

Inflation Convergence and Inflation Targeting: International Evidence

Philip Arestis[♦]
University of Cambridge
pa267@cam.ac.uk

Georgios Chortareas
Department of Management, *King's College London* and Department of
Economics, *University of Athens*
Georgios.chortareas@kcl.ac.uk, gchortar@econ.uoa.gr

Georgios Magkonis
School of Management, *University of Bradford*
g.magkonis@bradford.ac.uk

Demetrios Moschos
Department of Economics, *University of Athens*
dmoschos@econ.uoa.gr

Abstract

We examine whether the inflation rates of the countries that pursue inflation targeting policies have converged as opposed to the experience of the OECD non-inflation targeters. Using a methodology introduced by Pesaran (2007a), we examine the stationarity properties of the inflation differentials. This approach has the advantage of avoiding setting arbitrarily a specific country as the benchmark economy. Our results indicate that the inflation rates converge irrespective of the monetary policy framework.

Keywords: Inflation Convergence, Inflation Targeting, Pair-wise approach, Unit Roots.

JEL Classification: E31, C22

♦ (*Corresponding author*) Cambridge Centre for Economic and Public Policy, Department of Land Economy, University of Cambridge, 19 Silver Street, Cambridge CB3 9EP, UK. Email: pa267@cam.ac.uk

1. Introduction

Since the late 1980s an increasing number of countries have adopted explicit inflation targets as a means for anchoring expectations and securing price stability. In addition to the theoretical research that establishes analytically the rationale for inflation targeting (e.g. Svensson, 2011), substantial evidence has been produced on the effects of inflation targeting on the inflation rate, its volatility, and output growth, focusing on both the time series and the cross sectional dimension. The results are far from conclusive with the evidence upon the effects of targets on inflation being mixed. Extensive evidence has been produced emphasising the importance of targets in the reduction of both the inflation level and its persistence (e.g. Hyvonen, 2004; Johnson 2002, Levin *et al.*, 2006; Lin and Ye, 2007, Goncalves and Salles, 2008). Nevertheless, other analyses suggest that the declining tendency of inflation in several inflation targeting countries cannot be attributed to the inflation targeting (e.g. Ball and Sheridan, 2005; Ball, 2010; Genc *et. al*, 2007).

Another line of research considers the process of inflation convergence across countries in a time series context. The member countries of the Economics and Monetary Union (EMU) in Europe constitute a popular focus of this literature (e.g. Buseti *et al.*, 2007). Other studies consider the provinces or the cities of a particular country (e.g. Honohan and Lane, 2003; Beck *et al.*, 2009). The focus of this literature, however, is on inflation convergence and none of these analyses focuses on the implications of inflation targeting.

In this paper we consider whether the inflation rates in the inflation targeting and non-inflation targeting OECD economies converge using the

pair-wise stationarity testing procedure of Pesaran (2007a) on bilateral inflation differentials. We also employ some recently developed panel unit-root tests for robustness tests purposes that allow us to consider whether the inflation convergence process differs for inflation targeters and non-targeters. The results indicate that convergence is evident regardless of whether central banks announce explicit inflation targets or not. This evidence is in line with findings from earlier literature that employs different methodologies and indicates that the inflation targeting regimes by themselves cannot explain the improved inflation performance observed during the periods of inflation targeting (e.g. Angeriz and Arestis, 2008; Ball and Sheridan, 2005). Overall, this study contributes towards answering one of the key enduring questions about inflation targeting, namely whether the “improvements in performance observed in countries that have adopted inflation targeting [are] the direct result of the change in policy regime” (Bernanke and Woodford, 2005, p. 2).

The reminder of the paper is structured as follows. The following section reviews the relevant literature on inflation targeting and on inflation convergence. Section 3 describes the econometric methodology, Section 4 discusses the findings, and, finally, Section 5 summarises and concludes.

2. Background literature: Empirical Analyses of Inflation Targeting and Macroeconomic Performance

A large number of studies have examined the effects of inflation targeting on macroeconomic performance. Early studies such as those of Neumann and Hagen (2002), Hu (2003), and Levin *et al.* (2004) find that adopting inflation targets reduces both the average level and the variance of

inflation. The contribution of inflation targeting in reducing inflation rates is corroborated by evidence suggesting that it has also been instrumental in reducing inflation expectations (e.g., Johnson, 2002; Johnson, 2003; Levin *et al.*, 2004; Gurkaynak *et al.*, 2008).

Interestingly enough these positive effects of inflation targeting do not seem to account for any potential cost of output. However, evidence has been produced that shows an overall improved growth performance for inflation targeters (e.g. Petursson, 2004; Mollick *et al.*, 2011). Moreover, the adoption of inflation targets appears to be associated with a reduction in output growth volatility (e.g. Goncalves and Salles; 2008).

More recent research outcomes, nonetheless, produce mixed results in terms of the impact of inflation targeting. A spate of papers suggests that inflation targeting has made a difference only in developing and emerging economies but not in advanced economies. Lin and Ye (2007) focusing on seven industrialised inflation targeters and evaluating the effects of inflation targeting find that adopting inflation targets does not lead to the reduction of inflation and its variability. On the contrary, when the same analysis is repeated for thirteen developing inflation targeters (Lin and Ye, 2009) the effect of inflation targeting in lowering inflation its volatility is large and significant. The analyses of Mishkin and Schmidt-Hebbel (2007) and Walsh (2009) support further the proposition that inflation targeting seems to play a role in emerging markets but it does not matter in advanced countries. Angeriz and Arestis (2007a) consider the implementation of the so-called 'inflation targeting lite' regime. This regime refers to the pursuit of inflation targeting by certain small emerging countries that use inflation targeting to define their monetary policy framework. Angeriz and Arestis (op. cit.)

conclude that priority to inflation targeting in relation to other objectives cannot be assigned in the case of ‘lite’ countries.

