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Inflation-Targeting and Inflation Volatility: International Evidence from the Cosine-Squared Cepstrum

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Abstract

Existing empirical evidence on the effect of inflation-targeting on inflation volatility is, at best, mixed. However, comparing inflation volatility across alternative monetary policy regimes, i.e., pre- and post-inflation-targeting, begs the question. The question is not whether the volatility of inflation has changed, but instead whether the volatility is different than it otherwise would have been. Given this, our paper uses the *cosine-squared cepstrum* to provide overwhelming international evidence that inflation targeting has indeed reduced inflation volatility in 22 out of the 24 countries considered in our sample of established inflation-targeters, than it would have been the case if the central banks in these countries did not decide to set a target for inflation.

JEL Codes: C22, C65, E42, E52, E64
Keywords: Cosine-Squared Cepstrum, Inflation-Targeting, Inflation Volatility

1. Introduction

Existing empirical evidence on the direct link of inflation targeting and inflation volatility, is at best mixed (see for example, Fang et al., (2010), Abo-Zaid and Tuzemen (2012), Gupta and Uwilingiye (2012), Ardakani et al., (2018), Agénor and Pereira da Silva (2019) for detailed literature reviews). In general, studies analyzing the macroeconomic performance of inflation targeting relies on comparisons between inflation-targeting and non-targeting countries (using panel data models of treatment effects), or are based on within country (time-series) comparisons across the pre- and post-inflation targeting eras. While the former set of analyses are subject to omitted variables or selection bias, the latter group of papers can be considered to be only providing preliminary evidence on the success or failure of inflation targeting. The obvious reason for this is that, when analyzing the effect of inflation targeting on the volatility of inflation (or any other measure of macroeconomic performance), the apt question to ask is whether the volatility of the inflation rate is higher than *it would have been* had central bank not moved to an inflation-targeting regime, and not necessarily whether the inflation volatility has increased or decreased post-inflation targeting. To address this issue, we use the *cosine-squared cepstrum*, and apply the technique to analyze the Consumer Price Index (CPI) inflation volatility of 24 relatively well-established inflation targeters, in terms of the adoption dates of inflation-targeting.

The intuition behind the *cosine-squared cepstrum* is that, if the move into inflation targeting by a specific country's central bank affected inflation volatility, then observed inflation can be

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depicted as the sum of two series: (i) the series that would have eventuated if the policy authority continued to pursue its earlier approach to monetary policy decisions; and (ii) a second series associated with the direct impact of the regime change that arrived in the wake of the decision to target inflation. If the second series is found to be positively correlated (in-phase) with the series that would have eventuated, then one can conclude that the volatility of inflation has increased. But if the second series is negatively correlated (out-of-phase), then volatility can be considered to have gone down, since fluctuations have dampened in the series that would have eventuated. Note that, the cosine-squared cepstrum behaves like an autocovariance function, but with sharper resolution that helps in identifying the arrival and phase relationship of the secondary series with great precision. This is because a local extremum appears as an impulse, and its direction determines whether the secondary series have increased or reduced (inflation) volatility.

To the best of our knowledge, this is the first paper to apply the cosine-squared cepstrum technique to analyse the impact of inflation targeting on the volatility of as many as 24 developed and developing inflation targeting countries. In fact, the application of this technique is limited to only three studies in mainstream economics namely, Cunningham and Vilasuso (1994), Gupta and Uwilingiye (2012), and Gupta (2013). While the first study looked into the role of the collapse of the Bretton Woods on the volatility of output growth of the United States, the latter two studies concentrated on the impact of inflation targeting and adoption of a flexible exchange rate regime respectively, on inflation volatility of South Africa. Our paper can thus be considered to be an extension of the work of Gupta and Uwilingiye (2012) to multiple inflation targeters, including South Africa. Note that, Gupta and Uwilingiye (2012) found that inflation targeting has resulted in heightened inflation volatility. The remainder of the paper is organized as follows: In Section 2 we provide a brief outline of the methodology, with Section 3 discussing the data and results, and finally, Section 4 concludes the paper.

2. Methodology

The power cepstrum of a signal $x(t)$ was introduced by Bogert et al. (1963) as the power spectrum of the logarithm of the power spectrum of the signal. Power cepstrum is usually calculated by:

$$c(t) = |\mathcal{F}^{-1}\{log|\mathcal{F}\{x(t)\}|^2\}|^2, \tag{1}$$

where $\mathcal{F}(\cdot)$ and $\mathcal{F}^{-1}(\cdot)$ are Fourier transform and inverse Fourier transform, respectively.

