“Targeting Inflation Expectations?"

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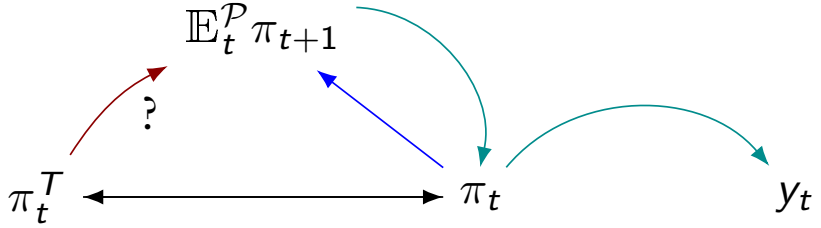
November 2022

Are Expectations Relevant?

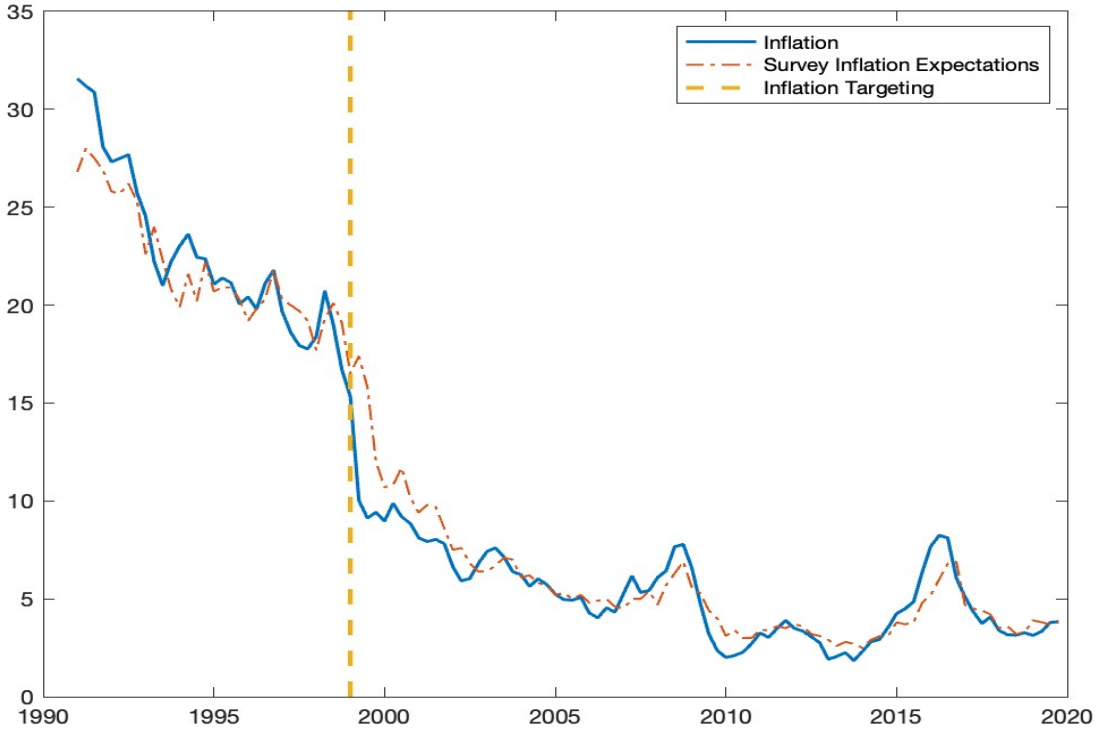
- Modern macroeconomic theory emphasises the role of expectations for inflation.



- Policy changes are introduced to anchor expectations and communicate with the public.
- Limited information on the formation and updating of these expectations
  1. Specifically, under regime changes.

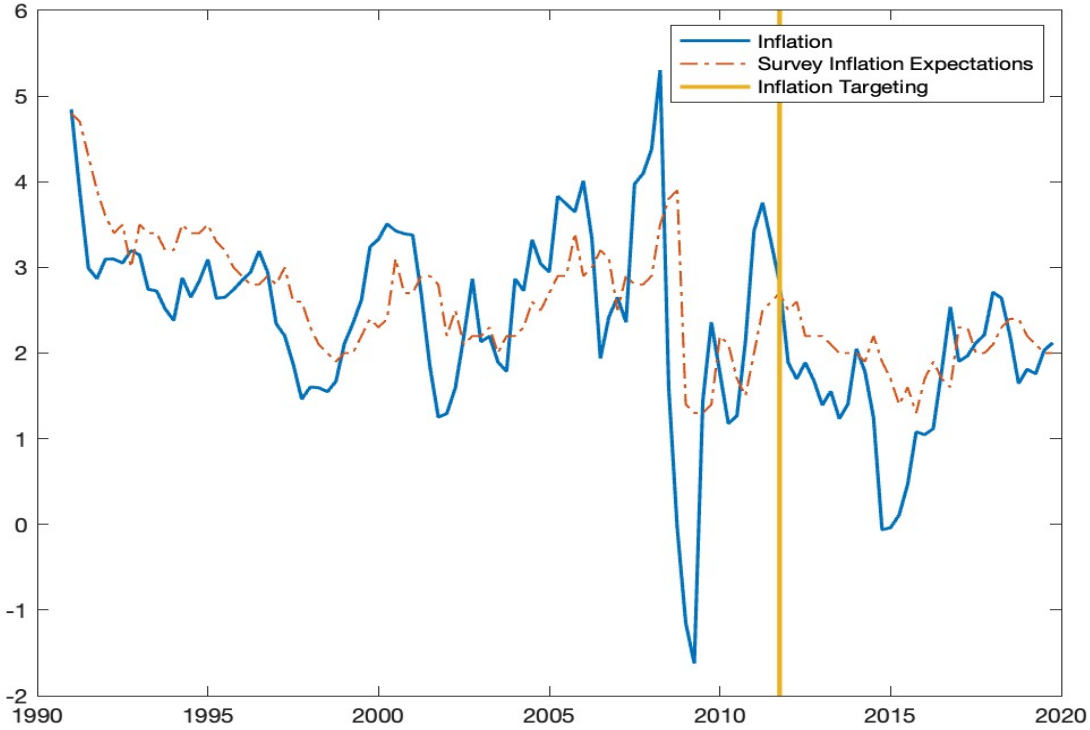
How do inflation and expectations evolve?

Figure: Colombia Inflation and Inflation Expectations



How do inflation and expectations evolve?

Figure: US Inflation and Inflation Expectations



Policy Change and Expectations

- Do agents respond to a change in monetary policy, specifically, the introduction of Inflation Targeting?
  1. Do agents change their priors, at the time of implementation?
     - The data suggests no.
  2. Does anticipation (announcement) of the policy play a role in the way priors are updated?
     - In a negligible way

Key Finding: Inflation leads expectations.

