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Inflation Persistence in Brazil - A Cross Country Comparison

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Abstract

Inflation persistence is sometimes defined as the tendency for price shocks to push the inflation rate away from its steady state—including an inflation target—for a prolonged period**.** Persistence is important because it affects the output costs of lowering inflation back to the target, often described as the "sacrifice ratio". In this paper I use inflation expectations to provide a comparison of inflation persistence in Brazil with a sample of inflation targeting (IT) countries. This approach suggests that inflation persistence increased in Brazil through early 2013, in contrast to many of its IT peers, mainly due to "upward" persistence. The 2013 rate hiking cycle may have contributed to some recent decline in persistence.

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I. INTRODUCTION

Inflation persistence is sometimes defined as the tendency for price shocks to push the inflation rate away from its steady state—including an inflation target—for a prolonged period**.** Persistence is important because it affects the output costs of lowering inflation back to the target, often described as the "sacrifice ratio". Equivalently, the lower is persistence the greater is "policy space," defined as the ability of monetary policy to accommodate temporary price shocks. Countries with high persistence and low policy space may need to adjust macroeconomic policies in a material way to price shocks given that they influence overall inflation and inflation expectations for a sustained period.

This is a reduced form interpretation of persistence and does not provide a structural explanation. Persistence may change due to a number of structural reasons, including: inertia in the underlying "driving process," such as marginal costs or the output gap; the policymaker's reaction function to price or output shocks; and inertia intrinsic to the inflation process itself, including indexation by price-setters. Recent studies, notably Fuhrer (2010), suggest that intrinsic factors may be the most important explanation for large changes in persistence. The likely pivotal role of intrinsic persistence is of particular importance for Brazil given its long history of indexation, particularly before the start of the inflation targeting regime.

Some authors propose that intrinsic inflation persistence may not be structural in the sense of Lucas (1976) and is, in fact, sensitive to the monetary policy regime. Benati (2008) estimates the parameters of a sticky-price DSGE model for euro area countries before and after the introduction of the common currency and for the United Kingdom and Canada before and after the introduction of inflation targeting (henceforth IT). He finds that the structural inflation persistence parameter—the AR(1) term in the Phillips curve—falls significantly during the latter sample periods. In other words, implementation of explicit IT is associated with lower intrinsic persistence. Like Fuhrer (2010), model simulations suggest that even dramatic changes in the monetary policy rule are unable to explain the large changes in persistence observed in the data. This too is an important finding for Brazil, which itself transitioned successfully to full-fledged IT.

In this paper, I compare "backward looking" reduced-form inflation persistence in Brazil with a sample of other IT countries, on the basis of historical inflation data. The key contribution of this paper is to assess how persistence in Brazil and other countries may be changing using a more "forward looking" approach based on inflation expectations. Why is this useful? As I will show, most notably for Brazil, relying on backward looking data can miss inflexion points in persistence. For policymakers that rely on real-time estimates of persistence when calibrating monetary policy, a more forward looking approach can offer a more up-to-date assessment of persistence and the sacrifice ratio.

II. BACKWARD-LOOKING PERSISTENCE

In this section I compare reduced form inflation persistence in Brazil with other IT economies.

A. Data

The sample of countries was guided by Roger (2010) and included the 26 countries that target inflation plus China, the euro area, India, Japan, Russia, Switzerland, and the United States. I included these last countries given their economic and financial importance. The adoption date of IT by these 26 countries varies widely, with the first adoption in 1991 (New Zealand) and the latest in 2007 (Ghana). The sample includes a mix of 12 advanced countries and 21 emerging and low income countries. Five Latin American economies are included in the sample, with the date of IT adoption in parentheses: Brazil (1999), Chile (1999), Colombia (1999), Mexico (2001), and Peru (2002).

The inclusion of a broad sample of IT countries is motivated by the common assumption that inflation expectations are well anchored and, as a result persistence is lower, in a credible IT regime. Empirical evidence of this assertion is provided by, among others: Mishkin and Schmidt-Hebbel (2007) using a panel of IT and non IT countries; Benati (2008) who finds that reduced-form persistence declines substantially following the introduction of IT; and Gürkaynak, Levin, and Swanson, (2010) who assessed the behavior of inflation risk premia embedded in long-term bond yields. If the policy regime is so important, then Brazil should be compared to other countries that share a similar framework.

Inflation is measured as 400 times the quarterly log change in the seasonally adjusted quarterly average headline consumer price index for each country. This provides an approximate annualized rate of inflation in percent. The seasonal adjustment is carried out uniformly on non-seasonally adjusted price indices published by the IMF's *International Financial Statistics* using the U.S. Census Bureau's X12 procedure. The sample period starts in Q1 1990 but in many cases the analysis is performed for a sample that begins in Q1 2000. During the 1999-2002 period, the adoption of IT started to gain momentum with nine of the 21 emerging economies, including all of the Latin American countries in the sample, moving to IT. Focusing on the results since 2000 helps avoid large structural regime breaks, particularly for Brazil. At the same time, changing target levels and the gradual build-up of credibility may still impart long-lasting effects on inflation behavior. Descriptive statistics for the seasonally adjusted data are presented in Table 1.

B. Unit Root Tests

A natural way to assess inflation persistence is to determine whether it is stationary; in other words, whether shocks permanently affect the level of inflation or instead fade over time. The results from unit root tests (the final two columns of Table 1) provide strong evidence that inflation is stationary in almost all of the sample countries over 2000-13, even though inflation targets have changed in some cases since the adoption of IT (which should impart some trend in inflation).

Table 1. Inflation: Summary Statistics, Q1 2000 – Q4 2013

	Annualized seasonally adjusted quarterly change in the log CPI							
	Summary statistics						Unit root tests 1/	
	Mean	Median	Min.	Max.	Std. Dev.	Skew	ADF	PP
New Zealand	2.5	2.5	-0.8	11.1	1.9	1.6	0.0000	0.0000
Canada	2.0	2.0	-4.1	5.2	1.9	-0.7	0.0000	0.0000
United Kingdom	2.3	1.9	-0.4	6.5	1.5	0.7	0.0006	0.0006
Sweden	1.4	1.2	-3.4	5.5	1.7	0.2	0.0008	0.0008
Australia	2.9	2.8	0.0	15.1	2.2	2.9	0.0000	0.0000
Czech Rep	2.5	2.2	-1.1	11.0	2.3	1.0	0.0006	0.0009
Israel	2.0	1.7	-5.3	9.7	2.9	0.0	0.0016	0.0014
Poland	3.1	2.8	-1.5	10.8	2.5	1.0	0.0025	0.0033
Brazil	6.3	5.4	2.2	22.5	3.5	2.7	0.0027	0.0031
Chile	3.1	3.1	-3.2	10.9	2.8	0.3	0.0011	0.0125
Colombia	5.0	5.0	-0.4	10.1	2.3	0.0	0.0496	0.0791
South Africa	5.8	5.2	-3.0	15.1	3.4	0.4	0.0151	0.0089
Thailand	2.6	2.8	-11.7	11.8	3.3	-0.8	0.0001	0.0003
Korea	2.9	2.8	0.1	7.6	1.7	0.5	0.0000	0.0000
Mexico	4.6	4.2	1.4	9.0	1.7	0.7	0.0067	0.0001
Iceland	5.6	4.8	0.0	21.3	4.3	1.5	0.0040	0.0031
Hungary	5.3	4.9	-0.7	14.0	3.0	0.4	0.0052	0.0064
Norway	1.9	1.7	-7.7	10.6	2.6	0.0	0.0000	0.0000
Peru	2.6	2.6	-2.8	7.3	2.2	0.0	0.0021	0.0017
Philippines	4.0	3.8	-13.3	13.0	3.6	-1.5	0.0000	0.0000
Guatemala	6.1	6.4	-4.1	14.8	3.6	-0.1	0.0017	0.0015
Indonesia	7.5	6.0	-0.1	37.3	5.4	3.3	0.0000	0.0000
Romania	11.0	7.3	-1.2	43.8	9.4	1.5	0.0120	0.0790
Turkey	15.6	9.7	2.6	79.3	14.9	2.2	0.1448	0.0365
Serbia	16.6	11.5	1.1	146.8	23.1	3.9	0.1330	0.0127
Ghana	14.8	12.0	3.9	47.5	8.7	1.8	0.0171	0.0112
China	2.3	2.0	-4.2	10.5	2.9	0.6	0.0044	0.0032
India	6.7	5.8	-1.1	19.5	4.0	0.9	0.0018	0.0018