To explain the power cepstrum analysis, let us examine a simple example of a composite signal which can be presented as a sum of a basic wavelet and a single echo:

$$x(t) = s(t) + \alpha s(t - t_0), \tag{2}$$

where α is the amplitude of the echo and t_0 denotes the echo arrival time. The power spectrum of such a signal is given by:

$$|X(\omega)|^2 = |S(\omega)|^2[1 + \alpha^2 + 2\alpha \cos \omega t_0]. \tag{3}$$

The logarithm of the power spectrum is:

$$\log\big(X(\omega)\big) = log\big(S(\omega)\big) + log(1 + \alpha^2 + 2\alpha \cos \omega t_0). \tag{4}$$

To calculate the power cepstrum we expand the second part of (4) in a series and then take the power spectrum of the resulting expression. Kemerait and Childers (1972) show that the peaks in the power cepstrum occur at the echo arrival time and integer multiples thereof. Moreover, the authors show that power cepstrum yields the best indication of echo arrival times even in the presence of noise. Specifically, the authors show that when noise is present, smoothing improves the detection of peaks in the power cepstrum.

Cunningham and Vilasuso (1994) introduce the cosine-power cepstrum calculated by:

$$\tilde{c}(t) = c(t) \times sgn\{Re[\mathcal{F}^{-1}\{log|\mathcal{F}\{x(t)\}|^2\}]\}. \quad (5)$$

The addition of the signum function allows the cepstrum to determine not only the echo arrival time, but also its polarity relative to the original series.

To calculate the power cepstrum and recover the echo arrival times we follow the algorithm suggested by Kemerait and Childers (1972) and Cunningham and Vilasuso (1994). The steps followed by the algorithm are, (a) demean the discrete time series to avoid the dominance of the zero component frequency component in the power spectrum, (b) calculate the power spectrum find its logarithm, (c) perform moving average smoothing, (d) calculate the cosine-power cepstrum according to (5).

3. Data and Results

Our data set involves the Consumer Price Index (CPI)-based (quarter-on-quarter) inflation rate for 23 countries namely, Australia, Brazil, Canada, Chile, Colombia, Czech Republic, Guatemala, Hungary, Iceland, Indonesia, Israel, Mexico, New Zealand, Norway, Peru, Philippines, Poland, Romania, South Africa, South Korea, Sweden, Thailand, Turkey, and the United Kingdom (UK). The data was sourced from the International Monetary Fund's (IMF's) International Financial Statistics (IFS) database, and covers the quarterly period of 1976Q2 to 2016Q4 for majority (19) of the countries, with the start and end dates being purely driven by the availability of data. Further details about the inflation-targeting adoption date and the data coverage of each of these 24 countries have been provided in Table A1 in the Appendix A of the paper, while Figure A1 plots the inflation rates. Since the cosine-squared cepstrum approach requires stationarity of data, estimates of the long-memory parameter have been reported in Table A2, which in turn is a much general approach to checking whether a series is random walk or not, rather than standard tests of unit roots, and have been extensively used in the inflation-targeting literature to analyze change in inflation persistence across monetary policy regimes (Canarella and Miller, 2017). Looking at alternative versions of the autoregressive fractionally integrated moving average (ARFIMA) model characterized by no deterministic terms, a constant, a constant and a linear time trend, along with uncorrelated white noise, ARMA and seasonal AR(1) error structures (i.e., Models 1, 2 and 3 respectively), we find that all our inflation rates are indeed mean-reverting under at least one type of specification. Note that the choice of these inflation-targeting countries is primarily motivated by the fact that these countries in general have been targeting inflation for a prolonged period of time now, as can be seen from Table A1.

In Figure 1, we present the first 25 cepstral estimates with the inflation targeting date at the centre, i.e., the 13th observation.[1] As can be seen, barring the case of Chile, Indonesia, Israel, Philippines, New Zealand, Norway and Turkey, the cepstral estimate is negative on the inflation targeting date for all other countries, which in turn suggests that adoption of inflation targeting did in fact reduced inflation volatility for these economies. Now for the remaining seven countries, if we look at the results more closely, then we find that for Chile, New Zealand, Norway, and Turkey, the volatility is reduced after two-quarters, two-quarters, four-quarters, and one-quarter respectively, i.e., a delayed effect is observed as discussed in Fang and Miller (2011). Interestingly, Indonesia shows a reduction in volatility the quarter before its inflation targeting date, which is possible, given that the decision to target inflation are often pre-announced, and is common knowledge to market participants before the actual adoption date.

[1] The cepstrum was computed using the Signal Processing Toolbox in MATLAB.

However, Israel and Philippines provides unambiguous evidence of an increase in inflation volatility due to inflation-targeting. In sum, we do find overwhelming evidence (for as many as 22 countries) in our sample that inflation targeting has indeed reduced inflation volatility, than it would have been the case if the central banks in these countries did not decide to set a target for inflation.

