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Inflation Targeting Evaluation: Short-run Costs and Long-run Irrelevance

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Abstract

Recent studies evaluate the effectiveness of inflation targeting through the average treatment effect and generally conclude the window-dressing view of the monetary policy for industrial countries. This paper argues that the evidence of irrelevance emerges because of a time-varying relationship (treatment effect) between the monetary policy and its effects on economic performance over time. Targeters achieve lower inflation immediately following the adoption of the policy as well as temporarily slower output growth and higher inflation and output growth variability. But these short-run effects will eventually disappear in the long run. This paper finds substantial empirical evidence for the existence of such intertemporal tradeoffs for eight industrial inflation-targeting countries. That is, targeting inflation significantly reduces inflation at the costs of a lower output growth and higher inflation and growth variability in the short-run, but no substantial effects in the medium to the long-run.

Journal of Economic Literature Classification: C23; E52

Keywords: inflation targeting, time-varying treatment effects, short-run costs, long-run irrelevance

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1. Introduction

Monetary economists have evaluated the effectiveness of monetary policy for many years. Recently, more and more central banks have adopted inflation targeting as their monetary policy control mechanism, since New Zealand's adoption of this monetary policy in 1990. Closely related research on central banking falls into many categories, such as optimal central bank contracts (Walsh, 1995a,b) and the independence, credibility, accountability, transparency, and communication of central banks as well as the evaluation of monetary policy strategies (e.g., Faust and Svensson, 2001; Issing, 2005; Fatás *et al*., 2007; Acemoglu *et al*., 2008; Blinder *et al*., 2008; and Svensson, 2009).

Bernanke *et al*. (1999), Truman (2003), Bernanke and Woodford (2005), Mishkin (2007), and Mishkin and Schmidt-Hebbel (2007) provide detailed discussion of how central banks conduct inflation targeting in the world economy and how to improve the framework and institutions of monetary policymaking. Walsh (2009) surveys recent evidence on the effects of inflation targeting on macroeconomic performance. Surprisingly, the empirical literature does not explicitly account for lagged effects of inflation targeting. This omission, we argue, leads to mixed findings and conclusions when evaluating inflation targeting due to long and variable lags in the effects of the monetary policy on future inflation and other economic variables.

Macroeconomists have long known that monetary policy affects prices and the real economy with a lag (e.g., Friedman, 1948, 1961; Goodhart, 2001). In the inflation targeting era, Svensson (1999, 2009) supports flexible inflation targeting, where the central bank strives not only to stabilize inflation around the inflation target but also to stabilize the real economy. A strict inflation targeting regime strives only to stabilize inflation. Time plays a crucial role in a flexible inflation targeting regime. Svensson (1997, 1999) demonstrates theoretically that when policy makers also target output fluctuations, gradual adjustment of the intermediate inflation target to the long-run goal is optimal. Bernanke *et al*. (1999) conclude that "output and employment remain concerns of policy-makers after the switch to inflation targeting can be seen in the fact that all the targeting countries have undertaken disinflation only gradually, to avoid putting undue pressure on the real economy." (p.291). The time necessary for the central bank to achieve its inflation target depends on the weight assigned to output stabilization. Smets (2003) shows in the Euro area that when the society puts equal weight on inflation stabilization and output gap stabilization, the optimal policy horizon for maintaining an inflation target equals 4 years. An increasing weight on output gap implies that the optimal policy horizon becomes longer and the central bank moves more gradually.[1]

Recently, Vega and Winkelried (2005) use the propensity score matching method to evaluate treatment effects of inflation targeting for a sample of 109 countries, including both developed and developing countries, and find that inflation targeting reduces the level and volatility of inflation in inflation-targeting countries. Gonçalves and Salles (2008) and Lin and Ye (2009) discover that inflation-targeting developing countries significantly lower inflation and its variability. Gonçalves and Carvalho (2009) show that inflation targeting OECD countries suffer smaller output losses in terms of sacrifice ratio during the disinflationary period than non-targeting counterparts.

The inflation-targeting policy garners less support in industrial countries, however. Ball and Sheridan (2005) employ cross-section difference-in-difference regressions to examine the treatment effects of inflation targeting in 20 OECD countries, seven of which adopt inflation targeting. They discover that after adopting inflation targeting, the economic performance of

[1] This issue becomes more complicated in today's worldwide economic recession originating in the US subprime mortgage market and the run up in energy and food prices. The inflation targeting countries cannot place too much emphasis on inflation, potentially at the expense of economic recovery.

these countries improves. But, non-targeting countries also experience improvements around the same time. Thus, they argue that better economic performance reflects factors other than the monetary regime and conclude that inflation targeting does not produce a major effect. In other words, inflation targeting is irrelevant.