Source: International Financial Statistics; Haver; and author's estimates.
1/ p-value of the null hypothesis that quarterly inflation is a unit root process. A p-value of less than 0.05 implies that the null can be rejected at a 95% level of confidence.

C. First-Order Autocorrelations

A reasonable follow-up to these results is a test of persistence assuming that inflation follows a stationary autoregressive AR(p) process, where p denotes the number of lags. Specifically, to what extent is inflation in the current period determined by inflation in the previous period? Consider an AR(1) process:

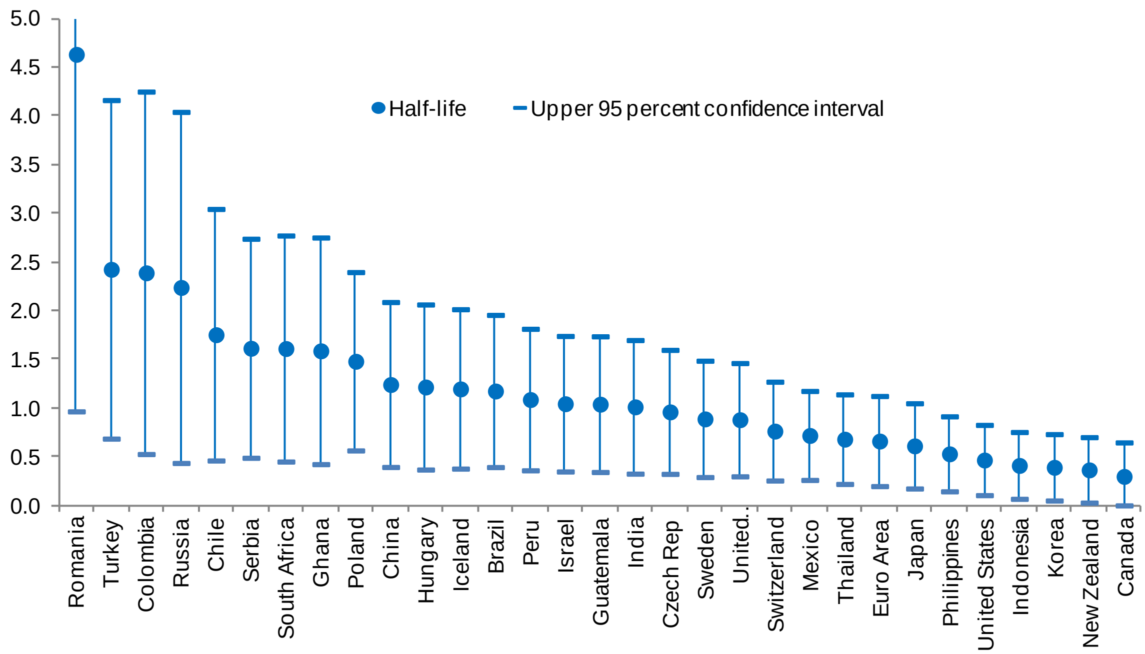
$$\pi_t = k + a\pi_{t-1} + \varepsilon_t \qquad (1)$$

In (1), the measure of persistence is the parameter *a*, where π_t is quarterly inflation in period *t*, *k* is a constant, and ε is an iid shock to inflation. Expressing (1) in moving average form, *a* can be regarded as the persistence of all previous inflation shocks ε.

$$\pi_t = \sum_{i=0}^{\infty} a^i \, \varepsilon_{t-i} \qquad (2)$$

I estimate *a* in (1) with OLS and without correction for bias since there is no evidence that quarterly inflation for the countries in this sample either exhibits a time trend or is a "near-unit root" process in the sense of Andrews and Chen (1994). An interesting way to understand the parameter *a* is by calculating half-lives. This is the estimated time taken for half of a shock to the quarterly inflation rate to fade. Based on an estimate of the regression (1) over 2000 Q1 to 2013 Q2, Figure 1 presents estimated half-lives and 95 percent confidence intervals (with the lower interval bounded at zero). Half lives for shocks to headline inflation range from less than half of one quarter (Canada and New Zealand) to over four quarters (Romania). Latin American countries, including Brazil, are mainly in the upper end of the range but are broadly comparable with their IT peer group.

Figure1. Inflation Shock Half-Lives, Q1 2000 – Q4 2013



Source: Author's estimates.

I find that generalizing the AR(1) model to incorporate more lags, as done for example by Benati (2008) and Capistrán and Ramos-Francia (2009), is unnecessary for most countries. Partial autocorrelations estimate that the impact of changes in inflation two or more quarters earlier are typically insignificant for the current quarter's inflation (not shown); specifically, lags of $p>1$ were statistically significant for only one country for headline inflation out of a total sample size of 33 countries.

