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JEL Classification: E31, E52

Keywords: anchoring, credibility, Inflation expectations, Inflation persistence, terms of trade

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Expectations' Anchoring and Inflation Persistence*

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Abstract

Understanding the sources of inflation persistence is crucial for monetary policy. This paper provides an assessment of the influence of inflation expectations' anchoring on the persistence of inflation. We construct an index of inflation expectations' anchoring using survey-based inflation forecasts for 45 economies since 1989. We then study the response of consumer prices to terms-of-trade shocks and find that these shocks have a significant and persistent effect on consumer price inflation when expectations are poorly anchored. By contrast, inflation reacts by less and returns quickly to its pre-shock level when expectations are strongly anchored.

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"With expectations of inflation anchored, any given shock to inflation—whether it is from aggregate demand, energy prices, or the foreign exchange rate—will have a smaller effect on expected inflation and hence on trend inflation. These shocks will then have a much less persistent effect on actual inflation."

—Mishkin (2007)

1 Introduction

Theory indicates that the persistence of inflation in response to temporary shocks is affected not only by intrinsic factors, such as the extent to which price setters index prices to past inflation, but also by how monetary policy is conducted and its credibility (Fuhrer, 2010). While the credibility of monetary policy is not directly observable, it is reflected in the extent to which the public's long-term inflation expectations are anchored. Indeed, the decline in inflation persistence in the United States is often attributed to an improvement in expectations' anchoring (e.g., Williams, 2006; Bernanke, 2007; Mishkin, 2007). Yet, despite the importance attributed to expectations' anchoring for inflation dynamics, there is little systematic evidence on the evolution and cross-country differences in inflation expectations' anchoring and its impact on inflation persistence.

This paper documents the extent of anchoring of inflation expectations in a large sample of economies and explores whether it affects the persistence of the inflationary process. Drawing from the inflation expectations literature[1], we use survey-based measures of long-term inflation forecasts from professional analysts in 45 advanced and emerging economies since 1989 to construct three complementary met-

[1]See Capistrán and Ramos-Francia (2010); Dovern et al. (2012); Demertzis et al. (2012); Kumar et al. (2015); Coibion and Gorodnichenko (2015); and Coibion et al. (2018b).

rics of anchoring of inflation expectations:[2] (i) a measure of absolute deviations in inflation forecasts from a target; (ii) a measure of the variability of inflation forecasts over time; and (iii) the dispersion of inflation forecasts across individual forecasters. We then combine these metrics in a summary index that is comparable across countries. Our index shows that the extent of anchoring of inflation expectations improved significantly over the past few decades, especially among emerging economies. But despite this large improvement, there are still substantial differences across countries.

We then test whether the persistence of inflation dynamics is related to the extent of anchoring of inflation expectations by studying the response of consumer prices to well-identified external shocks under varying degrees of anchoring. More precisely, we estimate the response of consumer prices to terms-of-trade shocks using local projection methods (Jordà, 2005). We identify exogenous variation in countries' terms of trade with changes to country-specific commodity terms of trade indices from Gruss and Kebhaj (2019), which are based on international prices and are arguably unrelated to domestic developments (Chen and Rogoff, 2003; Ricci et al., 2013; Fernández et al., 2017).[3] To disentangle how the persistence of inflation relates to anchoring, we compare the response of consumer prices to a terms-of-trade shock under varying degrees of anchoring. Since the transmission of these shocks to consumer prices would differ depending on whether the exchange can ad-

[2]We focus on long-term inflation forecasts—that is, three years ahead and beyond—reported by Consensus Economics surveys that should not reflect the effect of transitory shocks and the response of monetary policy. While alternative sources of long-term inflation forecasts exist for some countries (e.g., surveys conducted by Central Banks), the Consensus Economics database offers wider country and time coverage, and ensures consistency in the construction of surveys across countries.

[3]The change in the international price of 45 commodities is weighted by the ratio of net exports of each commodity to GDP. The commodity terms-of-trade index provides an estimate of the changes in disposable income, relative to GDP, arising from fluctuations in commodity prices.

just or not, we condition on the exchange rate regime and focus on nonpegs.

The change in relative prices following a terms-of-trade shock is expected to be reflected in consumer price inflation for some time after the shock in the presence of nominal rigidities. But we find that the dynamics of inflation are systematically different depending on how well anchored inflation expectations are. More precisely, negative terms-of-trade shocks (i.e., increases in commodity import prices relative to commodity export prices) lead to a persistent increase in consumer price inflation when expectations are poorly anchored—when the anchoring index takes a value corresponding to the 25^{th} percentile of the sample distribution—and vice versa for positive shocks. Instead, the response of inflation is statistically indistinguishable from zero when inflation expectations are strongly anchored—that is, when the anchoring index is equal to the 75^{th} percentile of the sample distribution. Our findings suggest that the difference in inflation dynamics between economies with poorly- and strongly-anchored expectations is only partly due to differences in the extent of exchange rate depreciation and also reflect differences in pass-through.

This paper is related to the literature on inflation persistence (see Fuhrer, 2010 for a survey), and especially to empirical studies documenting differences across countries and time (e.g., Alogoskoufis and Smith, 1991; Levin and Piger, 2004; Cogley and Sargent, 2005; Pivetta and Reis, 2007; Cogley and Sbordone, 2008; Cogley et al., 2010). The closest paper to ours is Benati (2008), who analyzes the relationship between post-WWII inflation persistence and the monetary regime in a sample of advanced economies—Canada, Japan, New Zealand, Sweden, Switzerland, the United Kingdom, the United States, the euro area, and its largest countries (France, Germany, and Italy). He finds low or null serial correlation of inflation under inflation targeting, the gold standard, and in the European Monetary Union;

and argues that under regimes with clearly defined nominal anchors inflation appears to be purely forward-looking. However, there is substantial heterogeneity in the quality of monetary policy within a given regime.[4] We contribute to this literature by testing explicitly the role of anchoring of inflation expectations in affecting inflation persistence on a large sample that includes both advanced and emerging economies. Rather than estimating a measure of reduced-form persistence, which can be subject to substantial uncertainty (see, for instance, Pivetta and Reis, 2007 and Cogley et al., 2010), we exploit the variability in the degree of anchoring to assess the differences in the response of inflation to external shocks.

Our paper is also related to studies that explore the extent of anchoring of inflation expectations (e.g., Kumar et al., 2015; Coibion and Gorodnichenko, 2015; Demertzis et al., 2012; Ehrmann, 2015; Kose et al., 2018; Coibion et al., 2018b; Carvalho et al., 2020). We contribute to this strand of the literature by providing several complementary metrics of anchoring of inflation expectations and a summary index using consistent data on professional forecasters' expectations across a large sample of advanced and emerging economies.[5]

The rest of the paper is organized as follows. Section 2 presents our metric for capturing the extent of anchoring of inflation expectations, documents how it varies across countries and over time. Section 3 explores how the extent of anchoring affects the persistence of inflationary shocks. Finally, Section 4 concludes and draws

[4]See, for instance, evidence on the variability of transparency of monetary policy within inflation targeters in Brito et al. (2018).

[5]We focus on professional forecasters' expectations to construct anchoring metrics for a large sample of countries. A recent and growing literature has been exploiting surveys on firms' and households' inflation expectations (e.g., Coibion et al., 2018a; Coibion et al., 2018c; Coibion et al., 2018b; Coibion et al., 2019b; Coibion et al., 2020; Coibion et al., 2019a). However, such surveys are only available for a handful of countries and their methodologies are not necessarily comparable across countries.

implications.

2 Measuring Inflation Expectations' Anchoring

The concept of anchored inflation expectations has no widely agreed-upon definition. The literature, however, identifies a set of predictions about the behavior of inflation forecasts in economies that feature a strong nominal anchor. Under those circumstances, expectations for inflation over a sufficiently long horizon should be centered around the explicit or implicit target (Bernanke, 2007; Demertzis et al., 2012; Kumar et al., 2015). Similarly, revisions of long-term forecasts should be minor (ibid.), so the average of long-term forecasts should be stable over time. In addition, if the monetary framework is credible and inflation expectations are well anchored, the dispersion (range of values) of individual long-term inflation forecasts should be low (Capistrán and Ramos-Francia, 2010; Dovern et al., 2012; Ehrmann, 2015; Kumar et al., 2015).

Building on these operational characteristics, we first use survey-based long-term inflation forecasts from professional forecasters to construct three complementary metrics aimed at capturing the extent of anchoring of inflation expectations at the country level. We then construct a country-specific index summarizing the information of the individual anchoring metrics.

2.1 Data

Inflation Expectations

To construct the anchoring metrics, we focus on the public's expectations about consumer price inflation over the medium term. We capture the public's inflation expectations using survey-based inflation forecasts from professional forecasters reported by Consensus Economics for horizons of three and five years ahead.[6] Focusing on horizons three years ahead and beyond ensures that beliefs about inflation in the long term are captured—rather than the effect of transitory shocks and the response of monetary policy.

For each period t in which there is a survey available, we use two moments of the distribution of survey responses by individual forecasters j for horizon h: (i) the average of individual inflation forecasts, $\pi_t^{e,h} = \frac{1}{J}\sum_{j=1}^{J}\pi_{j,t}^{e,h}$; and (ii) the standard deviation across individual forecasts, $\sigma_t(\pi_{j,t}^{e,h})$.

Long-term inflation surveys by Consensus Economics are available at biannual frequency up to 2013 and quarterly thereafter. The data covers 24 advanced and 21 emerging economies but is unbalanced, starting between 1989 and the early-1990s for most countries, and in 2009 in a few cases.[7]

[6] For any Consensus Economics survey, the one-year-ahead horizon corresponds to forecasts for the current calendar year, the two-year-ahead horizon corresponds to the following calendar year, and so forth. The farthest forecasts available are for seven years ahead.

[7] We rely on the income classification of the October 2018 IMF World Economic Outlook. Early Consensus Economics' surveys only report mean forecasts; the dispersion of responses is only available since 2005, or even later in a few cases (see data availability in Figure A.1 and Table A.1 and online annex for further details).

Inflation Target

Some of the anchoring metrics we propose below require a value for the inflation target at each forecast horizon. For economies that adopted an inflation-targeting regime, the inflation target at each point in time for the current year and up to five years ahead are retrieved from published central bank inflation reports. When a single target is announced, it is assumed that the target refers to the objective for the current year as well as for all subsequent years. When a target is announced for the near term and the long term but without an explicit path for the intermediate horizons (e.g., the target for three years ahead), the assumption is that the long-term target corresponds to the inflation target three years after the last explicit short-term target (and intermediate targets are obtained by linear interpolation).[8] For economies that do not follow inflation-targeting regimes, the inflation target at all horizons is set to the mean inflation forecast for the longest-term horizon available, $\pi_t^{e,7+}$.[9]

2.2 Anchoring Metrics

We start by constructing three country-specific metrics aimed at capturing the extent of anchoring of inflation expectations at horizon h over a given time interval (rolling window) ω:

- *Metric #1 - Deviation of long-term mean inflation forecasts from target.* If inflation expectations are well anchored, beliefs about future inflation should

[8]See online annex for further details.