The analysis of Ball and Sheridan (2005), who examine the effect of the IT adoption on the average level of inflation, poses a more fundamental challenge. Applying the ‘differences-in-differences’ methodology, Ball and Sheridan (2005) estimate the following equation

$$\pi_i^{post} - \pi_i^{pre} = a + bI_i + c\pi_i^{pre} + u_i \quad (1)$$

where π_i^{post} and π_i^{pre} are the inflation rates after and before the adoption of inflation targets, respectively, I_i is a dummy that takes the value of one in the case of a country that is an inflation targeter and zero otherwise, and u_i is the error term. Examining 7 inflation targeters and 13 non-targeters, they find that the IT dummy is statistically insignificant; that is, the reduction in the inflation rate takes place irrespective of the IT adoption. While the sample of Ball and Sheridan (2005) includes only advanced economies Goncalvez and Salles (2008) extend the analysis to include emerging inflation targeters and non-targeters. Their evidence suggests that IT matters; the inflation targeters experienced greater drop in inflation rates than the non-targeters.

Another set of evidence suggests that although inflation targeting has gone hand-in-hand with low inflation, the inflation targeting approach was introduced well after inflation had begun its downward trend. Angeriz and Arestis (2008) make this point and go further to apply intervention analysis to multivariate structural time series models to produce evidence for the OECD countries, which suggests that after the adoption of the inflation targeting

framework inflation is 'locked in' at low rates. However, the non-inflation targeting central banks appear to have also been as successful on this score.

These findings are intrinsically related to the literature, which emphasises the issue of endogeneity of the monetary policy regime; that is, the dependence of the monetary policy regime on the whole nexus of economic policy decisions. Mishkin and Schmidt-Hebbel (2002) and Gertler (2005) point out that the adoption of inflation targeting is only one part of an overall process of economic and political reform. Thus, the improvement of the macroeconomic performance prior to the August 2007 crisis, which is found to be related to inflation targeting, may not necessarily be due to the new monetary framework. Indeed, Angeriz and Arestis (2008) conclude that 'globalisation' may be a better explanation of the improvement of macroeconomic performance referred to above.

The literature on inflation targeting reviewed so far does not address the issue of inflation convergence. The only exception is Ball and Sheridan (2005) who interpret the statistically significant π_i^{pre} in the right-hand side of equation (1) as evidence of convergence. This resembles to the notion of β -convergence; greater reduction in inflation rates is achieved by countries that initially faced higher such rates. As argued above the fact that the IT dummy is found to be insignificant is actually an indication that inflation targeting does not account for the inflation convergence. Ball and Sheridan's analysis is extended by Hyvonen (2004) who uses a larger number of countries and separates the time span into three sub-periods. According to his empirical evidence inflation convergence still holds for the extended grouping, but this process, however, mainly takes place in the most recent period; 1983-1993.

Hyvonen (op. cit.) concludes that it remains an open question whether the observed convergence is due to inflation targeting.

While the concept of convergence has not been explicitly linked to the effects of the inflation targeting adoption, an extended literature exists focusing on inflation convergence. One part of these studies considers the stationarity properties of inflation differentials between countries and interprets the presence of stationarity as evidence of convergence. For example, Busetti *et al.* (2007) employ univariate and multivariate unit root and stationarity tests to examine whether inflation rates converge among EMU countries and provide results consistent with the notion of club-convergence. A similar strategy followed by Busetti *et al.* (2006) for the Italian regions produces analogous results. Kocenda and Papell (1997) were among the first who applied panel unit root tests to consider inflation convergence among the EU countries, while other authors use similar tests to examine for inflation convergence in the Central and Eastern European countries, with mixed results (e.g. Kocenda, 2001; Kutan and Yigit, 2004). Yilmazkuday (2013) uses Pesaran's (2007a) test to compare the convergence properties of various CPI groups' inflation rates among Turkish geographical regions before and after inflation targeting.

Another popular empirical approach to test for inflation convergence relies on cointegration analysis. Siklos and Wohar (1997) and Westbrook (1998) use Johansen's methodology to analyse a wide set of countries and find evidence of inflation convergence. Using a similar methodology Thom (1995) and Crowder and Phengpis (2007) arrive to a similar result for the EMU members and the G7 economies respectively

Finally, another set of papers utilises other methodological tools. For instance, Koedijk and Kool (1992) and Becker and Hall (2009) use variants of principal component analysis with mixed findings for the EMU and the EU countries, respectively. In a similar vein, Beck *et al.* (2009) compare the inflation convergence process of European regions with that of US regions. Their results indicate that there is higher inflation dispersion among European provinces.

In this paper we analyze the process of inflation convergence among the OECD countries by considering the stationarity properties of inflation differentials. Contrary to the studies examined so far, we examine whether the adoption of inflation targeting has made any difference in this process. In this way, we bring new evidence to both the inflation targeting debate and the convergence literature.

3. Empirical Methodology

Stochastic convergence suggests that any difference between series that are temporary in nature will fade away in the long run with shocks dissipating over time (e.g., Bernard and Durlauf, 1995; 1996). More specifically, considering the inflation rate (π_t) for countries i and j convergence implies that:

$$\lim_{h \rightarrow \infty} \frac{1}{h} \sum_{t=0}^{h-1} (\pi_{i,t} - \pi_{j,t}) = 0, \quad (2)$$

where I_t denotes the information set at time t . A less strict definition allows for a nonzero constant as a limit and implies an equilibrium differential that remains constant through time. A direct implication is that stochastic convergence can be tested by examining the stationarity properties of the differential between the two variables, i.e. $d_{i,j,t} = \pi_{i,t} - \pi_{j,t}$. A commonly used approach focuses on the stationarity properties of this differential. Typically, the differentials considered emerge from setting one country as the benchmark and focusing upon it. This approach, however, can be considered as arbitrary. If one wishes to analyze inflation convergence among developed economies, there is no obvious reason for setting one specific country as the benchmark. In addition, the results can be sensitive to the choice of the reference country and the focus on only one possible dimension may lead to the loss of substantial information from the other combinations.