D. Rolling Regressions

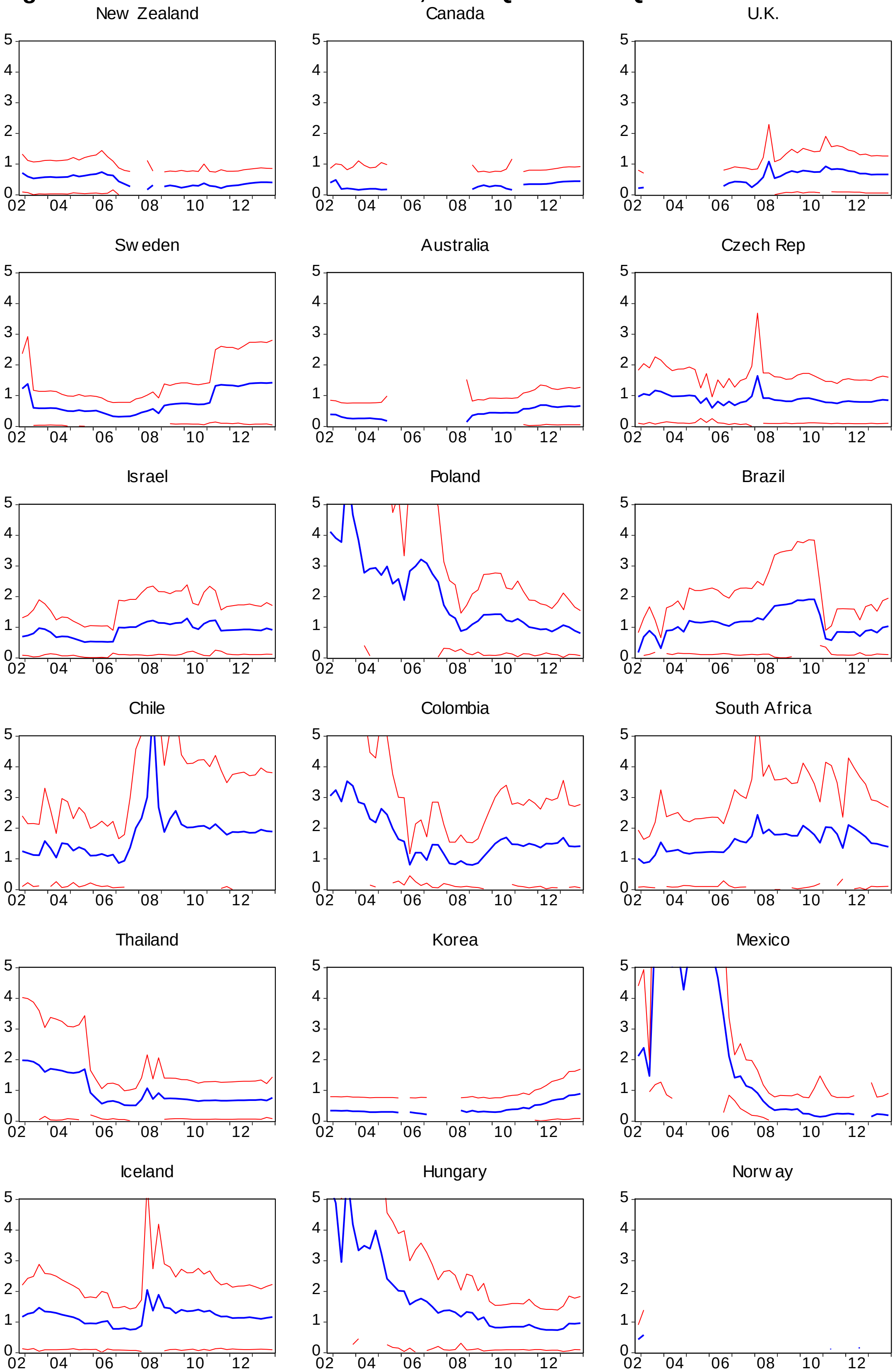
A more serious problem for an assessment of persistence than the number of lags is its time variation. In fact, estimates of persistence can change dramatically based on the sample period used, particularly in Latin America and Brazil. But the shift to lower persistence is unlikely to be discrete and may happen only gradually, as credibility in the new policy regime is accumulated over time.

To account for time variation, I estimate half-lives using the parameter *a* from (1) with shorter rolling samples. Figures 2a and 2b show estimated half-lives from regressions estimated over overlapping rolling 8 year samples of quarterly data. I use this window size as it balances the objectives of adequately assessing time-variation with estimation using sufficiently large sample periods. Specifically, the sample of the first estimation is Q1 1995 through Q4 2002. The second sample then starts and finishes one quarter later, from Q2 1995 through Q1 2003 and so on. The dates on the horizontal axis of the charts in Figure 2 refer to the end date of the estimations. When $a \leq 0$, the half-life is not defined and is represented by breaks in the time series. In some cases, the half-life for large parts of the sample is not defined but these data are shown for completeness (e.g., Norway). When it is not possible to reject the null hypothesis that the parameter *a* (and the half-life) is zero, the lower 95 percent confidence interval for the half-life is not defined and only the upper interval is shown.

The benchmark cases remain Canada and New Zealand with rolling half-lives that are both low and statistically insignificant. More broadly, experiences vary by country but for Latin America, there is no clear evidence (with one exception) that persistence is declining firmly towards the low levels of Canada or New Zealand. In some cases, persistence fell during the early years of IT (e.g., Colombia and Peru). But for most countries in the region persistence since 2008 has remained broadly constant and statistically significant (Chile) or increased (Colombia, Guatemala, and Peru). The one exception is Mexico, where persistence is now statistically insignificant following the large sustained decline that followed the introduction of IT in 2001.

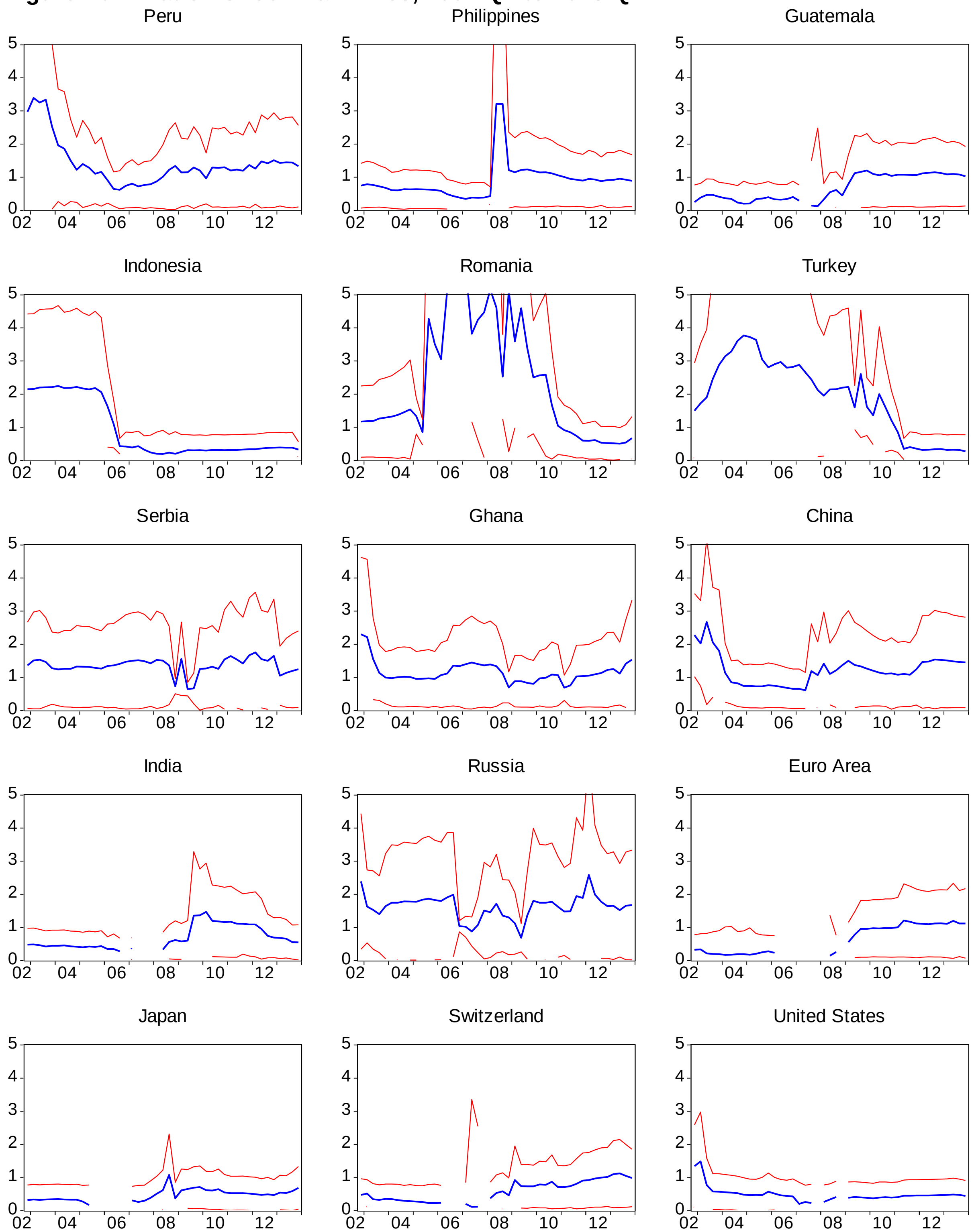
In Brazil, inflation persistence appears to have been rising again following a substantial fall in the half-life from almost 2 quarters in 2010. In fact, this apparent step-decline in persistence is mainly due to the 2002-03 period falling out of the 8-year sample window. Excluding this effect (for example by selecting samples that start in 2004), persistence has been more stable. At the same time, persistence has increased since 2009. I will show that this result, in which current assessments may be strongly influenced by historical outliers and less by more recent development, also highlights an important drawback of the backward-looking autoregressive approach.