Policy Implication: Focus on inflation as the sole objective.

Paper builds on three strands of the literature

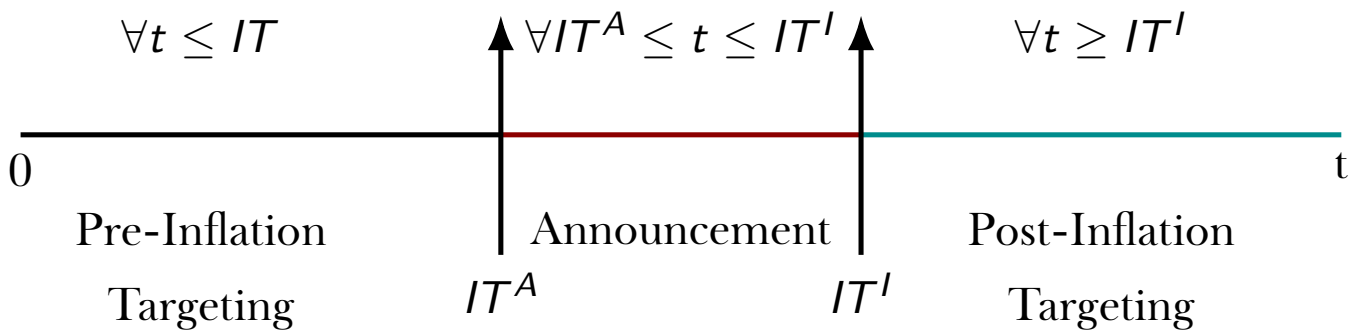
1. Inflation Targeting and Inflation Expectations (RE): Impact of a change in policy under deviations from RE. Ball and Sheridan (2004), Gürkaynak et al. (2010), Beechey et al. (2011)
2. Inflation Expectations and Subjective Beliefs: Survey data from 32 countries and anticipation of the policy. Coibion and Gorodnichenko (2015), Coibion et al. (2018), Carvalho et al. (2021), Gáti (2022).
3. Credibility: Assess the credibility of the target. Kostadinov and Roldán (2020), King et al. (2020), Duggal and Rojas (2022)

Roadmap

- Agents' Expectations
  1. Rational Expectations
  2. Subjective Expectations
- Empirical Framework
  1. Ifo World Economic Survey
  2. Method and Strategy
- Does the target matter for expectations? (Results)
- Simulations of an alternate perceived law of motion (PLM)
- Conclusion

Agents' Expectations

Timing


$\forall t \leq IT$
$\forall IT^A \leq t \leq IT^I$
$\forall t \geq IT^I$
0
t
Pre-Inflation Targeting
Announcement
Post-Inflation Targeting
IT^A
IT^I

Inflation

Inflation evloves according to a univariate unobserved component model, based on Stock and Watson (2007) and Stock and Watson (2016).

$$\pi_t = \tau_t + \varepsilon_t, \text{ where, } \varepsilon_t = \sigma_{\varepsilon,t}\zeta_{\varepsilon,t} \tag{1}$$

$$\tau_t = \tau_{t-1} + \vartheta_t, \text{ where, } \vartheta_t = \sigma_{\vartheta,t}\zeta_{\vartheta,t} \tag{2}$$

$$\ln \sigma^2_{\varepsilon,t} = \ln \sigma^2_{\varepsilon,t-1} + \nu_{\varepsilon,t} \tag{3}$$

$$\ln \sigma^2_{\vartheta,t} = \ln \sigma^2_{\vartheta,t-1} + \nu_{\vartheta,t} \tag{4}$$

$\zeta_t = (\zeta_{\varepsilon,t}, \zeta_{\vartheta,t}) \sim iid(0, I_2)$ and $\nu_t = (\zeta_{\nu,t}, \zeta_{\nu,t}) \sim iid(0, \gamma I_2)$. Moreover, $Cov(\zeta_t, \nu_t) = 0$. Where, γ is a smoothing parameter for the stochastic volatility process.

Rational Expectations: Jump in Expectations

1. Under RE, agents have perfect knowledge about the underlying process for inflation.
2. Pre-inflation targeting: $\mathbb{E}_t \pi_{t+h|t} = \tau_t$ (Alternatively, the inflation bias à la Barro-Gordon)
3. Post-Inflation Targeting: $\mathbb{E}_t \pi_{t+h|t} = \pi^T$ (Full Commitment)

Takeaway: Expectations jump from τ_t to π^T

Subjective Expectations: Adaptive Learning

1. Agents do not know the underlying process for inflation.
2. Agents behave as econometricians
   - Use past information to forecast future inflation.
3. **Assumption**: Agents use an unobserved component model (constant gain learning) to forecast inflation

$$\pi_t = \beta_t + \epsilon_t \tag{5}$$

$$\beta_t = \beta_{t-1} + \eta_t \tag{6}$$

Where, $\epsilon_t \sim iid\mathcal{N}(0, \sigma_\epsilon^2)$ and $\eta_t \sim iid\mathcal{N}(0, \sigma_\eta^2)$ are independent of each other and jointly *iid*. Therefore, $\mathbb{E}[(\epsilon_t, \eta_t)|\mathcal{I}_{t-1}] = 0$.

Pre-Inflation Targeting

4 β_t is unobserved and estimated using the **Kalman Filter**.

5 Therefore, $\beta_t|\mathcal{I}_t \sim \mathcal{N}(\tilde{\beta}_t, \tilde{\sigma}^2)$.

6 **Optimal updating** then implies that $\tilde{\beta}_t$ evolves recursively according to,

$$\tilde{\beta}_t = \tilde{\beta}_{t-1} + \kappa(\pi_t - \tilde{\beta}_{t-1}) \tag{7}$$

7 And expectations are therefore given by, $\mathbb{E}_t^{\mathcal{P}} \pi_{t+1} = \tilde{\beta}_t$.

8 κ is the gain and is defined as the strength with which agents update their beliefs.