[INSERT FIGURE 1 HERE]

At this stage, it must be clarified that unlike us, Gupta and Uwilingiye (2012) had observed an increase in inflation volatility for South Africa due to its adoption of inflation-targeting. We can confirm, details of which are available upon request, that the difference in their findings with that of us is due to Gupta and Uwilingiye (2012) using a first-differenced series of the inflation rate, to ensure stationarity, than the level of the inflation rate (which in our case is indeed stationary as shown in Table A2). Clearly, using a general approach to detecting mean-reversion based on the ARFIMA model ensures that we do not over-difference the data and obtain possibly incorrect inferences.

As a robustness check, and following the extant literature, we also carried out an analysis based on the propensity score matching (treatment effect) approach (Rosenbaum and Rubin, 1983), complete details of which is available in Table A3 of the Appendix. As can be seen from Table A3, the alternative methodology also confirms that inflation targeting has indeed reduced inflation volatility for both developed and developing countries.[2]

4. Conclusion

The effect of inflation-targeting on the volatility of inflation still remains an open question. Against this backdrop, we use the cosine-squared cepstrum to ask whether the volatility is different than it would otherwise be, had the monetary authority of a specific country not decided to target inflation. Using a sample of 24 well-established developed and developing inflation-targeters, we find overwhelming evidence for 22 countries that inflation has been less volatile on or around the inflation targeting dates than it would have been had monetary authorities continued to set interest rates based on whatever their other primary goals were prior to targeting inflation.

It must be emphasized that the cosine-squared cepstrum is not free of limitations. Firstly, the decreased inflation volatility under the inflation-targeting regime may not be permanent, but rather a pulse-like response in the inflation rate, and; secondly, without the recovery of the secondary series, the cepstrum is limited to studies in which the response to a possible event can be isolated in time, i.e., it takes additional economic insight to isolate the possible economic causes of the event. Nevertheless, the strong findings of reduced inflation volatility following inflation-targeting in majority of the economies considered cannot be overlooked.

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[2] The treatment effect analysis is based on annual data over the period of 1985 to 2013, with inflation volatility measured as the standard deviation of the three-year moving average of the annual inflation rate. The inflation-targeting countries in this case were the same 24 countries used in the cepstrum-analysis plus 5 additional economies (Albania, Armenia, Ghana, Serbia and Uruguay), for which we could not secure quarterly data or could not pin down the exact quarter of the adoption date. Note that, the control groups included Austria, Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Japan, The Netherlands, Portugal, the United States (US) for developed countries, and; Algeria, Bulgaria, China, Costa Rica, Croatia, Dominican Republic, Egypt, Estonia, Hong Kong, Iran, Jamaica, Jordan, Kazakhstan, Kenya, Latvia, Lithuania, Macao, Malaysia, Mauritius, Morocco, North Macedonia, Russia, Saudi Arabia, Singapore, Slovakia, Slovenia, Trinidad and Tobago, Tunisia for developing countries.

As part of future research, it would be interesting to extend our analysis to study the impact of inflation-targeting on volatility of other macroeconomic aggregates such as, output growth, interest rates and exchange rates.

