Low-and middle-income countries (LMI)

	1981-85	1986-90	1991-95	1996-00	2001-05	2006-10	2011-15	2016-19
India	9.3	8.5	10.5	7.7	4.0	8.8	7.9	4.0
LMI	10.8	9.3	13.7	6.6	5.3	6.3	4.5	3.2
World	9.3	6.8	8.7	4.8	3.5	4.9	3.0	2.0

Source: WDI for LMI and world, and MOSPI, CEIC for India, Author's Calculations

Based on correlations like these, some authors (e.g. Chhibber 2020) have argued that Indian inflation is heavily influenced by global developments, reducing the effectiveness of monetary policy. We analyzed the correlation of global inflation and Indian headline, food and fuel inflation series at monthly, quarterly, and annual frequencies. It turns out that Indian inflation is *not* highly correlated with global inflation. For most part, there is no systematic time pattern in these correlations.[11]

Alternative measures

A challenge for monetary policy generally is the measurement of inflation. This is true for India, where there was no composite cost of living index before 2011. Instead, there existed separate CPI series

[11] Results available on request. These findings are not surprising: food prices in India have been much more stable than global prices because they are administered, while energy prices were similarly more stable than global prices until about 2015, and comove more strongly with global prices after they became more market based.

for industrial workers, agricultural workers and nonagricultural rural workers. The CPI for industrial workers was commonly used as a proxy for the composite CPI.[12]

A unified CPI series has been available since January 2011. It can be used to calculate monthly year-over-year inflation starting in January 2012. Whereas the RBI used the WPI in monetary policy analysis until about March 2014, it now utilizes the headline CPI.[13] The WPI consists of the prices of bulk transactions of goods in the domestic market. It includes manufacturing and commodities but not services (see Table 2).

CPI inflation has been higher than WPI inflation on average. Whereas the average difference between CPI and WPI inflation was 0.4 percent between 1997 and 2009, it widened to 3.2 percent in 2009-2019. Divergences between the two series can be attributed both to food inflation (which has a higher weight in the CPI) and manufacturing inflation (which has a larger weight in the WPI).

Table 2: Composition of the Wholesale Price Index and Headline Consumer Price Index

	WPI		**CPI**
Primary products/food	22.6	Food, Beverages and Tobacco	48.2
Fuel	13.2	Fuel & Light	6.8
Manufactured	64.2	Housing	10.1
		Miscellaneous	28.3
		Clothing & Footwear	6.5

The question is which series the RBI should target. The WPI may not be best for two reasons. First, it places a large weight on oil and commodity prices, which are volatile; second, it has a zero weight on services. Headline CPI inflation is also affected by volatile commodity prices, albeit to a lesser extent than the WPI. More importantly, food prices account for nearly half of the CPI, and food prices are often heavily affected by sector-specific non-monetary factors such as weather and harvests. Insofar as shocks to food prices are transient, there is an argument that the RBI should look through them.[14] Such arguments favor a core (non-food- non-fuel) CPI. Counterarguments favoring headline inflation include: (i) that it is easier to explain to the public and thus more effective in anchoring expectations; and (ii) that

[12] There have been five different CPI series: CPI Industrial Workers (CPI-IW), CPI Agricultural Labor (CPI-AL), CPI Rural Labor (CPI-RL), and the CPI Urban Non-Manual Employees (CPIUNME). The last one of these has been discontinued. The weights of different components in the baskets for CPI combined, and CPI-Industrial worker are similar; whereas the CPI for agricultural labor and CPI for rural workers have a larger weight on food, nearly 70 percent. See Mohan and Ray (2018) for a discussion of the composition and dynamics of different inflation series.

[13] When estimating reaction functions, we follow this practice, using the CPI inflation starting 2012 and WPI inflation before that.

[14] Relatedly, it has been argued (by inter alia Banerjee 2020) that IT has led to a worsening of the agricultural terms of trade and declining rural/agricultural incomes. Variants of this argument are that the government has grown more reluctant to raise support prices for agricultural products because it wishes to help the RBI to lower inflation, or that it has grown more reluctant because it fears the wider repercussions on the economy of the RBI raising interest rates in response. We find the first variant implausible (helping the RBI hit its inflation target is not a government priority). The second variant amounts to the statement that government support for the rural sector costs the economy as a whole through either higher inflation or higher interest rates. The 2015 inflation targeting agreement reflected a consensus that taking these costs in the form of inflation was higher than taking them in the form of interest rates. We do not see what has changed.

food inflation feeds back into core inflation, and hence needs to be tamed lest it becomes structural and strongly entrenched.[15]

Figure 2: Consumer and Wholesale Price Inflation

Figure 2A: Different inflation series: WPI, CPI, Industrial workers, Headline CPI
Percent

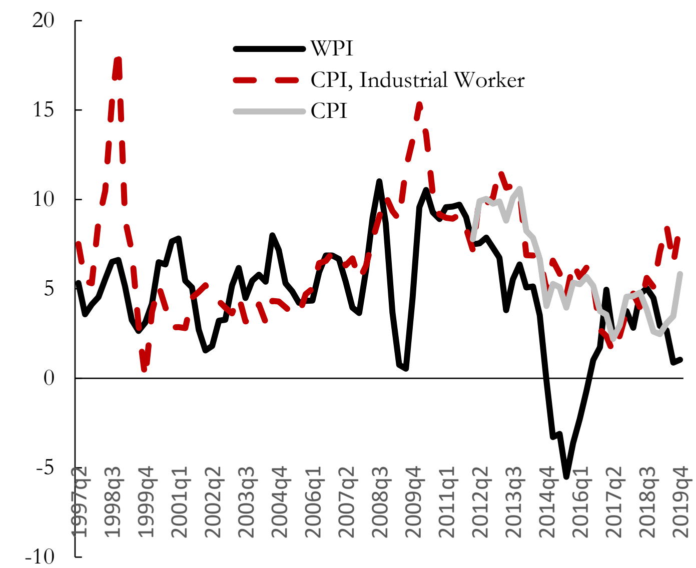
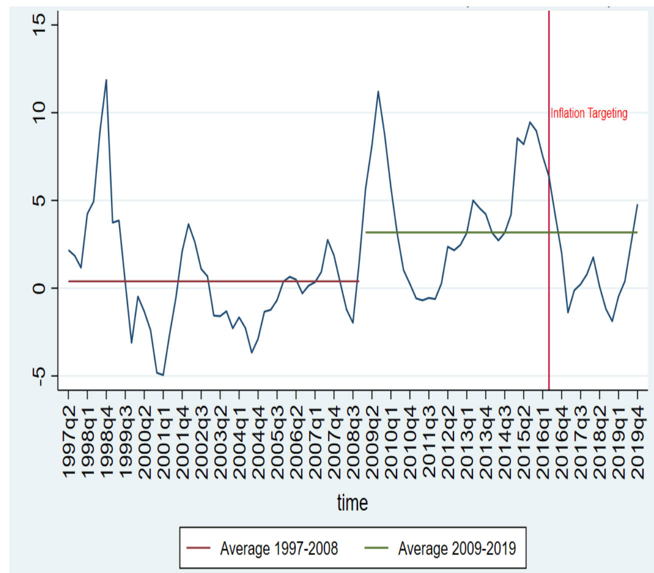


Figure 2B: Difference between CPI and WPI
Percent



Source: MOSPI, CEIC. Note: CPI inflation series consists of CPI, Industrial worker until 2011, and CPI combined from 2012.

The choice of WPI or CPI is inconsequential if the two series co-move closely. But this is not generally the case, as shown in Figure 2. In the period 2014 Q3 to 2016 Q4, for example, WPI inflation (headline) averaged -1.2 a quarter while CPI inflation (headline) averaged more than 5 percent a quarter.

The correlation between WPI headline and CPI headline inflation has not been very high, although it rose in the last decade and is significantly greater than zero at the 95 percent confidence level (see Table 3). Given the relative composition of their baskets, it is unsurprising that WPI headline inflation is correlated more strongly with WPI core inflation, and that CPI headline inflation is correlated more strongly with food inflation. Their respective food and core inflation series are correlated more strongly than their respective headline inflation series.[16]

[15] Stephen (2007), and Mohanty (2014) recommend targeting headline inflation. JPMorgan (2018) uses a modified version of core inflation, which besides food and fuel further excludes elements that may be impacted by fuel prices. They term this measure "core-core CPI" and suggest that India should target core or core-core inflation. The argument runs that instead of core inflation converging to food/headline inflation, it is food/headline inflation that converges to core inflation in India. Hence an elevated core inflation can be undesirable, and ought to be monitored and targeted directly. As we show below, we do not find evidence to support the argument.
[16] These patterns have not changed in the last decade.

Table 3: Correlation matrix of inflation measures

Inflation measure	WPI Headline	WPI Food	WPI Core	CPI Headline	CPI Food	CPI Core
A: 1997 Q2 -2008 Q4						
WPI Headline	1					
WPI Food	0.34*	1				
WPI Core	0.82*	0.20	1			
CPI Headline	0.32*	0.90*	0.09	1		
CPI Food	0.41*	0.93*	0.26	0.94*	1	
CPI Core	-0.04	0.63*	-0.32*	0.81*	0.58*	1
B: 2009 Q1 -2019 Q4						
Inflation measure	WPI Headline	WPI Food	WPI Core	CPI Headline	CPI Food	CPI Core
WPI Headline	1					
WPI Food	0.55*	1				
WPI Core	0.93*	0.27	1			
CPI Headline	0.58*	0.91*	0.39*	1		
CPI Food	0.34*	0.89*	0.10	0.92*	1	
CPI Core	0.77*	0.74*	0.67*	0.86*	0.61*	1
Note: * denotes significance at 5% level.						

Table 4: Level and volatility of CPI inflation and its components (quarterly data from 1997q2-2019q4)

	Mean	Standard deviation	Coefficient of Variation
CPI	6.41	3.31	0.52
CPI, Food	6.29	5.01	0.80
CPI, Fuel	6.96	4.96	0.71
CPI, Core	6.47	2.76	0.43

Persistence

Contrary to popular presumption, food price inflation has not been higher than core and headline inflation (Table 4).[17] Neither is it more persistent. We estimate first order autocorrelation coefficients for rolling windows of 20, 30 and 40 quarters. The coefficients for core and headline inflation are higher than for food price inflation.[18] Nor has inflation persistence declined over time (in contrast to evidence for the United States – e.g. Fuhrer 2010).

[17] See Appendix B for details.

[18] Unit root tests conducted on all inflation measures provide mixed results. While we cannot reject the null of unit root for core inflation at 5% level using both ADF and PP tests (implying high persistence), but for food, fuel and headline inflation we reject the null of unit root when lag length considered for ADF and PP tests is less than 4.

We also calculate the largest autoregressive root or dominant root in the univariate autoregressive process for each inflation series. In the long run, the effect of a shock will be dominated by this largest root. The dominant roots confirm that core and headline inflation are more persistent than food price inflation. The sum of autoregressive coefficients gives a similar result: high persistence across inflation series and higher persistence of core inflation.

Yet another measure of persistence is the impulse half-life, the number of periods it takes for the impulse response to fall below 0.5 following a unit shock. This measure also confirms the higher persistence of core inflation (see Appendix B). The half-life for headline inflation is estimated at around 4 quarters, and for core inflation around 5 quarters. These findings are consistent with the earlier results of Ball, Chari and Mishra (2016), who similarly document the shorter duration of food price shocks.

We estimate a VAR model to identify the timing relationship between food price inflation and core inflation.[19] We treat food and core inflation as endogenous and fuel inflation as exogenous (as given largely by global economic conditions).[20] We estimate specifications with 2, 4 and 8 lags. Food price inflation has a larger and more consistent impact on core inflation than vice versa. The impact is significant for two quarters. Fuel inflation does not impact food or core inflation at a quarterly frequency. Granger causality tests in Table 5 further suggest that food inflation Granger causes core inflation. This result is robust to different lag lengths. In contrast, there is no evidence that core inflation Granger causes food inflation. Put differently, past values of food inflation help predict core inflation, but past values of core inflation do not help predict food inflation.

Table 5. Granger Causality Wald tests (VAR model)

Dependent Variable (y)	Explanatory Variable (x)	F	df	df_r	Prob > F	Does x granger cause y?
Lag length 2						
Food Inflation	Core Inflation	2.4129	2	81	0.096	No
Core Inflation	Food Inflation	3.4081	2	81	0.0379	Yes
Lag length 4						
Food Inflation	Core Inflation	3.3246	4	73	0.0147	Yes
Core Inflation	Food Inflation	3.3435	4	73	0.0143	Yes
Lag length 8						
Food Inflation	Core Inflation	0.69824	8	61	0.6917	No
Core Inflation	Food Inflation	2.9597	8	61	0.0073	Yes
Note: Granger causality is based on 5% significance level; "No" indicates that we fail to reject the null hypothesis: x does not granger cause y.						

[19] Data is from 1997q1 to 2019q4. We use standard splicing method to expand our CPI 2011-12 inflation series which starts from 2012 onwards. Prior to 2012, CPI-IW inflation is used for each component—food, fuel, and core.
[20] India being a net importer of fuel, its base price is determined globally, and retail prices by the base price and taxes. During the earlier period in the analysis, the retail price was administered.

Contrary to popular perception, then, we do not find food price inflation to be higher, more volatile or persistent than core inflation. There is evidence, however, the changes in food inflation lead to subsequent changes in core inflation, but not the other way around. This reinforces a finding of Mishra and Roy (2012).[21] We confirm that this relationship has not changed post inflation targeting.

Other authors (e.g. Chhiber 2020) have suggested that the RBI should "look through" (i.e. disregard) movements in food price inflation on the grounds that food prices are volatile, and that focusing on them distorts the conduct of policy. In responding to food price inflation, the central bank will be focusing on transitory inflation threat and neglecting other more important objectives of policy. We find, to the contrary, that food-price inflation feeds through to core inflation as producers mark up the prices of other products. Central banks in advanced economies have been able to look through fluctuations in food and fuel price inflation without consequences for core inflation and therefore without jeopardizing their inflation targets. In India, where food is a much more important component of consumption baskets, this may not be the case. This is not an argument that the central bank should react to each and every movement in headline and food inflation. But it does suggest that neglecting food price inflation that diverges from target for an extended period of time can have negative consequences.