Post-Inflation Targeting

- **Two Possibilities**
  1. The process remains unchanged

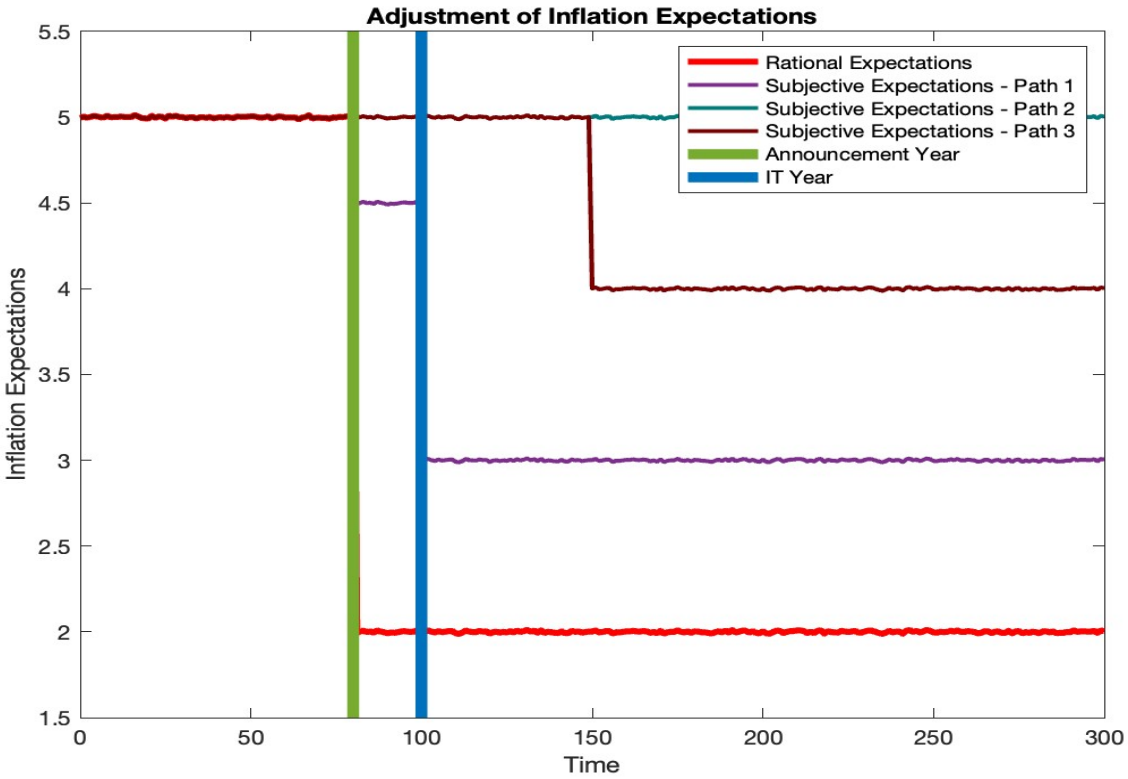
$$\tilde{\beta}_{t\geq IT} = \tilde{\beta}_{IT} + \kappa(y_{IT} - \tilde{\beta}_{IT-1}) \tag{8}$$

     - Priors adjust: $\beta_{IT}|\mathcal{I}_{IT} \sim \mathcal{N}(\tilde{\beta}_{IT}, \tilde{\sigma}^2_{IT})$.

  2. Alternatively, the agents incorporate the inflation target in their PLMs and the rule changes to the following,

$$\tilde{\beta}_{t\geq IT} = \tilde{\beta}_{IT} + \kappa(y_{IT} - \alpha\pi^{T} - (1-\alpha)\tilde{\beta}_{IT-1}) \tag{9}$$

Hypothesis


Adjustment of Inflation Expectations
Rational Expectations
Subjective Expectations - Path 1
Subjective Expectations - Path 2
Subjective Expectations - Path 3
Announcement Year
IT Year
Inflation Expectations
Time
5.5
5
4.5
4
3.5
3
2.5
2
1.5
0
50
100
150
200
250
300

Empirical Framework

Ifo World Economic Survey

1. Survey of **professional forecasters**.
2. Expectations about inflation **six-months-ahead** (two-quarters-ahead)
3. Sample period: 1991Q1 - 2019Q4
4. Data for **32 Inflation Targeting** countries
5. **Forecast Errors**: $\underbrace{FE_t}_{\Psi_t} = \pi_{t+h} - \mathbb{E}_t^{\mathcal{P}} \pi_{t+h|t}$
   - If $\Psi_t < 0 \Rightarrow$ **Overprediction**
   - If $\Psi_t > 0 \Rightarrow$ **Underprediction**
6. **Announcement date**: Based on first discussion of an interest rate/Taylor rule in the monetary policy statements.
7. **Implementation date**: Based on when the new memorandum comes into effect.

Methods

1. Event study approach by Borusyak et al. (2021) to assess any change in the levels and volatility of inflation expectations, forecast errors and inflation.
2. **Assumption**: Unobserved Heterogeneity is common for all countries ($\delta_i = \bar{\delta}$).
3. **Assumption**: $\bar{\delta} = 0$
   - Otherwise, expectations would revolve around a trend unable to reach the Rational Expectation Equilibrium (REE).

Event Study

Empirical Strategy: Regression

$$\beta_{it} = \underbrace{\bar{\delta}}_{0} + \beta_{it-1} + \kappa(y_{it} - \beta_{it-1}) + \gamma_1 t + \gamma_2 \bar{\pi}_t + D_{it}\tau_{it} + \epsilon_{it} \qquad (10)$$

- β_{it} are the inflation expectations from the survey.
- y_{it} is the realised inflation
- κ is the Kalman gain
- $\bar{\pi}_t$ is the world inflation
- $D_{it} = 1$ if IT is active in country i at time t. Zero, otherwise
- τ_{it} is the treatment effect in country i at time t.

Event Study Details

Empirical Strategy: Horizons Example

1. Let country $n1$ be treated at time $t = 2$ and country $n2$ be treated at time $t = 4$. Then,

$$\tau_{it} = \begin{bmatrix} 0, & \tau_{n1,2}, & \dots, & \tau_{n1,T}, & 0, & \dots, & \tau_{n2,4}, & \tau_{n2,5}, & \dots, & \tau_{n2,T} \end{bmatrix}'$$

2. To compute the effect for each horizon $h = \{1, 2, 3, \dots\}$

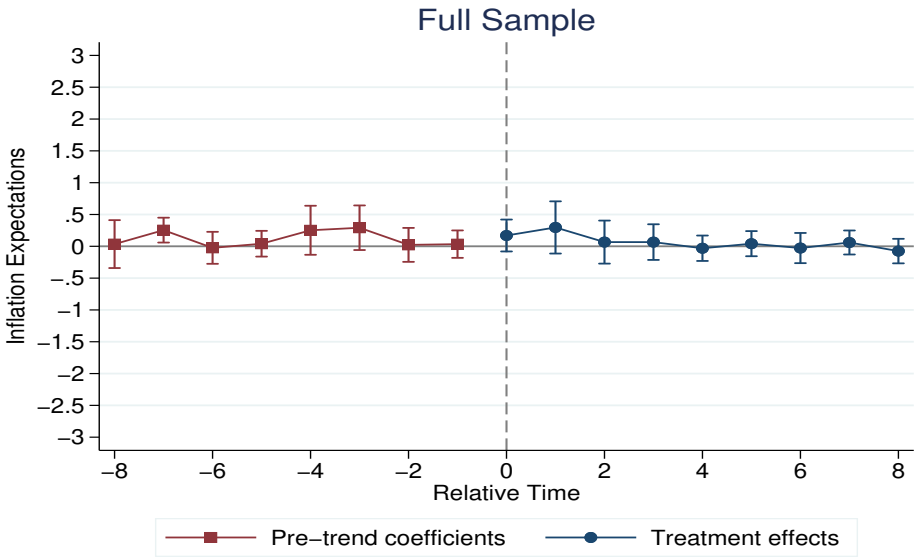
$$\tau_h = \frac{1}{\Omega_{1,h}} \sum \tau_{ih}$$

   Where, $\Omega_{1,h}$ is the number of observations that are treated in $h = t - E_i$ periods after the policy and E_i is the date of the event.