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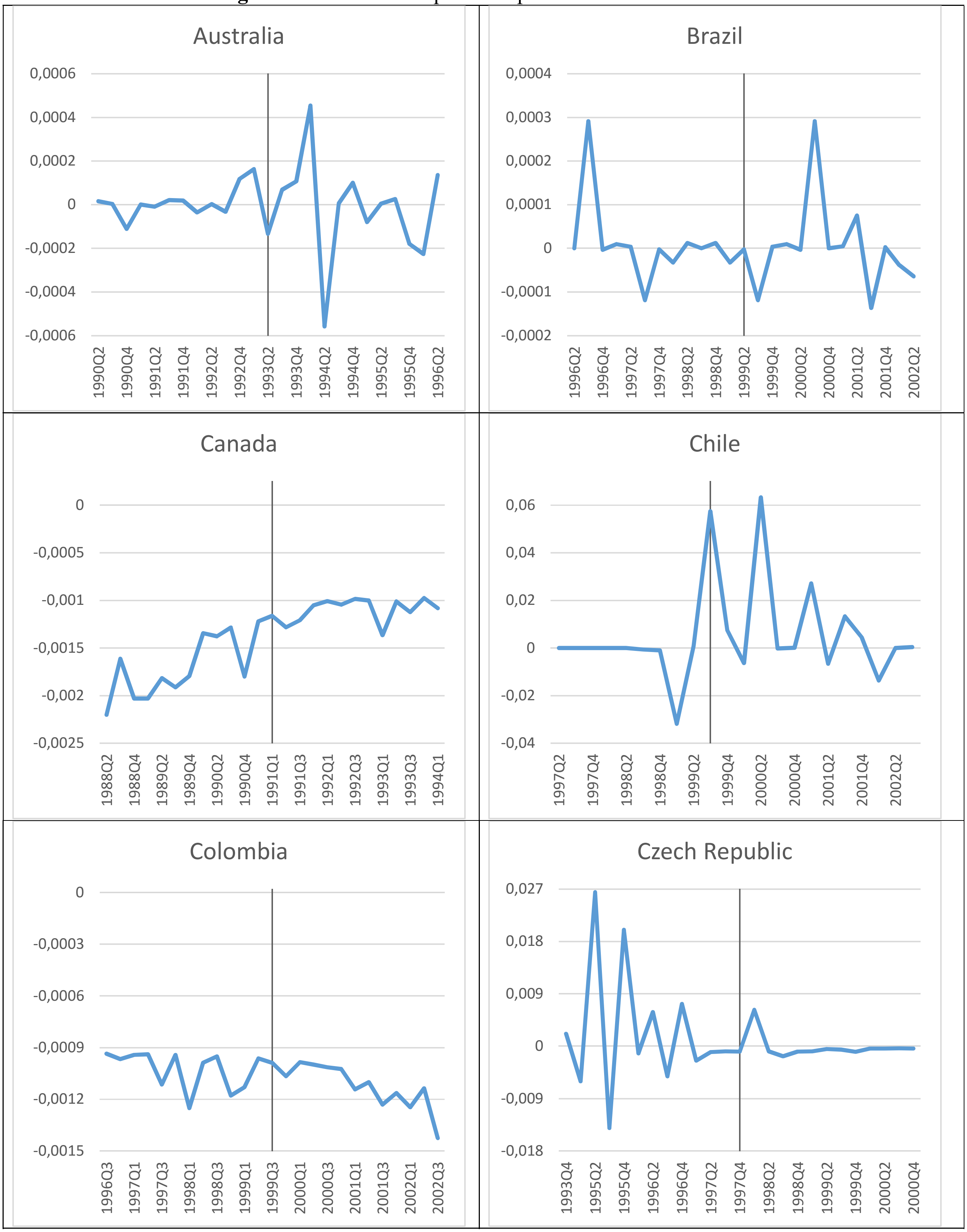
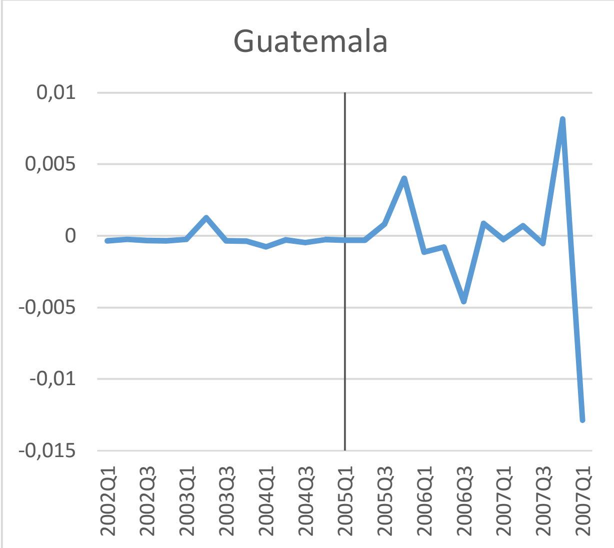
Figure 1. The Cosine-Squared Cepstrum for Inflation Rates