Dueker and Fisher (2006) provide comparative analysis. They match three inflation-targeting countries (New Zealand, Canada, and the United Kingdom) with three nearby non-inflation-targeting countries (Australia, the United States, and Germany), finding little empirical evidence that an inflation-targeting regime performs better than a non-inflation-targeting regime. Lin and Ye (2007) use matching methods to evaluate the treatment effects (i.e., adopting inflation targeting) on seven industrial countries with fifteen non-inflation targeting industrial countries as the non-treatment group. They show no significant effects on inflation and its variability, arguing the window-dressing view of inflation targeting. Angeriz and Arestis (2008), employing intervention analysis, find lower inflation rates, well-anchored and accurate inflation expectations for both targeting and non-targeting countries. Walsh (2009) uses the same method and sample data as Lin and Ye (2007), finding that inflation targeting does not significantly affect output growth or its variability.

The empirical evidence suggests that inflation targeting does not produce significant changes in economic performance for industrial countries. These studies, however, assess inflation targeting implicitly assuming a constant average treatment effect, or a constant relationship between the monetary policy and its effect on economic performance over time. More specifically, the method of analysis assumes that inflation targeting immediately changes inflation and other macroeconomic variables and that such effects are full and permanent. No delayed response exists.

Time lags in the effect of monetary policy generally imply different treatment effects at different times after policy adoption. Misspecification of the treatment effects will occur when we specify them as instantaneous and constant. Laporte and Windmeijer (2005) demonstrate that different estimations lead to different estimates of treatment effects, when such effects, in fact, vary over time. Also, De Loecker (2007) reports that exporters become more productive relative to their pre-export level of productivity *vis-à-vis* their domestic counterparts. Moreover, although the productivity does not grow significantly faster year to year upon entering the export market, the cumulative productivity does increase significantly for exporters over the years following the export activity.

Long-run inflation targeting provides the background for short-run adjustments. This paper focuses on the economic performance of inflation targeting in eight industrial countries, addressing time-varying treatment effects or relationships between inflation targeting and measures of macroeconomic performance over time, while twelve non-inflation targeting major industrial economies in the OECD constitute the non-treated control group used in propensity scoring exercise. We report significant evidence that inflation targeting does lower inflation rates for the targeting countries in the short run. The effects occur after the year of adopting inflation targeting and decay gradually. Policy evaluation that ignores the dynamics of the inflation process concludes that inflation targeting does not affect macroeconomic performance and is, thus, irrelevant. No free lunch exists, however. Short-run costs emerge in reduced output growth as well as increased inflation and output growth variabilities. The rest of the paper is organized as follows. Section 2 presents the sample matching techniques and demonstrates how to evaluate inflation targeting policy over time. Section 3 discusses the data and performs some preliminary analyses. Section 4 reports the dynamic treatment effects. Section 5 concludes.

2. Treatment effect, matching, and propensity score

This study evaluates inflation targeting through the treatment effects on the level and variability of inflation and output growth. Consider the average treatment effect on the treated (*ATT)* of inflation targeting that depends on the following equation:

$$ATT = E[Y_{i1} | D_i = 1] - E[Y_{i0} | D_i = 1], \quad (1)$$

where D_i is the 0-1 binary dummy variable for the treatment under consideration. That is, $D_i = 1$ denotes the treatment state or country i adopts inflation targeting while $D_i = 0$ denotes the non-treatment state or country i does not adopt inflation targeting. Thus, $(Y_{i1} | D_i = 1)$ equals the value of the outcome (e.g., the inflation rate) actually observed in the inflation targeting country and $(Y_{i0} | D_i = 1)$ equals the counterfactual outcome that would occurred, if the targeting country did not adopt the policy. Two issues arise in this equation. First, we cannot observe the second term in the *ATT*. We do not know the inflation rate of the inflation-targeting country, absent such a policy. Second, the first term assumes implicitly that once the binary variable switches from 0 to 1, the inflation rate adjusts instantaneously and remains constant thereafter. No room exists for a lag effect when implementing the targeting policy or for differing magnitudes of effects over time.