Such issues, however, can be circumvented by using a pair-wise testing procedure developed by Pesaran (2007a), which takes into account all pair-wise differential combinations. Let $\pi_{i,t}$ be the inflation rate for country i at time t , where $i=1...N$, $t=1...T$ and $d_{i,j,t} = \pi_{i,t} - \pi_{j,t}$ be the inflation differential of countries i and j at time t . The Pesaran (2007a) pair-wise approach is based on the examination of stationarity properties of all differentials of N countries without taking into account any benchmark. Instead, it considers the stationarity properties of all possible differentials between all countries under study. Specifically, the number of all differentials are $N(N-1)/2$.¹ The fact that this methodology is based on the computation of all possible differentials, and

¹ The number $N(N-1)/2$ is equal to the number of combinations of N per 2; in other words,

$$\frac{N(N-1)}{2}.$$

not only on the differentials based on one benchmark, reveals its main advantage; that is, it provides additional information concerning the process of convergence.

Suppose $Z_{i,j,t}$ is an indicator function that takes the value of one if the null of unit root is rejected at significance level α and zero otherwise. Specifically, $Z_{i,j,t}=1$ when $ADF(k)<C_{\alpha,k,T}$ or $Z_{i,j,t}=0$ when $ADF(k)>C_{\alpha,k,T}$, where $C_{\alpha,k,T}$ is the critical value for size α , lag order k and T observations. Pesaran (2007a) shows that under the null of unit root (non-stationarity) the fraction of differentials for which the null is rejected is equal to the significance level. Formally, this fraction is equal to:

$$\frac{1}{N} \sum_{i=1}^N \frac{1}{T} \sum_{t=1}^T Z_{i,j,t} \quad (3)$$

and under the assumption that the null of unit root holds, we have:

$$\lim_{T \rightarrow \infty} \frac{1}{N} \sum_{i=1}^N \frac{1}{T} \sum_{t=1}^T Z_{i,j,t} = \alpha \quad (4)$$

In the case where convergence (i.e. stationarity) holds, the percentage of rejections tends towards 100% as the number of observations tends to infinity, i.e. $T \rightarrow \infty$. Consequently, the higher the proportion of rejections is, the stronger the evidence in favour of convergence.

We consider the stationarity of each differential through the use of unit root tests, including the Augmented Dickey-Fuller (ADF) tests and the cross-

sectional ADF tests (CADF, hereafter), as developed by Pesaran (2007b). The ADF equation is written as:

$$\Delta d_{i,l,t} = a + \beta d_{i,l,t-1} + \sum_{l=0}^k \gamma_l \Delta d_{i,l,t-l} + \varepsilon_t \quad (5)$$

where $d_{i,l,t}$ is the inflation differential of country i relative to country l at time t , Δ is the difference operator and k is the lag order. The inference is based on the t -statistic of the β coefficient. If β is not found to be statistically different from zero, then the series contains one unit root.

Given the fact that we consider all possible differentials, a potential problem that may be raised is that of cross-sectional dependence. The obvious dependence between $d_{i,l,t}$ and $d_{i,f,t}$ with $l \neq f$ may induce problems in inference concerning the existence of convergence. So, the existence of dependence among the variables under study, i.e. among all the examined differentials, has to be detected. This is done by performing the cross-section dependence (CD) test proposed by Pesaran (2004). The first step is to estimate the ADF equation of the form (5) for each cross-section separately and compute the pair-wise cross-section correlation coefficients of the residuals from equation (5), i.e. $\hat{\rho}_{i,j}$. The simple average of these coefficients across all the $N(N-1)/2$ pairs, $\bar{\hat{\rho}}$, is equal to:

$$\bar{\hat{\rho}} = \frac{2}{N(N-1)} \sum_{i=1}^{N-1} \sum_{j=i+1}^N \hat{\rho}_{i,j} \quad (6)$$

Using these calculations, Pesaran (2004) shows that the test:

$$\frac{\sum_{i=1}^N \left(\frac{\sum_{t=1}^T \Delta d_{i,t}}{T} \right)^2}{N} \xrightarrow{d} \chi^2_1 \quad (7)$$

is normally distributed (see also Pesaran, 2007b, p. 297).

Given the existence of cross-section dependence, the ADF test has to be modified. Pesaran (2007b) proposes such a modification according to which equation (5) is now rewritten as:

$$\Delta d_{i,t} = a_i + \beta_i d_{i,t-1} + c_i \bar{d}_{t-1} + \sum_{l=0}^k d_l \Delta \bar{d}_{t-l} + \varepsilon_{i,t} \quad (8)$$

where $\bar{d}_t = M^{-1} \sum_{i=1}^M d_{i,t}$ is the cross-sectional average of all M differentials at time t . The inclusion of the average term, and its differences, takes into account the existence of dependence among variables. As in the standard ADF test, the inference about the unit root is based on the t -statistic of β coefficient. This statistic, however, does not follow either the t -student or the Dickey-Fuller ones. For this reason, specific and relevant critical values are provided by Pesaran (2007b).

The above pair-wise testing procedure draws on unit root tests applied on a single series of inflation differentials sequentially and the inference is based on the aggregate behaviour of these individual tests. As a robustness check to the pair-wise approach, we perform panel unit root tests for the examined differentials. That is, instead of looking into the time series

properties of each differential, we now draw our attention to the whole panel of the series, which have the advantage of increased power.