4. Reaction functions

We now ask whether monetary policy decisions are influenced more by the output gap or inflation, whether the reaction function has changed with the adoption of inflation targeting, whether output gap and inflation carry different weights in the reaction function at high and low values, and whether the reaction function is different for headline and core inflation.[22] All estimated reaction functions include the output gap and inflation, but in an augmented version we also include the lagged policy rate, the percentage change in exchange rate, and the budget deficit or government borrowing.

A number of earlier papers have estimated reaction functions for the RBI (see Appendix A4). These studies find that the output gap is important (Hutchison et al 2013, Mohanty and Klau 2005) but that the exchange rate also matters, especially from the late 1990s when it became more flexible. Inflation in general has a much smaller coefficient, both absolutely and relative to the Taylor rule benchmark of 1.5.

These analyses typically use quarterly data, since quarterly GDP growth is available from 1997; we follow this standard practice.[23] For inflation, we use the WPI inflation until 2013 and the CPI inflation thereafter, since these are the inflation rates monitored by the RBI.

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[21] This is consistent with Ball, Chari and Mishra (2016) who show that changes in headline inflation feed into expected inflation and future core inflation. Raj et al (2020) evaluate several possible measures of core inflation and similarly find that headline inflation does not converge to core inflation.

[22] Rangarajan (2020) suggests that inflation targeting in India is flexible in the sense that "what inflation targeting demands is that when inflation goes beyond the comfort zone, the exclusive concern of monetary policy must be to bring it back to the target level. When inflation is within the comfort zone, authorities can look to other objectives."

[23] Papers estimating reaction functions at a monthly frequency use the industrial production index as a proxy for output, which we regard as unreliable.

For the policy rate we adopt two approaches. First, we construct a composite policy rate series in the manner of Patra and Kapur (2013).[24] This is based on which series was used by the RBI at the time for monetary policy purposes, as detailed in Table 6. In the second approach, we use bank rate for the period 1997-2001 and repo rate from 2002[25] (See Figure 3B). The exchange rate is calculated as quarter-over-quarter percent change in the nominal exchange rate with respect to US dollar. The budget deficit and market borrowing variables are highly seasonal at quarterly frequency, so we adjust them for seasonality and express as a percent of seasonally adjusted nominal GDP.[26]

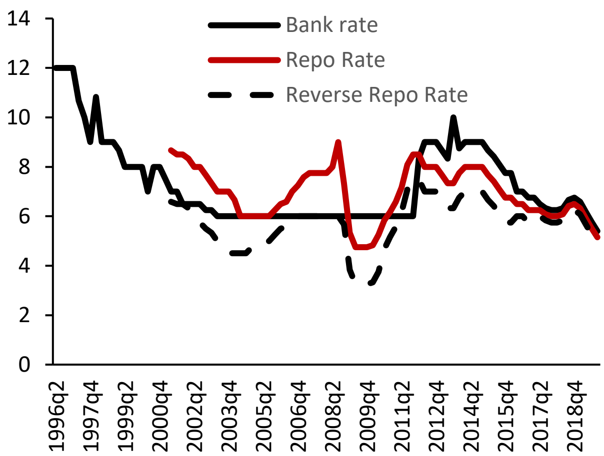
Table 6: Effective policy rates

	Instrument	Duration	
		Month	Quarter (cal. year)
Effective Policy rate	Bank rate	Jan1996 - Feb2002	1996q1 - 2002q1
	Reverse repo rate	Mar2002 - June2006	2002q2 - 2006q2
	Repo rate	July2006 - Nov2008	2006q3 - 2008q4
	Reverse repo rate	Dec2008 - May2010	2009q1 - 2010q2
	Repo rate	June2010 - present	2010q3 – present

Source: Based on information in Patra and Kapur (2013).

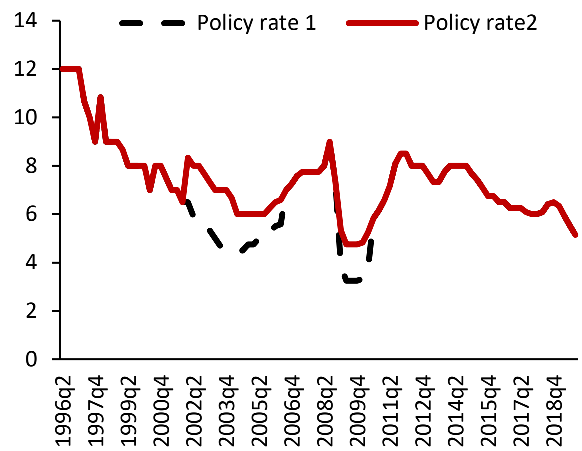
Figure 3: Policy rates

Figure 3A: Bank rate, the repo rate, and the reverse repo rate



Source: RBI, CEIC

Figure 3B: Composite policy rate series



Source: Authors' Calculations

Note: The first composite policy rate series is based on the policy rates at different points in time, as per Table 6. In the second composite policy rate series, bank rate is used for the period 1996-2001 and repo rate from 2002. The correlation between the two policy rate series is 0.93.

[24] Bank rate, the repo rate, and the reverse repo rate are available as monthly averages and end of month values. The results are insensitive to the two series. In the results reported here, we have used monthly averages.
[25] The two series are highly correlated, as is evident in Figure 4.
[26] We use both X-11 and X-13 ARIMA SEATS to seasonally adjust these series. The choice of filter does not seem to matter in the results.

The output gap is measured as the difference between seasonally adjusted real GDP and its trend, obtained via the HP filter (as in Patra and Kapur 2012) and expressed as a percentage of seasonally adjusted real GDP.[27] Summary statistics and correlations for these variables are presented in the Appendix Table A4.[28] The policy rate is positively and significantly correlated with the output gap and exchange rate depreciation. It is also positively correlated with inflation, although the correlation is weaker and significant only at 10 percent level.

We estimate the following baseline specification of the reaction function using OLS:

$$\text{epr}_t = \alpha_0 + \alpha_1 \text{gap}_t + \alpha_2 \text{inflation}_t + \epsilon_t$$

where, epr_t is the effective policy rate; gap_t denotes the output gap expressed as a percentage of GDP; and inflation_t denotes the inflation measure as targeted by the RBI. We assess if the policy rate is different after controlling for output gap and inflation once the country moved to inflation targeting by including a dummy for the period since inflation targeting in the regression.

In all variants in Table 7 the output gap has a positive and significant coefficient, as anticipated. Inflation also has a positive coefficient.[29] When we add the lagged policy rate as an explanatory variable (the Woodford 2001 version of the Taylor Rule), its coefficient indicates significant inertia. The output gap and inflation remain positive as before.

Table 7: Monetary policy reaction functions
(Dependent variable is effective policy rate)

	I	II	III	IV
Inflation	0.11	0.06	0.08***	0.08***
	(1.25)	(0.62)	(3.23)	(2.86)
Output gap (% of	0.36***	0.40***	0.20***	0.21***
GDP)	(4.43)	(4.96)	(2.65)	(2.64)
IT		-0.82***		-0.07
		(2.98)		(0.75)
Lagged Effective			0.85***	0.85***
Policy rate			(18.00)	(17.85)
Constant	6.17***	6.56***	0.48*	0.53*
	(13.27)	(11.29)	(1.73)	(1.80)
Observations	91	91	90	90
Adjusted R^2	0.11	0.13	0.89	0.89

Note: Robust t statistics in parentheses. *, **, ***, indicate significance at 10, 5 and 1 percent respectively.

[27] The quarterly real GDP series is seasonally adjusted using the X-11 algorithm (of the US Department of Commerce).
[28] The policy rate is most persistent (or inertial), followed by inflation. The output gap and exchange rate are least persistent, as per their AR (1) coefficients.
[29] It is significantly less than the standard Taylor rule benchmark of 1.5. The coefficients on the output gap and inflation are similar to those in other papers estimating reaction function for India, including Hutchison et al 2013 Patra et al 2012, RBI Study 2010 (Singh), and Mohanty and Klau 2004. Bhoi et al (2019) estimate a reaction function for 2000-2018, using weighted average call money rate as the policy rate, and similarly find the coefficient on the output gap to be larger post inflation targeting.

We also include a dummy variable for the inflation targeting period to address complaints that interest rates have been higher post-inflation targeting. We find, to the contrary, that rates have been lower once one accounts for inflation and the output gap, though not always significantly so.[30]

Policy rates were lowered dramatically during the global financial crisis. Was this reaction unusual, given that growth slowed sharply between 2007 and 2008? When we add a dummy for the global financial crisis, its coefficient is negative and significant, confirming that the RBI moved more quickly than predicted by its standard reaction function. Another question is whether policy rates react to the inflation series that the RBI tracks formally or to one or more of the CPI inflation series. When we include different inflation series in the reaction function, the results suggest that monetary policy responds to headline and core inflation but not to food inflation.

We also ask if the weights on the output gap and inflation are different in periods when these variables take on unusually high or low values. Contrary to previous suggestions, we do not find evidence of such threshold effects.[31]

While there is evidence of autocorrelation in our OLS estimates and hence, when we correct the standard errors using Newey-West correction significance levels are unaffected. Previous studies have used GMM for estimating the reaction function on the grounds that OLS coefficients may suffer from endogeneity and simultaneity bias. When we do so, the coefficients of inflation and output gap are similar to the OLS estimates obtained when we include the lagged policy rate. When we do not include lagged policy rates, the GMM estimates of the coefficients for both inflation and output gap are larger and more significant than the OLS estimates (see Appendix D).

Some scholars believe that even though India formally moved to inflation targeting in September 2016, it had de facto started paying more attention to the level of inflation and had announced a glide path for inflation starting in 2014.[32] In lieu of the formal inflation targeting, we define another dummy which takes a value 1 from 2014 Q1 onwards. This variable does not show up as significant or impact our other results. When we add the budget deficit or government's market borrowings (both as percent of GDP), their coefficients are insignificant.

5. Outcomes pre and post inflation targeting

[30] We also included two additional terms interacting inflation and the output gap with this same IT dummy. The coefficient on the output gap was consistently positive, that on inflation consistently negative, although a dozen or so quarterly observations for the IT period do not give us sufficient variation and degrees of freedom to estimate these coefficients reliably and precisely.

[31] Specifically, we define dummies for very high values of inflation as when it exceeds 9 percent; for a very large output gap as when it exceeds 1.5; for very low levels of inflation as when inflation is below 3 percent, and for a low output gap as when it is below -1.5. The cutoffs have been selected at about top 10 or bottom 10 percent of the observations for inflation and the output gap. We include one of these dummy variables at a time in the regressions. The only coefficient that is significant at 10 percent level is for a high output gap. This coefficient is negative, indicating that at very high GDP growth rate (and output gap), the policy rate does not increase proportionately.

[32] Mohan (2018) notes that while formally IT was adopted in 2016, the monetary policy framework of the RBI had started tilting towards IT from 2014, and after Raghuram Rajan joined the RBI as governor. The RBI started publishing a bi-annual Monetary Policy Report to provide an assessment of the overall macroeconomic conditions as well as forecasts of inflation and growth. It also put forth the objective to lower CPI inflation to below 8 percent by January 2015, and below 6 percent by January 2016.

Studies of the impact of inflation targeting have reached different conclusions depending, inter alia, on the countries, period and measures considered. We tabulate these studies in Appendix F. For emerging markets, there is evidence of lower inflation under IT, but results for inflation volatility are less consistent.[33] There is no clear consensus on the effects of IT on output growth—Brito and Bystedt (2010) find a significant negative effect on growth while other studies (Naqvi and Rizvi 2009, IMF 2011) find insignificant effects of IT on growth. Goncalves and Salles (2005) find that IT reduces output volatility, whereas Batini and Laxton (2006) find no such evidence.

We now compare the behavior of a range of economic and financial variables before and after the adoption of IT in India. We compare percentage changes and, where appropriate, volatility. Unless noted otherwise, the data are again quarterly and extend from 1997 through 2019. Our baseline specification is of the form:

$$y_t = \alpha_0 + \alpha_1 \mathrm{IT}_t + \alpha_2 \mathrm{GFC}_t + \alpha_3 \mathrm{Post\ GFC}_t + \epsilon_t^y$$

where, y_t denotes the outcome variable; $\mathrm{IT}_t, \mathrm{GFC}_t$ and Post GFC_t denote inflation targeting dummy (Q3 2016-Q4 2019), global financial crisis dummy (Q3 2008-Q1 2009) and a post global financial crisis dummy (Q2 2009-Q4 2019).[34] CPI headline, core and food inflation are all lower in the IT period, as shown in Table 8.[35] While CPI inflation increased after the global financial crisis, all measures of CPI inflation declined after the shift to inflation targeting. CPI headline inflation declined 4.9 percentage points relative to the post GFC average, and food inflation declined even more sharply, by 6.9 percentage points. WPI inflation also declined by 1.5 percent, though the change is not statistically significant.

Table 8: Inflation is lower after inflation targeting

	WPI Inflation	CPI headline inflation	CPI core inflation	CPI food inflation
Inflation Targeting	-1.53	-4.91***	-3.29***	-6.91***
	(1.56)	(8.23)	(5.76)	(6.12)
Global Financial Crisis	2.65	3.98***	0.26	7.79***
Dummy	(1.46)	(7.14)	(0.61)	(7.81)
Post Global Financial	-0.66	3.14***	2.31***	4.20***
Crisis Dummy	(0.70)	(4.43)	(3.46)	(4.05)
Constant	5.13***	5.55***	5.87***	5.11***
	(20.50)	(11.63)	(14.60)	(7.12)
Observations	91	91	91	91
Adjusted R^2	0.06	0.29	0.17	0.27

Note: Robust t statistics in parentheses; *, **, ***, indicate significance at 10, 5 and 1 percent.