Figure 2a. Inflation Shock Half-Lives, 2002-Q1 to 2013-Q4



Source: Author's estimates

Figure 2b. Inflation Shock Half-Lives, 2002-Q1 to 2013-Q4



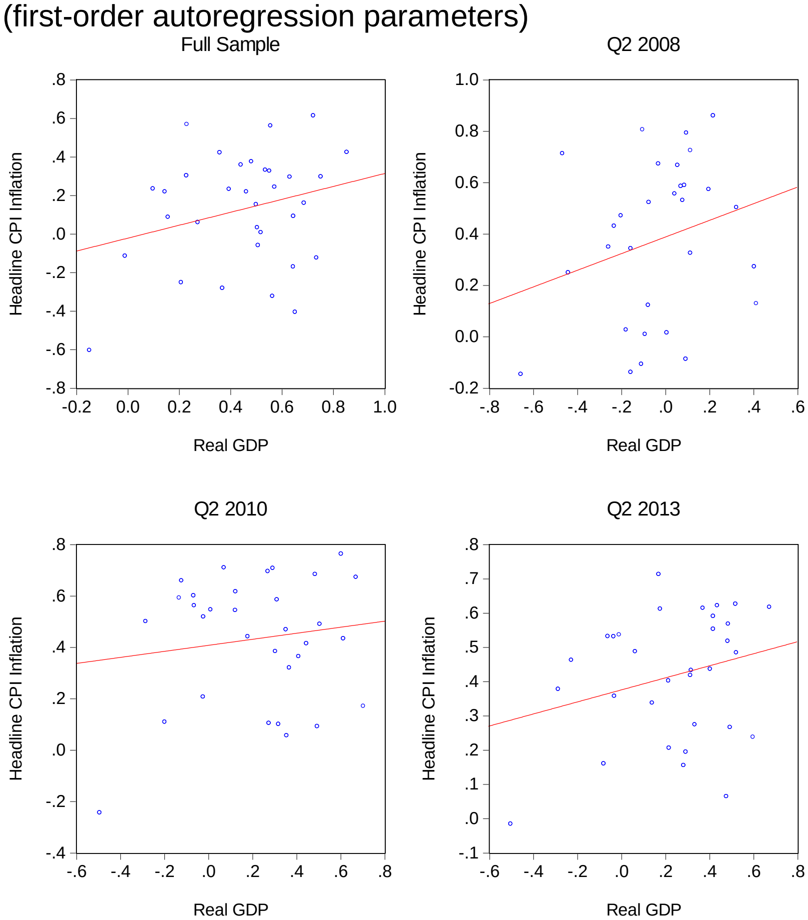
Source: Author's estimates

E. Output Growth as the Driving Process

Can we explain the cross-country variation in inflation persistence by inherited persistence of the driving process? A simple analysis, in which the driving process is assumed to be output growth, suggests not. Ideally, the driving process is measured by marginal costs or the output gap. Given lack of comparable marginal cost data and uncertainties about output gap measurement across countries, I use the quarterly change in log real GDP.

Figure 3 shows scatter plots of the AR(1) coefficients from estimates of (1) for the quarterly change in inflation and GDP for each country. To incorporate possible time variation, these scatter plots were produced for estimates of (1) using the full sample starting in Q1 2000 and also three 32 quarter sub-samples ending in Q2 2008, Q2010, and Q2 2013 (the GDP data are updated with a greater lag than inflation, hence this sample ends two quarters earlier). For all of these sample periods, the linear correlation between the inflation and GDP AR(1) coefficients was only weakly positive and not statistically significant. Structural models that incorporate an Euler equation and a Phillips curve suggest that a weak reduced form relationship might reflect either a modest impact of the driving process (output growth) on inflation or significant idiosyncratic white noise inflation variance.

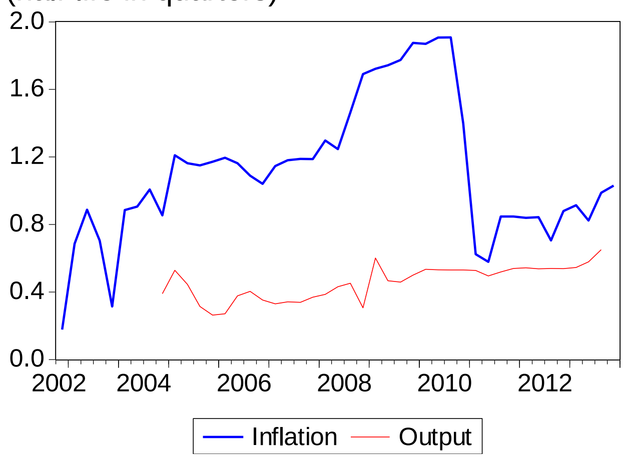
Figure 3. Cross Section of Quarterly Inflation and Real GDP Persistence (first-order autoregression parameters)



Source: Author’s estimates.

For Brazil, the evidence that inflation persistence is mainly inherited from the driving process is somewhat stronger. Figure 4 shows that the rolling estimates of the half-life of quarterly GDP growth has been rising but at a very moderate pace, in contrast to the large rise and subsequent decline in the inflation half-life. This suggests that while inherited persistence may explain some part of the fluctuations in inflation persistence, they may be due more to intrinsic persistence, including indexation, and changes in the monetary policy reaction function.

Figure 4. Brazil: Inflation and Real GDP Half-Lives, Q4-2002 to Q4-2013
(half-life in quarters)



Source: Author's estimates.

III. FORWARD LOOKING PERSISTENCE

Central banks require a good understanding of inflation persistence now and in the future when calibrating policies. Estimates based on historical data are an obvious starting point, but this approach can be slow to pick up changes in persistence as they happen. This is because, by construction, the estimates are telling us what has occurred in the past. Reducing sample size to increase the weight on more recent observations, such as the rolling estimations in section II, is one answer to obtain more time-sensitive estimates but this can leave the results dependent on a small number of outliers.