3. Therefore, $\tau_1 = \frac{1}{2}(\tau_{n1,2} + \tau_{n2,4})$.

Fact 1: *Inflation expectations do not respond to the implementation of the policy.*

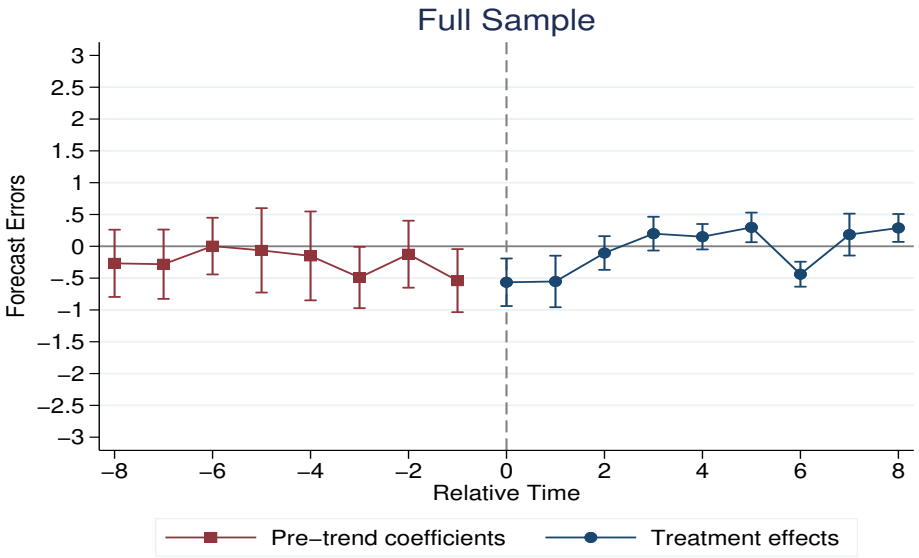
Figure: Inflation Expectations Around Implementation



Up to five years | Advanced Economies | Developing Economies | New Targeters | Old Targeters

Fact 2: *Agents over predict inflation following an introduction of IT.*

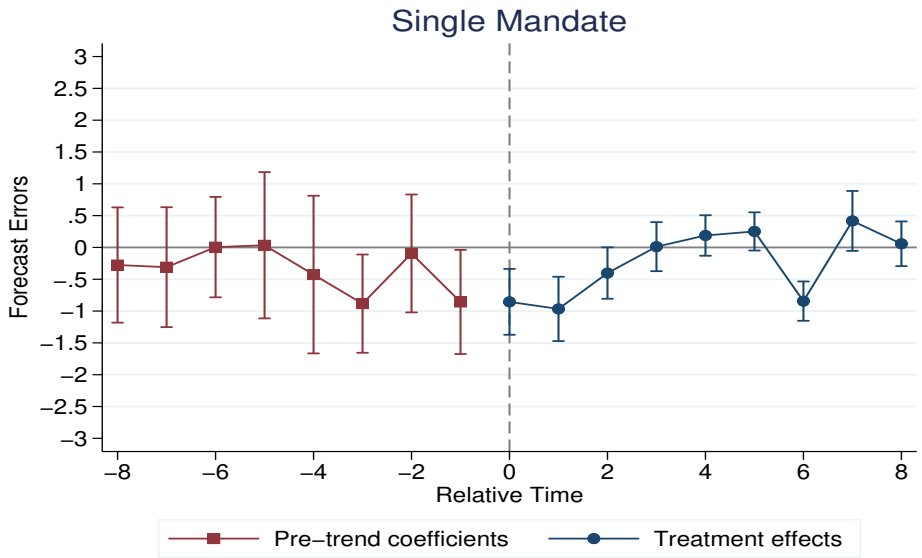
Figure: Forecast Errors Around Implementation



Dual Mandates

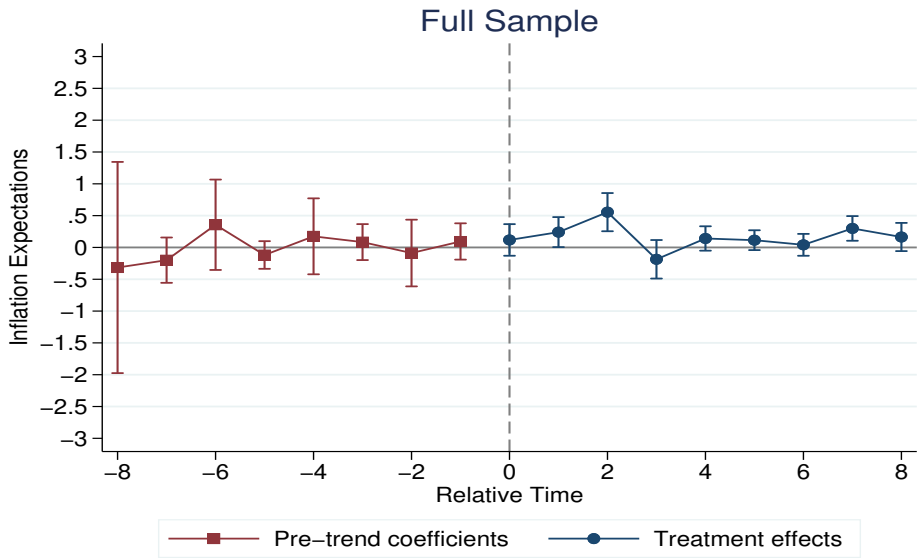
Fact 3: *Forecast errors for those countries whose central banks have single mandates are close to zero a few quarters after implementation.*