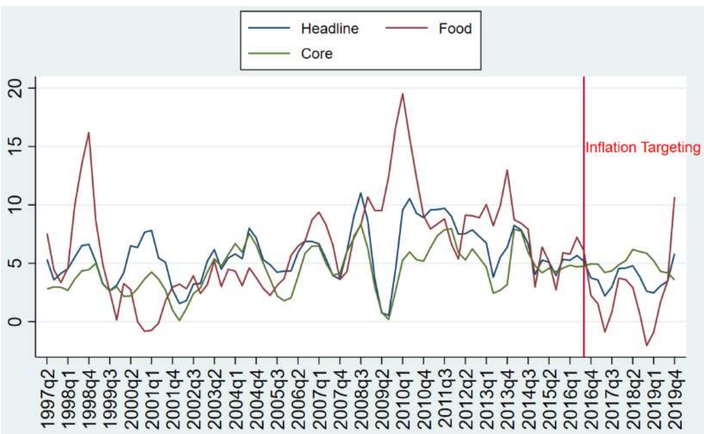
[33] Vega and Winkelried (2005), Batini and Laxton (2006), Li and Ye (2009), and IMF (2011) conclude that inflation volatility is significantly lower after IT, whereas Goncalves and Salles (2008) and Brito and Bysted (2010) find any difference to be insignificant.
[34] We acknowledge that this framework cannot strictly establish any causal effects of inflation targeting, since we have not controlled for confounding factors and developments.
[35] In an alternative specification, we control for output gap, and see an even sharper decline in headline inflation.

The same analysis for inflation volatility, calculated as the quarterly average of the 15-month rolling standard deviation of monthly inflation series, shows lower inflation volatility after the adoption of IT, except for the case of food price inflation, over which the central bank arguably has less control. Plotting this volatility measure (Figure 4) indicates that, except for food-price inflation, volatility is lower after the shift to IT relative to the preceding decade. This is borne out in Table 9, where except for food-price inflation, the volatility of all measures of inflation have declined.

Figure 4: Inflation and its volatility

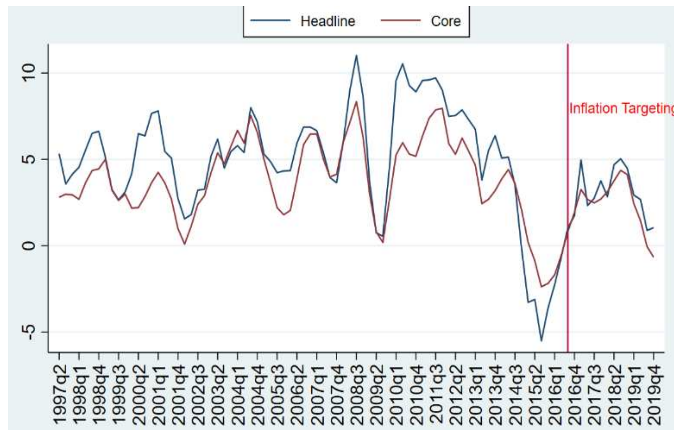
A: Consumer Price Inflation

Percent



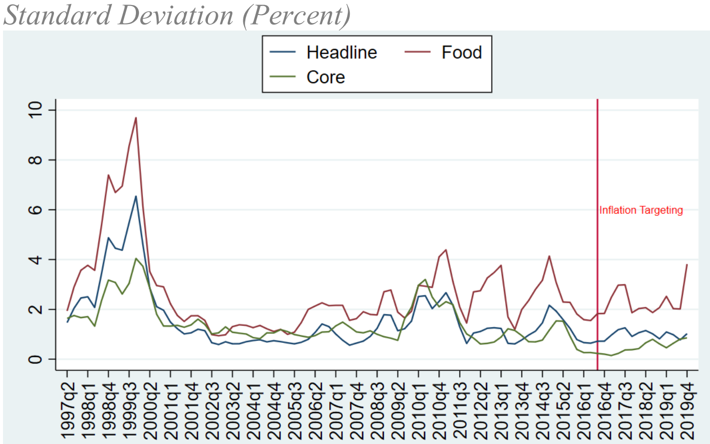
B: Wholesale Price Inflation

Percent



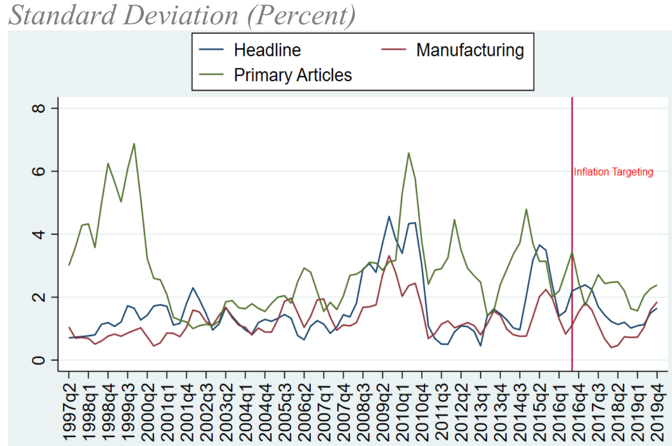
C: Consumer Price Inflation Volatility

Standard Deviation (Percent)



D: Wholesale Price Inflation Volatility

Standard Deviation (Percent)



Source: CEIC, Author's Calculations

Note: Inflation volatility is computed as 15-month rolling standard deviation of monthly inflation series which is then averaged at quarterly frequency.

Table 9: Inflation volatility under IT

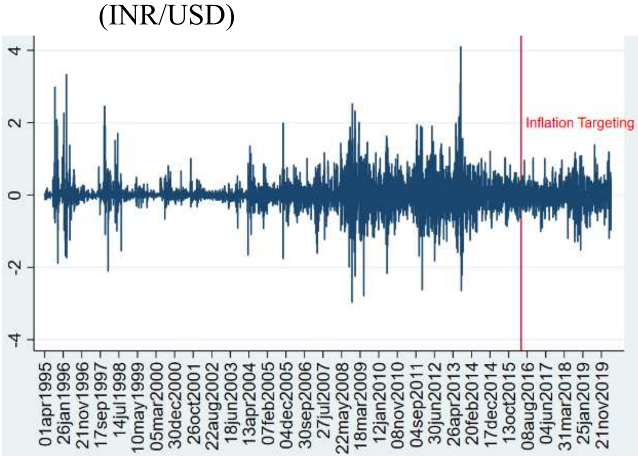
	Volatility of CPI Inflation			Volatility of WPI Inflation		
	Headline	Core	Food	Headline	Primary articles	Manufacturing
Inflation Targeting	-0.42***	-0.80***	-0.28	-0.48*	-0.99***	-0.41**
	(3.32)	(5.01)	(1.26)	(1.69)	(3.92)	(2.17)
Global Financial Crisis	-0.12	-0.65***	-0.31	1.65***	0.33	0.62***
Dummy	(0.43)	(5.15)	(0.73)	(18.80)	(1.34)	(9.95)
Post Global Financial	-0.31	-0.27	-0.13	0.80***	0.59*	0.42***
Crisis Dummy	(1.23)	(1.44)	(0.36)	(3.12)	(1.84)	(2.86)
Constant	1.71***	1.57***	2.73***	1.26***	2.69***	1.09***
	(7.53)	(13.03)	(8.37)	(22.43)	(11.49)	(18.38)
Observations	91	91	91	91	91	91
Adjusted R^2	0.02	0.19	-0.03	0.19	0.04	0.11

Note: Robust t statistics in parentheses; *, **, ***, indicate significance at 10, 5 and 1 percent respectively.

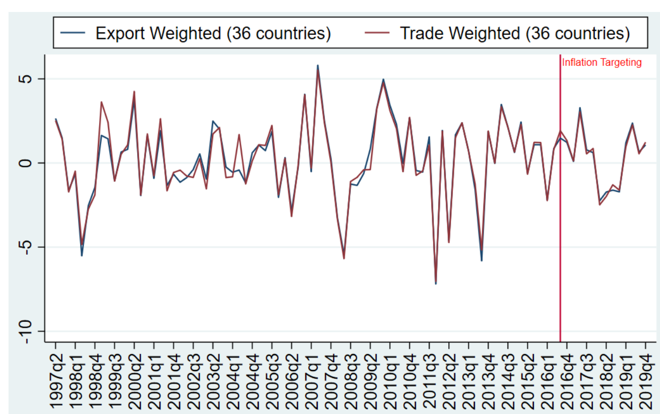
Figure 5 and Table 10 indicate no change in exchange rate depreciation or appreciation (computed as an average of daily changes), foreign exchange reserves, or portfolio debt flows. Portfolio equity flows are somewhat smaller (as a percentage of GDP) under the IT regime, however. Yields on government debt are smaller, on average by about 90 basis points, after the adoption of IT.

Figure 5: Exchange rates and reserves

A. % Change in Nominal Exchange Rate (INR/USD)

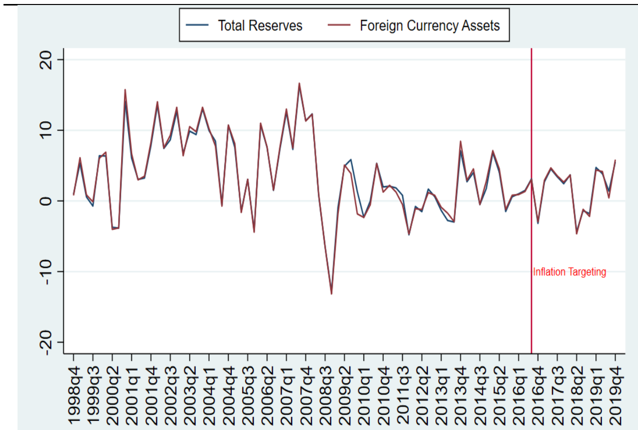


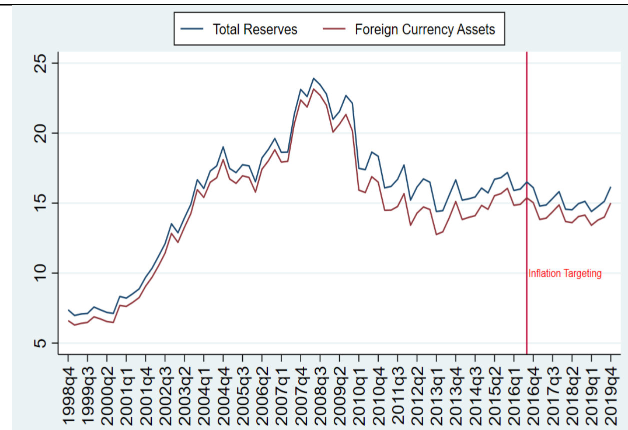
B. % Change in Real Effective Exchange Rate



C. % Change in Foreign Exchange Reserves

D. Foreign Exchange Reserves (% of GDP)





Source: Author's calculations

Source: Author's calculations

Note: Foreign exchange reserves are expressed as a percentage of annual (calendar year) GDP in D (bottom-right panel).

Table 10: Exchange rates, reserves and portfolio flows

	Nominal exchange rate (% change)	Trade Weighted REER (% change)	% change in reserves (q-o-q)	Portfolio equity flows % of GDP	Portfolio debt % of GDP	G-Sec secondary market10-year maximum yield
Inflation Targeting	-0.63	-0.08	0.47	-0.74***	-0.23	-0.91***
	(0.66)	(0.13)	(0.47)	(3.06)	(1.03)	(5.69)
Global Financial Crisis	5.83***	-0.87**	-13.12***	-1.56***	0.06	-0.56
Dummy	(2.75)	(2.25)	(4.34)	(6.95)	(0.24)	(0.90)
Post Global Financial	0.70	0.39	-5.08***	0.18	0.34***	-0.15
Crisis Dummy	(0.83)	(0.64)	(4.89)	(0.80)	(2.70)	(0.41)
Constant	0.38	0.09	6.37***	0.75***	0.05	8.49***
	(1.02)	(0.26)	(7.28)	(5.29)	(1.60)	(24.87)
Observations	91	91	85	84	84	86
Adjusted R^2	0.08	-0.02	0.32	0.14	0.05	0.03

Note: Robust t statistics in parentheses; *, **, ***, indicate significance at 10, 5 and 1 percent respectively.

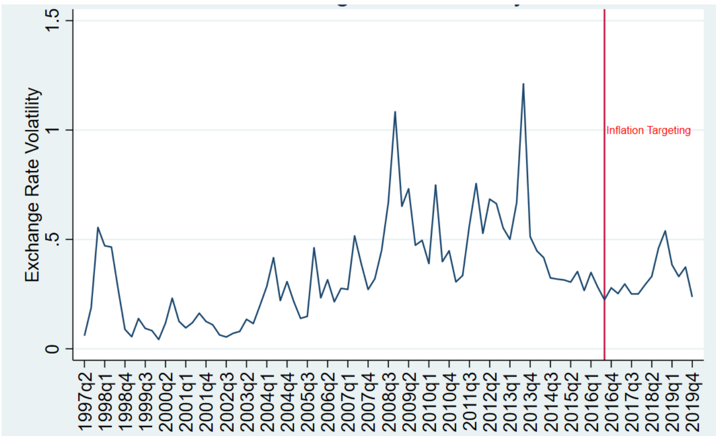
We measure exchange rate and equity market volatility by the standard deviation of percentage changes in daily value of the rupee to dollar exchange rate and equity markets, respectively. Table 11 suggests that the exchange rate and equity market have become less volatile under IT. Measuring the volatility of portfolio flows as the standard deviation of daily flows (measured in USD billions) within a quarter, we note that their average volatility has increased since the global financial crisis, but it has not changed with the shift to IT, relative to the post global financial crisis period average.

The weighted average call rate (or WACR), the interest rate at which banks lend overnight money to one other, is the RBI's operating target under its IT framework. Table 11 suggests that its volatility has declined under the IT relative to the post global financial crisis period.