An alternative approach is to use expectations of inflation. If expectations are "good" forecasters of future inflation, then persistence may be reliably measured by assessing the impact of changes in actual inflation on these expectations. The idea is to identify whether, and by how much, a shock to inflation today leads to a rise in expected inflation for some future period. If surveyed expectations then influence the behavior of price-setters in the economy, then this would provide a more timely indication of how long inflation shocks will persist. Before moving to the first step in this approach—testing the forecasting properties of inflation expectations—I will describe the data to be used in this section.

A. Data

Inflation is measured each month by the annual change in the headline consumer price index for each country over a sample period of January 2000 through January 2014. Inflation expectations are the predictions for this annual rate of inflation 12 months ahead. Expectations are measured by the responses from surveys conducted by central banks, statistical agencies, and in some cases private research firms in IT countries. I include all countries for which a relatively long time series of inflation expectations exists. The actual timing of these surveys each month can vary but where there is an option to choose (e.g., from the weekly Focus survey for Brazil) I select the latest available data point to maximize the probability that the survey reflects all relevant information.

A statistical summary of the data is provided in Table 2 and unit root tests (indicating that almost all series are stationary) are presented in Table 3. For those countries for which the variables are non-stationary, there was strong evidence that the inflation and inflation expectations are cointegrated.

Table 2. Annual Inflation and 12-Month Inflation Expectations: Summary Statistics
(percent unless specified otherwise)

		Headline CPI Inflation				12-Month Expected Inflation			
	Number of observations	Mean	Min.	Max.	Standard deviation	Mean	Min.	Max.	Standard deviation
Brazil	147	6.54	2.96	17.24	2.93	5.36	3.43	12.52	1.45
Chile	104	3.46	-2.29	9.85	2.57	3.21	2.00	6.00	0.67
Colombia	124	4.32	1.75	7.94	1.68	4.21	2.87	6.10	0.87
Mexico	170	4.88	2.91	12.32	1.71	4.53	3.42	11.14	1.52
Peru	143	2.69	-1.08	6.75	1.59	2.60	1.63	4.71	0.58
Czech Republic	170	2.56	-0.42	7.55	1.71	2.92	1.40	5.00	0.83
Israel	170	2.10	-2.74	6.94	2.02	2.29	0.30	4.10	0.64
Poland	170	3.42	0.16	11.64	2.46	3.50	0.20	13.50	2.76
Turkey	109	8.30	3.99	12.06	1.81	6.83	5.42	8.99	0.71
Korea	170	2.95	0.85	5.98	1.04	3.55	2.80	4.60	0.56
Canada	170	2.02	-0.95	4.68	0.97	1.94	0.58	2.70	0.39

Source: Author's calculations.

Table 3. Annual Inflation and 12-Month Inflation Expectations: Unit Roots and Cointegration
(p-values of the null hypotheses of a unit root or no cointegration)

	Unit root tests				Cointegration tests 1/	
	Engle-Granger		Philips-Perron			
	Headline Inflation	Expected Inflation	Headline Inflation	Expected Inflation	Johansen Test	Engle-Granger Test
Brazil	0.045	0.012	0.200	0.071	...	...
Chile	0.023	0.005	0.247	0.098	...	...
Colombia	0.343	0.449	0.422	0.451	0.00	0.31
Mexico	0.002	0.000	0.000	0.000	...	...
Peru	0.036	0.152	0.034	0.044	...	...
Czech Republ	0.289	0.254	0.121	0.233	0.01	0.16
Israel	0.050	0.002	0.046	0.000	...	...
Poland	0.065	0.223	0.129	0.172	0.00	0.17
Turkey	0.082	0.000	0.082	0.006	...	...
Korea	0.106	0.349	0.051	0.180	0.05	0.47
Canada	0.014	0.000	0.008	0.014	...	...

Source: Author's calculations.

B. Inflation Expectations as Forecasters

As a first step, I assess whether inflation expectations provide unbiased and competitive forecasts of actual inflation. To test in-sample bias, I estimate the following regression for each country where both actual and expected inflation are stationary:

$$\pi 12_t - \pi 12_{t-12} = \alpha + \beta(E_{t-12}(\pi 12_t) - \pi 12_{t-12}) + \varepsilon_t \quad (3)$$

The endogenous variable is the actual change in the annual inflation rate over a 12 month period. The exogenous variable is the change in the inflation rate over this same period predicted 12 months previously by the survey. The first two columns of Table 4 present the estimates of the coefficients α and β from (3) over the largest sample available for each country over a maximum sample period of Jan-2000 through Jan-2014. The third column in Table 4 presents the results from a test of the null hypothesis that inflation expectations are in-sample unbiased. This is a joint test of the restrictions in (1) that α=0 and β=1. All of the indicators of significance and hypothesis tests in Table 4 use Newey-West standard errors with a bandwidth appropriate to accommodate the serial correlation introduced by using overlapping observations. The results show that this null hypothesis can be rejected at the 5 percent level in 5 out of 11 cases. In Brazil, bias is due to persistent underestimation (a positive and significant α coefficient). In most other cases, expectations do not make persistent directional errors but they do tend to underestimate the volatility of inflation (a β coefficient greater than one).

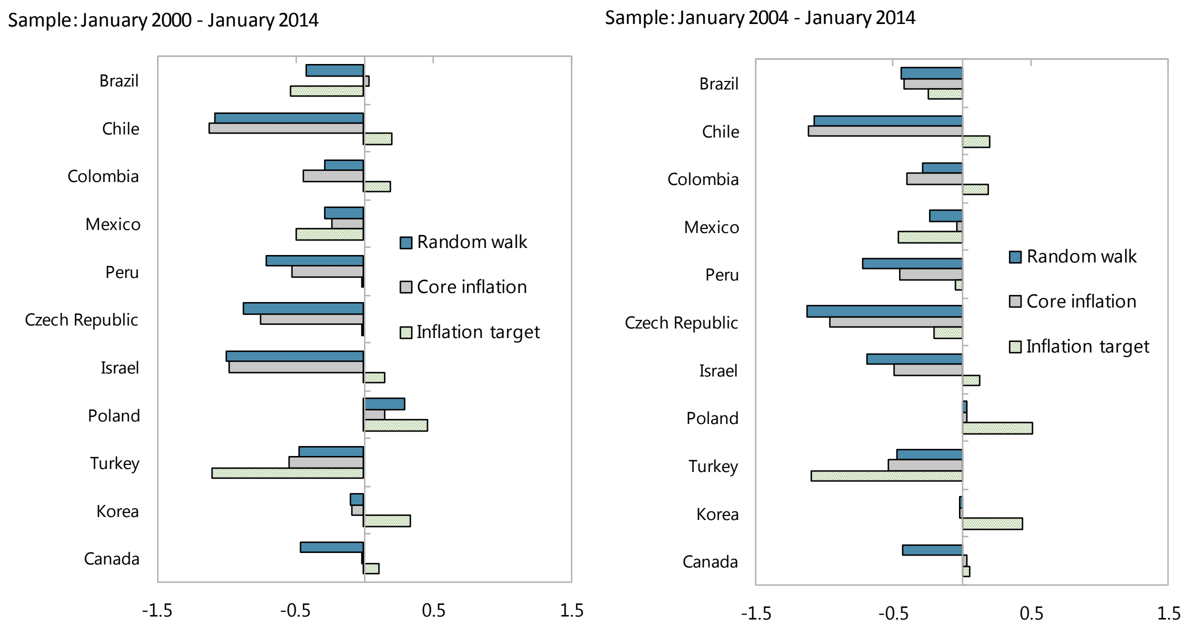
Table 4. Inflation Expectations: In-Sample Tests of Bias, Jan-2000 to Sep-2013

	Constant α	Coefficient β	Wald test
Brazil	1.14 **	1.00 ***	0.0604
Chile	0.35	1.32 ***	0.4690
Colombia	-0.18	0.92 **	0.7990
Mexico	-0.06	1.08 ***	0.8412
Peru	0.31	1.58 ***	0.0369
Czech Republic	-0.65 *	1.38 ***	0.0003
Israel	-0.17	1.18 ***	0.7600
Poland	-0.58	-0.87 *	0.0001
Turkey	0.81	1.71 ***	0.0000
Korea	-0.59 *	0.93 ***	0.1313
Canada	0.13	1.68 ***	0.0019

Source: Author's estimates.