Figure: Forecast Errors Around Implementation



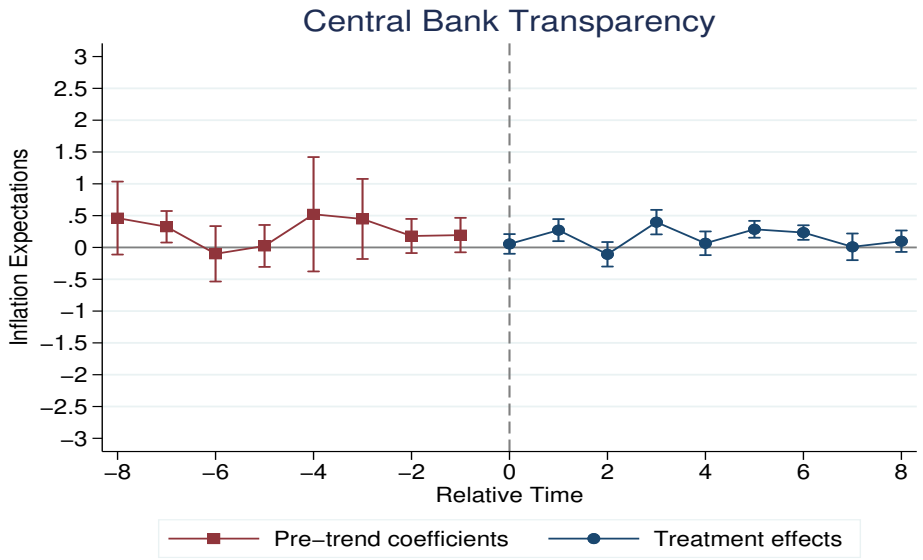
Fact 4: *There is minimal change in inflation expectations upon announcement.*

Figure: Inflation Expectations Around Announcement



Fact 5: *Controlling for Central Bank Independence and Transparency does not change the result.*

Figure: Inflation Expectations After controlling for Transparency



(Fact 6) *Let there be FIRE: Forecast Revisions predict forecast errors more than before IT.*

VARIABLES	1	2
Forecast Errors	0.742***	0.844***
	(0.227)	(0.156)
Cons$*\mathbb{1}_{t\geq t^*}$		-0.0957
		(0.214)
FE$*\mathbb{1}_{t\geq t^*}$		-1.395***
		(0.495)
Constant	-0.176**	0.756***
	(0.0846)	(0.0839)
Observations	115	115

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Story thus far

1. Rational expectations predicts expectations jump from τ_t to π^T.
2. Agents use a constant gain model to learn.
3. Priors do not adjust to the inflation target π^T.
4. Agents over predict inflation after the introduction of IT.
   - Because inflation declines post-IT.
   - Countries with single mandates lead this change.

Alternative PLM

Post-Inflation Targeting

At $t = IT$ inflation targeting is introduced.

1. Agents' beliefs about inflation are given by,

$$\pi_t = (1-\alpha)\beta_t + \alpha\pi^T + \epsilon_t \tag{11}$$

$$\beta_t = \beta_{t-1} + \eta_t \tag{12}$$

Moreover, $\epsilon_t \sim iid\mathcal{N}(0, \sigma_\epsilon^2)$ and $\eta_t \sim iid\mathcal{N}(0, \sigma_\eta^2)$ are independent of each other and jointly *iid*. Therefore, $E[(\epsilon_t, \eta_t)|I_{t-1}] = 0$.

Post-Inflation Targeting

2 Optimal updating then implies that $\tilde{\beta}_t$ evolves recursively according to,

$$\tilde{\beta}_t = \tilde{\beta}_{t-1} + \kappa(\pi_t - \alpha\pi^T - \tilde{\beta}_{t-1}(1-\alpha)) \tag{13}$$

3 Kalman Gain is given by,

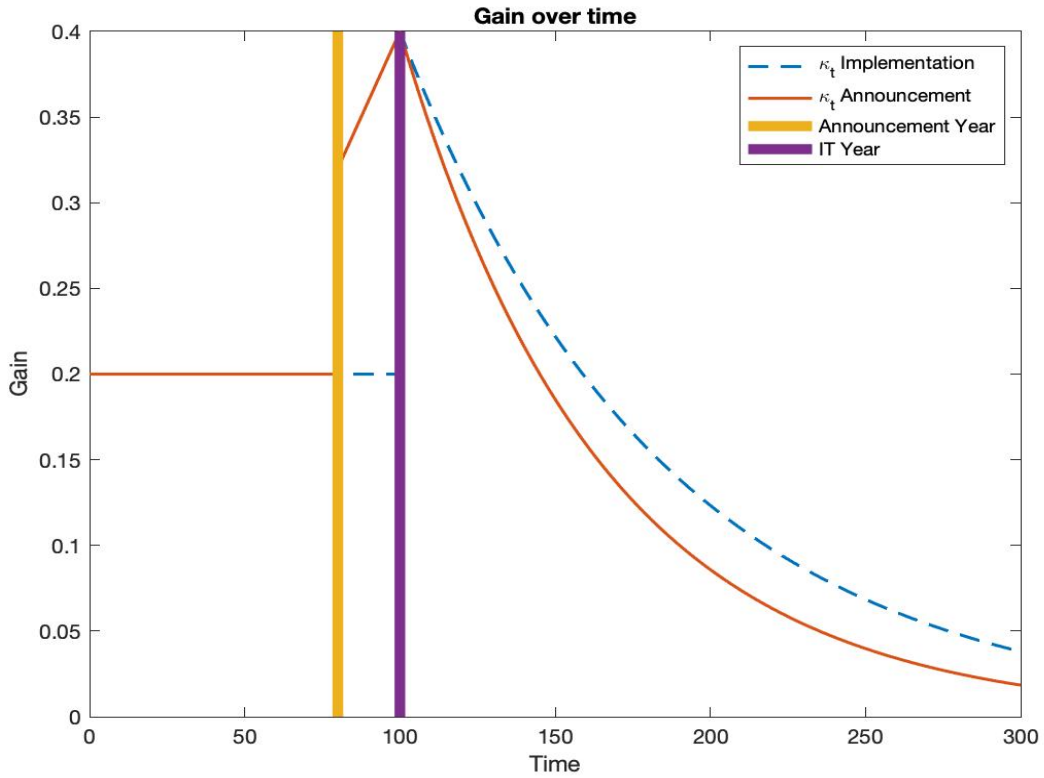
$$\kappa = \frac{\tilde{\sigma}^2_\beta(1-\alpha)}{(1-\alpha)^2\tilde{\sigma}^2_\beta + \sigma^2_\epsilon} \tag{14}$$

4 Variance of the prior is updated according to,

$$\tilde{\sigma}^2_\beta = \tilde{\sigma}^2_{\beta,0} - \kappa(1-\alpha)\tilde{\sigma}^2_{\beta,0} + \sigma^2_\eta \tag{15}$$