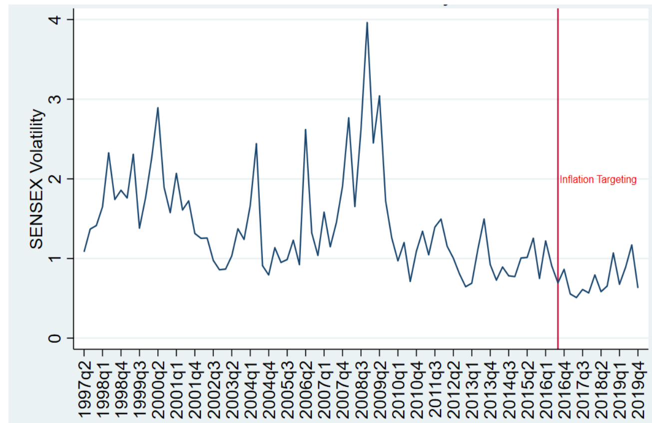
In sum, the exchange rate, the stock market, and the call money rate all became less volatile following the adoption of inflation targeting. In contrast, the volatility of portfolio capital flows has not changed.

Figure 6: Volatility of macro financial indicators

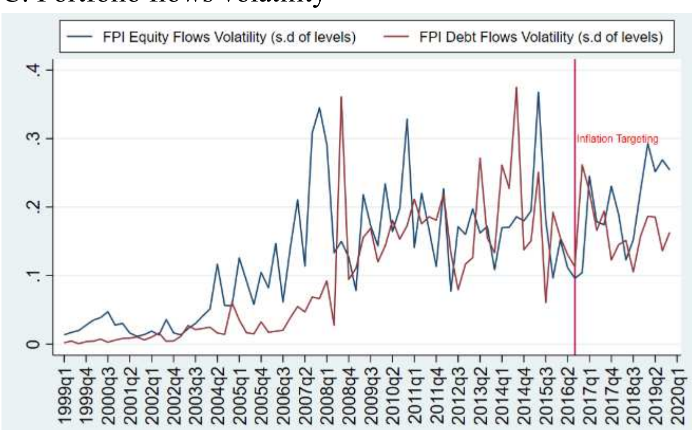
A: Exchange rate volatility



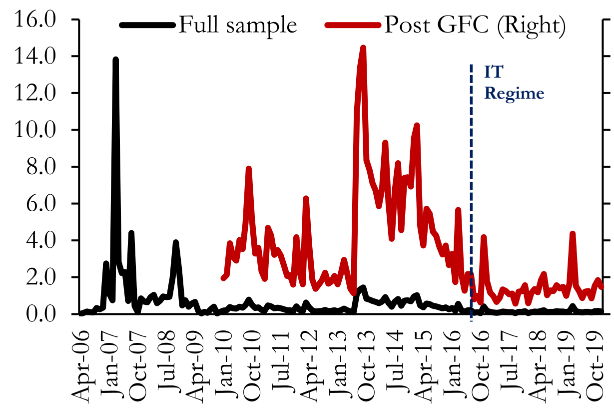
B: Stock market index volatility



C: Portfolio flows volatility



D: Weighted Average Call Rate volatility



In Table 12 we ask whether inflation targeting impacted output growth and its volatility. We use year-on-year percentage changes in industrial production index (IIP) as a proxy for output growth.[36] Volatility is defined as the 15-month rolling standard deviation of the year-on-year percent changes (which is then averaged at a quarterly frequency). There is no evidence of a change in the rate of growth, but volatility is lower under the IT relative to the post GFC average.

[36] We use IIP instead of GDP growth as IIP is available at a monthly frequency.

Table 11: Volatility of Financial Variables

	Exchange Rate Volatility	SENSEX Volatility	Weighted Average Call Rate Volatility	Portfolio equity Volatility	Portfolio debt Volatility
Inflation Targeting	-0.17***	-0.38***	-0.31***	0.02	-0.01
	(3.84)	(3.82)	(5.51)	(0.99)	(0.50)
Global Financial Crisis Dummy	0.58*** (4.89)	1.47*** (3.62)	-0.59 (0.55)	0.04* (1.77)	0.17** (2.30)
Post Global Financial Crisis Dummy	0.28*** (6.36)	-0.42*** (3.58)	-1.84** (2.12)	0.10*** (5.58)	0.15*** (12.33)
Constant	0.22***	1.54***	2.32***	0.08***	0.02***
	(10.18)	(19.02)	(2.68)	(5.64)	(6.28)
Observations	91	91	55	84	84
Adjusted R^2	0.45	0.43	0.30	0.33	0.69

Note: Robust t statistics in parentheses; *, **, ***, indicate significance at 10, 5 and 1 percent respectively.

We do not find changes in the rate of growth of government total, revenue (operating and recurrent), or capital spending under the IT regime. The rate of growth of interest payments is somewhat smaller, which is probably a reflection of lower bond yields.

Table 12: Industrial production and government expenditure

	Index of Industrial Production (% change)	Volatility of Index of Industrial Production	Total government Expenditure (% change)	Revenue Expenditure (% change)	Capital Expenditure (% change)	Interest Payments (% change)
Inflation Targeting	-0.88	-0.99***	-1.58	-1.43	9.31	-5.45
	(1.02)	(3.36)	(0.42)	(0.44)	(0.41)	(1.39)
Global Financial Crisis Dummy	-6.98** (2.15)	3.28*** (5.60)	23.95** (2.42)	26.23** (2.27)	-6.80 (0.42)	2.52 (0.30)
Post Global Financial Crisis Dummy	-3.68*** (4.24)	1.22*** (4.17)	-0.90 (0.30)	-2.63 (1.11)	-0.55 (0.03)	2.08 (0.63)
Constant	7.85***	2.19***	12.54***	13.61***	22.35	11.60***
	(13.11)	(17.49)	(5.39)	(8.66)	(1.52)	(4.95)
Observations	91	91	87	87	87	87
Adjusted R^2	0.24	0.33	0.08	0.19	-0.03	-0.02

Note: Robust t statistics in parentheses; *, **, ***, indicate significance at 10, 5 and 1 percent respectively.

Finally, we looked for evidence that the transmission of policy impulses to banking and financial markets improved with the adoption of IT. Historically, evaluations of transmission in India have been mixed. Mishra, Montiel, and Sengupta (2016) examined the strength of transmission using a structural VAR methodology. They found that a tightening of policy is associated with a significant increase in bank lending rates. Although passthrough to lending rates is only partial, they conclude that their result for India compares favorably with those for other developing countries. Consistent with these findings Acharya (2017) and Dua (2020) argue that transmission to money market and long-term interest rates is rapid and relatively complete, but that bank deposit and lending rates adjust more slowly and less completely.

We collated monthly data on government bonds yields of 1, 2, 5 and 10 year maturities, treasury bill rates, and average lending rates on new and outstanding loans. We used the repo rate as the relevant policy rate. Table 13 confirms that transmission is greater for treasury bill and short-tenure bonds. Transmission to government bonds yields and bill rates improved somewhat following the adoption of inflation targeting. Transmission to bank lending rates is relatively weak, as other authors have shown, and has not improved with the adoption of IT.

Table 13: Transmission of policy rate

	1 year govt bond yield	91 day T bill rate	Bank lending rate on outstanding loans	Bank lending rate on new loans
Repo Rate	0.94***	1.15***	0.61***	0.64***
	(20.25)	(20.23)	(12.56)	(17.77)
IT	-1.35***	-0.41	0.87**	-0.12
	(2.99)	(0.89)	(1.99)	(0.34)
Repo Rate x IT	0.33***	0.18**	-0.23***	-0.06
	(4.59)	(2.59)	(3.38)	(1.03)
Constant	0.12	-1.52***	7.30***	6.31***
	(0.38)	(3.93)	(19.49)	(23.00)
Observations	232	233	102	71
Adjusted R^2	0.59	0.59	0.91	0.91

Note: Robust t statistics in parentheses; *, **, ***, indicate significance at 10, 5 and 1 percent respectively.

6. Are expectations better anchored?

Kose et al. (2019) find that long-term inflation expectations have declined in the past two decades in both advanced economies and emerging markets and developing economies (EMDEs). Although inflation expectations are less well anchored in EMDEs, their sensitivity to domestic and global shocks has declined. They suggest that an IT regime and greater central bank transparency are associated with better anchoring.[37]

[37] Lower public debt and greater trade openness are also associated with better anchoring of expectations. Using monthly survey data from Consensus Economics for a sample of 22 EMDEs and 14 advanced economies in a structural vector autoregressive model, Davis (2014) similarly finds that the introduction of inflation targeting is associated with

Studies of India similarly suggest that expectations have become better anchored in recent years. For example, Asnani et al (2019) analyze the inflation expectations of households and find that inflation expectations have become better anchored during the inflation targeting period; in particular, there is only limited spillover from food inflation to food and non-food inflation expectations in the inflation targeting period.[38]

The RBI has been conducting its Inflation Expectations Survey of Households (IESH) since 2005, recording survey respondents' perceptions of current inflation and expectations of inflation three months and one year ahead. The survey records both qualitative and quantitative responses. It was conducted quarterly (viz., Mar, Jun, Sep and Dec) until March 2014. At that point two additional rounds in May and November were added to align it with the bi-monthly monetary policy review cycle.

The RBI has also been conducting a survey of professional forecasters since the second quarter of 2007-08, drawing responses from forecaster with both financial and non-financial institutions. Initially, the survey was conducted at quarterly frequency, but this was changed to bi-monthly in 2014-15. The survey collects annual quantitative forecasts for two financial years (the current year and next year) and quarterly forecasts for five quarters (the current quarter and next four quarters). We analyze how the inflation expectation series for India has changed since the implementation of inflation targeting. For the analysis below, we use both the household and professional forecaster series averaged at quarterly frequencies.[39] We use the CPI inflation expectations of professional forecasters, and compare household and professional forecasts with CPI inflation.[40]

Both professional forecasts and households' expectations of inflation declined with the shift to IT. Even so, household expectations of inflation consistently exceed actual inflation, and the deviation has not declined. Figure 7 shows that the average of professional forecasts has been close to actual inflation, while household expectations have often exceeded actual inflation. In the last few years, and particularly since the shift to IT, expected inflation has declined, in line with the decline in actual inflation. However, households' expectations have declined less than actual inflation and continue to be higher (by about 3 percentage points).

a statistically significant reduction in the response of inflation expectations (12-month-ahead) to shocks in oil prices and observed inflation.

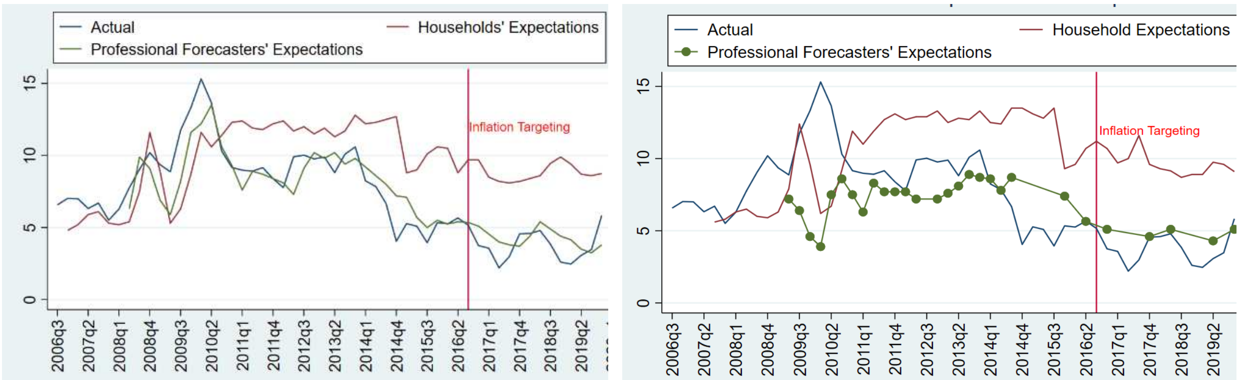
[38] Benes et al. (2017) and Patra and Ray (2010) similarly found that lagged inflation, as well as current and lagged changes in fuel and food prices significantly affected inflation expectations prior to inflation targeting.

[39] We restrict our analysis to a quarterly frequency in order to have comparable results across sectors.

[40] We use the CPI combined inflation series from 2012 onwards and prior to that the CPI-IW. Professional forecasters' expectations are for the CPI-IW prior to 2014, and for the combined series from 2014 onwards.

Figure 7: CPI inflation and household and professional one quarter and four ahead inflation expectation

A: One-quarter ahead expectations **B: Four-quarter ahead expectations**



Note: Data for last 2 quarters of 2013 of Professional forecasters' expectations series are not available. We report mean expectations for both household and professional forecasters series.