In-sample tests of efficiency and bias can tell us whether expectations may be useful for forecasting, but they do not evaluate their forecast accuracy (and hence their use as indicators of future inflation persistence). As Granger and Newbold (1977) argue, the distributional properties of forecasting variables and actual values are almost always different; as a result, a direct comparison of the two is of limited use. The real test of the utility of expectations is their out-of-sample forecasting properties. Figure 5 compares the performance of survey expectations against a random walk, core inflation, and the inflation target. The figures represent the difference between the root mean squared error (RMSE) for expected inflation and each of the naive forecasts. In most cases, RMSEs for inflation expectations are substantially lower (indicated by negative values in Figure 5). Forecasting performance was compared over the whole sample and also for a sample starting in January 2004 to remove the effect of very high inflation volatility from the results for Brazil.

Figure 5. Inflation Expectations Forecast performance Root Mean Squared Error (compared to naive forecasts, percentage points)



Source: Author's estimates.

From this I conclude that while inflation expectations exhibit some shortcomings as a forecasting tool, they are still hard to beat out-of-sample, at least using naive methods including core inflation.

C. Forward-Looking Persistence Using Expectations

On this basis, I use expectations to provide a more forward-looking assessment of inflation persistence. Specifically, I assume that inflation exhibits more (less) persistence the greater (lesser) is the effect of a change in actual inflation on expected inflation at some future date. The specification for the estimations is:

$$\Delta E_t(\pi 12_{t+12}) = \gamma_0 + \gamma_1 \Delta\pi 12_{t-1} + \beta \Delta E_{t-1}(\pi 12_{t+11}) + \varepsilon_t$$

Where:

$$\Delta E_t(\pi 12_{t+12}) = E_t(\pi 12_{t+12}) - E_{t-1}(\pi 12_{t+11}) \quad (4)$$

$$\Delta\pi 12_{t-1} = \pi 12_{t-1} - \pi 12_{t-2}$$

The endogenous variable is the change in expected annual inflation at a rolling 12-month horizon in the current month compared to the previous month. The first exogenous variable is the change in the actual annual inflation rate lagged by one month. I have lagged this variable for two reasons: it ensures that expectations have the time necessary to incorporate fully any relevant information from actual inflation which is often reported with a short lag; and it avoids issues of endogeneity as changes in expectations can affect price-setting behavior. The coefficient γ_1 measures persistence. The second exogenous variable is change in expected annual inflation lagged by one month to capture slow-moving changes in expectations, including due to herd behavior among analysts.

I estimate an alternative specification to admit the possibility that inflation shocks of different signs exhibit varying persistence. For example, a rise in actual inflation may have a larger effect than a fall on expected inflation. This asymmetry might result from the market's perception that monetary and other policies may respond differently to falling inflation than to rising inflation based on an understanding of the policymaker's loss function. This specification is given by

$$\Delta E_t(\pi 12_{t+12}) = \gamma_0 + \gamma_1 d_1 \Delta\pi 12_{t-1} + \gamma_2 d_2 \Delta\pi 12_{t-1} + \beta \Delta E_{t-1}(\pi 12_{t+11}) + \varepsilon_t \quad (5)$$

This specification is identical to (4) with the following difference: the dummy variables d_1 and d_2 take on the values 1 and 0 when the lagged change in actual inflation is positive and negative, respectively. I then interpret γ_1 and γ_2 as measures of upward and downward inflation persistence, respectively.

I estimate equations (4) and (5) using OLS and Newey-West standard errors for all 11 countries using all of the available data. The first column of Table 6 shows the estimate of forward-looking persistence using the symmetric specification—i.e., coefficient γ_1 from (4). The second and third columns show the estimates of persistence from the asymmetric specification—i.e., coefficients γ_1 and γ_2 from (5).

The results show that forward-looking persistence is still quite high and statistically significant, particularly among emerging market countries. For example, on average over the sample period in Poland over ⅓ of any given percentage point change in actual inflation is passed on to expected inflation 12 months ahead. Persistence is lower among the advanced economies. A second result is that in Brazil and other Latin American countries, upward persistence is larger and more often statistically significant that downward persistence. In particular, a rise in inflation passes through to expectations. In contrast the pass through from a decline in inflation to expectations is either smaller or insignificant. This asymmetry is particularly striking in Brazil.

Table 6. Effects of Actual Inflation on Expected Inflation, Jan-2000 to Jan-2014

	Coefficient on Lagged Inflation Change	Coefficients on Lagged Inflation		Sample size
		Increases	Decreases	
Brazil	0.11 *	0.18 *	0.06	146
Chile	0.14 ***	0.16 ***	0.12 **	103
Colombia	0.19 ***	0.24 ***	0.16 ***	123
Mexico	0.09 ***	0.13 **	0.05	168
Peru	0.16 ***	0.17 ***	0.16 ***	142
Czech Republic	0.11 ***	0.11 *	0.10 **	168
Israel	0.02	0.02	0.03	168
Poland	0.36 ***	0.35 ***	0.36 ***	168
Turkey	0.13 ***	0.14 ***	0.12 ***	109
Korea	0.12 ***	0.17 ***	0.09 **	143
Canada	0.05 **	0.05 *	0.04	168