Speed of Adjustment

Figure: Change in weight to information



Moments

Table: Moments

	Pre-IT		Post-IT	
Moment	Model	Data	Model	Data
$\widehat{E(\pi_t^e)}$	22.67	22.03	5.78	5.636
$\widehat{\sigma_{\pi_t^e}}$	1.92	2.87	4.64	3.041
$\widehat{\rho_{\pi_t^e}}$	0.938	0.447	0.82	0.780
$\widehat{E(\pi_t - \pi_t^e)}$	0.570	0.684	-0.35	-0.366
$\widehat{\sigma_{\pi_t - \pi_t^e}}$	0.871	1.65	0.049	1.395
$\widehat{\rho_{\pi_t - \pi_t^e}}$	0.216	0.217	0.417	1.017

Parameters

Table: Parameters

Parameters	Pre-IT	Post-IT	
		2 years	5 years
κ	0.0553	0.057	0.110
α	-	0.10	0.11

Conclusions

- Priors do not adjust after the introduction of IT.
- Forecast errors adjust because of a change in inflation.
- **Agents rely on past inflation to make forecasts** $\Rightarrow$ **Inflation leads expectations**
- Credibility of the central bank following the announcement is small ($\alpha \approx 0.1$).
  1. Successful anchoring requires: $\alpha \approx 1$.
  2. But central banks can become credible ex-post.
- **Policy** should focus on a single objective even though the adjustment is not based on the anticipated channel.

Thank You!

Feel free to send questions, comments or just a hi!

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Appendix

Inflation Targeting

A country is called an Inflation Targeter (Hammond et al. (2012)) when the following conditions are met.

1. Price stability is recognised as the explicit goal of monetary policy.
2. There is a public announcement of a quantitative target for inflation.
3. Monetary policy is based on a wide set of information, including an inflation forecast.
4. Transparency
5. Accountability mechanisms.

Research Question

Short-Run Expectations

Consider the Euler equation,

$$u'(c_t) = \beta \mathbb{E}_t \left[u'(c_{t+1}) \frac{(1 + i_t)}{1 + \pi_{t+1}} \right] \tag{16}$$

- Equation (16) explains how consumption today, adjusts to inflation expectations one-period ahead. Thus, adjustment to short run expectations leads to stimulation of consumption which further contributes to a rise in inflation.
- The objective of Inflation Targeting is respond to deviations in target irrespective of the length of time of deviations.

Agents' Expectations

Barro-Gordon

Let's assume the following simple model of the central bank with the loss function given by,

$$\mathcal{L}^{CB} = \max_{\pi_t} \frac{1}{2}\left[(y_t - y^*)^2 + a(\pi_t - \pi_t^*)^2\right] \tag{17}$$

Where, y_t and π_t are the current output and inflation levels. y^*, π^* are the potential output and inflation target. $\mathcal{L}^{CB}$ represents the loss function of the central bank subject to the following constraint,

$$y_t = b(\pi_t - \pi_t^e) \tag{18}$$

(18) is the Phillips Curve, $a, b > 0$ and there is perfect foresight. Given there are rational expectations this would imply that $\pi_t^e = \pi_t$. That is, agents always know the optimal level of inflation from the central bank's loss function. Let us now consider the switch in regimes.

Pre-Inflation Targeting

Take first order conditions and solve for optimal inflation with given inflation expectations and $\pi^* = 0$,

$$\pi_t = \frac{b(\pi_t^e + y^*)}{a + b} \tag{19}$$

$$\pi_t^e = \frac{(a + b)\pi_t - by^*}{b} \tag{20}$$

Given the central bank does not have commitment and agents have rational expectations, the inflation will follow (20) which is often referred to as the inflation bias level.

Agents' Expectations

Post-Inflation Targeting

Assume that the bank now has full commitment to bring reduce inflation to the target and let $\pi_t^* \geq 0$.

Then, following the same procedure as above we find the following,

$$\pi_t = \pi_t^* = \pi_t^e \tag{21}$$

Therefore, with rational expectations and full commitment by the central bank, inflation expectations will always be equal to the inflation target.

Agents' Expectations

IT Countries

Name of Country	Development Status	Mandate	Hyper Inflation
Argentina	Developing	No-mandate	Yes
Austria	Advanced	Dual	No
Belgium	Advanced	Dual	No
Brazil	Developing	Single	Yes
Chile	Developing	Single	No
Colombia	Developing	Single	No
Czech Republic	Developing	Single	Yes
Finland	Advanced	Dual	No
Germany	Advanced	Dual	No
Hungary	Advanced	Single	No
India	Developing	Single	No
Ireland	Advanced	Dual	No
Israel	Developing	Single	No
Italy	Advanced	Dual	No
Japan	Advanced	Single	No
Korea	Developing	Single	No

Name of Country	Development Status	Mandate	Hyper Inflation
Mexico	Developing	Single	No
Netherlands	Advanced	Dual	No
Norway	Advanced	Single	No
Paraguay	Developing	Single	No
Peru	Developing	Single	Yes
Philippines	Developing	Single	No
Poland	Advanced	Single	Yes
Russia	Developing	Single	Yes
South Africa	Developing	Single	No
Spain	Advanced	Dual	No
Switzerland	Advanced	Dual	No
Thailand	Developing	Single	No
Turkey	Developing	Single	Yes
Ukraine	Developing	Single	Yes
United States	Advanced	Dual	No
Uruguay	Developing	Single	Yes

Survey

REH Test

Country	Pre-IT	Post-IT
Argentina	.431***	.529***
	(.099)	(0.069)
Austria	.296***	.659***
	(.048)	(0.059)
Belgium	.202	.611***
	(.128)	(0.511)
Brazil	.410***	.455***
	(.046)	(0.077)
Chile	.167***	.650***
	(.041)	(0.055)
Colombia	.355***	-.162
	(.062)	(0.221)

Newey West SE in parentheses

Country	Pre-IT	Post-IT
Czech Republic	.654***	.269**
	(.134)	(.142)
Finland	.401**	.521***
	(.147)	(.057)
Germany	.448***	.470***
	(.038)	(0.070)
Hungary	.054	.290***
	(.072)	(0.080)
India	.592***	1.139***
	(.150)	(0.042)
Ireland	.695***	.449***
	(.095)	(0.082)

Newey West SE in parentheses

Country	Pre-IT	Post-IT
Israel	2.22**	0.693***
	(.0672)	(0.207)
Italy	.038	0.411***
	(.089)	(0.054)
Japan	.288**	.598***
	(.094)	(.081)
Korea	.526**	.539***
	(.211)	(.114)
Mexico	.041	.396**
	(.058)	(.135)
Netherlands	.467***	.343***
	(.130)	(.083)

Newey West SE in parentheses

Country	Pre-IT	Post-IT
Norway	.612**	.881***
	(.221)	(.059)
Paraguay	.343***	.535**
	(.086)	(.224)
Peru	.572***	.669***
	(.074)	(.067)
Philippines	.430***	.547***
	(.064)	(.107)
Poland	.034	.262***
	(.122)	(.059)
Russia	-.367***	.385***
	(.019)	(.102)