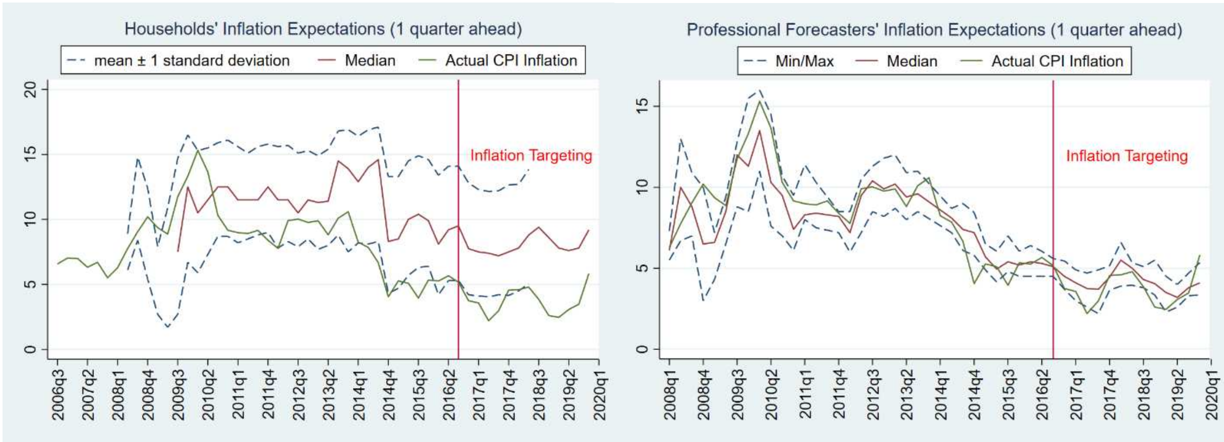
Table 14: Inflation expectations declined after inflation targeting

	Households' Expectations			Professional Forecasters' Expectations			
	Current	1-quarter ahead	1-year ahead	1-quarter ahead	2-quarter ahead	3-quarter ahead	4-quarter ahead
Inflation Targeting	-1.22***	-0.94**	-1.27**	-4.08***	-3.39***	-2.89***	-2.74***
	(2.70)	(2.06)	(2.59)	(9.50)	(9.13)	(9.46)	(8.16)
Constant	9.47***	9.82***	10.52***	8.29***	7.83***	7.44***	7.26***
	(22.48)	(22.98)	(23.95)	(20.90)	(22.10)	(26.04)	(26.42)
Observations	54	54	54	45	45	45	30
Adjusted R^2	0.03	0.01	0.03	0.51	0.47	0.50	0.44

Note: Robust t statistics in parentheses; *, **, ***, indicate significance at 10, 5 and 1 percent respectively.

In addition, while household inflation expectations continue to display considerable variation around their mean and median, professional forecaster expectations show a smaller range since the shift to IT, consistent with firmer anchoring (see Figure 8).

Figure 8: Expectations before and after IT



Note: Prior to 2014, Professional forecasters' expectations are for CPI-IW, and from 2014 onwards for combined series.

Do shocks to current inflation influence expectations about future inflation?

To assess whether shocks to current inflation influence expectations about future inflation, we regress expected inflation, q quarters ahead, on current inflation. Our baseline specification is:

$$E_t\pi_{t+q} = \beta_0 + \beta_1\pi_t + \epsilon_t$$

$E_t\pi_{t+q}$ denotes expectations at time t of inflation in period t+q and, π_t denotes CPI inflation in period t. The coefficient β_1 captures the extent to which current inflation exerts an influence on the current expectations about inflation in period t+q. If inflation expectations are well-anchored, then one would expect β_1 to be small and insignificant.[41] Since our goal is to assess whether inflation expectations have become better anchored under IT, we also estimate:

$$E_t\pi_{t+q} = \beta_0 + \beta_1\pi_t + \beta_2\mathrm{IT}_t + \beta_3\pi_t * \mathrm{IT}_t + \epsilon_t$$

For household expectations, we find that, for a one percentage point increase in current inflation, expectations about one-quarter and one-year ahead inflation increase by about 40 basis points (Table 15). The magnitude of this pass-through has remained the same since the shift to IT (β_3 is insignificant). For the professional forecasters, pass-through from inflation to expectations has declined significantly since

[41] For households, we use three months and one-year ahead mean inflation expectations and for professional forecasters, we use one to four quarter ahead mean (CPI) inflation expectations.

the shift to IT.

Table 15: Do shocks to current inflation affect inflation expectations?

	Households' Expectations		Professional Forecasters' Expectations			
	1-quarter ahead	1-year ahead	1-quarter ahead	2-quarter ahead	3-quarter ahead	4-quarter ahead
CPI Inflation	0.40***	0.41***	0.70***	0.50***	0.30***	0.13
	(3.17)	(3.09)	(10.26)	(5.74)	(3.56)	(1.23)
Inflation Targeting	1.18	0.42	0.50	0.34	-0.06	-0.43
	(0.91)	(0.29)	(0.62)	(0.39)	(0.08)	(0.42)
CPI Inflation ×	-0.08	0.05	-0.32*	-0.35**	-0.36***	-0.42***
Inflation Targeting	(0.48)	(0.20)	(1.95)	(2.31)	(2.83)	(3.57)
Constant	6.50***	7.10***	2.31***	3.52***	4.83***	6.06***
	(5.34)	(5.71)	(3.80)	(4.86)	(7.15)	(6.12)
Observations	54	54	45	45	45	30
Adjusted R^2	0.12	0.15	0.87	0.72	0.62	0.45

Note: Robust t statistics in parentheses; *, **, ***, indicate significance at 10, 5 and 1 percent respectively.

Do inflation expectations feed into actual inflation?

To assess whether inflation expectations feed into actual inflation, we estimate the following specification:

$$\pi_t = \beta_0 + \underbrace{\beta_1 \pi_{t-1}}_{\text{persistence}} + \underbrace{\beta_2 E_{t-1}\pi_t}_{\text{expectations}} + \underbrace{\beta_3 \text{output gap}_t}_{\text{supply side shock}} + \epsilon_t$$

The expectation term is the expectation of current inflation in the previous quarter. Lagged inflation captures the persistent nature of inflation, and the output gap controls for supply side shocks. As before, the output gap is defined as the difference between seasonally adjusted GDP and potential GDP, expressed as a percentage of seasonally adjusted GDP. β_1 captures the magnitude of pass-through from inflation expectations to actual inflation. To compare the strength of any feedback from expectations to actual inflation pre- and post-IT, we interact the expectations term with an inflation targeting dummy.

The estimated results are in Table 16. Pre-IT, there is no pass-through from households' expectations to actual inflation. However, a one percentage point increase in professional forecaster's expectations about next quarter's inflation implies, on an average, an increase in inflation in the next quarter by about 40 basis points. This impact of inflation expectations on inflation has become muted under IT, again consistent with better anchoring.

Table 16: Do inflation expectations feed into actual inflation?

Dependent Variable: CPI Inflation (%)				
	Households' Expectations		Professional Forecasters' Expectations	
Lagged Inflation	0.90***	0.90***	0.62***	0.61***
	(8.36)	(8.46)	(4.46)	(4.38)
Inflation Expectations	-0.10	-0.11	0.39**	0.41**
	(1.14)	(1.34)	(2.66)	(2.66)
Inflation Targeting	6.14*	5.85	2.77	2.75
	(1.79)	(1.64)	(1.51)	(1.48)
Inflation Expectations × Inflation Targeting	-0.75**	-0.71*	-0.73**	-0.70*
	(2.09)	(1.90)	(2.09)	(1.97)
Output gap (% of GDP)		-0.12		-0.09
		(0.93)		(0.81)
Constant	1.72**	1.91**	0.13	0.03
	(2.04)	(2.25)	(0.14)	(0.04)
Observations	53	53	44	44
Adjusted R^2	0.84	0.84	0.86	0.86

Note: Robust t statistics in parentheses; *, **, ***, indicate significance at 10, 5 and 1 percent respectively.

7. COVID-19 and credibility

The question of the day is how an inflation-targeting central bank should respond to an exceptional shock like the Covid-19 pandemic. In practice, we have seen central banks around the world, including in emerging markets and developing countries, cut interest rates sharply and engage in a wide range of credit-market operations. This response contrasts with the response to past external crises affecting EMDEs when central banks were reluctant to cut interest rates significantly for fear of fanning inflation expectations. That inflation expectations in a number of EMDEs are now better anchored than before, we would argue, is part of the explanation for why they have been able to do more.[42]

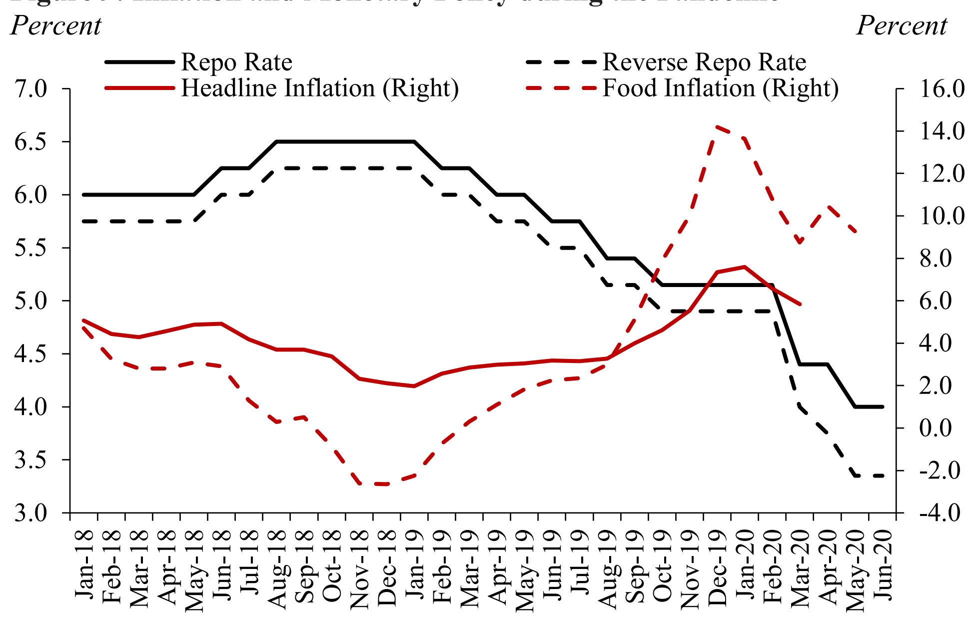
This is the case of India. On March 27, 2020, the RBI cut the repo rate by 75 basis points, the reverse repo rate by 90 basis points, and the Cash Reserve Ratio by 1 percent.[43] It followed by another 25 basis point reduction in the reverse repo rate and lowered the liquidity coverage ratio required of banks to 80 percent of the previous requirement. The RBI then further reduced the repo rate by 40 bps on May 22, for a total reduction of 115 bps between March and May 2020. The reverse repo rate was also decreased by 40 bps on May 22, 2020.

[42] We would not deny that there is also a role for Federal Reserve (and advanced country central bank policy in general) in the contrast. That the Fed responded so aggressively to the crisis opened up space for central banks, including in EMDEs, to do more.

[43] In addition, the requirement of minimum daily CRR balance maintenance was also reduced from 90 percent to 80 percent for 3 months, while the borrowing limit for the Marginal Standing Facility (MSF) was increased from 2 to 3 percent of the SLR.

The RBI took these steps despite the fact that consumer price inflation in March (according to figures published in mid-April) was running at 5.91 percent, at the top of the RBI's 2-6 percent target range and down only slightly from 6.58 percent in February (Figure 9). It did so despite the possibility that CPI inflation might accelerate further, given the impact of the lockdown and other supply-side disruptions on food prices and of exchange rate depreciation on the cost of imports. Thus, the fact that inflation expectations had become better anchored allowed the RBI to temporarily disregard the fact that inflation was already at the top of the Bank's target range and respond to this exceptional shock.

Figure 9: Inflation and Monetary Policy during the Pandemic



Source: RBI, CEIC

Three further literatures speak to the consequences of such actions. One is concerned with how an inflation-targeting central bank should respond to supply shocks, Covid-19-related lockdowns and disruptions to supply chains and production being, in part, a negative supply shock. Monetary policy is an awkward instrument for dealing with the consequences of supply shocks, since it operates mainly on aggregate demand rather than aggregate supply.[44] The dilemma for monetary policy committee members is that raising the policy rate in response to the inflationary consequences of a negative supply shock will only worsen the output shortfall, but reducing rates will only worsen the inflation overshoot.[45]

Thus, the standard advice for an inflation-targeting central bank is to cut rates – or at least to refrain from raising them – if the negative supply shock is temporary. If the shock is temporary, there will be higher prices and inflation now but lower prices and less inflation, or even deflation, in the future.

[44] Other non-monetary policies of central banks designed to buttress the liquidity and stability of specific financial assets and even institutions can be thought of as supply side interventions insofar as they prevent credit-market disruptions from interfering with supply.
[45] Especially since a classic negative supply shock will not increase the output gap – it will only reduce actual output, since potential output has fallen, while increasing unemployment.

The central bank should therefore be able to "look through" today's inflation when setting rates. For an economy not infrequently subject to supply shocks, this is an argument for the central bank to adopt a relatively long horizon when formulating its inflation forecast. When supply shocks, both positive and negative, tend to fall disproportionately on food and fuel prices, this is an argument for focusing not on headline CPI, which includes them, but core CPI, which does not.

There are three caveats to these points. First, the Covid-19 pandemic has elements of both a negative supply shock and a negative demand shock, as firms halt investment projects and households increase their precautionary saving and see their incomes fall. The negative demand shock may only materialize with a lag, and it may be smaller in India than elsewhere insofar as households living close to the margin of subsistence have little scope for reducing spending. But demand-side considerations point in the direction of interest rate cuts, insofar as they imply weaker inflation going forward.

Second, this logic assumes that the negative supply shock from Covid-19 is temporary. Unfortunately, there is also a scenario in which the shock, if not permanent, is at least very persistent – that it will require continuous or repeated lockdowns and distancing, with associated disruptions to trade and production, until a vaccine is successfully identified, manufactured and distributed or herd immunity develops. A permanent shock of this sort, which is inflationary, ceteris paribus, suggests raising rates.

Third, even if the shock is transient, there is the danger that allowing inflation to stray above the top of the target range may un-anchor inflation expectations. Agents may see current inflation above target as evidence that the central bank has lost control of the inflation process, igniting a wage-price spiral. Thus, if monetary policy lacks credibility, the costs of monetary accommodation of the shock will be greater. This is something that in principle can be inferred from observed measures of inflation expectations.