[9]Setting the inflation target at all horizons equal to the mean inflation forecast for the longest-term horizon ($\pi_t^{e,7+}$) for all countries and periods, regardless of whether the central bank has an explicit target, does not lead to significant differences in our anchoring metrics.

be, on average, close to the inflation target pursued by the monetary authority (Demertzis et al., 2012; Kumar et al., 2015). The root-mean-square deviation of the mean inflation forecast at horizon h from the inflation target over each rolling window ω is given by:

$$\sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(\pi_t^{e,h} - \pi_t^*\right)^2}, \text{ with } h = 3, 5; t \in \omega \tag{1}$$

in which π_t^* is the central bank's inflation target for inflation-targeting economies or the one-year moving average of inflation forecasts for the longest term horizon ($\pi_t^{e,7+}$) otherwise.

- *Metric #2 - Variability of mean long-term inflation forecasts.* If inflation expectations are well anchored, revisions of agents' long-term forecasts should be small, and thus the average forecast relatively stable over time (ibid.). The standard deviation of the mean inflation forecast at horizon h over each rolling window ω is given by:

$$\sqrt{\frac{1}{T-1}\sum_{t=1}^{T}\left(\pi_t^{e,h} - \overline{\pi^{e,h}}\right)^2}, \text{ with } h = 3, 5; t \in \omega \tag{2}$$

in which $\overline{\pi^{e,h}}$ is the average of mean inflation forecasts over each rolling window ω.

- *Metric #3 - Dispersion of long-term inflation forecasts.* Individual beliefs about long-term inflation should be close to each other if expectations are well-anchored—and would coincide if they are perfectly anchored (Capistrán and Ramos-Francia, 2010; Dovern et al., 2012; Ehrmann, 2015; Kumar et al., 2015). The dispersion of forecasts is captured by the standard deviation of

h-year-ahead inflation forecasts of individual forecasters at each period t, averaged over the time interval ω:

$$\frac{1}{T}\sum_{t=1}^{T}\left[\sqrt{\frac{1}{J-1}\sum_{j=1}^{J}\left(\pi_{j,t}^{e,h}-\pi_{t}^{e,h}\right)^{2}}\right], \text{ with } h=3,5; t\in\omega \tag{3}$$

in which $\pi_{j,t}^{e,h}$ denotes the inflation forecast of forecaster j at time t for horizon h and $\pi_{t}^{e,h}$ is the average across forecasters.

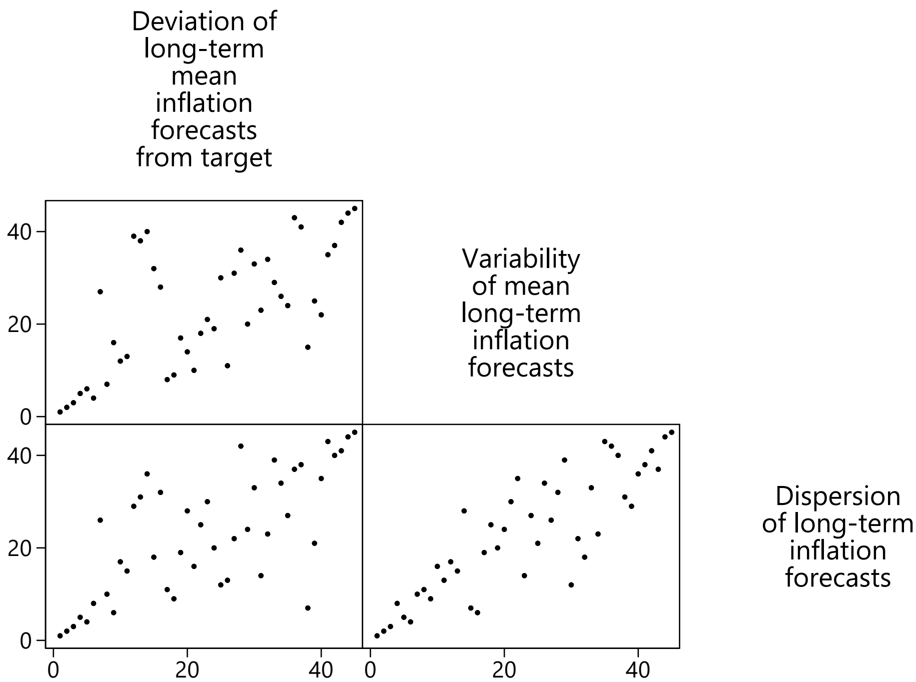
We compute these measures using, alternatively, three- and five-year-ahead inflation forecasts. Annex Figure A.2 shows the cross-country distribution of anchoring based on three-year-ahead (i.e., $h = 3$) inflation expectations for a balanced panel of economies with data available since 1998.

2.3 A Summary Anchoring Index

The three anchoring metrics we propose are highly correlated. For instance, the correlation between the relative ranking of countries across any two of the anchoring measures based on three-year-ahead inflation forecasts ranges from 0.76 to 0.82 (Figure 1).

However, the three metrics capture distinctive characteristics of the behavior of inflation expectations, with advantages and shortcomings—including in terms of data coverage—and no single metric necessarily captures the full extent of anchoring. For instance, if long-term expectations are well coordinated and stable around a level above the central bank's objective, one may argue that the economy has a strong nominal anchor. This would be reflected in relatively good readings for *Met-*

Figure 1: Alternative Anchoring Metrics
(Ranking of countries, average over 2004–17)



ric #2 and *Metric #3*, although *Metric #1* would score poorly. Similarly, if long-term expectations are stable around the target on average, but there is substantial disagreement across individual forecasters, the good reading in *Metric #1* and *Metric #2* would stand in contrast with a poor score under *Metric #3*.

To capture the complementary nature of these metrics, we construct a country-specific index summarizing the information of the three anchoring metrics as follows. For each metric m based on h-years ahead inflation expectations $x^{m,h}_{i,\omega}$, where i denotes countries and ω denotes time intervals (rolling windows), we first construct a standardized measure $z^{m,h}_{i,\omega} = (x^{m,h}_{i,\omega} - \bar{x}^{m,h})/\sigma(x^{m,h})$, where $\bar{x}^{m,h}$ and $\sigma(x^{m,h})$ denote the average and standard deviation of metric m (at horizon h) across all countries and periods between 1989 and 2017. Observations for each standardized metric will then be centered around zero, with a standard deviation of one. The summary anchoring index for horizon h is then constructed as the negative of the simple average of the three standardized metrics ($z_{i,\omega}^{m,h}$), so that a higher (lower) value of the index corresponds to a better (worse) anchoring of inflation expectations.[10] In the analysis that follows, we focus on the index using three-year-ahead inflation forecasts, but we consider five-year ahead inflation forecasts in robustness exercises (Section 3.4).

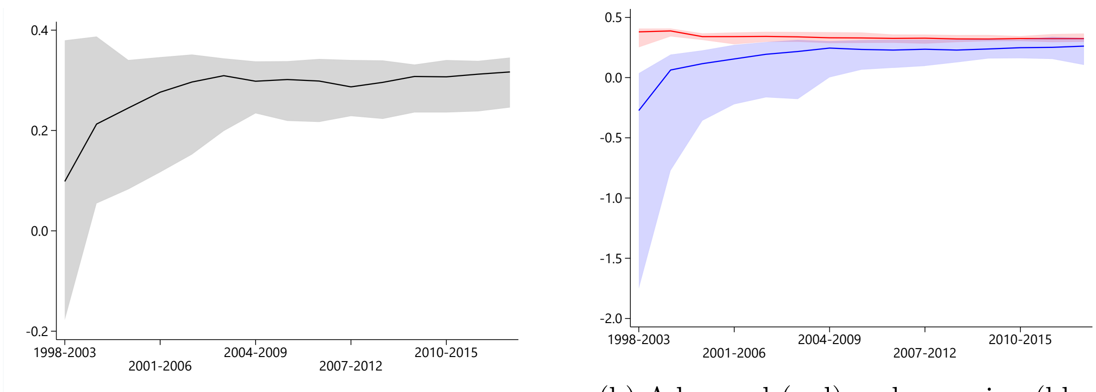
Figure 2 shows the evolution of the anchoring index based on three-year-ahead inflation expectations for a balanced sample of economies with data available since 1998. The extent of anchoring increased substantially over the sample period. While the upper quartile of the distribution remained broadly stable at a value of about 0.35 (Figure 2, panel [a]), the bottom quartile increased from about -0.18 in the first subperiod (1998–2003) to around 0.25 at the end of the sample (2012–17). The median across countries increased much less—from about 0.10 to 0.30 over the sample period.

Most of the improvement in anchoring happened among emerging economies, and primarily up to the mid-2000s (Figure 2, panel [b]). Subsequent gains have been relatively subdued. The median anchoring across advanced economies was broadly stable over the past two decades, although the interquartile range narrowed during the 2000s as a result of improvements at the lower end of the distribution.

Despite the large improvement in anchoring registered by several economies, substantial variation persists. Figure 3 shows the average value of the anchoring in-

[10] Since data on the dispersion of Consensus Economics survey responses are only available since 2005, the summary index is constructed as the average of the standardized *Metric #1* and *Metric #2* up to 2004 and as the average of all three standardized metrics from 2005 onward. See online annex for further details.

Figure 2: Index of Inflation Expectations' Anchoring, 1998–2017
(Three-Year-Ahead Inflation Expectations)



(a) All economies

(b) Advanced (red) and emerging (blue) economies

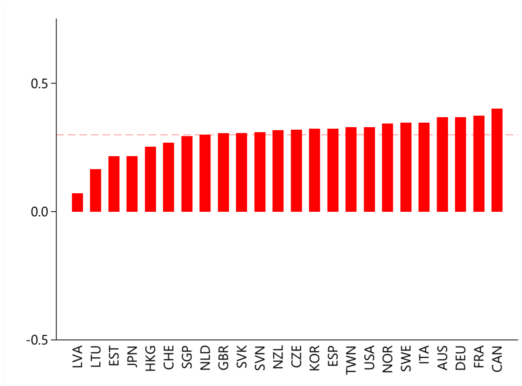
Note: The figures show the evolution of the anchoring index computed over six-year rolling windows for a balanced panel of countries with data available since 1998. The lines denote the median across countries and the shaded areas denote interquartile ranges.

dex for each country in the sample during 2004–17, when anchoring was broadly stable both among advanced and emerging economies. There is significant cross-country heterogeneity in the value of the anchoring index, especially among emerging economies. While on average anchoring in these economies is weaker than in advanced economies, the level of anchoring in some countries (e.g., Chile and Poland) was even higher than the average for advanced economies. But for the emerging economies at the bottom of the distribution (e.g., Argentina, Ukraine, and Russia) the index value is substantially lower.