We employ panel versions of ADF and CADF tests. In particular, we use the panel version of ADF proposed by Im *et al.* (2003) (henceforth, IPS), which constitutes a simple average of individual ADF unit root tests and has the following form:

$$t_{ns} = \frac{\sqrt{M}(\bar{t} - E(t_i))}{\sqrt{Var(t_i)}} \quad (9)$$

where M is the number of cross-sectional units (here, differentials) and \bar{t} is the corresponding average, i.e. $\bar{t} = M^{-1} \sum_{i=1}^M t_i$, with t_i being the individual ADF t -statistic. The values of $E(t_i)$ and $Var(t_i)$ are computed through simulations by Im *et al.*

The IPS test, however, does not take into account cross-sectional dependence. To overcome this shortcoming, Pesaran (2007b) incorporates cross-sectional means, as in the CADF test. In fact, performing for each single differential the CADF test, and taking the average values of the CADF t -statistics, give rise to the following test statistic:

$$t_{ns} = M \sum_{i=1}^M t_i^{CADF} \quad (10)$$

where t_i^{CADF} is the t -statistic of the individual CADF tests and the subscript ‘CIPS’ refers to ‘cross-sectional IPS’. Pesaran (2007b) provides critical values

for this panel test. In fact the two panel unit tests are the average versions of individual ADF and CADF tests.

4. Data and Empirical Results

Our dataset consists of quarterly series of CPI from 1990:1 up to 2011:4. All data come from the International Financial Statistics (IFS) of the IMF. From these series we calculate the quarterly annualised inflation as $\pi_t = \ln P_t - \ln P_{t-4}$. According to Hammond's (2012) classification, twenty-six economies have adopted inflation targeting with the New Zealand being the first economy to do so in December 1989. In the present study we focus on those economies that established the inflation targeting framework during the whole decade of the 1990s. In this way we exclude the economies, which officially adopted targets during the 2000s. Moreover, we exclude countries, such as the Czech Republic and Poland, due to lack of data despite the fact that they employed IT during the 1990s. The included economies in our sample are shown in the upper panel of Table 1. The left column shows these countries and the corresponding dates of the adoption. According to the pair-wise analysis presented in the previous section, we analyse $N=11$ economies and we compute $N(N-1)/2=55$ pair-wise differentials.

The analysis is repeated for a group of 11 OECD non-targeters (right column of Table 1). By testing the time series properties of differentials in each group, we are able to examine whether there is inflation convergence within each of the two groups, which differ according to the monetary policy regime.

Apart from convergence within each group, it is of interest to explore any pattern of convergence considering both inflation targeters and non-

targeters as a single group; i.e. when the countries are grouped together irrespective of their monetary policy framework ($N=22$). In this way we can investigate the existence of inflation convergence among countries irrespective of the monetary policy pursued.

Table 1 here

Since the group of 11 inflation targeters includes Brazil, Chile, Colombia and South Korea, which introduced inflation targeting in the late 1990s, we also consider a narrower group that excludes these countries and consists of 7 countries that adopted targeting in the early 1990s. The pair-wise convergence analysis is repeated separately for the narrower groups of 7 early 1990s inflation targeters and 7 non-targeters (lower panel of Table 1), as well as for the joint set, which includes the 14 inflation targeter and non-targeter countries.

Figure 1 shows the average inflation rates for inflation targeters and non-targeters. In early 1990s the differential between two averages is relatively higher than the corresponding ones of the late 1990s and the whole decade of 2000s ones. Interestingly enough, after the mid-1990s the inflation differential varies between 0% and 2% without any volatile behaviour. This indicates that convergence between the two groups was achieved.

Figure 1 here

Table 2 presents the results of pairwise ADF(k) tests for $k=0,1,2,3,4$. The first panel shows the percentage of rejections for the wide groups. As far

as the inflation targeters are concerned, under the null of unit root (i.e. of no convergence), we expect the percentage of rejection to be close to the level of significance. At the 5% significance level the proportion of rejections ranges from 56.36% to 87.27%. The range of rejection percentages is roughly the same when 10% is used as the level of significance. These results provide clear evidence of inflation rates convergence among inflation targeters.

For the non-inflation targeters group, the findings are even stronger concerning the support of the convergence hypothesis. When we use one, two and three lags in the ADF test, the percentage of rejections reach 100%, as all the pair-wise differentials are found to be stationary at the 5% significance level. Consequently, within both groups inflation seems to converge. Unsurprisingly, inflation convergence is also supported for the joint set consisting of both inflation targeters and non-targeters. At the 5% level of significance, the lowest percentage of rejections is 72.73%, while at the 10% level it is 83.12%.

Table 2 here

The same analysis is performed for the smaller group of economies that adopted inflation targets in the early 1990s. For the smaller groups the results are similar in nature and provide even stronger support for inflation convergence, irrespective of whether or not the countries are classified according to the monetary policy regime. As shown in the second panel of Table 2, for the majority of the chosen lags the percentage of rejections is 100% in all the three groups.

The validity of the results in Table 2, however, could be questioned. As illustrated in the previous section, cross-sectional dependence is likely to bias the outcomes. The first step is to test the existence of such dependence. Table 3 shows the results from the CD test statistic. In all cases, the null of cross section independence is strongly rejected. Note that the dependence is higher for the non-targeters. This may be due to the fact that the non-inflation targeters group is more homogeneous than the group of inflation targeters.

Table 3 here

In view of the evidence of high dependence among economies, due to globalisation in particular, we also investigate the stationarity properties using the Pesaran (2007b) testing procedure, which takes into account cross-sectional dependence. As shown in Table 4, for all the groupings under investigation the results suggest that the convergence hypothesis seems to hold when cross-sectional dependence is accounted for. However, the percentages of rejection of the null of non-convergence still exceed the chosen levels of significance, although lower than those of Table 2. The only case where the proportion of rejections is slightly lower than the 5% level occurs when the lag order is set at 4 in the non-targeters group of 7 countries.