This last observation is taken up in the second relevant literature, that on escape clauses for inflation-targeting central banks. The question here is whether an inflation-targeting central bank can invoke an exceptional event – unavoidable circumstances that provide a temporary reprieve from performing its obligations under a contract, which is the definition of *force majeure* – and depart from its inflation target without damaging its credibility. *Force majeure* clauses are included in a variety of private contracts in both civil law and common law countries. Few central banks include them in descriptions of their inflation-targeting regimes. The Czech National Bank is a rare case of a central bank that, when establishing its inflation target in 1998 and revising it in 2001, specified escape clauses. These included major changes in the world prices of raw materials and energy, major changes in the exchange rate not due to domestic economic fundamentals, major changes in regulated prices, step changes in indirect taxes, and natural disasters). Heenan, Peter and Scott (2006) report that, at the time of writing, only five inflation-targeting central banks specified exceptions in their target definition; most of these pertained to administered prices and indirect taxes.[46] Some central banks have added escape clauses to their monetary policy statements in exceptional circumstances. Thus, the Monetary Policy Committee of the Bank of England added an explicit financial stability escape clause to their bank rate forward guidance in 2013.

[46] They do not specify these, but the three of which we are aware are New Zealand, the Philippines and the aforementioned Czech Republic.

Hennan, Peter and Scott argued that the advantages of explicit escape clauses are likely to be limited. As they note, the central bank would have to identify the shock, explain the impact, detail its policy response and forecast the inflation path whether or not there was a formal escape clause. They worry that formal escape clauses are overly legalistic and may divert the public communications of the central bank from the underlying macroeconomic issues toward the technical details of the escape clause itself.

In addition, there is a closely related literature on exchange rate escape clauses concerned with the circumstance under which an exchange-rate targeting central bank can alter the target. Obstfeld (1997) warns that exchange rate escape clauses can be destabilizing. If the escape clause permits or requires the policy maker to alter or suspend the target when certain economic and financial conditions obtain, investors anticipating the possibility that the escape clause will be invoked may take actions that produce those very conditions.

Grossman and van Huyck (1988) specify the conditions under which invoking an escape clause will not result in reputational damage (under which it will not diminish the credibility of the policy regime or be destabilizing). First, the shock must be independently verifiable. Second, the shock must not be of the central bank's own making. Covid-19 clearly satisfies these conditions. These conclusions suggest that central banks, including the RBI, may be able to temporarily exceed their inflation targets without damaging their credibility – assuming, that is, that the other preconditions discussed above are met.

Third, and finally, there is a literature on the optimal degree of discretion in monetary policy (e.g. Athey, Atkeson and Kehoe 2005). It may be that the full extent of the shock is not independently verifiable, so the Grossman-van Huyck conditions are not satisfied. But the central bank may know better – it may have private information about the severity of the shock. This is plausibly the case of a novel coronavirus, when estimating the effects requires compartmental epidemiological modeling and also estimates of the behavioral response. Knowing that a major negative shock is coming, the central bank may then have good reason to cut rates even though inflation is currently running above target.

The question is whether it can do so without damaging its credibility. The main threat to credibility, Athey, Atkeson and Kehoe argue, is that the central bank may abuse those same discretionary powers in the future by, for example, overly stimulating the economy in the manner of the classic time inconsistency problem. The solution, they show, is a cap on the target rate of inflation that penalizes the central bank when that target is exceeded. This kind of reputational or political penalty is precisely what inflation targeting is designed to apply. This in turn suggests that an inflation targeting central bank should have more room than other central banks to cut rates in this situation because it is granted more discretion and invites less damage to its credibility.

Table 17: Policy response to Covid-19 by IT and non-IT central banks

	IT	Non IT	India
# of countries	27	43	
Average policy rate at end 2019	4.70	5.27	5.15
Average policy rate change between December 2019 and May 2020 (percentage points)	-1.31	-0.90	-1.15
Average inflation rate during 2019	3.13	3.19	3.7

Source: Haver, authors' calculations. Inflation is the monthly average during 2019. Policy rate is as of the end 2019; the change in policy rate is between end May 2020, and end December 2019 levels.

So did IT give central banks, the RBI and in general, more room for maneuver? In Table 17 we show policy rate changes between January and May 2020, together with the 2019 rate of inflation, for 74 emerging and developing countries, distinguishing IT and non-IT central banks. The cut in policy rates is larger for IT than non-IT central banks, despite the fact that IT central banks had less "space" (their policy rates started out closer to zero). The contrast is suggestive of greater anti-inflation credibility that makes for more policy room for maneuver.

Table 18: Change in Policy Rate during the COVID Crisis

Dependent Variable	Change in Policy Rate		
	I	**II**	**III**
Inflation Targeting	-0.41	-0.48**	-0.47*
dummy	(1.57)	(2.04)	(1.96)
Policy rate at end 2019		-0.12***	-0.09*
		(2.82)	(1.97)
Inflation at end 2019			-0.06
			(0.94)
Constant	-0.90***	-0.25	-0.23
	(5.74)	(1.18)	(1.02)
Observations	70	70	70
Adjusted R^2	0.02	0.23	0.22

Note: Robust t statistics in parentheses; *, **, ***, indicate significance at 10, 5 and 1 percent respectively.

In Table 18 we regress the change in the policy rate over the same period on a dummy variable for IT central banks, the lagged policy rate, and the lagged rate of inflation. The resulting estimates confirm that IT central banks lowered their policy rates by more, even after controlling for inflation and the level of the policy rate.[47] This suggests that inflation targeting, or more accurately the complex of

[47] We find the same thing when we construct the dependent variable as the change in policy rate as percent of lagged rate.

institutional arrangements associated with it, had a payoff in terms of greater policy credibility and room for maneuver in the Covid-19 crisis.[48]

8. Conclusion

Inflation targeting in India is barely four years old, a fact that has hindered earlier efforts at performance evaluation. Here we take advantage of the (limited) accumulation of data to analyze what if anything changed with the advent of IT. We show that the RBI is best characterized as a flexible inflation targeter: contrary to some assertions and criticisms, it does not neglect changes in the output gap when setting policy rates. We do not find that the RBI became more hawkish following the transition to IT; to the contrary, adjusting for inflation and the output gap, policy rates became lower, not higher. We find some evidence that inflation has become better anchored: increases in actual inflation do less to excite inflation expectations, indicative of improved anti-inflation credibility. This is consistent with the fact that a number of other inflation-related outcomes are more stable post-IT than before.

Finally, we ask whether the shift to IT has enhanced the credibility of monetary policy such that the RBI is in a position to take extraordinary action in response to the Covid-19 crisis. We argue that the rules and understandings governing IT regimes come with escape clauses allowing central banks to disregard their inflation targets, under specific circumstances satisfied by the Covid-19 pandemic. Cross-country comparisons confirm that inflation targeting, in conjunction with related institutional arrangements, had benefits in terms of additional policy room for maneuver in the crisis.

[48] IT frameworks are not assigned randomly, of course. The literature suggests several approaches to instrumenting IT status. Virtually all of them produced negative coefficients on the IT specification in Table 18, although significant levels varied. The coefficient in question was significantly less than zero when the instrumental variable was real GDP in 2010 U.S. dollars (on the grounds that larger economies adopt IT while smaller ones prefer to peg the exchange rate), the World Bank measure of voice and accountability (on the grounds that IT tends to be adopted in countries with a culture of transparency), and regulatory quality (on the grounds that IT requires administrative capacity that is common to monetary policy and other forms of regulation).

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Appendix A

Table A1. India's Monetary Policy Framework

	Initial phase	Developmental Years	Credit Planning	Monetary Targeting	Multiple Indicator Approach	Flexible Inflation Targeting
	1935-1949	**1949-1969**	**1969-1985**	**1985-1998**	**1998-2015**	**2016 onwards**
Objective	Sterling-rupee parity	Development and Stability	Financing economic growth and ensuring price stability	Inflation and growth	Inflation and growth	Price stability while simultaneously focusing on growth when inflation is under control
Target	Exchange Rate	Administering supply and demand of credit	Priority sector credit targeting	Reserve money (M0) was used as the operating target, and Broad money (M3) as an intermediate target	Multiple indicators: rates, credit, external, fiscal variables and expectations survey used for growth and inflation projections	Headline consumer price index inflation
Operating Procedure (instruments)	Bank rate, Open market operations (OMOs), Cash reserve ratio (CRR)	Bank rate, Reserve requirements and Open market operations (OMOs)	Bank rate, Reserve requirements, selective credit controls and Open market operations (OMOs)	Bank rate, Reserve requirements (CRR, SLR)	Direct: CRR, SLR; Indirect instruments: Repo operations under LAF and OMOs	Repo rate as intermediate target and weighted average call rate (WACR) as the operating target

Additional comments	1. The focus of monetary policy was on regulating liquidity in the system through OMO—by buying and selling of government securities—so as to maintain exchange rate parity; 2. Cash reserve ratio (CRR) was to be used in exigencies rather than as an active instrument of credit control. RBI used selective credit control and moral suasion to restrain banks from extending credit for speculative purposes.	1.Statutory liquidity ratio (SLR) requirement prescribed for banks emerged as a secured source for government borrowings; 2. In the 1960s, inflation was considered to be structural and inflation volatility primarily caused by agricultural failures, so there was greater reliance on selective credit controls.		1. Monetary targeting was flexible to accommodate changes in real GDP growth. In practice, it was an indicative monetary targeting framework with a feedback from real economic activity; 2. CRR was used as the primary instrument for monetary control; 3. By the second half of the 1990s, the RBI was able to move away from direct instruments to indirect market-based instruments in its liquidity management operations.	Some of these instruments including changes in reserve requirements, standing facilities and OMOs were meant to affect the quantum of marginal liquidity, while changes in policy rates, such as the Bank Rate and reverse repo/repo rates were the instruments for changing the price of liquidity.	
Source: Mohanty (2017); RBI Governor Speech (Jan 2020)						

Table A2: Description of variables used in the analysis

Variable	Description
CPI Inflation	This measure is equal to “2011-12 CPI headline inflation” series from 2012q1 onwards. Prior to 2012q1, it is equal to CPI-Industrial worker headline inflation.

CPI Food Inflation	This measure is equal to "2011-12 CPI food inflation" series from 2012q1 onwards. Prior to 2012q1, it is equal to CPI-Industrial worker food inflation.
CPI Core Inflation	This measure is equal to "2011-12 CPI core inflation" series (i.e. Headline excluding food & beverages and fuel & light) from 2012q1 onwards. Prior to 2012q1, it is equal to CPI-Industrial worker core inflation.
WPI (Manufacturing/Food) Inflation	The three measures—WPI, WPI Manf., WPI Food of Wholesale Price Index Inflation are spliced using standard splicing methodology. For instance, if new inflation rate series starts from 2012q1, we consider the new series from there on, and prior to that inflation rate as implied by old series is considered.
Inflation	This inflation measure is defined as: $$\text{Inflation}_t = \begin{cases} \text{CPI Inflation}_t \text{ if t } \geq \text{Q1 2014} \\ \text{WPI Inflation}_t \text{ if t } \leq \text{ Q4 2013} \end{cases}$$ This definition of headline inflation has been used while estimating the central bank's reaction function.
Core Inflation	This inflation measure is defined as: $$\text{Core Inflation}_t = \begin{cases} \text{CPI Core Inflation}_t \text{ if t } \geq \text{Q1 2014} \\ \text{WPI Man. Inflation}_t \text{ if t } \leq \text{ Q4 2013} \end{cases}$$ This definition of core inflation has been used while estimating the central bank's reaction function.
Food Inflation	This inflation measure is defined as: $$\text{Food Inflation}_t = \begin{cases} \text{CPI Food Inflation}_t \text{ if t } \geq \text{Q1 2014} \\ \text{WPI Food Inflation}_t \text{ if t } \leq \text{ Q4 2013} \end{cases}$$ This definition of food inflation has been used while estimating the central bank's reaction function.
Exchange Rate	We use quarter-on-quarter percentage point change in INR/USD exchange rate. Thus, $$\text{Exchange Rate}_t = 100 * \left(\frac{\text{INR/USD}_t}{\text{INR/USD}_{t-1}} - 1\right)$$ where, t denotes the quarter.
Output Gap	We apply HP filter to the seasonally adjusted quarterly real GDP series and then express the output gap as a percentage of GDP. Seasonal adjustment is carried out using X-11 filter. Output gap obtained by applying X-13 ARIMA SEATS for seasonal adjustment are very similar to the one obtained using X-11 method.
IT (Inflation Targeting dummy)	IT period starts from 2016q3 because in May 2016, amendment was made to RBI Act, 1934 to provide a statutory basis for the implementation of the flexible inflation targeting framework. We consider the start date from third quarter as the Act was amended in the middle of 2nd quarter. Thus, $$\text{IT}_t = \begin{cases} 1 \text{ if t } \geq \text{Q3 2016} \\ 0 \quad \text{otherwise} \end{cases}$$
Global Financial crisis (dummy)	This denotes the global financial crisis period i.e. Q3 2008 – Q1 2009. Thus, $$\text{GFC}_t = \begin{cases} 1 \;\; if \;\; Q3\ 2008 \leq t \leq Q1\ 2009 \\ 0 \qquad otherwise \end{cases}$$
Post Global Financial crisis (dummy)	This denotes the post global financial crisis period i.e. Q2 2009 – Q4 2019. Thus,