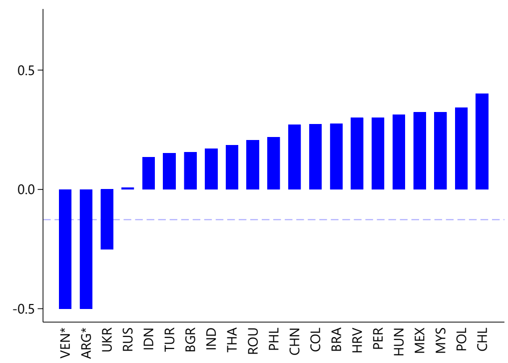
2.4 Comparison with Institutional Characteristics and Other Anchoring Metrics

The literature suggests that the extent of anchoring is intimately related to the credibility of monetary policy (Cukierman and Meltzer, 1986; King, 1995). A mon-

Figure 3: Index of Inflation Expectations' Anchoring—Cross-Country Heterogeneity (Average over 2004–17)



(a) Advanced economies



(b) Emerging economies

Note: The red (blue) dashed line denotes the average across advanced (emerging) economies. The values for Venezuela and Argentina are -5.3 and -1.5, but we set the minimum of the vertical axis to -0.5 to ease visualization.

etary policy plan is credible if the public believes that the monetary authority does not have incentives to deviate from that plan or does not need to subordinate it to other considerations, such as restoring fiscal solvency. In this regard, an independent central bank and sound and sustainable fiscal policy are key attributes for the credibility of monetary policy (Mishkin, 2000; Mishkin and Savastano, 2001) and therefore potential drivers of the extent of anchoring of inflation expectations.[11] Transparency about the objective and conduct of monetary policy is also a key determinant of inflation expectations.[12]

To explore how our anchoring index relates to measures of central bank indepen-

[11] Some studies find an association between fiscal institutions and credibility on the one hand and inflation performance and the anchoring of inflation expectations on the other hand (Combes et al., 2017; Montes, Acar, et al., 2018), or a link between expected fiscal performance and inflation expectations (Celasun et al., 2004).

[12] Levin et al. (2004) and Gürkaynak et al. (2010) find that announcing an explicit inflation target helped anchoring long-term inflation expectations in advanced economies. Capistrán and Ramos-Francia (2010) find that the dispersion of inflation forecasts in emerging economies tends to fall after adopting an inflation targeting regime, while Brito et al. (2018) show that the reduction in disagreement that follows the adoption of inflation targeting is largely due to increased central bank transparency.

dence and transparency and indicators of sound fiscal frameworks, we regress our index, computed over six-year non-overlapping windows between 1994 to 2017, over the following variables: (i) the central bank independence index compiled by Garriga (2016) (an extension of Cukierman et al., 1992 index); (ii) a dummy indicating whether a fiscal rule is in place;[13] and (iii) the index of central bank transparency compiled by Dincer and Eichengreen (2014).

The results are shown in Table 1. We find that the extent of anchoring of inflation expectations in our sample is positively and significantly correlated to the degree of central bank independence (column 1). We also find that inflation expectations are better anchored when countries have a fiscal rule in place (column 2). Finally, the extent of anchoring in our sample is positively related to the degree of transparency of central bank policy (column 3).

Table 1: Relationship Between Anchoring and Institutional Framework

	(1)	(2)	(3)
Central bank independence	2.592**		
	(1.285)		
Fiscal rule		0.383***	
		(0.139)	
Central bank transparency			0.129**
			(0.060)
Observations	161	135	160
R-squared	0.171	0.213	0.259
Countries	44	37	44

Notes: The dependent variable in all regressions is the summary anchor index. Each time period corresponds to a six-year non-overlapping window between 1994 and 2017. All regressions include country and time fixed effects. Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

[13] We use data on whether countries have a fiscal rule with a numerical target from the IMF fiscal rules database (https://www.imf.org/external/datamapper/fiscalrules/matrix/matrix.htm).

Taken together, these results suggest that central banks are more likely to succeed in anchoring inflation expectations when they are transparent about their objective and how they conduct policy, and when the pursuit of their mandate does not appear subordinated to fiscal considerations.

Separately, our survey-based inflation anchoring metrics can be compared with the degree of anchoring estimated by Carvalho et al. (2020), where the authors model the formation of long term inflation expectations as a learning process that is based on short-term inflation surprises. The results, limited to nine OECD countries covered in Carvalho et al. (ibid.), reveal a strong and statistically significant correlation (in the 0.6-0.9 range) between the two approaches for measuring the degree of anchoring of inflation expectations (see Appendix B for details).

3 Anchoring and Inflation Persistence

Having documented a wide variation in the extent of anchoring of inflation expectations across countries and over time, this section explores how this heterogeneity relates to the persistence of inflationary shocks. To identify inflationary shocks, we exploit the exogenous variation in commodity terms of trade as described below.

3.1 Terms-of-Trade Shocks

A common challenge for analyzing empirically the effect of variations in the terms of trade is to identify exogenous shocks. Standard measures of terms of trade—the overall export-to-import price ratio—are affected by price rigidities and incomplete pass-through, making identification almost impossible (Chen and Rogoff, 2003). We follow an approach often adopted in the literature (Aizenman et al., 2012; Ricci et al., 2013; Fernández et al., 2017) that relies on country-specific commodity terms of trade indices based on international commodity prices. More precisely, we capture terms-of-trade shocks with the change in the natural logarithm of the commodity terms-of-trade index in Gruss and Kebhaj (2019), which provides an estimate of the changes in disposable income, relative to GDP, arising from fluctuations in commodity prices:

$$\Delta ctot_{i,t} = \sum_{c=1}^{C} \Delta P_{c,t} \Omega_{i,c}, \tag{4}$$

where $P_{c,t}$ is the logarithm of the real price (that is, in US dollars and divided by the IMF's unit value index for manufactured exports) of commodity c in period t, with $c = 1, ..., 45$; and Δ denotes first differences.

The commodity price variations are common across countries, but the weight of each commodity, $\Omega_{i,c}$, is country-specific and determined by the ratio of its net exports to output:

$$\Omega_{i,c} = \frac{x_{i,c} - m_{i,c}}{GDP_i}, \tag{5}$$

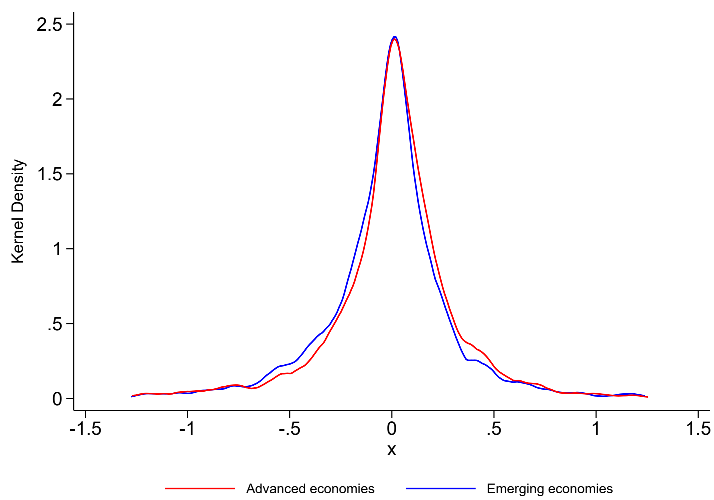
where $x_{i,c}$ ($m_{i,c}$) denotes the exports (imports) value of commodity c of country i, expressed in US dollars; and GDP_i denotes country i's nominal GDP is US dollars.[14] A one percentage point change in the commodity terms-of-trade index can

[14] Exports, imports, and GDP in equation (5) are averaged over 1980–2015, so the weight of commodity c in country i is time invariant. This ensures that the movement in the index is invariant to changes in import and export volumes in response to fluctuations in international prices. Using an alternative index from Gruss and Kebhaj (2019) based on time-varying weights, which can account for changes over time in the mix of traded commodities, yields similar results.

thus be interpreted as a change in aggregate disposable income equivalent to one percentage point of GDP—providing a convenient cross-country normalization of the income effect associated with terms-of-trade shocks.

For ease of interpretation, variations in *ctot* have been reversed, so that a positive change denotes a deterioration in the terms of trade. Figure 4 shows the distribution of commodity terms-of-trade shocks for the estimation sample. The distributions for both advanced and emerging economies are very similar, centered around zero, and with a standard deviation of slightly less than half percentage point.

Figure 4: Distribution of Commodity Terms-of-Trade Shocks



Note: The standard deviation for advanced (emerging) economies is 0.48 (0.44). The figure excludes observations below/above the $1^{st}/99^{th}$ percentile.

How do terms-of-trade shocks affect domestic consumer prices? Commodity terms of trade can affect domestic consumer prices through two channels, and their impact depends on whether the exchange rate can adjust. Consider, first, that the exchange rate does not adjust. The first channel is the direct effect from the change in international commodity prices on the domestic price of consumer goods. The effect through this channel is however ambiguous. An increase in the price of a given commodity, which would have a direct positive effect on consumer prices, can cause the commodity terms of trade to increase or decrease, depending on whether the country is a net exporter or net importer of that commodity. The direct effect also depends on the weight of that specific commodity in the consumption basket, which could be very low in some cases (e.g., for some metals).

The second channel is indirect and due to the income effect from the terms-of-trade shock. The direction of the effect is unambiguous. A negative terms-of-trade shock, for instance, would lead to a decline in aggregate disposable income. This, in turn, would imply subdued aggregate demand and put downward pressure on domestic consumer prices.

If the exchange rate can adjust, there would be an additional and important propagation mechanism. A deterioration in the commodity terms of trade, with a consequent negative income effect, would trigger a depreciation of the domestic currency. Regardless of the direct effect associated with the change in international prices (i.e., in US dollars) that moved the terms of trade, the exchange rate depreciation triggered by the shock would have an unambiguous inflationary impact on consumer prices expressed in domestic currency.

In the analysis that follows, we thus condition the responses on the exchange rate regime and focus on the effect of anchoring within floats (i.e., under relatively flexible exchange rate regimes) where this channel is present.[15] We want to assess whether the inflationary effect of a negative shock to the terms of trade that triggers a de-

[15] Anchoring can also be imperfect under fixed exchange rate regimes, especially if the commitment towards the regime is perceived to be weak. While that could be an interesting aspect to investigate, we focus on the effect that the credibility of monetary policy may have on inflation persistence among floats. See Alogoskoufis and Smith (1991) and Benati (2008) for evidence on persistence in fixed exchange rate arrangements.

preciation of the domestic currency is smaller and fades out quicker when inflation expectations are better anchored. To test this hypothesis we explore whether the cumulative response of consumer prices after a terms-of-trade shock depends on how well anchored inflation expectations were before the shock hit.

3.2 Empirical Approach and Main Results

We estimate the cumulative response of the consumer price index over 12 months to a change in the country-specific commodity terms-of-trade index in a panel setting using the local projection method of Jordà (2005). A key advantage of this approach is that it can easily accommodate nonlinearities in the impulse response functions and handle potential cross-country correlation in the error term (Auerbach and Gorodnichenko, 2012). Our baseline specification is as follows:

$$\begin{aligned} p_{i,t+h-1} - p_{i,t-1} = \alpha^h &+ \beta_1^h anchor_{i,t-1} + \beta_2^h flex_{i,t} + \beta_3^h \Delta ctot_{i,t} \\ &+ \beta_4^h flex_{i,t} \times \Delta ctot_{i,t} + \beta_5^h anchor_{i,t-1} \times \Delta ctot_{i,t} \\ &+ \beta_6^h flex_{i,t} \times anchor_{i,t-1} \times \Delta ctot_{i,t} + \beta_7^h flex_{i,t} \times anchor_{i,t-1} \\ &+ \sum_{j=1}^{J} \rho_j^h \Delta p_{i,t-j} + \sum_{s=1}^{S} \gamma_s^h \Delta ctot_{i,t-s} + \mu_i^h + \nu_t^h + \epsilon_{i,t+h-1}, \text{ with } h = 1, ..., 12, \end{aligned} \tag{6}$$

where $p_{i,t}$ denotes the natural logarithm of the consumer price level in country i in period t;[16] μ_i are country fixed effects that capture any time-invariant country-

[16] Consumer prices correspond to headline consumer price indices (CPI) at monthly frequency reported by national authorities and obtained from Haver Analytics.

specific characteristics; ν_t are time fixed effects; Δ denotes first difference; and $\epsilon_{i,t+h}$ is a random disturbance. *anchor* is the average value of the inflation expectations anchoring index described in Section 2.3 over a rolling window that covers the preceding six years. *anchor* enters the equation lagged by one month, consistent with the approach adopted by Ramey and Zubairy (2018). $flex$ is a dummy variable that takes a value of zero for fixed exchange rate regimes and a value of one otherwise, based on the exchange rate regime index of Ilzetzki et al. (2017).[17]

As discussed in Stock and Watson (2018), the dynamic nature of macroeconomic problems approached with local projections requires—beyond the contemporaneous exogeneity condition—a strong lead-lag exogeneity condition to produce valid inference, such that the shock is uncorrelated with past shocks. In our case, if the terms-of-trade shock is serially correlated, we could misinterpret inflation persistence as resulting from monetary policy credibility while it is actually due to the characteristics of the disturbance process (Fuhrer, 2010). Although the persistence of $\Delta ctot$ is low in our sample (estimates of a country-specific autoregressive process of order one ranges from 0.3 to 0.4), we include two lags of the terms-of-trade shock (i.e., $S = 2$) based on a general-to-specific lag selection procedure. We also include 12 lags of the change in consumer prices (i.e., $J = 12$).