Table 4 here

The application of cross-sectional ADF testing procedure leads to the same conclusions as before. The inflation rates seem to have converged both among the inflation targeters and non-targeters. Moreover, pairwise

convergence does not seem to be a phenomenon specific to countries, which adopt a common monetary policy regime. The panel unit root test results in Table 5 confirm this conclusion. The null of unit root (no-convergence) is rejected by both the IPS and the CIPS tests for all the groups under consideration. In all cases both tests give results, which are significant at the 1% level.

Table 5 here

Overall, the evidence produced by employing two different empirical methods point to the same direction. Specifically the empirical results strongly support the existence of inflation convergence. But this result applies equally to inflation-targeting countries and non-inflation targeting ones. Indeed, utilising three different groupings of countries according to whether a country has adopted the inflation targeting policy prescription or not, we conclude that the employment of inflation targets does not play a significant role in explaining the pre-2007 inflation convergence. This finding is in line with the literature stressing the fact that the reduction of the inflation rates should not be attributed to the introduction of the inflation targeting regime. Instead, it could be the outcome of a more general process of economic and political reforms, and possibly globalisation (Angeriz and Arestis, 2007b).

5. Conclusion

This paper examines the behaviour of the inflation rates across inflation-targeting and non-inflation-targeting countries. In particular we focus on

inflation convergence. Instead of considering countries or regions that share common economic characteristics (such as the EMU economies, or regions of given countries), we draw our attention to a number of countries with different monetary policy frameworks. Putting it differently, we investigate whether the inflation rates of the countries that have adopted inflation targeting have converged; and, most importantly, whether non-inflation targeting countries have had the same experience or not. This is undertaken by examining the stationarity properties of the inflation differentials of the inflation targeting and the non-targeting economies. Moreover, we conduct the same analysis for all the examined economies regardless of the introduction or otherwise of inflation targets. Our findings indicate that the inflation rates converge within the inflation-targeters group as well as within the non-targeters group. In addition, the inflation rates converge across the two groups, which clearly implies that inflation targeting does not seem to be associated with different patterns of inflation rate behaviour. This finding is in line with the literature stressing the fact that the reduction of the inflation rates should not be attributed to the introduction of the inflation targeting regime. Instead, the reduction of inflation rates and inflation convergence could be the outcome of the coordination implicit in the economic policies pursued in a globalized environment rather than that of inflation targeting per se.

References

- Angeriz, A. and Arestis, P. (2007a) Assessing the Performance of 'Inflation Targeting Lite' Countries, *World Economy*, 30, 1621-1645.
- Angeriz, A. and Arestis, P. (2007b), "Monetary Policy in the UK", *Cambridge Journal of Economics*, 31(6), 863-884.
- Angeriz, A. and Arestis, P. (2008) Assessing Inflation Targeting Through Intervention Analysis, *Oxford Economic Papers*, 60, 293-317.
- Ball, L., (2010) The Performance of Alternative Monetary Regimes in Friedman, B.M. and Woodford, M. (eds.), *Handbook of Monetary Economics*, 1303-1343.
- Ball, L. and Sheridan, N. (2005) Does Inflation Targeting Matter? in Bernanke B.S. and Woodford, M. (eds.), *The Inflation Targeting Debate*, University of Chicago Press, 249-276.
- Beck, G.W., Hubrich, K. and Marcellino, M. (2009) Regional Inflation, *Economic Policy*, 143-184.
- Becker, B. and Hall, S. (2009) How far from the Euro Area? Measuring Convergence of Inflation Rates in Eastern Europe, *Economic Modelling*, 26, 788-798.
- Bernanke, B. S. and Woodford, M. (2005) Introduction in Bernanke B.S. and Woodford M. (eds.), *The Inflation Targeting Debate*, University of Chicago Press.
- Bernard, A.B. and Durlauf, S.N. (1995) Convergence in International Output, *Journal of Applied Econometrics*, 10, 97-108.
- Bernard, A.B. and Durlauf, S.N. (1996) Interpreting Tests of the Convergence Hypothesis, *Journal of Econometrics*, 71, 161-173.

- Busetti, F., Fabiani, S. and Harvey, A. (2006) Convergence of Prices and Rates of Inflation, *Oxford Bulletin of Economics and Statistics*, 68, 863-877.
- Busetti, F., Forni, L. Harvey, A. and Venditti, F. (2007) Inflation Convergence and Divergence within the European Monetary Union, *International Journal of Central Banking*, 3, 95-121.
- Crowder, W.J. and Phengpis, C. (2007) A Re-examination of International Inflation Convergence over Modern Float, *Journal of International Financial Markets, Institutions and Money*, 17, 125-139.
- Genc, I. H., Lee, M., Rodriguez, C.O. and Lutz, Z. (2007) Time Series Analysis of Inflation Targeting in Selected Countries, *Journal of Economic Policy Reform*, 10, 15-27.
- Gertler, M., (2005) Comment on Ball, L. and Sheridan, N. Does inflation targeting matter? in Bernanke B.S. and Woodford M. (eds.), *The Inflation Targeting Debate*. University of Chicago Press for the National Bureau of Economic Research.
- Goncalves, C.E. and Salles, J.M. (2008) Inflation Targeting in Emerging Economies: What Do the Data Say?, *Journal of Development Economics*, 85, 312-318.
- Gurkaynak, R.S., Levin, A.T., Marder, A.N, and Swanson, E.T. (2008) Inflation Targeting and the Anchoring of Inflation Expectations in the Western Hemisphere. Central Bank of Chile. Working Paper.
- Hammond, G. (2012) State of the Art of Inflation Targeting, Centre for Central Banking Studies, Handbook-No.29, Bank of England.
- Holmes, M.J. (2002) Panel Data Evidence on Inflation Convergence in the European Union, *Applied Economics Letters*, 9, 155-158.