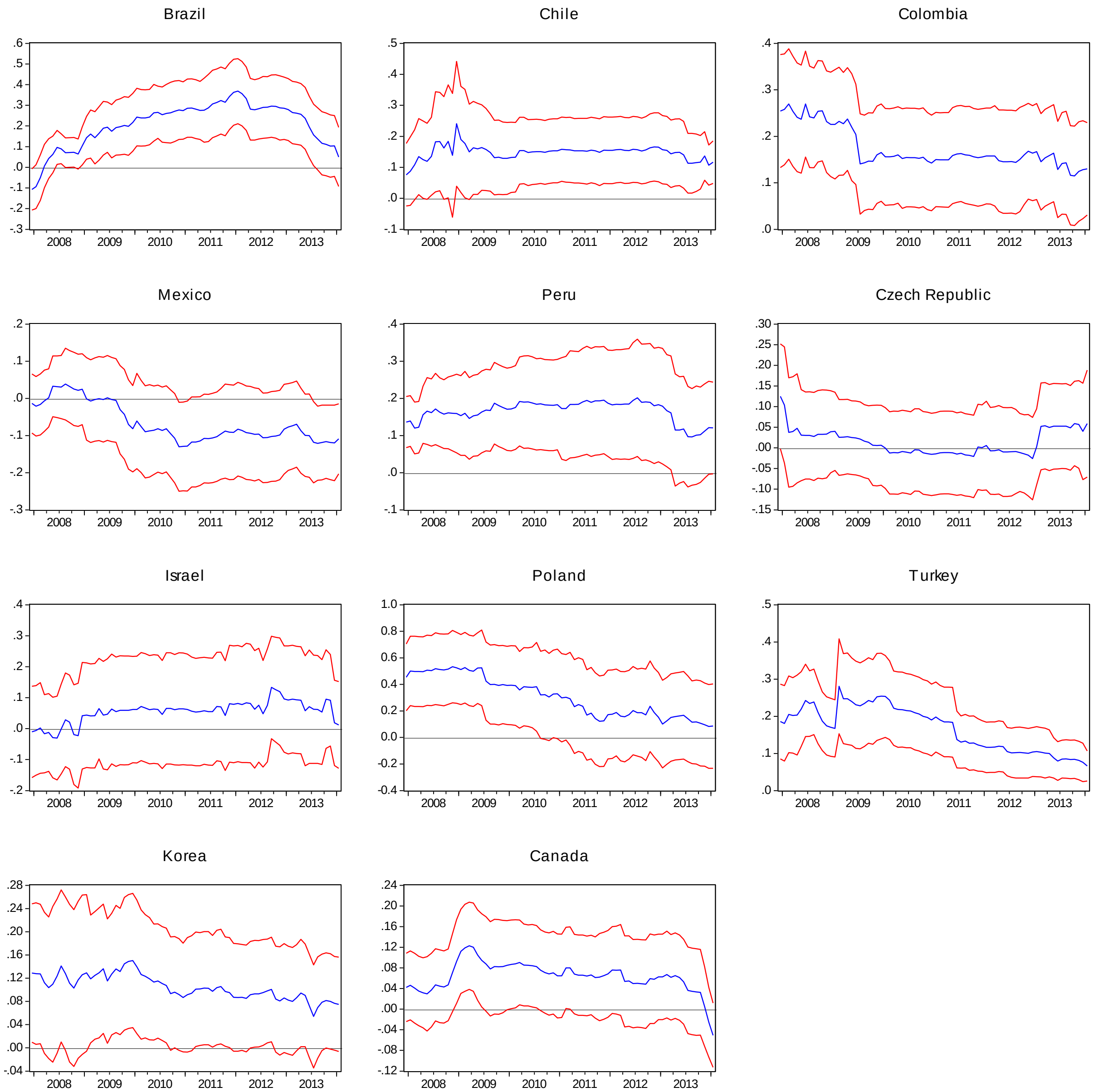
Source: Authors' estimates.

For Brazil, evidence of asymmetry is important for understanding how inflation expectations are formed and actual inflation persists. One interpretation is that the historical legacy of high and persistent inflation appears to have endured through the first 10-15 years of inflation targeting. Institutionalized indexation and other remnants of a high inflation past may take time to dismantle. This underscores the difficult task policymakers have had in building inflation credibility but, as credibility is gained, holds out the reward of less persistent inflation in the future. A second possible interpretation is that markets correctly perceive some asymmetry in policymakers' reaction function, with more willingness to tackle falling inflation (and associated declines in output growth) and greater tolerance of rising inflation (and higher output).

A simple reduced form model cannot provide conclusive answers as to which interpretation is correct but an enhanced empirical approach can shed some light on the mystery. Consider estimates based on rolling samples. If forward-looking persistence (particularly upward persistence) is declining over time, then this would be more consistent with the first, more benign, interpretation of the results in Table 6. In contrast, if upward persistence were stable or even rising, then this would be more consistent with the second interpretation related to asymmetries of policy reaction functions.

Figure 6 presents estimates of upward inflation persistence—coefficient γ_1 from (5)—for rolling 60-month samples using all available data for each country. The estimates shown for some countries include those from windows with less than 60 observations which explain some of the instability in the coefficient estimates early in the sample. In most countries the clear falling trend in persistence and emerging lack of statistical significance lends weight to the interpretation that policymakers are gaining credibility over time (e.g., Czech Republic, Poland, and Mexico). One notable exception is Brazil, for which persistence increased and became statistically significant between 2003 and early 2013, in contrast to the backward-looking estimates that suggested the opposite occurred over the same period.

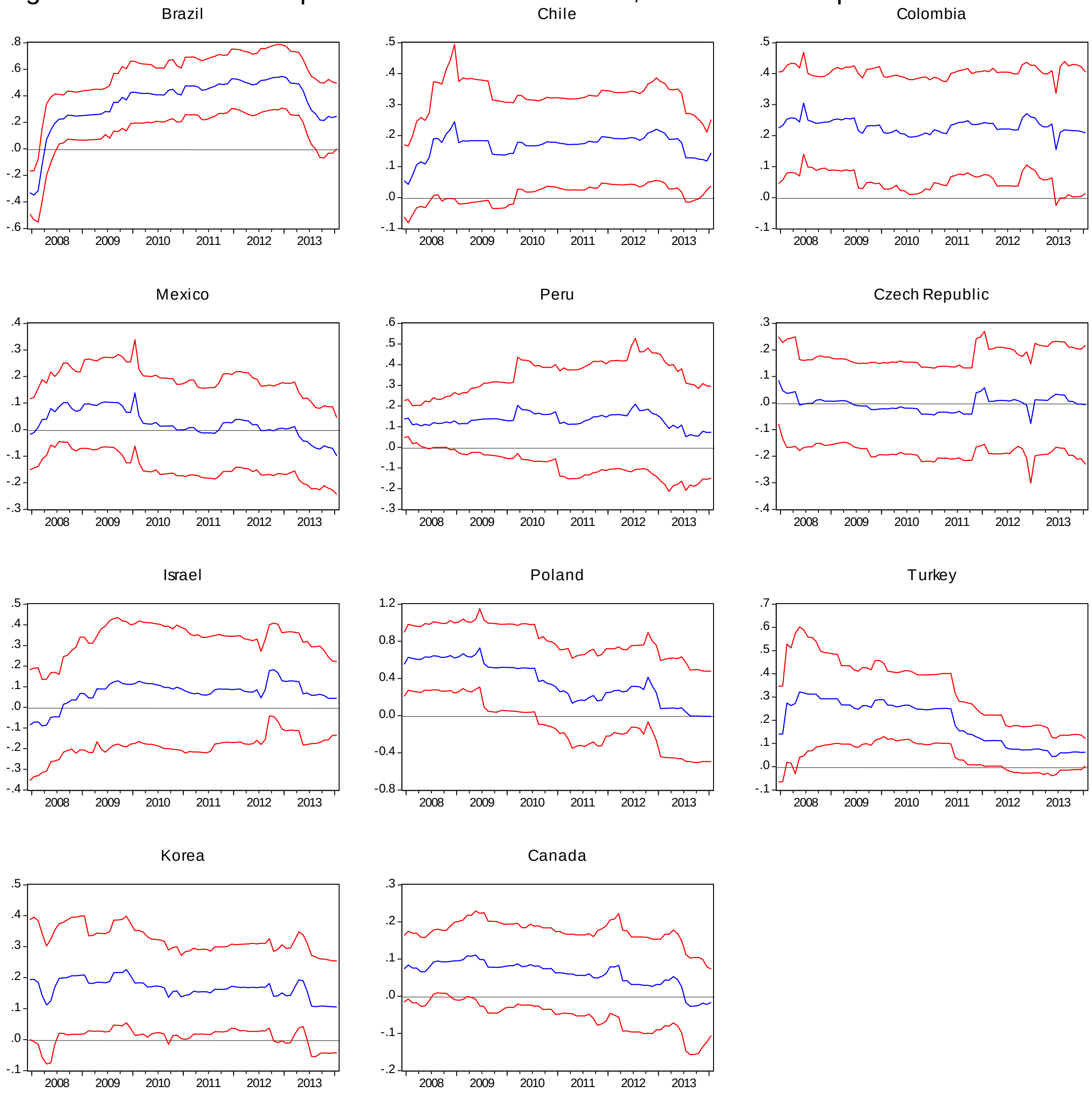
Figure 6. Estimates of Forward-Looking Inflation Persistence, Jan-2005 to Jan-2014



Source: Author's estimates.