One may argue that other factors that have an effect on prices should be controlled

[17] Observations with coarse classifications 1 and 2 were considered fixed exchange regimes (i.e., $flex = 0$). These include: no separate legal tender; pre announced peg or currency board arrangement; pre announced horizontal band that is narrower than or equal to +/-2 percent; de facto peg; pre announced crawling peg; pre announced crawling band that is narrower than or equal to +/-2 percent; de facto crawling peg; de facto crawling band that is narrower than or equal to +/-2 percent. Observations with coarse classification codes 5 ("free falling") and 6 ("dual market in which parallel market data is missing") were excluded. Other classifications are considered floats (i.e., $flex = 1$). In robustness exercises of Section 3.4 we: (i) include also observations classified as "free falling" (coarse classification 5); and (ii) consider the de facto exchange rate regime classification of Shambaugh (2004).

for, such as monetary policy decisions or the degree of fiscal dominance. We contend, however, that the degree of anchoring is ultimately a function of these factors and therefore they should not be controlled for. For instance, in a country with fiscal slippages financed by central bank issuance, anchoring is expected to be weak as the monetization by the central bank would lead inflation expectations to systematically drift away from the target (consistent with the relationship between anchoring and proxies for fiscal institutions shown in Section 2.4) and to higher prices. Under these circumstances, controlling for some measure of fiscal dominance would lead to a specification in which the coefficient on the interaction term between the shock and the degree of anchoring captures only elements that are orthogonal to aspects of anchoring related to fiscal dominance, defeating the purpose of the exercise.[18]

The specification in (6) is estimated by ordinary least squares for each $h = 1, ..., 12$ using monthly data for 31 economies over 1999m1–2017m12.[19] Since the dependent variable is defined in cumulative terms—it measures the cumulative growth in prices between $t-1$ and $t+h$—the estimate of β_3^h provides a measure of the cumulative impact of an innovation in the terms of trade on the CPI. Following Jordà et al. (2015), we use country-based cluster-robust standard errors to correct for potential serial correlation and heteroscedasticity.[20]

[18] In a series of supplementary exercises, we augment the baseline specification with the monetary policy rate and the credit default swap spread (and their lags), thereby limiting the coefficients of interest to proxy aspects of anchoring that are unrelated to monetary policy decisions and fiscal dominance. While the number of observations drops to roughly two thirds or less and the results cannot be compared with those of the baseline specification, the main messages survive. Results are available upon request.

[19] We exclude euro area countries from the analysis since, at the individual level, they don't have an independent monetary authority. We also exclude Venezuela, which experienced hyperinflation during the sample period, and Ukraine, where inflation dynamics towards the end of the sample were influenced by tensions with Russia and the military conflict in the eastern part of the country.

[20] The Driscoll and Kraay (1998) procedure, that is also robust to cross-sectional dependence, is

We argued before in favor of conditioning on the exchange rate regime and focusing on flexible arrangements since the transmission of terms-of-trade shocks to consumer prices differs depending on whether the exchange rate can react to the shock or not. So before studying the influence of anchoring on inflation persistence for floats, we first explore whether shocks to the terms of trade have a significantly different effect on consumer prices between floats and pegs. To facilitate the interpretation of the results, it is useful to compute the conditional cumulative effect of a change in *ctot* on the CPI: [21]

$$\frac{\delta\left(p_{i,t+h-1}-p_{i,t-1}\right)}{\delta \Delta ctot_{i,t}} = \beta_3^h + \beta_4^h flex_{i,t} + \beta_5^h anchor_{i,t-1} + \beta_6^h flex_{i,t} \times anchor_{i,t-1}, \text{ with } h = 1, ..., 12, \tag{7}$$

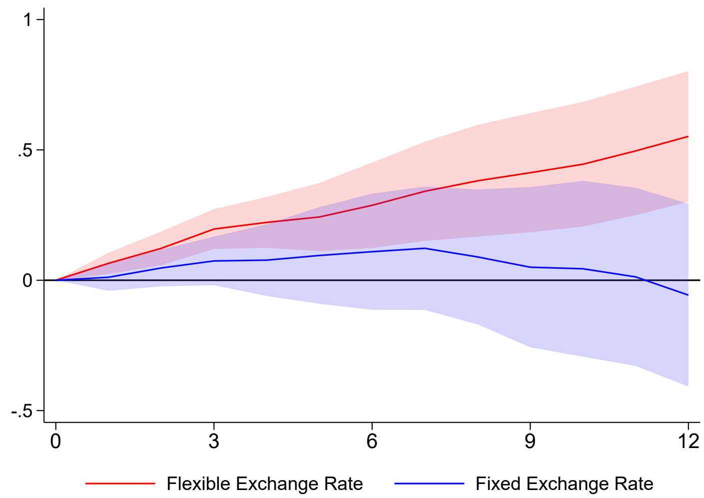
Figure 5 shows the cumulative effect of a negative terms-of-trade shock for pegs ($flex = 0$) and floats ($flex = 1$) on CPI, with *anchor* evaluated at its average across countries and periods in the estimation sample. The results indicate that, indeed, a negative terms-of-trade shock leads to a significant increase in consumer prices in economies with flexible exchange rate regimes. Compared to the path of CPI in the absence of shocks, the price level increases steadily over the following 12 months. Instead, the response of consumer prices for pegs is statistically indistinguishable from zero.

We next turn to the main hypothesis we want to test: is the effect of a negative shock to the terms of trade on consumer price inflation less persistent when ex-

used in robustness exercises (Section 3.4).

[21] The estimation results for all horizons h are shown in Annex Table A.2. The estimated coefficient β_6^h is negative—meaning that, for floats, better-anchored inflation expectations are associated with a smaller increase of consumer prices following a negative terms-of-trade shock—for all $h = 1, ..., 12$ and statistically significant at the 99 percent confidence level.

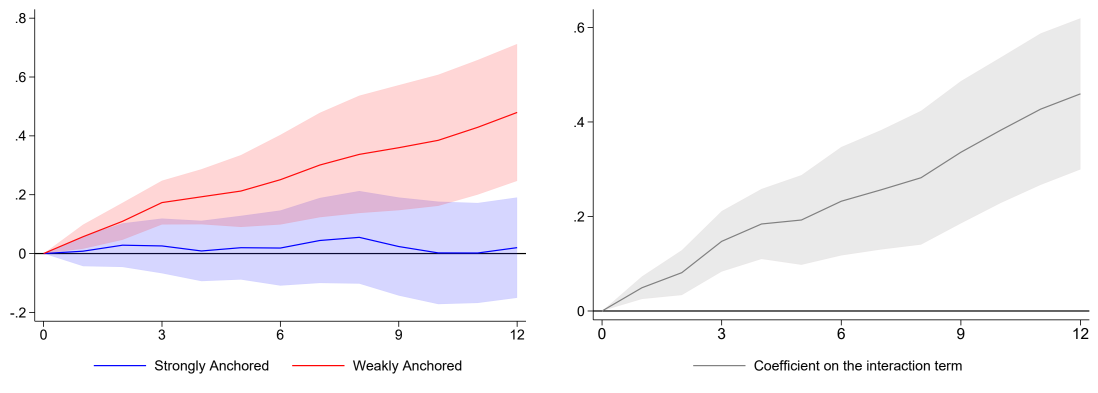
Figure 5: Response of Consumer Prices to a Terms-of-Trade Shock, by Exchange Rate Regime



Note: The figure shows the cumulative response of consumer prices to a negative terms-of-trade shock of 1 percent. The x-axis corresponds to months after the shock. The response of flexible (fixed) exchange rate corresponds to $\hat{\beta}_3^h + \hat{\beta}_4^h + \hat{\beta}_5^h \times \overline{anchor} + \hat{\beta}_6^h \times \overline{anchor}$ ($\hat{\beta}_3^h + \hat{\beta}_5^h \times \overline{anchor}$) in equation (7), where $\overline{anchor}$ denotes the average of the anchoring index in the estimation sample. Shaded areas denote 95 percent confidence intervals computed with country-based cluster-robust standard errors.

pectations are better anchored? We start by exploring the response of the price level. Figure 6, panel (a), shows the cumulative response of the CPI for floats over 12 months following a negative terms-of-trade shock when: (i) expectations are strongly anchored (*anchor* set at the 75^{th} percentile of its sample distribution); and (ii) expectations are weakly anchored (*anchor* set at the 25^{th} percentile of its sample distribution). The results indicate that when inflation expectations are poorly anchored, a deterioration in the terms of trade associated with a drop in disposable income of one percent of GDP leads to a significant and persistent increase in consumer prices. The CPI increases by 0.25 percentage point after six months and 0.48 percentage point one year after a shock that reduces disposable income by one percentage point of GDP. Instead, when inflation expectations are strongly anchored, the cumulative response of consumer prices is indistinguishable from zero. The difference between the responses under weakly and strongly anchored expectations is statistically significant at the 95 percent confidence level (Figure 6, panel [b]).