Newey West SE in parentheses

Country	Pre-IT	Post-IT
South Africa	.355***	.652***
	(.070)	(.098)
Spain	.025	.487***
	(.141)	(.052)
Switzerland	.225***	.401***
	(.049)	(.077)
Thailand	.673***	.592***
	(.145)	(.081)
Turkey	.187	-.082
	(.130)	(.080)
Ukraine	.564***	.968***
	(.089)	(.171)

Newey West SE in parentheses

Country	Pre-IT	Post-IT
United States	.689***	.791***
	(.094)	(.070)
Uruguay	.130**	.588***
	(.041)	(.105)

Newey West SE in parentheses

Survey

Structural Break Test

	π_t^e		π_t	
	(1)	(2)	(1)	(2)
Lagged Var	0.939***	0.957***	0.944***	0.881***
	(0.005)	(0.008)	(0.004)	(0.007)
Lag$*\mathbb{1}_{\{t\geq t^*\}}$		-0.042***		0.108***
		(0.011)		(0.009)
Constant	0.194***	0.285***	0.136***	0.718***
	(0.032)	(0.093)	(0.028)	(0.079)
Constant$\mathbb{1}_{\{t\geq t^*\}}$		-0.042		-0.739***
		(0.100)		(0.085)

Note: HAC Robust standard errors in parenthesis.

$*p < 0.10, **p < 0.05, ***p < 0.01$.

Survey

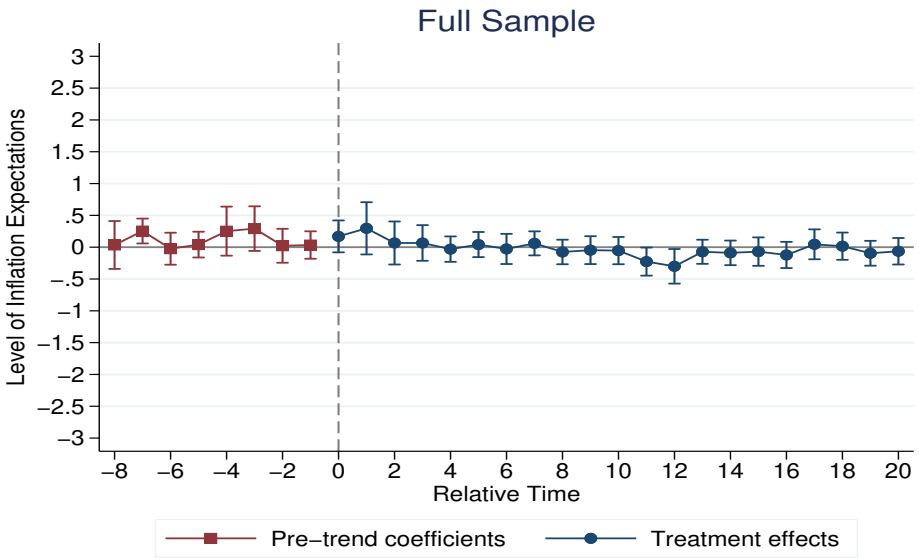
Event Study

1. For all untreated observations in Ω_0, compute β_{it} by OLS. Thus, for this paper the regression is given by equation 10 to estimate $\hat{\kappa}, \hat{\gamma}_1, \hat{\gamma}_2$.
2. For all the treated observations in Ω_1 and $w_{it} \neq 0$ compute $\beta_{it}(0) = \bar{\alpha} + \beta_{it-1} + \hat{\kappa}(y_{it} - \beta_{it-1}) + \hat{\gamma}_1 t + \hat{\gamma}_2 \bar{\pi}_t + \epsilon_{it}$.
3. Compute, $\beta_{it} - \beta_{it}(0) = \tau_{it}$ which gives us the treatment effect.
4. Finally, the effect for each period after the treatment is computed as per $w_{it} = \frac{1}{\Omega_{1,h}}$ where $\Omega_{1,h} = \{it : K_{it} = h\}$ and $K_{it} = t - E_i$ which is the relative time since the adoption of the policy.

Methods

Fact A1: *Inflation expectations do not respond to the implementation of the policy.*

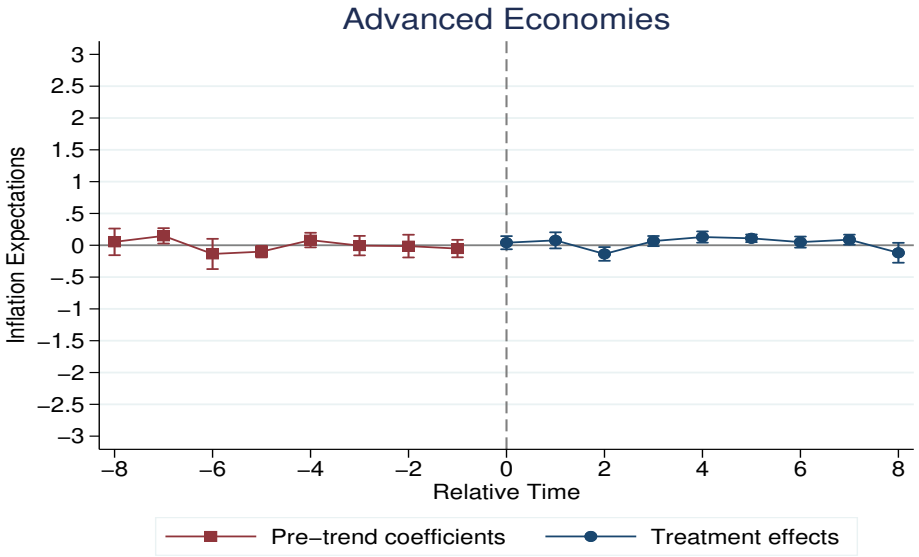
Figure: Inflation Expectations Around Implementation