For most countries, changes in upward persistent explain most of the variation on overall persistence. This is especially true for Brazil as shown in Figure 7.

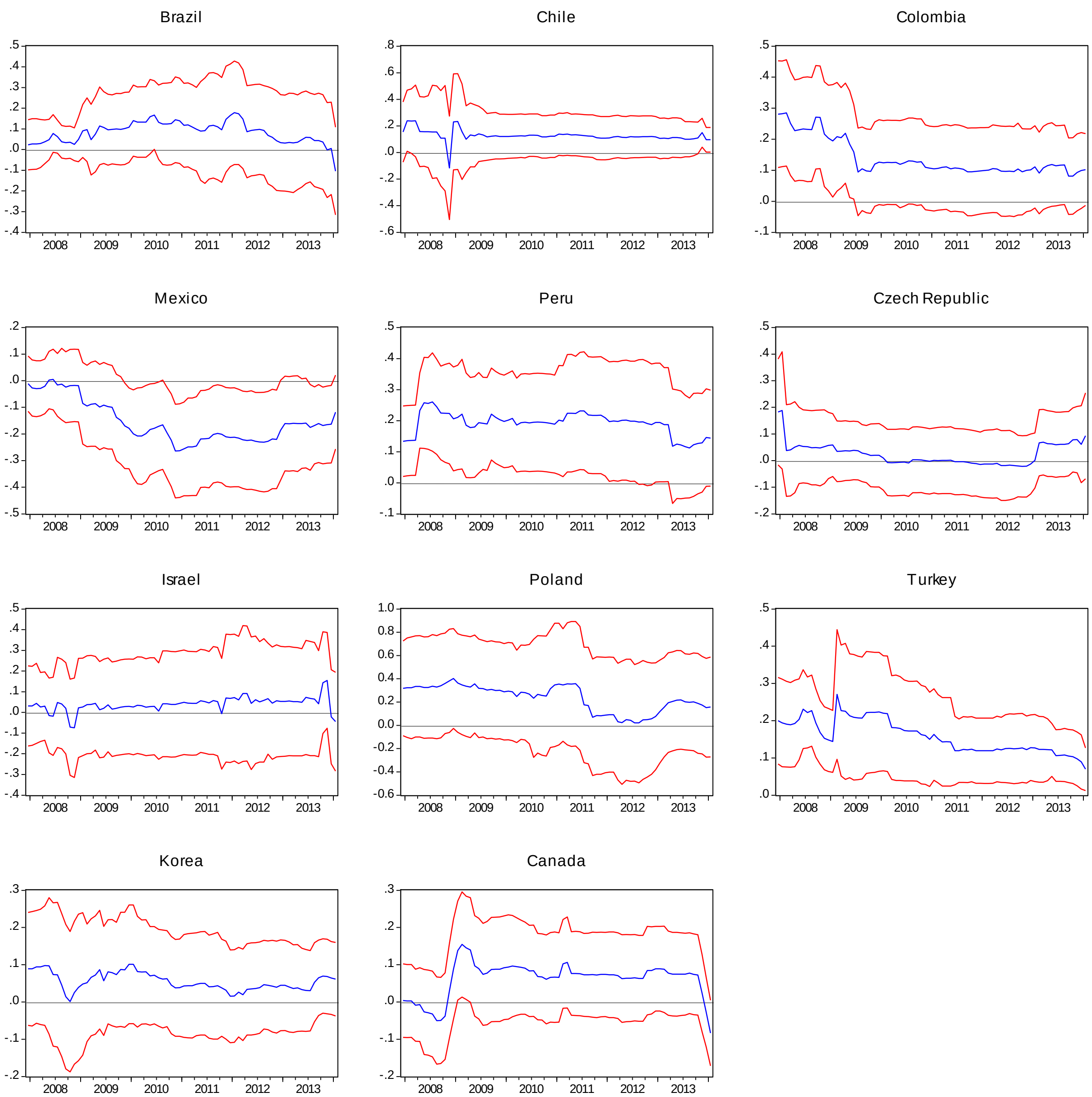
Figure 7. Estimates of Upward Inflation Persistence, Jan-2005 to Sep-2013



Source: Author’s estimates.

The picture from downward persistence, shown in Figure 8, is very different. In almost all cases, including Brazil, downward persistence does not exhibit any clear trend and is not statistically significant. This strongly suggests that inflation persistence is typically asymmetric and biased to the upside and this is where the hard-won gains in credibility from inflation targeting come from.

Figure 8. Estimates of Forward-Looking Downward Inflation Persistence



Source: Author's estimates.

IV. Conclusion

Assessing inflation persistence using historical data may provide misleading conclusions. Brazil's inflation persistence, as measured using historical data and reduced-form autoregression models, appeared to decline suddenly in 2010 and sit within the range found among its inflation targeting peers. This suggests that inflation targeting has helped the country overcome is history of indexation by building credibility in the notion that inflation will remain anchored at the target and that temporary inflation shocks will quickly dissipate. But looking at historical data is, of course by definition, backward looking and may not reflect important changes at the margin. Indeed, there has been some pick-up in Brazil’s inflation persistence, notably upward persistence, when it is measured by the impact of changes on actual inflation on forward-looking expectations. The utility of this method relies on an assumption that inflation expectations provide reasonably effective out-of-sample forecasts and, for most countries, this is true. By using expectations, I can provide a more up-to-date estimate of inflation since the sample period effectively extends into the future.

Rising upward inflation persistence in Brazil between 2002 and early 2013 could signal that market participants believed that policymakers had become less responsive to rising, rather than falling, inflation. For example, if the economy experienced a positive inflation shock resulting from a transitory supply disturbance, there could be a perception that monetary policy would not respond as forcefully to minimize the second-round effects on underlying inflation. This would clearly be evident in a large effect of current inflation surprises on estimates of future inflation. An alternative explanation could be that intrinsic persistence is rising due, for example, to more prevalent indexation. The reduced-form empirical strategy I use in this paper cannot conclusively identify which is the correct explanation.

What I can conclude is that this increase in upward inflation persistence in Brazil was in contrast to many other IT countries, including other emerging markets. In many of these other countries, persistence had tended to gradually decline, consistent with a gradual buildup of policy credibility and increasingly well-anchored inflation expectations. Although upward persistence showed some early signs of falling during the central bank’s rate hiking cycle in 2013, this trend has paused and Brazil’s statistically significant inflation persistence continues to stand in sharp contrast to the low persistence benchmark economies such as Canada and New Zealand.

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