- Honohan, P. and Lane, P. (2003) Divergent Inflation Rates in EMU, *Economic Policy*, 37, 357-394.
- Hu, Y. (2003) Empirical Investigations of Inflation Targeting, Working paper 03-6, Washington: Institute for International Economics.
- Hyvonen, M., (2004) Inflation Convergence Across Countries, Discussion paper 2004-04. Sydney: Reserve Bank of Australia.
- Im, K.S., Pesaran, M.H. and Shin, Y. (2003) Testing for Unit Roots in Heterogeneous Panels, *Journal of Econometrics*, 115, 53-74.
- Johnson, D.R. (2002) The Effect of Inflation Targeting on the Behaviour of Expected Inflation: Evidence from an 11 Country Panel, *Journal of Monetary Economics*, 49, 1521-1538.
- Johnson, D.R. (2003) The Effects of Inflation Targets on the Level of Expected Inflation in Five Countries, *Review of Economics and Statistics*, 55, 1076-1081.
- Kočenda, E. (2001) Macroeconomic Convergence in Transition Countries, *Journal of Comparative Economics*, 29, 1-23.
- Kočenda, E., and Papell, D.H. (1997) Inflation Convergence within the European Union: A Panel Data Analysis, *International Journal of Finance and Economics*, 2, 189-198.
- Koedijk, K.G., and Kool, J.M.C. (1992) Dominant Interest and Inflation Differentials within the EMS, *European Economic Review*, 36, 925-943.
- Kutan, A.M. and Yigit, T.M. (2004) Nominal and Real Stochastic Convergence of Transition Economies, *Journal of Comparative Economics*, 32, 23-36.

- Levin, A.T., Natalucci, F.M. and Piger, J.M. (2004) The Macroeconomic Effects of Inflation Targeting, Federal Reserve Bank of St.Louis Review (July/August), 51-80.
- Lin, S., and Ye, H. (2007) Does Inflation Targeting Really Make a Difference? Evaluating the Treatment Effect of Inflation Targeting in Seven Industrial Countries, *Journal of Monetary Economics*, 54, 2521–2533.
- Lin, S., and Ye, H. (2009) Does Inflation Targeting Make a Difference in Developing Countries?, *Journal of Developing Economics*, 89, 118-123.
- Mishkin, F.S., (1999) International Experience with Different Monetary Policy Regime, *Journal of Monetary Economics*, 43, 579-605.
- Mishkin, F.S. and Schmidt-Hebbel, K. (2002) One Decade of Inflation Targeting in the World: What Do We Know and What Do We Need to Know? in Loayza N. and Soto, R. (eds.), *Inflation Targeting: Design, Performance, Challenges*, Central Bank of Chile.
- Mishkin, F.S. and Schmidt-Hebbel, K. (2007), Does Inflation Targeting Make a Difference in Mishkin F.S. and Schmidt-Hebbel, K. (eds.), *Monetary Policy Under Inflation Targeting*, Central Bank of Chile.
- Mollick, A.V., Torres, R.C. and Carneiro, F.G. (2011) Does Inflation Targeting Matter for Output Growth?, *Journal of Policy Modelling*, 33, 537-551.
- Neumann, M.J.M. and von Hagen, J. (2002) Does Inflation Targeting Matter?, Federal Reserve Bank of St.Louis Review (July/August), 127-148.
- Pesaran, M.H., (2007a) A Pair-wise Approach for Testing Output and Growth Convergence, *Journal of Econometrics*, 138, 312-355.
- Pesaran, M.H., (2007b) A Simple Panel Unit Root Test in the Presence of Cross-Section Dependence, *Journal of Applied Econometrics*, 22, 265-312.

- Siklos, P. and Wohar, M. E. (1997) Convergence in Interest Rates and Inflation Rates Across Countries and Over Time, *Review of International Economics*, 5, 129-141.
- Svensson, L.E.O. (2011), "Inflation Targeting", Friedman, B.M. and Woodford, M. (eds.), *Handbook of Monetary Economics*, Vol. 3B, Amsterdam: Elsevier Press.
- Thom, R. (1995) Inflation Convergence in the EMS: Some Additional Evidence: A comment, *Review of International Economics*, 131, 577-586.
- Walsh, C. E. (2009) Inflation Targeting: What Have we Learned? *International Finance*, 12, 195-233.
- Westbrook, J. A. (1998) Monetary Integration, Inflation Convergence and Output Shocks in the European Monetary System, *Economic Inquiry*, 36, 138-144.
- Yilmazkuday, H. (2013) Inflation Targeting, Flexible Exchange Rates and Inflation Convergence, *Applied Economics*, 45, 593-603.

TABLES AND FIGURES

Table 1

Selected Countries

Wide Group	
<i>Inflation Targeters as from the 1990s (month/year of adoption)</i>	<i>Non-targeters</i>
Australia--(6/1993)	Denmark
Brazil--(6/1999)	Finland
Canada--(2/1991)	France
Chile--(9-1999)	Germany
Colombia--(10/1999)	Ireland
Guatemala--(1/1991)	Italy
Israel--(6/1992)	Japan
New Zealand--(12/1989)	Netherlands
South Korea--(4/1998)	Portugal
Sweden--(1/1993)	Spain
United Kingdom--(10/1992)	United States
Narrow Group	
<i>Inflation Targeters as from the early 1990s</i>	<i>Non-targeters</i>
Australia--(6/1993)	Denmark
Canada--(2/1991)	France
Guatemala--(1/1991)	Germany
Israel--(6/1992)	Italy
New Zealand--(12/1989)	Japan
Sweden--(1/1993)	Spain
United Kingdom--(10/1992)	United States

Source: Hammond (2012).