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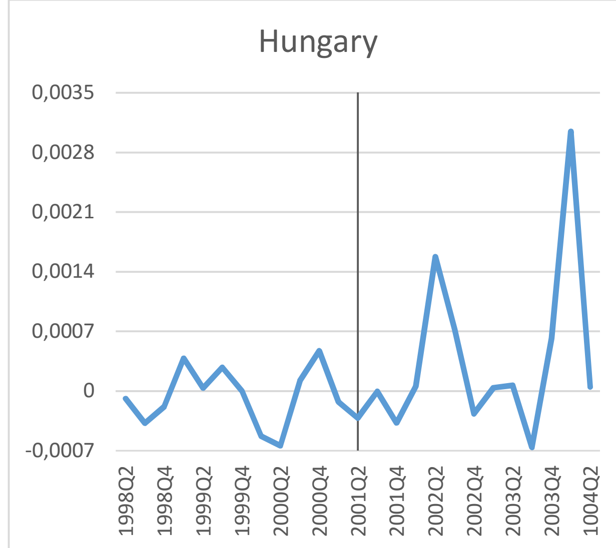
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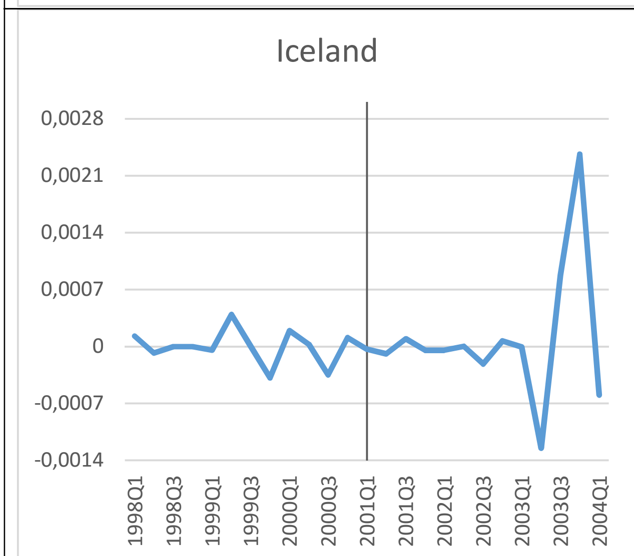
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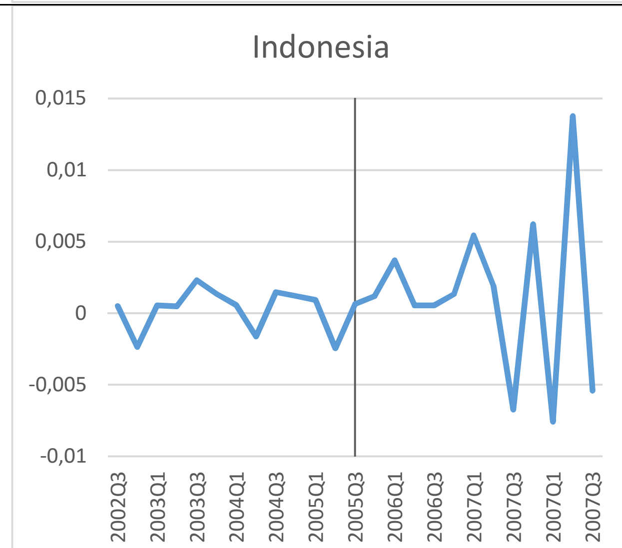
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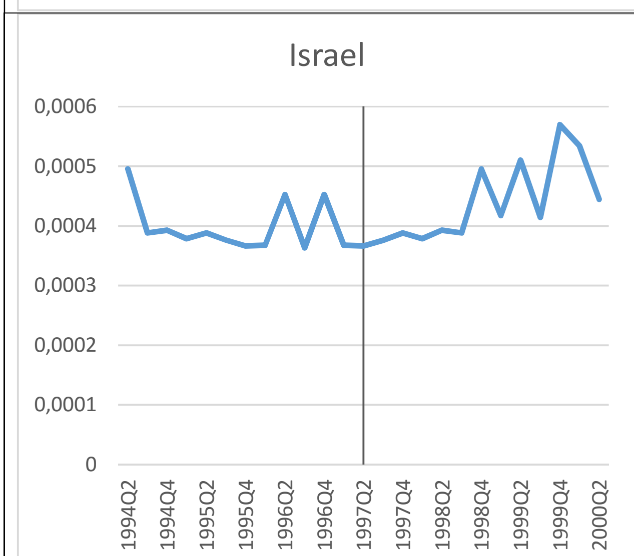
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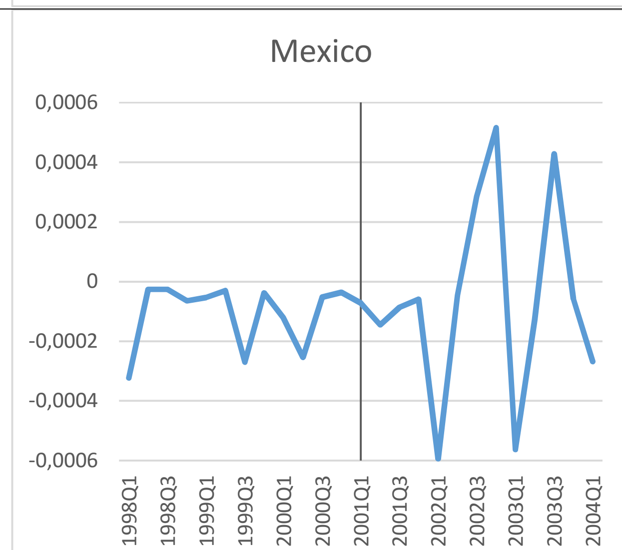
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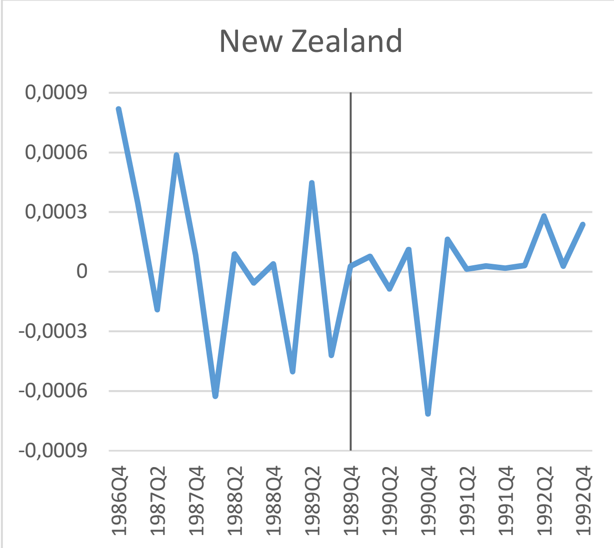