<table>
<tr><td></td><td>$$Post\ \text{GFC}_t = \begin{cases} 1 \ \ if \ \ Q2\ 2009 \ \le t \ \le \ Q4\ 2019 \\ 0 \qquad otherwise \end{cases}$$
Our last sample point is Q4 2019.</td></tr>
<tr><td>Effective Policy Rate</td><td>We define Effective policy rate as in Patra and Kapur (2013)
$$\text{Effective Policy Rate}_t = \begin{cases} \text{Bank Rate}_t & \text{if Q2 1997} \le \text{t} \le \text{Q1 2002} \\ \text{Reverse Repo Rate}_t & \text{if Q2 2002} \le \text{t} \le \text{Q2 2006} \\ \text{Repo Rate}_t & \text{if Q3 2006} \le \text{t} \le \text{Q4 2008} \\ \text{Reverse Repo Rate}_t & \text{if Q1 2009} \le \text{t} \le \text{Q2 2010} \\ \text{Repo Rate}_t & \text{if Q3 2010} \le \text{t} \le \text{Q4 2019} \end{cases}$$
Bank rate, Repo rate and Reverse repo rate represent average value in a quarter.</td></tr>
<tr><td>Fiscal Deficit/ Fiscal Deficit (% of GDP)</td><td>We aggregate Central government's monthly fiscal deficit at quarterly frequency. To compute, fiscal deficit to GDP ratio, we seasonally adjust both series using X-11 and X-13 ARIMA SEATS and construct two measures of deficit based on different filter applied.</td></tr>
<tr><td>Market Borrowings/ Market Borrowings (% of GDP)</td><td>We aggregate Central government's monthly market borrowings data at quarterly frequency. To compute, market borrowings to GDP ratio, we seasonally adjust both series using X-11 and X-13 ARIMA SEATS. Both seasonal filters give very similar results.</td></tr>
<tr><td>Portfolio Flows: Equity and Debt</td><td>We use daily portfolio flows (equity and debt) data as published by National Securities Depository Limited.</td></tr>
<tr><td>IIP (Index of Industrial production)</td><td>IIP series has been spliced using standard splicing method. Year on year growth rates starting 1996 are based on 1993-94 series; from April 2006, they are based on 2004-05 series and April 2013 onwards, they are based on 2011-12 series.</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">Additional Data used for analysis in Section 7: Covid and Credibility</td></tr>
<tr><td>Population</td><td>We use population data for year 2018. For regression analysis, we transform population sum into log level. (Source: WDI)</td></tr>
<tr><td>Real GDP (constant 2010 US$)</td><td>Data are in constant 2010 U.S. dollars. Dollar figures for GDP are converted from domestic currencies using 2010 official exchange rates. We use 2018 values and convert them into log terms for analysis. (Source: WDI, World Bank national accounts data, and OECD National Accounts data files)</td></tr>
<tr><td>Real GDP per capita (constant 2010 US$)</td><td>GDP per capita is gross domestic product divided by midyear population. Data are in constant 2010 U.S. dollars. We use 2018 values and convert them into log terms for analysis. (Source: WDI, World Bank national accounts data, and OECD National Accounts data files)</td></tr>
<tr><td>Trade (% of GDP)</td><td>Trade is the sum of exports and imports of goods and services measured as a share of gross domestic product. We use the values for 2018. (Source: WDI, World Bank national accounts data, and OECD National Accounts data files)</td></tr>
<tr><td>Central Bank Independence Weighted Index</td><td>(Source: Garriga, Ana Carolina. (2016). Central Bank Independence in the World: A New Data Set. International Interactions. 10.1080/03050629.2016.1188813) Central Bank Independence measure is</td></tr>
</table>

	based on rules pertaining to legislative reforms, policy formulation etc. which are coded and combined into a single weighted index. We use values for 2012 (the latest reported year).
Governance Indicators	The Worldwide Governance Indicators report on six broad dimensions of governance over the period 1996-2018—Voice and Accountability, Political Stability and Absence of Violence, Government Effectiveness, Regulatory Quality, Rule of Law, Control of Corruption. We use the percentile ranks for the year 2018 to conduct our analysis; and construct an average governance indicator (rank) by simply averaging the percentile ranks over six categories of reported indicators. (Source: World Bank.)
Financial development index and related indices	We use nine indices that summarize how developed financial institutions and financial markets are in terms of their depth, access, and efficiency. These indices are then aggregated into an overall index of financial development (Financial Development Index). All indices are for year 2017 (latest available). (Source: IMF Strategy, Policy and Review Department)
Source: Authors' Compilation	

Table A3: Inflation basket in Various CPI series

	CPI-Combined	**CPI Industrial Worker (CPI-IW)**	**CPI Agricultural Labor (CPI-AL)**	**CPI Rural Labor (CPI-RL)**
Base year	2012	2001	1986-87	1986-87
Weights of major groups				
Food, Beverages,Tobacco	48.24	48.47	72.94	70.47
Fuel & Light	6.84	6.42	8.35	7.9
Housing	10.07	15.29	–	–
Clothing & Footwear	6.53	6.58	6.98	9.76
Miscellaneous	28.32	23.32	11.73	11.87
Total	100	100	100	100
Compiling agency	CSO, GOI	Labour Bureau, GOI		
Source: CSO, GOI; Labour Bureau, GOI.				

Table A4: Correlation coefficients between the different variables and their summary statistics.

	Policy Rate	Output gap	Inflat ion	Exchange rate depreciation	Fiscal deficit/GDP	Government market borrowing
Policy Rate	1					
Output gap	0.35*	1				
Inflation	0.19	0.15	1			

Exchange rate depreciation	0.30*	-0.07	0.18	1		
Fiscal deficit/GDP	0.09	-0.32*	0	0.17	1	
Government market borrowing	-0.13	-0.27*	0.02	-0.06	0.49*	1

*indicates that the correlation coefficient is significant at 1 percent level. Correlation between policy rate and inflation is significant at 10 percent level.
Source: Authors' Calculations

Appendix B: Further Analysis of Food-Price-Core-Inflation Passthrough

We use a VAR model to identify the pass-through effect of food inflation on core inflation and vice-versa. Our sample goes from 1997q1 to 2019q4. We splice the respective CPI series using standard splicing methods to arrive at CPI-food, core and fuel inflation. In particular, we have used CPI-IW variant prior to 2012q1 and new CPI food/fuel/core 2011-12 series post that.

Our VAR model includes food and core inflation as endogenous variables and fuel inflation as exogenous. We select a lag length of 8 using the information criteria.[49] For fuel inflation, we consider 4 lags as exogenous to the model. As an additional check, we implement the same model by replacing each variable by its first difference (the optimal lag length changes to 4 with first difference specification).

a. Persistence of shocks: We find that inflationary shocks are quite persistence i.e. shock to food or core inflation doesn't dissipates in the next period but stays intact for almost 3 quarters and eventually converges to lower levels. For instance, in Figure B1 bottom right panel, we see that a one Cholesky standard deviation shock to food inflation stays intact until fourth quarter and tend to vanish fully only after a year. The same is true for core inflation shock as evident from top left panel of Figure B1.

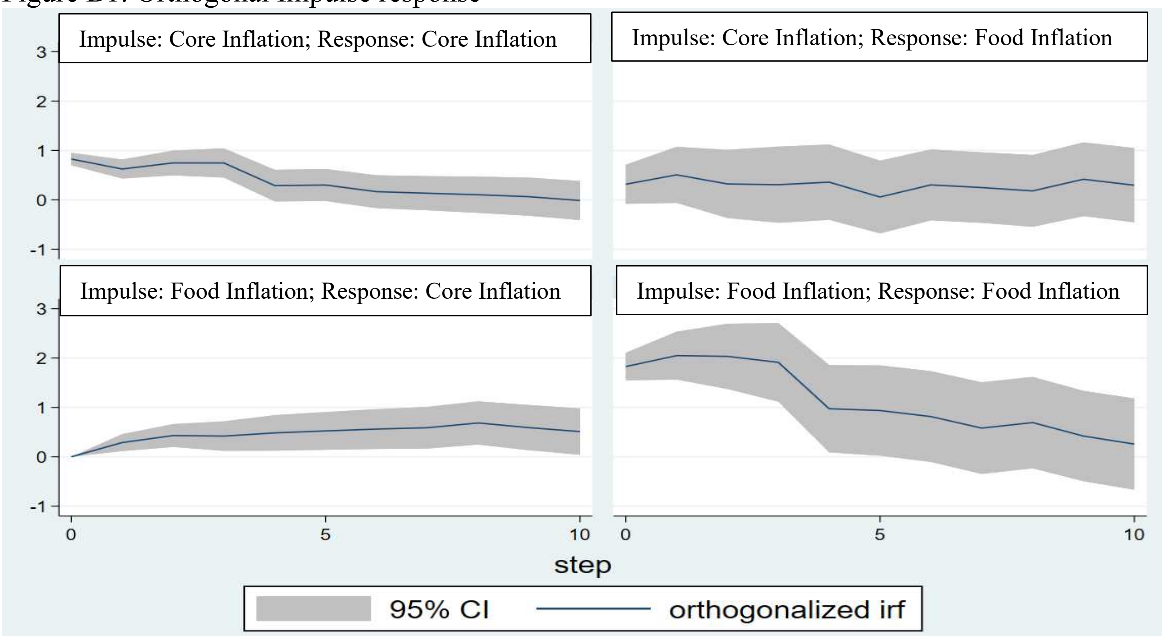
b. Pass through from food to core inflation: Bottom left panel of Figure B1 shows the orthogonal impulse response of one Cholesky standard deviation shock to food inflation with core inflation as the response. The effect of food inflation shock shows up after one quarter lag and tends to spiral up albeit at a slower pace until it starts moderating after the eighth quarter.

c. Pass through from core to food inflation. In the orthogonal impulse response of one Cholesky standard deviation shock to core inflation with food inflation as the response, the results suggest no pass through from core to food inflation despite an immediate jump in the point estimate of the orthogonal impulse response. The extreme wide confidence intervals signal the insensitivity of food inflation to core inflation shocks. This is not surprising given that food inflation in India is largely driven by supply side shocks such as rain and weather and climatic conditions.

d. Results using first difference specification: The persistence results as described in point (a) remains consistent with this first difference specification. However, the argument for the pass-through effects from food to core inflation weakens as the confidence interval around the impulse response widens. Results also suggests an immediate pass through from core inflation to food inflation which points to the role of channels other than supply shocks. The immediate pass through from core to food inflation is very short-lived and dies out in the third quarter.

[49] Optimal lag length is selected using both Schwarz Bayes and Akaike information criteria (SBIC & AIC).

Figure B1: Orthogonal Impulse response



Source: Author's Calculation

Appendix C: Inflation Persistence

1. First-order autocorrelations

We construct the rolling window estimates of first order autocorrelation for headline, core, food and fuel inflation [similar to Pivetta and Reis (2007), Fuhrer (2010)]. We consider three windows for rolling sample autocorrelation with length 20, 30 and 40 quarters. Headline and core inflation display similar time variation in their autocorrelation and, a very high degree of persistence with their autocorrelation coefficients lying in the range of 0.8-0.9 based on a ten-year rolling window (see Figures C1A and C1B). Food inflation persistence, as measured by the first order autocorrelation, appears to have declined from being highly persistent in 2010 (having a correlation coefficient slightly above 0.9); the autocorrelation coefficient has hovered around 0.8 in the recent quarters.

FigureC.1: First order autocorrelation for alternative inflation measures

Figure C1A: Headline inflation has shown high persistence

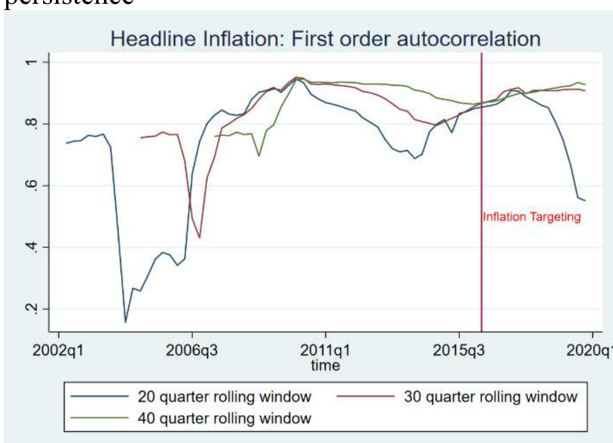


Figure C.1B: Core inflation has also been highly persistent

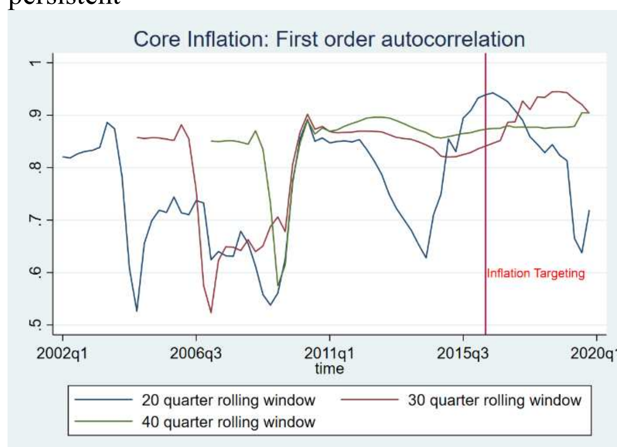


Figure C.1C: Food inflation appears to be less persistent than core

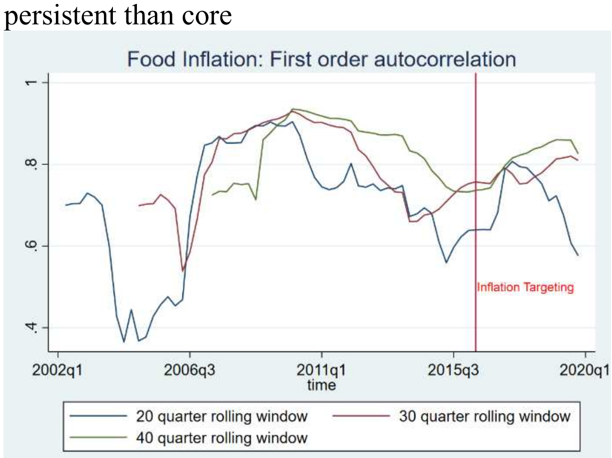


Figure C.1D: Fuel inflation persistence has increased over time

Source: Author's calculations

2. Dominant root of the univariate time series process

We now consider "Largest Autoregressive root (LAR)" or "Dominant root" implied by the univariate autoregressive process for inflation as a measure of persistence. Consider an AR(p) model:

$$y_t = \theta_0 + \sum_{i=1}^{p} \theta_i y_{t-i} + \epsilon_t$$

The lag polynomial obtained from the AR(p) model can written as:

$$L(p) = \left(1 - \theta_1 L - \theta_2 L^2 - \cdots . \theta_p L^p\right)$$

which can be factored and expressed as:

$$L(p) = \left((1 - \beta_1 L)(1 - \beta_2 L)(1 - \beta_3 L) \ldots . (1 - \beta_p L)\right)$$

where the β_i coefficients are ordered according to their size, with β_1 the largest. In the long run, the effect of a shock on inflation will be dominated by this largest root: in the case where β_1 is one, the series has a unit root, and all shocks are permanent. The advantage to the LAR measure is that it effectively measures how close a given inflation series is to having a unit root, that is, how close to permanent a given shock will be. A disadvantage, however, is that the other roots beyond the unit root are ignored, while they matter too in practice, for example, a series with a β_2 of coefficient of 0.8 will display more persistence than one with 0.2.