Table 2

Proportion of differentials for which ADF unit-root is rejected

1-Wide Group					
	<i>Inflation Targeters</i>				
Lag order	k=0	k=1	k=2	k=3	k=4
α=5%	56.36%	87.27%	87.27%	87.27%	74.55%
α=10%	63.64%	90.91%	89.09%	89.09%	87.27%
	<i>Non-Targeters</i>				
Lag order	k=0	k=1	k=2	k=3	k=4
α=5%	87.27%	100%	100%	100%	96.36%
α=10%	98.18%	100%	100%	100%	100%
	<i>All</i>				
Lag order	k=0	k=1	k=2	k=3	k=4
α=5%	72.73%	93.94%	92.64%	91.77%	83.12%
α=10%	83.12%	96.54%	95.24%	94.81%	92.21%
2-Narrow Group					
	<i>Inflation Targeters</i>				
Lag order	k=0	k=1	k=2	k=3	k=4
α=5%	71.43%	100%	100%	100%	76.19%
α=10%	85.71%	100%	100%	100%	100%
	<i>Non-Targeters</i>				
Lag order	k=0	k=1	k=2	k=3	k=4
α=5%	80.95%	100%	100%	100%	95.24%
α=10%	100%	100%	100%	100%	100%
	<i>All</i>				
Lag order	k=0	k=1	k=2	k=3	k=4
α=5%	80.22%	100%	100%	100%	85.71%
α=10%	92.31%	100%	100%	100%	100%

Note: Each entry shows the percentage rates of rejections of the null hypothesis $H_0 : \beta = 0$ at $\alpha=5\%$ and $\alpha=10\%$ level of statistical significance. The test equation has the form:

$$\Delta d_{i,l,t} = a + \beta d_{i,l,t-1} + \sum_{l=0}^k \gamma_l \Delta d_{i,l,t-l} + \varepsilon_t.$$

Table 3

CD Test for Cross-Sectional Dependence

	<i>Inflation Targeters</i>				
Lag order	<i>k=0</i>	<i>k=1</i>	<i>k=2</i>	<i>k=3</i>	<i>k=4</i>
Wide Group	10.30***	11.92***	12.33***	12.25***	11.15***
Narrow Group	6.33***	5.62***	5.82***	6.31***	7.06***
	<i>Non-Targeters</i>				
Lag order	<i>k=0</i>	<i>k=1</i>	<i>k=2</i>	<i>k=3</i>	<i>k=4</i>
Wide Group	18.46***	22.52***	22.60***	22.38***	18.20***
Narrow Group	13.10***	12.97***	12.80***	13.53***	13.30***
	<i>All</i>				
Lag order	<i>k=0</i>	<i>k=1</i>	<i>k=2</i>	<i>k=3</i>	<i>k=4</i>
Wide Group	30.39***	34.83***	36.15***	34.85***	34.63***
Narrow Group	11.41***	13.89***	15.13***	14.41***	15.19***

Note: Each entry shows p -values of CD statistic for cross-sectional dependence. Inference is based on normal distribution. *** shows rejection of null of independence at 1% level of significance.

Table 4

Proportion of differentials for which CADF unit-root is rejected

1-Wide Group					
	<i>Inflation Targeters</i>				
Lag order	<i>k=0</i>	<i>k=1</i>	<i>k=2</i>	<i>k=3</i>	<i>k=4</i>
$\alpha=5\%$	23.64%	52.73%	54.55%	61.82%	23.64%
$\alpha=10\%$	34.55%	70.91%	72.73%	74.55%	30.91%
	<i>Non-Targeters</i>				
Lag order	<i>k=0</i>	<i>k=1</i>	<i>k=2</i>	<i>k=3</i>	<i>k=4</i>
$\alpha=5\%$	16.36%	45.45%	43.64%	43.64%	12.73%
$\alpha=10\%$	32.73%	63.64%	65.45%	60.0%	25.45%
	<i>All</i>				
Lag order	<i>k=0</i>	<i>k=1</i>	<i>k=2</i>	<i>k=3</i>	<i>k=4</i>
$\alpha=5\%$	29.44%	60.61%	59.74%	61.90%	27.27%
$\alpha=10\%$	43.72%	70.13%	73.16%	71.00%	37.66%
2-Narrow Group					
	<i>Inflation Targeters</i>				
Lag order	<i>k=0</i>	<i>k=1</i>	<i>k=2</i>	<i>k=3</i>	<i>k=4</i>
$\alpha=5\%$	76.19%	71.43%	85.71%	80.95%	33.33%
$\alpha=10\%$	90.48%	90.48%	90.48%	90.48%	38.10%
	<i>Non-Targeters</i>				
Lag order	<i>k=0</i>	<i>k=1</i>	<i>k=2</i>	<i>k=3</i>	<i>k=4</i>
$\alpha=5\%$	23.81%	33.33%	33.33%	52.38%	4.76%
$\alpha=10\%$	38.10%	52.38%	52.38%	66.67%	28.57%
	<i>All</i>				
Lag order	<i>k=0</i>	<i>k=1</i>	<i>k=2</i>	<i>k=3</i>	<i>k=4</i>
$\alpha=5\%$	42.86%	50.55%	57.14%	57.14%	28.57%
$\alpha=10\%$	48.35%	62.64%	68.13%	70.33%	36.26%

Note: Each entry shows the percentage rates of rejections of the null hypothesis $H_0 : \beta = 0$ at $\alpha=5\%$ and $\alpha=10\%$ level of statistical significance. The test equation has the form:

$$\Delta d_{i,t} = a_i + \beta_i d_{i,t-1} + c_i \bar{d}_{t-1} + \sum_{l=0}^k d_l \Delta \bar{d}_{t-l} + \varepsilon_{i,t}.$$