Figure 6: Response of Consumer Prices to a Terms-of-Trade Shock, by Anchoring

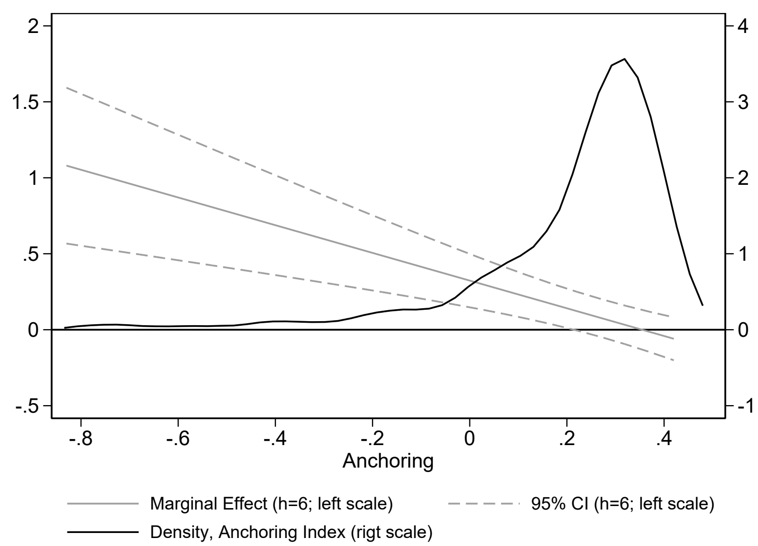


(a) Response by Anchoring Level (b) Difference Between Responses

Note: The figures show the cumulative response of consumer prices to a negative terms-of-trade shock of 1 percent when the exchange rate regime is flexible. The x-axis corresponds to months after the shock. The response under strongly (weakly) anchored expectations in panel (a) corresponds to $\hat{\beta}_3^h + \hat{\beta}_4^h + \hat{\beta}_5^h \times anchor_{p75} + \hat{\beta}_6^h \times anchor_{p75}$ ($\hat{\beta}_3^h + \hat{\beta}_4^h + \hat{\beta}_5^h \times anchor_{p25} + \hat{\beta}_6^h \times anchor_{p25}$) in equation (7), where $anchor_{p75}$ ($anchor_{p25}$) denotes the 75^{th} (25^{th}) percentile of the anchoring index in the estimation sample. Shaded areas denote 95 percent confidence intervals computed with country-based cluster-robust standard errors.

Figure 7 provides an alternative way to visualize our result, focusing on the cumulative response after 6 months for different degrees of anchoring. The solid grey line summarizes the marginal effect for floats of a negative shock to the commodity terms of trade at different values of the anchoring index. The dashed grey lines denote the 95 percent confidence interval. The black line shows the estimated kernel density of the anchoring index (i.e., distribution of anchoring) in the estimation sample. While the marginal effect at the 25^{th} percentile of anchoring is about 0.21 percent, it is much higher, about 0.62 percent, at the 10^{th} percentile of anchoring—that is, when the anchoring index is around -0.36. At the other extreme of the distribution the marginal effect is negative (e.g., it is -0.06 percent at the 95^{th} percentile). This probably reflects that, for those economies, the effect on prices from weaker domestic demand as a result of the negative income effect predominates.

Figure 7: Marginal Effect on Consumer Prices after 6 Months, by Anchoring

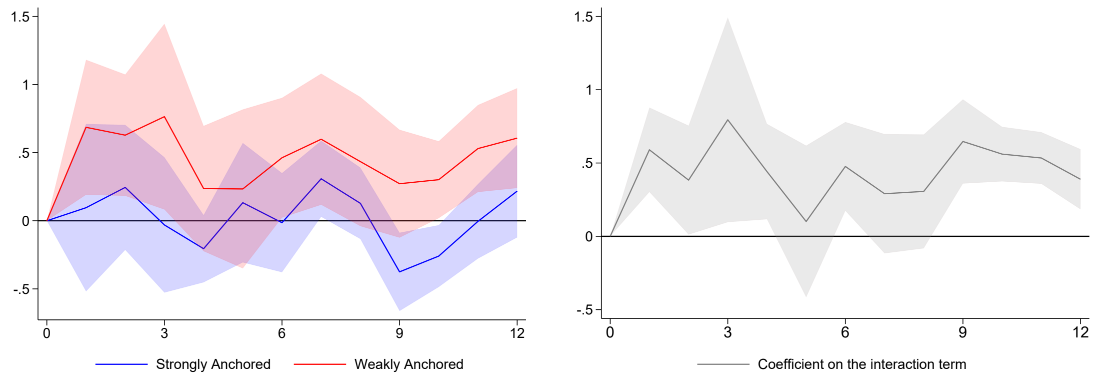


Note: The figure shows the marginal effect after six months of a negative terms-of-trade shock of 1 percent on consumer prices when the exchange rate regime is flexible. The chart reports results for levels of anchoring greater or equal than -0.83.

We next explore the implications of anchoring for the persistence of the inflation rate. To this end, we estimate equation (6) but redefining the dependent variable as the month-on-month inflation rate (that is, $\Delta p_{i,t+h-1}$ for $h = 1, ..., 12$) annualized, rather than the cumulative change in the price level. The results reported in Figure 8 indicate that the inflation rate increases by about 0.76 percentage points three months after the shock when inflation expectations are poorly anchored.[22] And, more importantly, the reaction of inflation is very persistent: on average, the month-on-month inflation rate remains more than 0.6 percentage point above its pre-shock level even 12 months after the shock. Instead, the response of the month-on-month inflation rate is not statistically different from zero when expectations are strongly anchored.

[22]The estimation results for all horizons h are shown in Annex Table A.3.

Figure 8: Response of Inflation to a Terms-of-Trade Shock, by Anchoring



(a) Response by Anchoring Level (b) Difference Between Responses

Note: The figures show the cumulative response of consumer price inflation to a negative terms-of-trade shock of 1 percent when the exchange rate regime is flexible. The x-axis corresponds to months after the shock. The response under strongly (weakly) anchored expectations in panel (a) corresponds to $\hat{\beta}_3^h + \hat{\beta}_4^h + \hat{\beta}_5^h \times anchor_{p75} + \hat{\beta}_6^h \times anchor_{p75}$ ($\hat{\beta}_3^h + \hat{\beta}_4^h + \hat{\beta}_5^h \times anchor_{p25} + \hat{\beta}_6^h \times anchor_{p25}$) in equation (7), where $anchor_{p75}$ ($anchor_{p25}$) denotes the 75^{th} (25^{th}) percentile of the anchoring index in the estimation sample. Shaded areas denote 95 percent confidence intervals computed with country-based cluster-robust standard errors.

3.3 Exchange Rate Depreciation and Pass-Through

These results suggest that the persistence of inflationary shocks is indeed larger when inflation expectations are poorly anchored. Given that the shock we are considering, a terms-of-trade shock, affects consumer prices primarily through the response of the exchange rate (as shown in Figure 5), a natural follow up question is whether the higher inflation persistence when expectations are poorly anchored is due to a larger currency depreciation, or to a larger exchange rate pass-through.

To answer this question, we explore whether the response of the exchange rate to a shock to the terms of trade is significantly different for economies with strongly and weakly anchored inflation expectations. We estimate the model in equation (6) but substituting consumer prices ($p_{i,t}$) with the natural logarithm of, alternatively, the nominal bilateral exchange rate (in local currency per U.S. dollar) and the import-weighted nominal effective exchange rate (as in Gopinath, 2015; and Carrière-Swallow et al., 2021).[23] The latter is given by:

$$\Delta neer_{i,t} = \sum_{j=1}^{J} \omega_{ij,t}(\Delta e_{i,t} - \Delta e_{j,t}), \text{ with } i \neq j \tag{8}$$

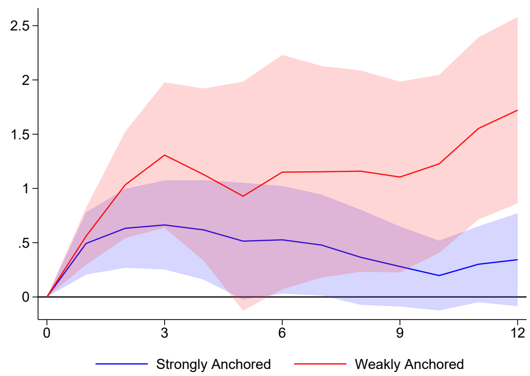
where $e_{i,t}$ is the natural logarithm of country i's bilateral exchange rate (expressed in local currency per U.S. dollar, so that an increase denotes a depreciation of the domestic currency); Δ is the first difference operator; and $\omega_{ij,t}$ is the share of exports from country j to country i in country i's total imports as reported in the IMF's *Direction of Trade Statistics*, lagged one year, and measured at annual frequency.

The results using the nominal exchange rate indicate that the magnitude of the depreciation following terms-of-trade shocks is related to the extent of anchoring, but the statistical significance of this relationship is marginal. Figure 9 shows the cumulative response of the exchange rate up to 12 months for floats after a negative terms-of-trade shock when inflation expectations are strongly anchored (*anchor* set at the 75$^{\text{th}}$ percentile of the sample distribution) and weakly anchored (*anchor* set at the 25$^{\text{th}}$ percentile). The response of the exchange rate is somewhat larger for weakly-anchored countries than for countries with well anchored expectations, although the difference is generally not statistically significant. The results using the nominal effective exchange rate suggest that the depreciation may also be larger

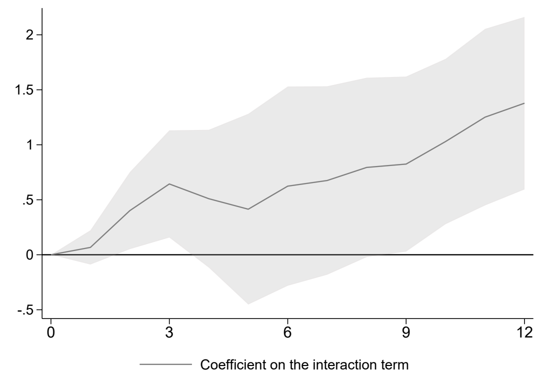
[23] By taking into account bilateral trade linkages, the nominal effective exchange rate may be able to summarize more closely the complete set of relative price adjustments that can be expected to affect consumer prices. However, if a substantial fraction of bilateral trade is invoiced in US dollars (as documented in Gopinath, 2015), the nominal exchange rate with respect to the US dollar may be a reasonable choice.

when expectations are poorly anchored (Figure 10). But, again, the difference is only statistically significant for a few horizons.

Figure 9: Response of the Nominal Exchange Rate to a Terms-of-Trade Shock, by Anchoring



(a) Response by Anchoring Level



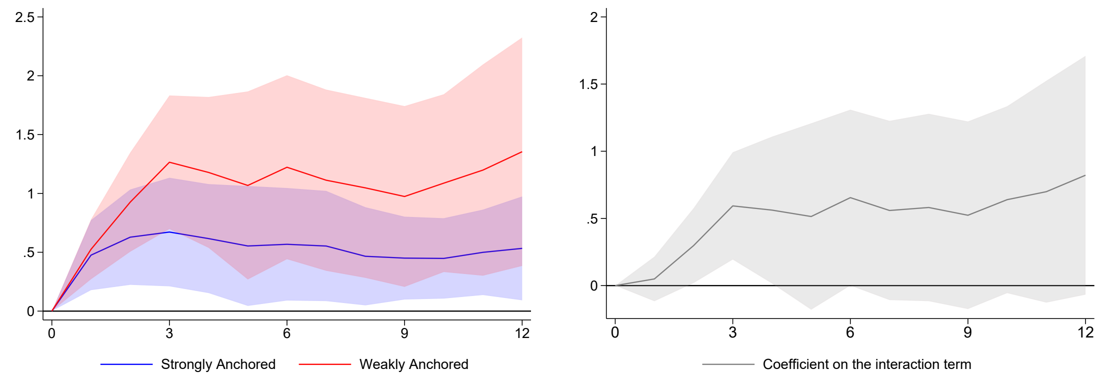
(b) Difference Between Responses

Note: The figures show the cumulative response of the nominal exchange rate to a negative terms-of-trade shock of 1 percent when the exchange rate regime is flexible. The x-axis corresponds to months after the shock. The response under strongly (weakly) anchored expectations in panel (a) corresponds to $\hat{\beta}_3^h + \hat{\beta}_4^h + \hat{\beta}_5^h \times anchor_{p75} + \hat{\beta}_6^h \times anchor_{p75}$ ($\hat{\beta}_3^h + \hat{\beta}_4^h + \hat{\beta}_5^h \times anchor_{p25} + \hat{\beta}_6^h \times anchor_{p25}$) in equation (7), where $anchor_{p75}$ ($anchor_{p25}$) denotes the 75^{th} (25^{th}) percentile of the anchoring index in the estimation sample. Shaded areas denote 95 percent confidence intervals computed with country-based cluster-robust standard errors.