Table C.1: Dominant AR root for inflation measures 1997q2-2019q4

CPI Inflation series	Dominant AR root			
	p= 1	p =2	p=3	p=4
Headline	0.85	0.71	0.72	0.66*
Core	0.87	0.84	0.76	0.77*
Food	0.80	0.69	0.58	0.74*
Fuel and Light	0.81	0.54*	0.76*	0.74*
Source: Author's Calculations				
Note: 1. * denotes complex roots; 2. Results are based on MLE estimation of AR(p) model.				

Table C.1 summarizes the results. All the measures of inflation are highly persistent as suggested by their dominant AR roots. Comparing across the measures, we find core inflation to be relatively more persistent than food inflation. It is worth noting that AR roots are estimated using OLS estimation and are likely to be biased downward.

3. Sum of autoregressive coefficients

Another widely used persistence measure is the sum of autoregressive coefficients (SARC). For this measure, the AR(*p*) measure chosen above for each of the inflation indices is estimated, and the θ coefficients in the equation are summed. The SARC is a widely used method for assessing persistence, first proposed with some modifications in Andrews and Chen (1994), who present it as a better single number estimate of long-term dynamics than unit root tests. However, it also has shortcomings, particularly those that relate to oscillating dynamics. If some of the θ coefficients are positive and others are negative, the sum will be close to zero despite what could be near-infinite dynamics. Table C.2 presents the SARC estimate for different AR models with varying lag-length. This measure also suggests a high degree of persistence across all four measures of inflation with persistence being relatively higher in core inflation than food or fuel inflation. For AR(1) model, the SARC estimates are very close to the dominant AR roots for all four inflation measures. Some of the observed difference in SARC estimates and

Table C.2: Sum of AR coefficients for inflation measures 1997q2-2019q4

CPI Inflation series	Sum of AR coefficients			
	p= 1	p =2	p=3	p=4
Headline	0.85	0.82	0.82	0.81
Core	0.88	0.87	0.85	0.82
Food	0.81	0.78	0.77	0.74
Fuel and Light	0.81	0.75	0.69	0.70
Source: Author's Calculations				
Note: Results are based on OLS estimation of AR(p) model				

dominant AR root estimates could be attributed to the estimation methodology as the former is estimated using OLS while the latter using MLE. Among the first four measures of persistence considered so far, none of them has quantified the time until which an inflation shock persists in the economy. The best way to visualize this is by analyzing the impulse response function estimated from a univariate or a multivariate time series model. However, to quantify the cut-off time period until which the shock lasts, we analyze another measure known as half-life.

3. Half-life

Another measure for estimating persistence is calculating the impulse half-life. For this method, an impulse response function for each of the AR(p) models is derived. The number of periods required to reduce the impulse response function below 0.5 from an initial unit shock is the half-life. Unlike the previously described methods, this produces integral measures of persistence. For an AR(1) model, a simplified formula is used to calculate half-life which we describe as below:

$$\text{Half-life (in periods)} = \frac{log(0.5)}{log(\theta_1)}$$

where θ_1 is the coefficient on AR(1) term in the AR(1) model. Table C.3 presents the half-life estimates based on OLS estimation of AR(1) model for different inflation components. The results suggest a higher persistence of core inflation as the shock's half-life is around 5 quarters while that of food and fuel is about 3 quarters. The half-life for headline inflation is estimated to be around 4 quarters.

Table C.3: Half-life for inflation measures 1997q2-2019q4

CPI Inflation series	Half-life
Headline	4.12
Core	5.16
Food	3.12
Fuel and Light	3.38
Source: Author's Calculations	
Note: Results are based on OLS estimation of AR(1) model.	

Appendix D: GMM Estimates of the Monetary Policy Reaction Function

Below we present results from the GMM estimation of the reaction function. In columns (1), (2), (5) and (6), inflation is instrumented by its four lags while output gap is treated as exogenous; in columns (3) and (7), output gap is instrumented by its four lags while inflation is treated as exogenous; and in columns (4) and (8), output gap and inflation are both assumed to be endogenous and are instrumented by four lags of inflation & output gap.

Table D.1: Estimation of Monetary Policy Reaction Function

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Inflation	0.33***	0.30***	0.19**	0.26***	0.11***	0.10***	0.09***	0.09***
	(4.15)	(3.70)	(2.56)	(3.01)	(3.79)	(3.22)	(3.45)	(3.27)
Output gap		0.37***	0.56***	0.53***		0.19***	0.22***	0.21***
(% of GDP)		(5.24)	(4.20)	(4.14)		(3.07)	(3.79)	(3.65)
Lagged					0.86***	0.82***	0.85***	0.85***
Effective					(19.30)	(17.59)	(19.27)	(20.31)
Policy rate								
Constant	4.81***	4.99***	5.74***	5.36***	0.27	0.59**	0.49*	0.45*
	(10.48)	(11.36)	(14.91)	(11.80)	(0.93)	(1.98)	(1.87)	(1.77)
Observations	87	87	87	87	87	87	87	87
Adjusted R^2	0.00	0.12	0.12	0.09	0.86	0.89	0.89	0.89

Robust t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Source: Authors' Calculations

Appendix E: Previous Estimates of Monetary Policy Reaction Functions for India

The theoretical model built by Taylor (1993) is used as a workhorse model for the empirical estimation of monetary policy reaction function. The model assumes policy rate as function of inflation gap and output gap. Many studies have conducted the empirical exercise of estimating the monetary reaction function for India. We list below some of them.

1. **Virmani (2004)** estimated India's monetary policy reaction function by using the Taylor (1993) rule as well as the McCallum (1988) rule augmented with change in the real effective exchange rate. The entire sample period was from the third quarter of 1992 to the fourth quarter of 2001. From the OLS and GMM estimations, it was found that the backward-looking Taylor rule captures the evolution of the short-term interest rate reasonably well, although the backward-looking McCallum rule also performs quite well.

2. **Mohanty and Klau (2005)** extended the Taylor rule to include changes in the real effective exchange rate and examined how the central bank changes the policy rate in response to inflation, output gap, and exchange rate. They used quarterly data from 1995 to 2002 in 13 emerging economies including India. Empirical results of OLS and GMM for India showed that all explanatory variables are significant with the expected signs, and that the interest rate responds to the exchange rate volatility more than inflation and output gap.

3. **Ranjan et al. (2007)** find significant response of the monetary policy index[50] to the output gap and inflation gap over the period 1951-2005 (coefficient on output gap: 0.88 and on inflation gap: 0.52). Both these coefficients go up (output gap:1.89, inflation gap:1.65) when the sample is restricted to begin in 1992. When the output gap is replaced by its first lag, the coefficient values decline in almost all the models, in both the periods. The authors estimate three different measures of output gap and results are robust to the choice of such a measure although coefficient on output gap change slightly.

4. **Takeshi and Shigeyuki (2009)** empirically estimate India's monetary policy reaction function by applying the Taylor (1993) rule and its open-economy version which employs dynamic OLS. The analysis uses monthly data of IIP (as a proxy for output), WPI, REER, call rate (as interest rate) from April 1998 to December 2007. When the simple Taylor rule was estimated for India, the output gap coefficient was statistically significant, and its sign condition was found to be consistent with theoretical rationale; however, the same was not true of the inflation coefficient. After including exchange rate, the coefficients of output gap and exchange rate had statistical significance with the expected signs, whereas the results of inflation remained the same as before.

5. **Hutchison et al. (2010):** This paper estimates an exchange-rate-augmented Taylor rule for India over the period Q1 1980 to Q4 2008. It investigates monetary policy changes between the pre- and post-liberalization periods in order to capture the potential impact of macroeconomic structural changes on the RBI's monetary policy conduct. Overall, it finds that the output gap seems to matter more to RBI than inflation, there is greater sensitivity to consumer price inflation, exchange rate

[50] Their analysis uses a composite index of policy actions (MPI), defined as a geometric mean of the index of the bank rate, CRR, and SLR.

changes do not constitute an important policy factor, and the post-1998 conduct of monetary policy seems to have changed in the direction of less inertia.

6. **Singh (2010)** estimates monetary policy reaction function for the Indian economy for the period 1951-2009. The function has exchange rate and interest rate smoothing terms in addition to inflation gap and output gap. In addition to estimating for the whole period, the author also estimates these functions separately for the period up to 1988 and thereafter. The coefficients have expected signs in most of the models. While the coefficients are significant in very few models in the pre-1989 period, in the remaining period these coefficients are significant in most of the models. This is in line with the findings of Ranjan et al. (2007). The interest rate smoothing term is highly significant in most of the models, more in the pre-1989 period than after that.

7. **Hutchison et al. (2013)** estimate a time-varying Taylor-type rule for India during 1987q1 to 2008q4 using IIP (as proxy for output), WPI, call money market rate & nominal exchange rate. They find that the conduct of monetary policy over the last two decades can be characterized by two regimes—hawk and dove. In the first of these two regimes, the central bank reveals a greater relative (though not absolute) weight on controlling inflation vis-à-vis narrowing the output gap. The central bank however was found to be in the "Dove" regime about half of our sample period, focusing more on the output gap and exchange rate targets to stimulate exports, rather than moderating inflation.

8. **Kumawat and Bhanumurthy (2016)** model the monetary policy response function for India, for the period April 1996 to July 2015. Using 91-day Treasury bill rate as the policy rate, they find that the monetary policy has been responsive to inflation rate, output gap and exchange rate changes during this period but with substantial time-varying behavior in the reaction function. The regime shift tests show that the transition is driven by inflation gap as well as exchange rate changes. Another important finding is that there is a high degree of inertia in the policy rates.

Appendix F: Literature comparing the macroeconomic performance pre-post Inflation targeting

Author	Sample		Estimation Methodology	Conclusions
	Countries	Time		
Ball and Sheridan (2005)	20 OECD members (all developed and moderate inflation economies): 7 IT and 13 NIT	1960-2001	Cross-section OLS (Difference-in-difference approach)	No evidence that inflation targeting improves macroeconomic performance as measured by the behavior of inflation, output, or interest rates.
Vega and Winkelried (2005)	World; 23 IT and 86 NIT		Propensity score matching	IT has helped in reducing the level and volatility of inflation in the countries that adopted it.
Goncalves and Salles (2006)	36 EMEs: 13 IT	1980-2005	Cross-section OLS	Compared to non-targeters, developing countries adopting the IT regime not only experienced greater drops in inflation, but also in growth volatility.
Mishkin and Schmidt-Hebbel (2007)	21 IT (8 AEs and 13 EMEs); 13 NIT AEs 21 IT (8 AEs and 13 EMEs); 13 NIT AEs 21 post-IT; 21 pre-IT Stationary IT; 13 NIT AEs	1990-2005	Cross-section OLS, IV Panel	They conclude that inflation targeting helps countries achieve lower inflation in the long run, have smaller inflation response to oil-price and exchange-rate shocks, strengthen monetary policy independence, improve monetary policy efficiency, and obtain inflation outcomes closer to target levels. The performance attained by industrial-country inflation targeters generally dominates performance of emerging-economy inflation targeters and is similar to that of industrial non-inflation targeting countries.
Batini and Laxton (2007)	21 IT; 29 NIT	1985-2004	Cross-section OLS	Targeting is associated with lower inflation, lower inflation expectations, and lower inflation volatility in the initial years of operation. There are no visible adverse effects of targeting on output, and performance along other dimensions—such as the volatility of interest rates, exchange rates, and international reserves—has been favorable.
Lin and Ye (2007)	AEs: 7 IT	1985-1999	Propensity score matching	Inflation targeting has no significant effects on either inflation or inflation variability in these seven countries. Evidence from long-term nominal interest rates and income velocity of

				money also supports the window-dressing view of inflation targeting.
Brito and Bystedt (2010)	EMEs: 13 IT and 46 NIT	1980-2006 (annual)	Various Panel models	No evidence that the inflation targeting regime (IT) results in lower inflation in developing countries. There is evidence of lower output growth during IT adoption.
Calderón and Schmidt-Hebbel (2010)	World: 24 IT; 73 NIT	1975-2005 (annual)	Multi-variate structural inflation model; Panel Models: Fixed Effects, Random Effects, and System GMM	Controlling for high-inflation and hyperinflation episodes, inflation-targeting (IT) regimes and fixed exchange rate regimes are associated with lower inflation.
Gemayel et al. (2011)	EMDEs: 10 IT; 29 NIT	1990-2008 (annual)	Cross-section OLS, Panel estimation (via GMM)	Inflation targeting is associated with lower inflation and inflation volatility. There is no robust evidence of an adverse impact on output.
Pontines (2011)	22 Industrial, 52 Developing; 23 IT (10 Industrial, 13 Developing)	1985-2005 (annual)	Treatment effect regression that jointly estimates the probability of being an inflation targeter and the outcome equation (considers the problem of self-selection in the countries' decision to be an inflation targeter).	Nominal and real exchange rate volatility are lower in inflation targeting countries than countries that do not target inflation.
Rose (2007)	23 IT; 42 countries in the control group (selected based on real GDP and population)	Jan 1990- Dec 2005 (monthly)	Difference in Difference (comparing pre-post IT while controlling other factors)	Inflation targeters have lower exchange rate volatility and less frequent sudden stops of capital flows than similar countries that do not target inflation. Inflation targeting countries do not have current accounts or international reserves that look different from other countries.
Source: Author's Compilation. IT stands for inflation targeting countries, NIT for non-inflation targeting countries, EME for emerging market economies, and AE for advanced economies.				