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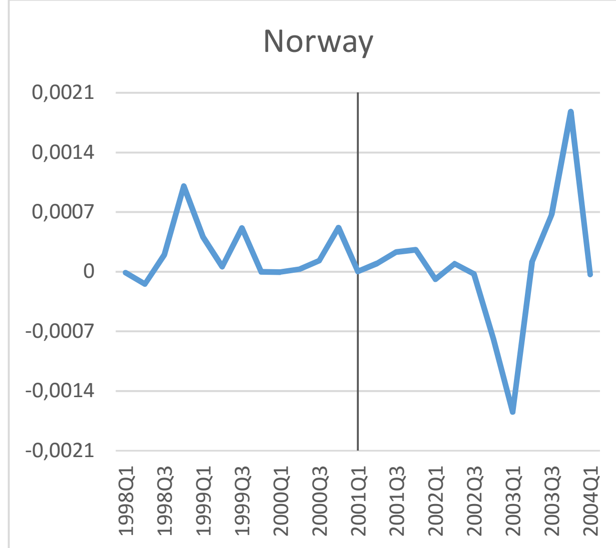
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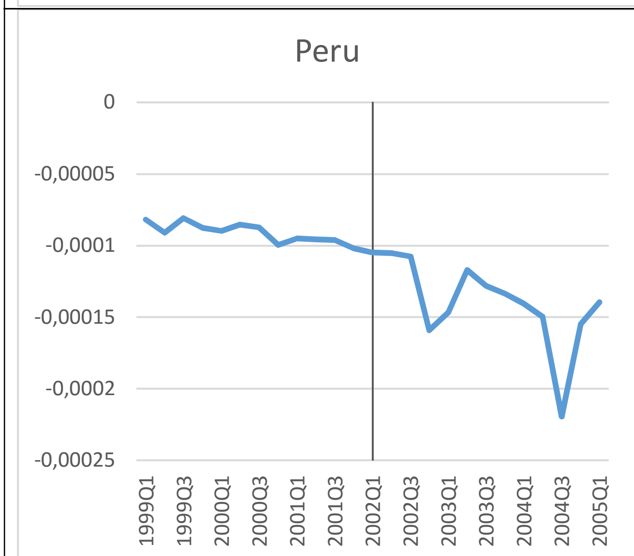
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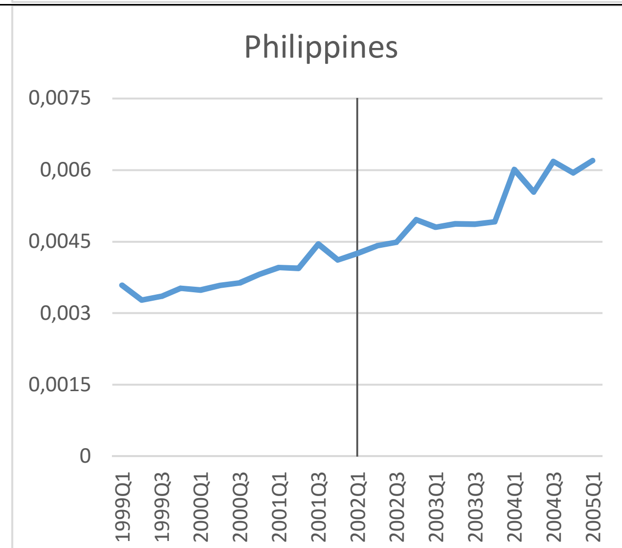
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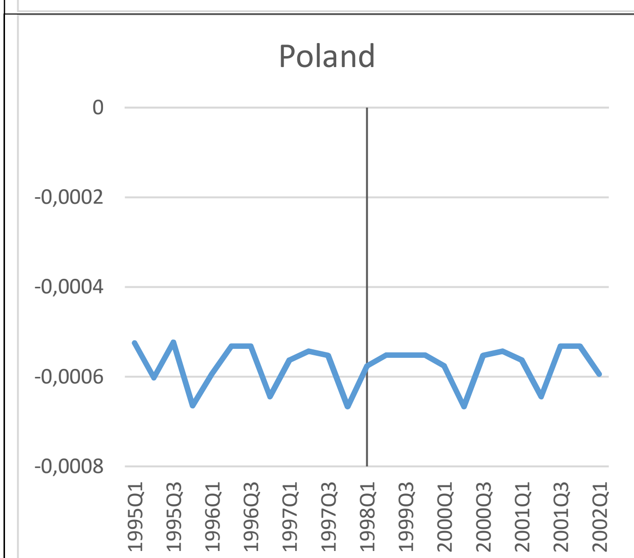
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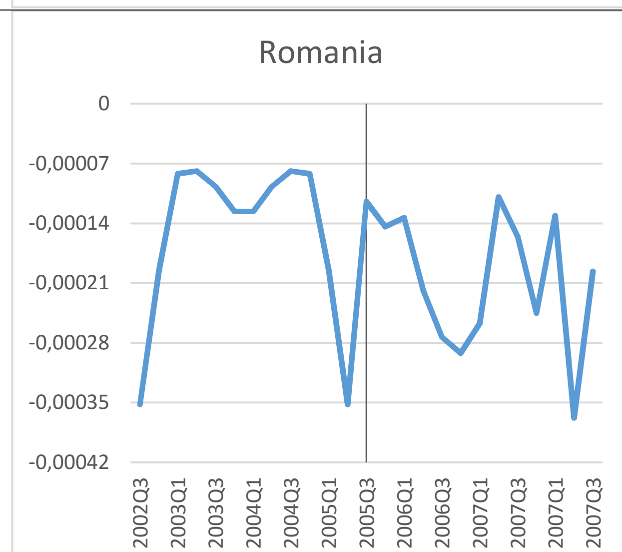
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Note: The vertical line in each of the sub-figures correspond to the date inflation targeting was adopted in these countries.