The weak significance of the marginal effect of anchoring on the exchange rate response, together with the strong significance for consumer prices, suggest that two things are at play. When inflation expectations are poorly anchored, the exchange rate appears to depreciate by more in response to a given deterioration in the terms of trade. But, in addition, the pass-through rate from a given currency depreciation triggered by a terms-of-trade shock seems to be larger when inflation expectations are poorly anchored.[24]

[24]This result is consistent with Carrière-Swallow et al. (2021), who find that exchange rate pass-through rates are negatively related to the dispersion of inflation forecasts across individual forecasters, a proxy for the extent of anchoring of inflation expectations.

Figure 10: Response of the Nominal Effective Exchange Rate to a Terms-of-Trade Shock, by Anchoring



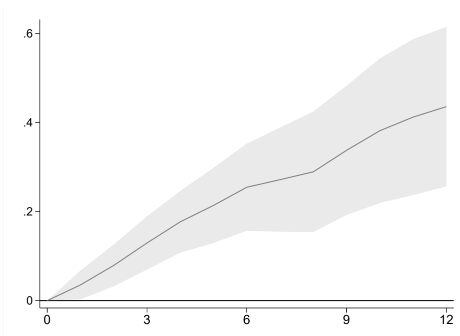
(a) Response by Anchoring Level (b) Difference Between Responses

Note: The figures show the cumulative response of the nominal effective exchange rate to a negative terms-of-trade shock of 1 percent when the exchange rate regime is flexible. The x-axis corresponds to months after the shock. The response under strongly (weakly) anchored expectations in panel (a) corresponds to $\hat{\beta}_3^h + \hat{\beta}_4^h + \hat{\beta}_5^h \times anchor_{p75} + \hat{\beta}_6^h \times anchor_{p75}$ ($\hat{\beta}_3^h + \hat{\beta}_4^h + \hat{\beta}_5^h \times anchor_{p25} + \hat{\beta}_6^h \times anchor_{p25}$) in equation (7), where $anchor_{p75}$ ($anchor_{p25}$) denotes the 75$^{\text{th}}$ (25$^{\text{th}}$) percentile of the anchoring index in the estimation sample. Shaded areas denote 95 percent confidence intervals computed with country-based cluster-robust standard errors.

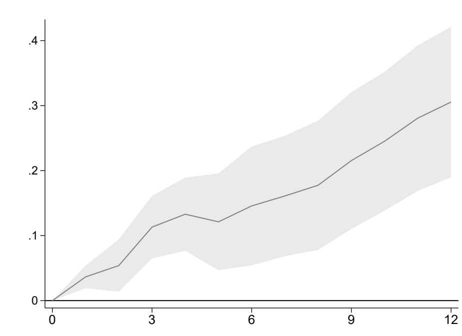
3.4 Robustness

In this section we present a set of robustness tests to our main findings. We first present a set of exercises related to the construction of the anchoring index we use (Figure 11). Our baseline summary anchoring index (Section 2.3) combines three individual metrics of anchoring of inflation expectations constructed from survey-based three-year-ahead inflation forecasts. We start by exploring the results when the individual anchoring metrics, rather than the summary index, are used. In panels (a) through (c) we show the estimated differences between the response of the CPI based on equation (6) when inflation expectations are strongly and weakly anchored using, alternatively, each of the individual anchoring metrics. Our main result largely holds when we use any of the three individual metrics. The results are somewhat weaker when only *Metric #3* is considered but we can still reject the null that the responses of consumer prices after six months under strongly and weakly anchored expectations are equal with a 95 percent confidence level.

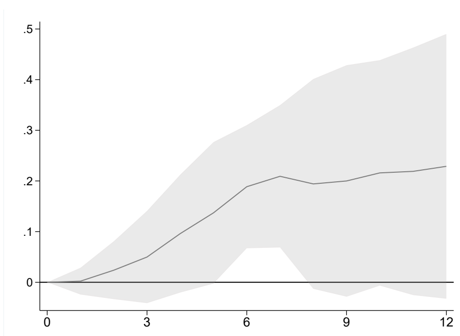
Figure 11: Anchoring Index Robustness Exercises—Response of Consumer Prices



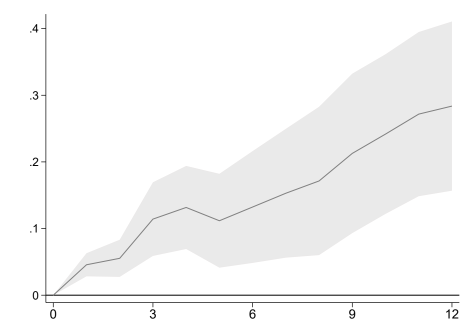
(a) Metric #1



(b) Metric #2



(c) Metric #3



(d) Index with 5-year ahead horizon

Note: The figures show the difference in the cumulative response of consumer prices to a negative terms-of-trade shock of 1 percent when the exchange rate regime is flexible under strongly and weakly anchored expectations (which correspond to the 75^{th} and the 25^{th} percentile, respectively, of the anchoring index in the estimation sample). The x-axis corresponds to months after the shock. Shaded areas denote 95 percent confidence intervals computed with country-based cluster-robust standard errors.

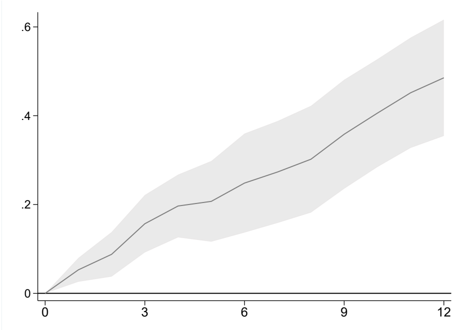
We then assess whether the results are robust to considering longer-term inflation expectations. The result in panel (d) shows that our main result holds when we use five-year ahead inflation expectations to construct the anchoring index, rather than three-year-ahead inflation expectations as in the baseline exercise.

An additional set of robustness exercises, related to the commodity terms of trade, the country sample, and alternative procedures to correct the standard errors, are reported in Figure 12. The assumption of the exogeneity of the commodity terms of trade is key for the identification strategy. One concern regarding this assumption is that demand from large economies may affect international commodity prices, invalidating our identification strategy. Similarly, if exports from a country account for a large portion of global trade in any given commodity, domestic supply shocks could affect its international price. The results reported in panel (a) show that excluding large countries (China and the United States) and countries with a global share in any commodity market higher than 40 percent of world exports does not affect our conclusion.

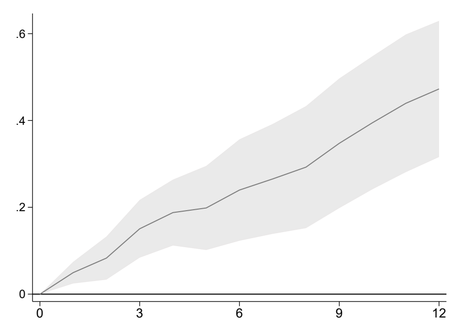
The baseline results rely on commodity terms-of-trade series constructed with fixed commodity weights, which ensure that the movements in the index do not reflect changes in import and export volumes in response to fluctuations in world commodity prices prices. However, the drawback of using indices based on fixed weights is that they cannot capture the evolving mix of traded commodities and their importance with respect to output. The results in panel (b) show that our main findings remain when we use alternative commodity terms-of-trade series from Gruss and Kebhaj (2019) which are constructed using time-varying weights.

Regarding sample selection, a relevant question is how our results change if we exclude countries that are relatively less dependent on international trade and for which terms-of-trade shocks would not lead to large movements in inflation, irrespective of anchoring. Panel (c) shows that the results do not change much when we exclude relatively closed economies, defined as those with a ratio of exports plus imports to output below the 25th percentile of the cross-country distribution

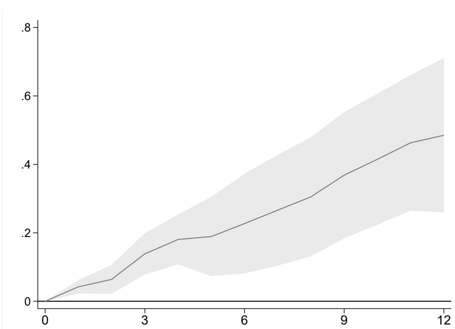
Figure 12: Additional Robustness Exercises—Response of Consumer Prices



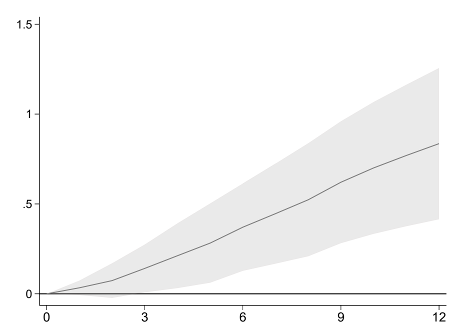
(a) Excluding large countries and dominant exporters



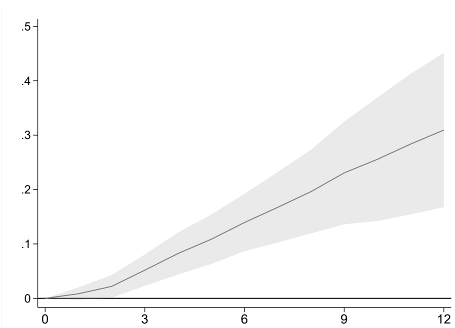
(b) Using time-varying weights



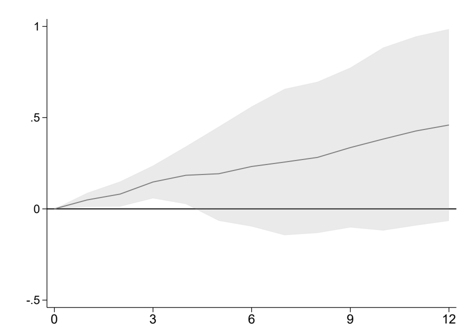
(c) Excluding closed economies



(d) Including free falling exchange rates



(e) Shambaugh (2004) exchange rate classification



(f) Driscoll and Kraay (1998) standard errors

Note: The figures show the difference in the cumulative response of consumer prices to a negative terms-of-trade shock of 1 percent when the exchange rate regime is flexible under strongly and weakly anchored expectations (which correspond to the 75^{th} and the 25^{th} percentile, respectively, of the anchoring index in the estimation sample). The x-axis corresponds to months after the shock. Shaded areas denote 95 percent confidence intervals computed with country-based cluster-robust standard errors.

in 2018.[25]

The exchange rate regime groups we use in our baseline exercise are based on Ilzetzki et al. (2017), but alternative classification schemes differ somewhat and could affect the country sample we use. In order to assess whether our results are sensitive to the classification criteria, panel (d) and (e) show the results under alternative classification schemes. Panel (d) is still based on Ilzetzki et al. (ibid.), but we include observations of free falling exchange rates—that in most classifications are lumped together with ordinary flexible exchange rate regimes although they correspond to regimes with very high inflation (over 40 percent per year). Panel (e), instead, uses the updated version of the exchange rate classification of Shambaugh (2004). The results are very similar to those in the baseline exercise.