Fact 1

Fact A2: *No change in expectations for advanced economies.*

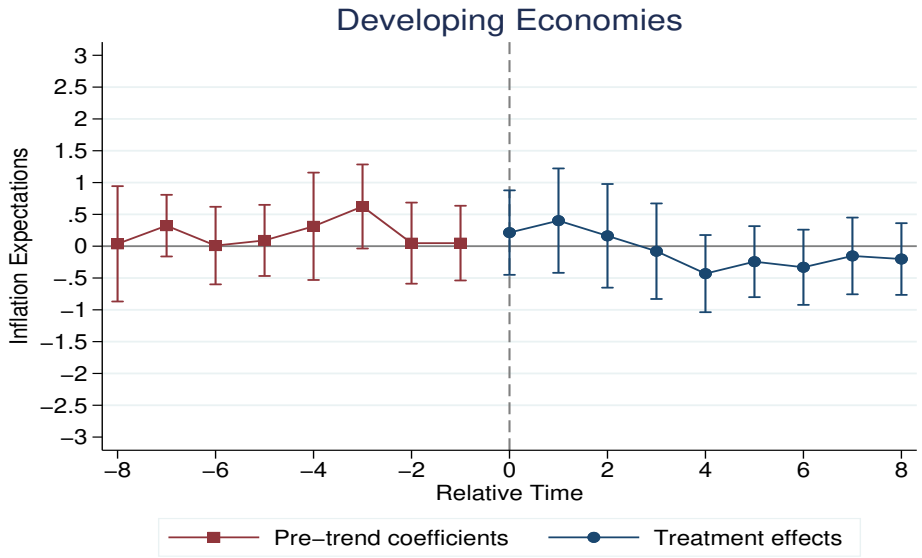
Figure: Inflation Expectations Around Implementation



Fact 1

Fact A3: *Statistically insignificant decline in expectations for developing economies*

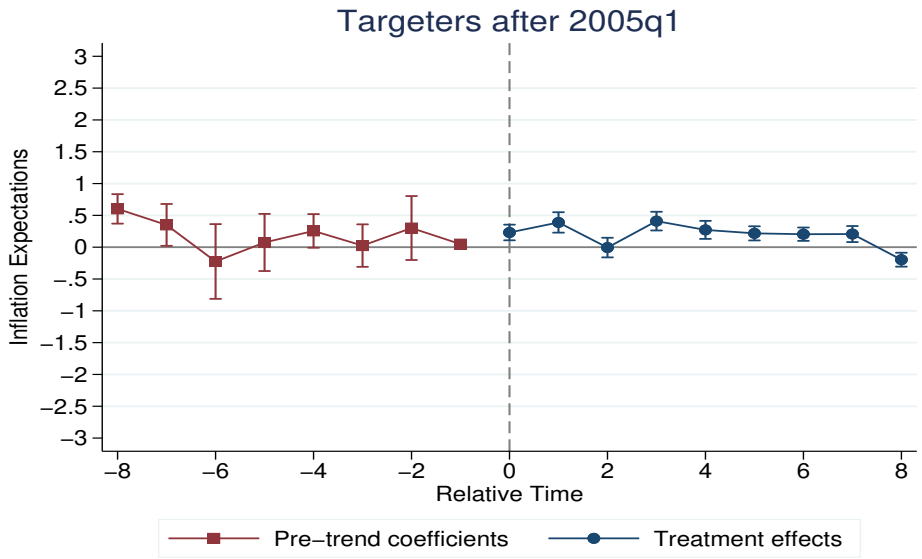
Figure: Inflation Expectations Around Implementation



Fact 1

Fact A4: *No change in expectations for those who adopted targeting in the 2000s*

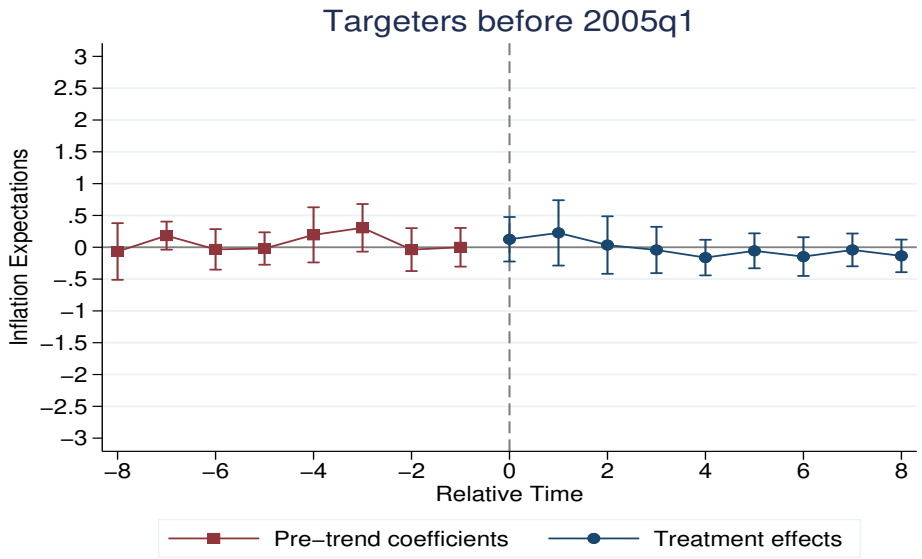
Figure: Inflation Expectations Around Implementation



Fact 1

Fact A5: *No change in expectations even prior to the 2000s*

Figure: Inflation Expectations Around Implementation



Fact 1

References I

Ball, L. M. and Sheridan, N. (2004). Does inflation targeting matter? In *The inflation-targeting debate*, pages 249–282. University of Chicago Press.

Beechey, M. J., Johannsen, B. K., and Levin, A. T. (2011). Are long-run inflation expectations anchored more firmly in the euro area than in the united states? *American Economic Journal: Macroeconomics*, 3(2):104–29.

Borusyak, K., Jaravel, X., and Spiess, J. (2021). Revisiting event study designs: Robust and efficient estimation. *arXiv preprint arXiv:2108.12419*.

Carvalho, C., Eusepi, S., Moench, E., and Preston, B. (2021). Anchored inflation expectations. *Available at SSRN 3018198*.

Coibion, O. and Gorodnichenko, Y. (2015). Information rigidity and the expectations formation process: A simple framework and new facts. *American Economic Review*, 105(8):2644–78.

References II

Coibion, O., Gorodnichenko, Y., Kumar, S., and Pedemonte, M. (2018). Inflation expectations as a policy tool? Technical report, National Bureau of Economic Research.

Duggal, M. and Rojas, L. E. (2022). (dis)inflation targeting. Working paper, Barcelona.

Gáti, L. (2022). Monetary policy & anchored expectations: an endogenous gain learning model.

Gürkaynak, R. S., Levin, A., and Swanson, E. (2010). Does inflation targeting anchor long-run inflation expectations? evidence from the us, uk, and sweden. *Journal of the European Economic Association*, 8(6):1208–1242.

Hammond, G. et al. (2012). State of the art of inflation targeting. *Handbooks*.

References III

King, R. G., Lu, Y. K., et al. (2020). Managing expectations in the new keynesian model. Technical report, HKUST Center for Economic Policy.

Kostadinov, R. and Roldán, F. (2020). *Credibility Dynamics and Disinflation Plans*. International Monetary Fund.

Stock, J. H. and Watson, M. W. (2007). Why has us inflation become harder to forecast? *Journal of Money, Credit and banking*, 39:3–33.

Stock, J. H. and Watson, M. W. (2016). Core inflation and trend inflation. *Review of Economics and Statistics*, 98(4):770–784.