APPENDIX

Table A1. Country List, Inflation Targeting Adoption Dates, and Sample Size

Country	Inflation Targeting Adoption Date	Sample Date
Australia	1998Q1	1976Q2-2016Q4
Brazil	1999Q2	1980Q2-2016Q4
Canada	1991Q1	1976Q2-2016Q4
Chile	1999Q3	1991Q2-2016Q4
Colombia	1999Q3	1991Q2-2016Q4
Czech Republic	1997Q4	1976Q2-2016Q4
Guatemala	2005Q1	1976Q2-2016Q4
Hungary	2001Q2	1976Q2-2016Q4
Iceland	2001Q1	1976Q2-2016Q4
Indonesia	2005Q3	1976Q2-2016Q4
Israel	1997Q2	1976Q2-2016Q4
Mexico	2001Q1	1976Q2-2016Q4
New Zealand	1989Q4	1976Q2-2016Q4
Norway	2001Q1	1976Q2-2016Q4
Peru	2002Q1	1976Q2-2016Q4
Philippines	2002Q1	1976Q2-2016Q4
Poland	1998Q1	1980Q2-2016Q4
Romania	2005Q1	1991Q1-2016Q4
South Africa	2000Q1	1976Q2-2016Q4
South Korea	1998Q2	1976Q2-2016Q4
Sweden	1993Q1	1976Q2-2016Q4
Thailand	2000Q2	1976Q2-2016Q4
Turkey	2006Q1	1976Q2-2016Q4
United Kingdom	1992Q3	1976Q2-2016Q4