Finally, in panel (f) we report the results when the standard errors are corrected using the Driscoll and Kraay (1998) procedure—rather than clustering by country—which are also robust to cross-sectional dependence. The 95-percent confidence intervals are wider under this alternative, but we can still reject the null that the responses of consumer prices under strongly and weakly anchored expectations are equal up to four months after the shock.

4 Conclusions

Theory indicates that that any temporary inflationary shock has a less persistent effect on consumer price dynamics when expectations are anchored. The contribution of this paper is twofold: (i) it constructs a novel index measuring the extent of

[25]The countries excluded are Argentina, Australia, Brazil, China, Colombia, Indonesia, Japan, and the United States.

anchoring of long-term inflation expectations for a large sample of countries; and (ii) it provides an empirical assessment of the influence of inflation expectations' anchoring on inflation persistence.

We first use survey-based long-term inflation forecasts to construct an index of inflation expectations' anchoring for 45 advanced and emerging economies starting in 1989. We document that the extent of anchoring of inflation expectations improved significantly over the past two decades, especially among emerging economies. But substantial cross-country heterogeneity persists.

We then estimate the response of consumer prices to external shocks to the terms of trade—captured by changes in country-specific terms of trade indices based on international commodity prices—conditional on the exchange rate regime and the extent of anchoring of inflation expectations. We find that when inflation expectations are poorly anchored—that is, when the anchoring index is set at the 25$^{\text{th}}$ percentile of the sample distribution—a negative terms-of-trade shock among countries with flexible exchange rates leads to a significant and persistent increase in consumer price inflation. The annualized month-on-month inflation rate remains more than 0.6 percentage point above its pre-shock level one year after a deterioration in the commodity terms-of-trade index equivalent to a drop of aggregate disposable income of one percent of GDP. Instead, when inflation expectations are strongly anchored—the anchoring index is set at the 75$^{\text{th}}$ percentile of the sample distribution—the response of inflation is not statistically different from zero.

Our findings have important implications for monetary policy and underscore the importance of shoring up the credibility of the nominal anchor. When the public's expectations about the future path of inflation are poorly anchored, temporary shocks to inflation have a more durable effect on the dynamics of consumer prices and require a stronger policy reaction to bring inflation under control.

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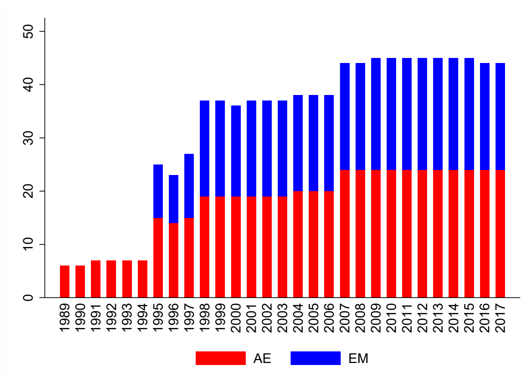
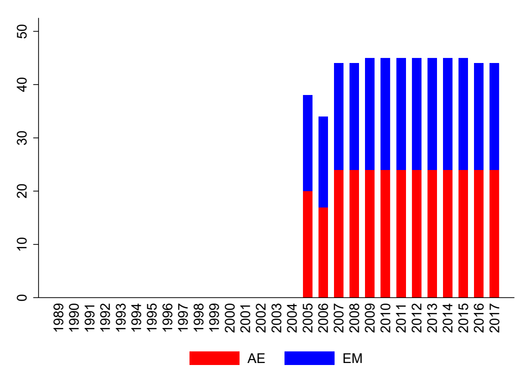
Appendix A. Data Sample and Additional Results

Figure A.1: Mean and Standard Deviation of Long-Term Inflation Forecasts—Data Availability
(Number of Countries)



(a) Mean forecast



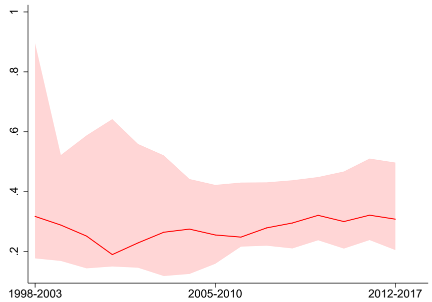
(b) Standard deviation of forecasts

Note: AE = advanced economies. EM = emerging economies.

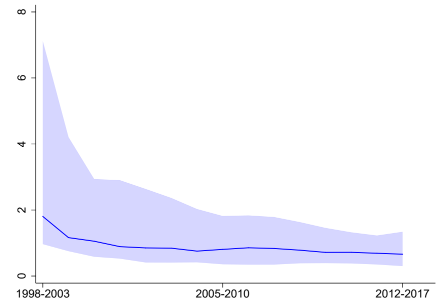
Table A.1: Mean and Standard Deviation of Long-Term Inflation Forecasts—Data Availability

Advanced Economies			Emerging Economies		
Country	Mean forecast	SD of forecasts	Country	Mean forecast	SD of forecasts
AUS	1991	2005	ARG	1993	2005
CAN	1989	2005	BGR	2007	2007
CHE	1998	2005	BRA	1995	2005
CZE	1998	2005	CHL	1993	2005
DEU	1989	2005	CHN	1995	2005
ESP	1995	2005	COL	1997	2005
EST	2007	2007	HRV	2007	2007
FRA	1989	2005	HUN	1998	2005
GBR	2004	2005	IDN	1995	2005
HKG	1995	2005	IND	1995	2005
ITA	1989	2005	MEX	1993	2005
JPN	1989	2005	MYS	1995	2005
KOR	1995	2005	PER	1997	2005
LTU	2007	2007	PHL	2009	2009
LVA	2007	2007	POL	1998	2005
NLD	1995	2005	ROU	1998	2005
NOR	1998	2005	RUS	1998	2005
NZL	1995	2005	THA	1995	2005
SGP	1995	2005	TUR	1998	2005
SVK	1998	2005	UKR	1998	2005
SVN	2007	2007	VEN	1993	2005
SWE	1995	2005			
TWN	1995	2005			
USA	1989	2005			

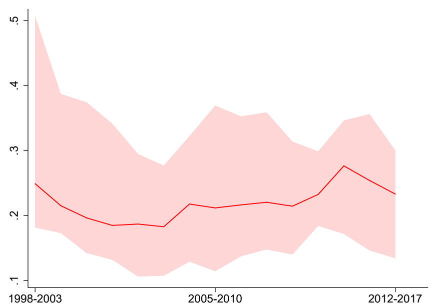
Figure A.2: Evolution of Anchoring Metrics, 1998–2017
(Three-Year-Ahead Inflation Expectations)



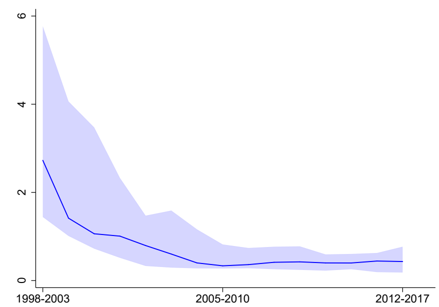
(a) AE, deviation of long-term inflation forecasts from target



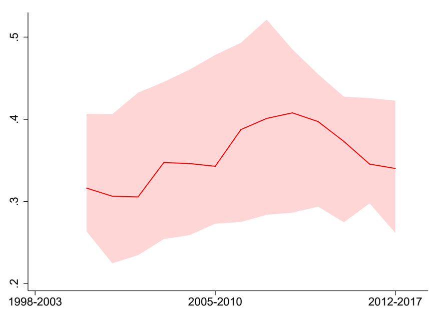
(b) EM, deviation of long-term inflation forecasts from target



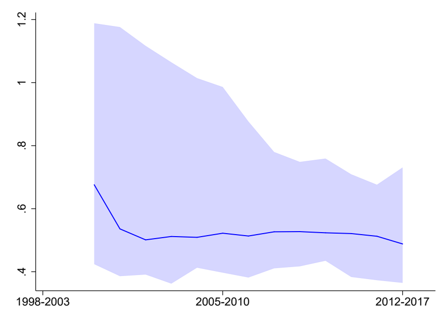
(c) AE, variability of mean long-term inflation forecasts



(d) EM, variability of mean long-term inflation forecasts



(e) AE, dispersion of long-term inflation forecasts



(f) EM, dispersion of long-term inflation forecasts

Note: The figures show the evolution of anchoring metrics computed over six-year rolling windows. The lines denote the medians across countries. The shaded areas denote interquartile ranges. A lower value denotes better-anchored expectations in all metrics. AE = advanced economies. EM = emerging economies.

Table A.2: Cumulative Response of Consumer Prices—Estimation Results

	(1) $h=1$	(2) $h=2$	(3) $h=3$	(4) $h=4$	(5) $h=5$	(6) $h=6$	(7) $h=7$	(8) $h=8$	(9) $h=9$	(10) $h=10$	(11) $h=11$	(12) $h=12$
$\Delta ctot$	0.010	0.044	0.072	0.075	0.093	0.106	0.119	0.086	0.046	0.037	0.006	-0.063
	(0.026)	(0.035)	(0.047)	(0.070)	(0.093)	(0.112)	(0.118)	(0.129)	(0.153)	(0.168)	(0.171)	(0.176)
$flex$	0.019	0.037	0.059	0.084	0.115	0.145	0.174	0.210	0.244	0.272	0.298	0.331
	(0.016)	(0.035)	(0.054)	(0.070)	(0.087)	(0.105)	(0.124)	(0.145)	(0.169)	(0.195)	(0.221)	(0.248)
$anchor$	-0.073***	-0.167***	-0.253**	-0.322**	-0.382**	-0.421**	-0.456*	-0.489*	-0.520	-0.527	-0.529	-0.538
	(0.025)	(0.059)	(0.093)	(0.124)	(0.156)	(0.191)	(0.230)	(0.272)	(0.315)	(0.359)	(0.403)	(0.448)
$\Delta ctot \times flex$	0.063*	0.091*	0.148**	0.175**	0.180*	0.217*	0.262*	0.339**	0.419**	0.467**	0.557***	0.686***
	(0.032)	(0.049)	(0.064)	(0.075)	(0.090)	(0.119)	(0.134)	(0.145)	(0.163)	(0.173)	(0.186)	(0.200)
$anchor \times flex$	0.015	0.061	0.093	0.088	0.062	-0.001	-0.073	-0.160	-0.261	-0.382	-0.513*	-0.630*
	(0.022)	(0.053)	(0.080)	(0.096)	(0.111)	(0.130)	(0.156)	(0.182)	(0.214)	(0.249)	(0.293)	(0.337)
$\Delta ctot \times anchor$	0.044**	0.077***	0.063**	0.043	0.058	0.085	0.096	0.093	0.107	0.172	0.185*	0.160
	(0.017)	(0.023)	(0.029)	(0.035)	(0.043)	(0.062)	(0.073)	(0.084)	(0.099)	(0.106)	(0.105)	(0.105)
$\Delta ctot \times anchor \times flex$	-0.237***	-0.395***	-0.641***	-0.766***	-0.814***	-0.997***	-1.103***	-1.200***	-1.426***	-1.674***	-1.861***	-1.964***
	(0.051)	(0.096)	(0.118)	(0.140)	(0.198)	(0.256)	(0.277)	(0.316)	(0.346)	(0.351)	(0.345)	(0.335)
Countries	31	31	31	31	31	31	31	31	31	31	31	31
Observations	6,214	6,214	6,214	6,214	6,214	6,214	6,214	6,214	6,214	6,214	6,214	6,214
R-squared	0.570	0.667	0.713	0.737	0.751	0.756	0.759	0.761	0.763	0.766	0.770	0.775