Table 5

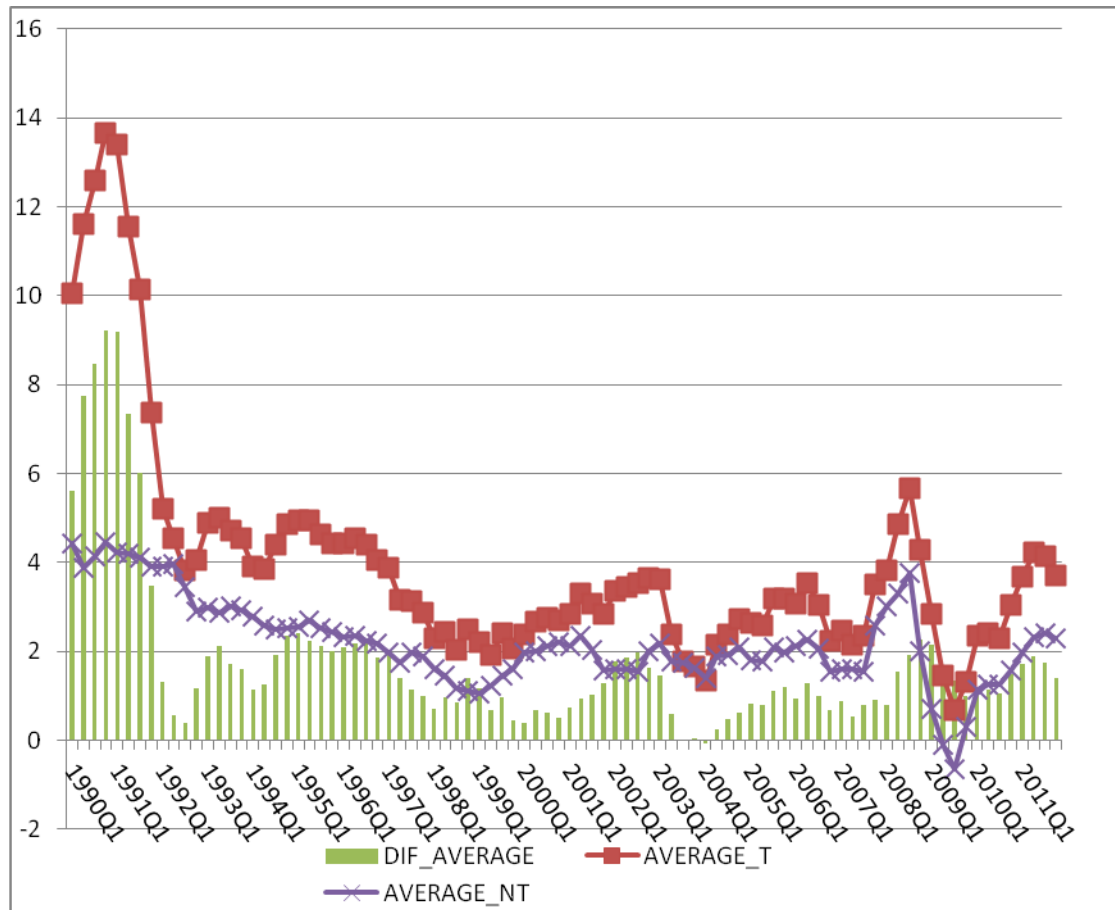
Values of IPS and CIPS panel unit root tests

1-Wide Group					
	<i>Inflation Targeters</i>				
Lag order	<i>k=0</i>	<i>k=1</i>	<i>k=2</i>	<i>k=3</i>	<i>k=4</i>
IPS	-5.660***	-14.390***	-12.912***	-13.293***	-7.457***
CIPS	-3.330***	-3.824***	-3.863***	-3.855***	-2.942***
	<i>Non-Targeters</i>				
Lag order	<i>k=0</i>	<i>k=1</i>	<i>k=2</i>	<i>k=3</i>	<i>k=4</i>
IPS	-8.679***	-13.491***	-14.121***	-15.876***	-8.871***
CIPS	-2.589***	-3.094***	-3.116***	-3.152***	-2.496***
	<i>All</i>				
Lag order	<i>k=0</i>	<i>k=1</i>	<i>k=2</i>	<i>k=3</i>	<i>k=4</i>
IPS	-13.921***	-29.456***	-29.132***	-32.051***	-20.082***
CIPS	-3.300***	-3.794***	-3.861***	-3.783***	-2.945***
2-Narrow Wide					
	<i>Inflation Targeters</i>				
Lag order	<i>k=0</i>	<i>k=1</i>	<i>k=2</i>	<i>k=3</i>	<i>k=4</i>
IPS	-3.883***	-10.123***	-11.779***	-11.688***	-9.303***
CIPS	-4.138***	-4.712***	-4.207***	-4.000***	-2.938***
	<i>Non-Targeters</i>				
Lag order	<i>k=0</i>	<i>k=1</i>	<i>k=2</i>	<i>k=3</i>	<i>k=4</i>
IPS	-5.675***	-7.372***	-7.764***	-9.430***	-4.482***
CIPS	-2.757***	-2.987***	-3.043***	-3.258***	-2.444***
	<i>All</i>				
Lag order	<i>k=0</i>	<i>k=1</i>	<i>k=2</i>	<i>k=3</i>	<i>k=4</i>
IPS	-9.658***	-19.987***	-21.847***	-23.340***	-17.068***
CIPS	-3.678***	-3.982***	-4.127***	-3.982***	-2.877***

Note: Each entry shows the values of the IPS and CIPS test. For the former test inference is based on normal distribution while for the latter Table 2 of Pesaran (2007b) is used.

*** shows rejection at 1% level of significance.

Figure 1
Average Inflation Rates



Source: Authors' calculations.