Table A2. Estimates of the Long-Memory Parameter from ARFIMA Models

Series	Model 1	Model 2	Model 3
Australia	0.30 (0.22, 0.40)	0.41 (0.25, 0.64)	0.28 (0.19, 0.39)
Brazil	0.85 (0.71, 1.09)	0.44 (0.30, 0.64)	0.88 (0.71, 1.17)
Canada	0.36 (0.27, 0.48)	0.24 (0.12, 0.38)	0.30 (0.19, 0.45)
Chile	0.42 (0.29, 0.61)	0.27 (0.11, 0.51)	0.44 (0.26, 0.71)
Colombia	0.19 (0.10, 0.32)	-0.06 (-0.16, 0.07)	0.19 (0.05, 0.41)
Czech Republic	0.09 (-0.01, 0.25)	0.13 (-0.04, 0.35)	0.08 (-0.05, 0.29)
Guatemala	0.57 (0.44, 0.74)	0.35 (0.16, 0.72)	0.61 (0.48, 0.77)
Hungary	0.31 (0.25, 0.39)	0.44 (0.34, 0.55)	0.24 (0.13, 0.39)
Iceland	0.62 (0.50, 0.79)	0.48 (0.37, 0.69)	0.63 (0.53, 0.76)
Indonesia	0.52 (0.35, 0.73)	0.14 (-0.07, 0.47)	0.51 (0.34, 0.74)
Israel	0.73 (0.64, 0.84)	0.95 (0.70, 1.26)	0.70 (0.60, 0.83)
Mexico	0.76 (0.64, 0.92)	0.55 (0.41, 0.77)	0.79 (0.64, 0.99)
New Zealand	0.43 (0.34, 0.56)	0.42 (0.28, 0.63)	0.44 (0.34, 0.56)
Norway	0.23 (0.16, 0.32)	0.37 (0.24, 0.55)	0.18 (0.09, 0.30)
Peru	0.63 (0.54, 0.76)	0.64 (0.48, 0.88)	0.64 (0.54, 0.77)
Philippines	0.48 (0.38, 0.63)	0.59 (0.31, 1.14)	0.49 (0.35, 0.66)
Poland	0.77 (0.58, 1.09)	0.01 (-0.15, 0.23)	0.79 (0.58, 1.18)
Romania	0.58 (0.43, 0.80)	0.26 (0.07, 0.54)	0.58 (0.42, 0.80)
South Africa	0.31 (0.20, 0.44)	0.18 (0.02, 0.37)	0.29 (0.18, 0.44)
South Korea	0.38 (0.29, 0.48)	0.52 (0.31, 0.80)	0.31 (0.21, 0.44)
Sweden	0.24 (0.16, 0.35)	0.32 (0.19, 0.55)	0.23 (0.13, 0.37)
Thailand	0.34 (0.23, 0.50)	0.14 (-0.03, 0.37)	0.34 (0.21, 0.53)
Turkey	0.44 (0.37, 0.52)	0.57 (0.46, 0.74)	0.38 (0.29, 0.49)
United Kingdom	0.26 (0.19, 0.35)	0.50 (0.35, 0.68)	0.28 (0.17, 0.43)

Note: The table reports the best-fitting estimates of d for the model: $y_t=\alpha+\beta t+x_t$, $(1-B)^d x_t=u_t$, t=1,2,.., with u_t being white noise, an ARMA process or a seasonal AR(1) process, corresponding to Model 1, Model 2 and Model 3 respectively.

Table A3. Results of the Treatment Effects Approach for Developed and Developing Countries

	Developed Countries	**Developing Countries**
A. Outcome equation		
inflatvollag1	0.1112***	0.8130***
turnover	0.0476	-8.2614
tradegdp	0.0031*	-0.2826**
rgdpcap	-7.74E-06**	0.0019*
exrregime	0.0297***	-1.5007
IT dummy	-0.9903***	-79.5621**
Constant	1.0389***	42.0569***
B. Treatment equation		
inflatlag1	-0.1227***	-0.0273***
tradegdp	-0.0058***	-0.0040
rgdpcap	1E-05**	1.57E-05***
financial openness	0.4060	0.0413
Constant	-0.5585	0.1606
N	508	1005
Wald chi-square	129.62	1554.33
p-value	0.0000	0.0000
Wald test indep. equations	37.89	745.79
p-value	0.0000	0.0000

Note: Selection equation for growth and inflation involves: Dependent variable: IT dummy - inflation-targeting dummy, 1 = declared inflation targeting for the relevant years, 0 otherwise; inflatlag1 – 1-period lag of inflation; tradegdp – trade openness (sum of exports and imports as a percentage of GDP); rgdpcap - real GDP per capita; finopen – Chinn and Ito (2006) index of financial openness; Outcome equation for inflation involves: Dependent variable: inflation volatility - the standard deviation of the three year moving average of the annual inflation rate; inflatvollag1 – 1-period lag of inflation volatility; turnover – central bank governor turnover rate in every five years; tradegdp; rgdpcap; exrregime – exchange rate regime dummy based on Ilzetzki et al., (2017); itdummy. All variables, unless specified, is derived from the World Bank's World Development Indicators (WDI) database; ***, **, * indicates significance at the 1%, 5% and 10% levels respectively.

Figure A1. Data Plot