Notes: All regressions include 12 lags of the change in consumer prices and 2 lags of the commodity terms-of-trade shock, and country and time fixed effects. Country-based cluster-robust standard errors in parentheses. $\Delta ctot$ is reversed so that a positive change denotes a deterioration in the terms of trade. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A.3: Response of Consumer Price Inflation—Estimation Results

	(1) $h=1$	(2) $h=2$	(3) $h=3$	(4) $h=4$	(5) $h=5$	(6) $h=6$	(7) $h=7$	(8) $h=8$	(9) $h=9$	(10) $h=10$	(11) $h=11$	(12) $h=12$
$\Delta ctot$	0.117	0.411	0.331	0.047	0.207	0.161	0.151	-0.395	-0.480	-0.103	-0.380	-0.827*
	(0.313)	(0.265)	(0.263)	(0.305)	(0.345)	(0.325)	(0.308)	(0.320)	(0.371)	(0.297)	(0.346)	(0.434)
$flex$	0.231	0.213	0.260	0.306	0.365	0.366	0.350	0.427	0.409	0.335	0.315	0.399
	(0.194)	(0.224)	(0.230)	(0.214)	(0.229)	(0.253)	(0.263)	(0.285)	(0.321)	(0.341)	(0.357)	(0.345)
$anchor$	-0.878***	-1.123**	-1.030**	-0.833**	-0.724*	-0.458	-0.423	-0.397	-0.377	-0.078	-0.029	-0.101
	(0.294)	(0.421)	(0.406)	(0.379)	(0.392)	(0.453)	(0.496)	(0.514)	(0.546)	(0.571)	(0.587)	(0.608)
$\Delta ctot \times flex$	0.754*	0.337	0.681	0.327	0.058	0.450	0.538	0.925**	0.954**	0.579	1.077***	1.555***
	(0.380)	(0.376)	(0.468)	(0.223)	(0.360)	(0.430)	(0.463)	(0.426)	(0.418)	(0.359)	(0.352)	(0.481)
$anchor \times flex$	0.185	0.549	0.388	-0.064	-0.313	-0.754*	-0.871**	-1.043**	-1.209**	-1.447***	-1.570**	-1.414**
	(0.269)	(0.364)	(0.333)	(0.281)	(0.309)	(0.407)	(0.424)	(0.407)	(0.482)	(0.520)	(0.636)	(0.621)
$\Delta ctot \times anchor$	0.529**	0.394**	-0.170	-0.234*	0.174	0.326	0.136	-0.034	0.168	0.777***	0.148	-0.294
	(0.206)	(0.148)	(0.189)	(0.136)	(0.300)	(0.322)	(0.270)	(0.222)	(0.258)	(0.166)	(0.357)	(0.326)
$\Delta ctot \times anchor \times flex$	-2.846***	-1.898**	-2.949**	-1.499**	-0.571	-2.197***	-1.276	-1.169	-2.707***	-2.977***	-2.246***	-1.233**
	(0.614)	(0.737)	(1.335)	(0.726)	(1.203)	(0.797)	(0.816)	(0.823)	(0.645)	(0.374)	(0.513)	(0.508)
Countries	31	31	31	31	31	31	31	31	31	31	31	31
Observations	6,214	6,214	6,214	6,214	6,214	6,214	6,214	6,214	6,214	6,214	6,214	6,214
R-squared	0.570	0.546	0.535	0.521	0.513	0.487	0.480	0.474	0.473	0.473	0.478	0.478

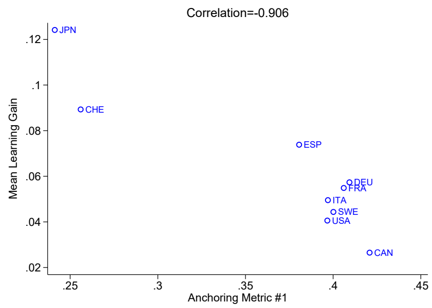
Notes: All regressions include 12 lags of the change in consumer prices and 2 lags of the commodity terms-of-trade shock, and country and time fixed effects. Country-based cluster-robust standard errors in parentheses. $\Delta ctot$ is reversed so that a positive change denotes a deterioration in the terms of trade. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Appendix B. Comparison of Inflation Anchoring Metrics with Model-Based Estimates from Carvalho et al. (2020)

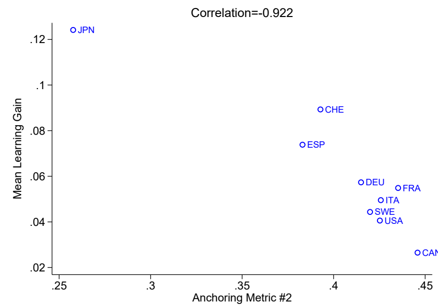
This appendix compares our measures of the degree of anchoring of inflation expectations with cross-country model-based measures produced by Carvalho et al. (ibid.). The comparison is of interest because the degree of anchoring in Carvalho et al. (ibid.) is assessed using a very different approach—as a byproduct of modeling long-term inflation expectations via a learning process that is triggered by short-term inflation surprises. The degree of anchoring in the model is defined as "learning gain". When anchoring is weak, the gain from learning is large and vice versa. Intuitively, more aggressive monetary policy responses to inflation surprises lead firms to put more weight on learning processes that are less sensitive (lower gain) to new information (i.e., short-term inflation surprises), so that small and decreasing learning gain is a dividend of well-anchored expectations. The model is estimated using data for the U.S. and applied to study, among other things, the degree of anchoring of inflation expectations in nine OECD countries over the 1985–2015 period.

For the comparison exercise, we focus on the overlapping time frame between the two studies, 2003–15, for nine OECD countries covered by Carvalho et al. (ibid.) and compare the average anchoring values across counties. Results in Figure B.1 reveal a strong correlation with the expected sign. Countries with more anchored inflation expectations, as measured by each of our metrics or the summary anchoring index, exhibit a systematically smaller average learning gain, as reported in Carvalho et al. (ibid.). The results are very similar if the median learning gain is used instead, with correlations in the 0.65-0.97 range.

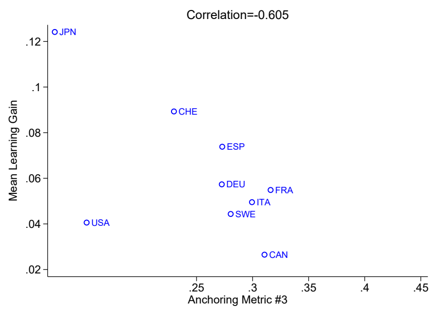
Figure B.1: Comparison of Inflation Anchoring Metrics with Model-Based Estimates



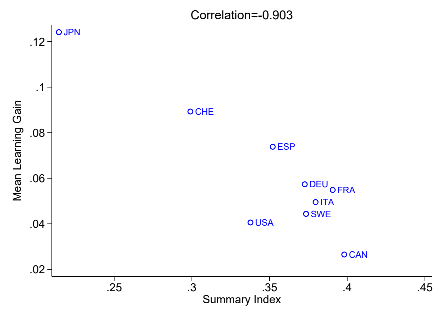
(a) Metric #1



(b) Metric #2



(c) Metric #3



(d) Summary Anchoring Index

Notes: Observations based on 2003-15 averages for each anchoring metric, except *Metric #3*, where data starts from 2005. Learning gain computed as the mean from the model-based distribution of leaning gains at each point in time, which is then averaged over the 2003-15 period.

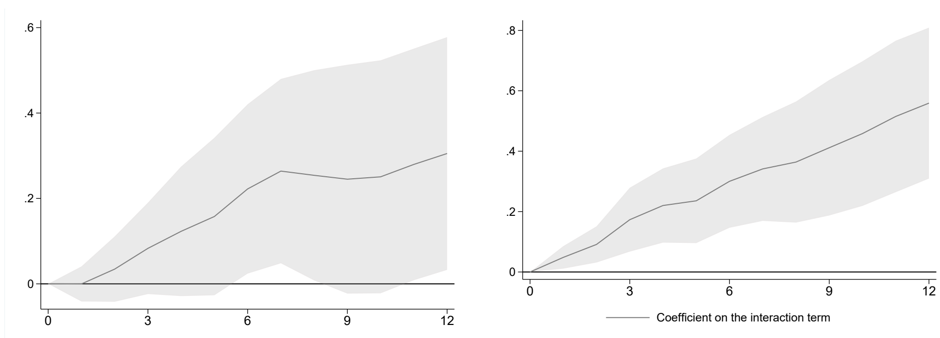
We also used our survey-based inflation forecasts to construct an empirical metric in the spirit of that in Carvalho et al. (2020). This alternative metric (*Metric #4*) is based on the sensitivity of long-term inflation forecasts to short-run forecasts (a proxy for inflation surprises). More precisely, the sensitivity of three-year-ahead inflation forecasts to short-term forecasts, β, is obtained by estimating the following country-specific regressions over period ω:

$$\Delta\pi_t^{e,3} = \alpha + \beta\Delta\pi_t^{e,1} + \epsilon_t;\ t \in \omega \qquad (9)$$

in which $\Delta\pi_t^{e,1}$ and $\Delta\pi_t^{e,3}$ denote the change in mean inflation forecasts for the short term (that is, for the current year) and for three years ahead, respectively, between surveys at $t-1$ and t.

We then repeat our inflation persistence analysis using this alternative anchoring metric. Figure B.2, panel (a), shows that our main result would also hold if we use *Metric #4* as a proxy for anchoring of inflation expectations. Panel (b) shows that the main result also holds when we construct an alternative summary index using all metrics *#1* to *#4*.

Figure B.2: Anchoring Metric #4—Response of Consumer Prices



(a) Metric #4 (b) Index with metrics #1 to #4

Note: The figures show the difference in the cumulative response of consumer prices to a negative terms-of-trade shock of 1 percent when the exchange rate regime is flexible under strongly and weakly anchored expectations (which correspond to the 75^{th} and the 25^{th} percentile, respectively, of the anchoring index in the estimation sample). Shaded areas denote 95 percent confidence intervals computed with country-based cluster-robust standard errors.

While *Metric #4* is a sensible alternative to capture the extent of anchoring and the main results hold, its use in our specific application may raise circularity concerns. Our approach consists of regressing consumer price inflation on terms of trade shocks, while allowing the response to differ depending on the extent of anchoring. In countries where shocks lead to higher inflation persistence, forecasters would be aware of this and tend to adjust their forecasts accordingly (including medium-term forecasts to some extent). Therefore, the transmission of shocks to inflation could, by construction, be found to be stronger in countries classified as weakly anchored according to *Metric #4*. Given this concern, we do not include *Metric #4* in our baseline summary anchoring index.