The existing literature developed the propensity score matching methods to address the first issue. Caliendo and Kopeinig (2008) provide an excellent review and practical guide for implementing the matching estimator. Most macroeconomic data do not come from randomized trials, but from observational studies. The matching method chooses a non-targeting control group of countries to mimic a randomized experiment to reduce the bias in the estimation of the treatment effects with observational data sets.

Logically, we can replace $E[Y_{i0} | D_i = 1]$ with $E[Y_{i0} | D_i = 0, X_i]$, which is observable. We assume conditional independence assumption, which requires that the i[th] country's outcome (the inflation rate, Y_{i1} or Y_{i0}) does not depend on the targeting policy chosen (i.e., the targeting dummy) conditional on a set of explanatory variables (X_i). In practice, however, the curse of dimensionality always exists. Too many covariates in *X* make the matching method difficult to apply. Rosenbaum and Rubin (1983) propose probit (or logit) models to estimate propensity scores in the binary dummy variable. The propensity scores measure the probabilities that countries *i* and *j* adopt inflation targeting policy, given *X*, to match the targeting countries and control (non-targeting) countries. In the selection process, we require that the common support condition, $P(D = 1 | X) < 1$, holds to ensure that analogous non-treatment units exist to compare with the treated ones. Becker and Ichino (2002) and Caliendo and Kopeinig (2008) suggest a test of the balancing condition in data. The condition holds when observations from the treated and non-treated units with the same propensity score exhibit the same characteristics of distribution, such as their mean values. Failure to pass the test indicates misspecification in the propensity score model.

Using propensity score matching, we estimate the *ATT* of equation (1) as follows:

$$ATT = \frac{1}{N_T} \sum_{i \in T \cap S_p} \left[Y_i - \sum_{j \in C} w(P_i, P_j) Y_j \right], \qquad (2)$$

where P_i and P_j equal the predicted probabilities of adopting inflation targeting for countries *i* (in the targeting group *T*) and *j* (in the control group *C*), respectively. N_T equals the number of treated countries in the set $T \cap S_p$. S_p is the region of common support. We construct the match for each treated unit $i \in T \cap S_p$ as a weighted average of the outcomes of non-treated countries, where $w(p_i, p_j)$ is the weight function.

The second issue motivates the estimation of the *ATT* of inflation targeting at and after the year of adoption to capture its time-varying effects. Following De Loecker (2007), we modify equation (2) to implement dynamic specifications as follows:

$$ATT^{t} = \frac{1}{N_T} \sum_{i \in T \cap S_p} \left[Y_{it} - \sum_{j \in C} w(P_i, P_j) Y_{jt} \right], \tag{3}$$

where t equals 0, 1, 2, 3, 4, denoting the adopting year (t=0) and four years after (t=1…4).[2]

We also estimate the treatment effect in a period from the adopting year to the fourth year or from any year (τ) since the policy adoption to the end of our sample (*H*) as follows:

$$ATT_{\tau}^{H} = \frac{1}{N_T} \sum_{i \in T \cap S_p} \left[\sum_{\tau}^{H} Y_{it} - \sum_{\tau}^{H} \sum_{j \in C} w(P_i, P_j) Y_{jt} \right]. \tag{4}$$

This estimator provides a cumulative effect of inflation targeting in a short-run or a medium to the long-run time frame.

Different matching algorithms produce different weights for the matching estimator and, thus, different results for the *ATT*. We apply four commonly used matching methods -- nearest neighbor matching, caliper matching, kernel matching, and local-linear matching techniques, programmed by Leuven and Sianesi (2003), to obtain results. Caliendo and Kopeinig (2008) provide detailed discussion for the four matching methods. Generally, the nearest neighbor matching algorithm finds for each treated unit, the non-treated group match with the closest propensity score. We implement this method with replacement, considering a single nearest-neighbor as well as the three nearest-neighbors. The caliper matching algorithm selects the nearest-neighbor within a caliper of width, *r*, and imposes a tolerance level on the maximum

[2] The selection of the lag length seems somewhat arbitrary, since we do not know exactly the weight the targeting countries put on inflation stabilization or other objectives. Smets (2003) shows that the optimal policy horizon equals four years when inflation and output stabilization receive equal weights.

distance between the propensity score of the treated and the non-treated units. We consider three tolerance levels as r=0.03, 0.01, and 0.005, followed by Lin and Ye (2007). The kernel matching algorithm, a non-parametric estimator, matches a treated unit with a kernel weighted average in proportion to its proximity to the treated one of all the non-treated units. The local-linear matching algorithm involves a non-parametric regression on a constant and the propensity score. In each of the cases, we use 1,000 bootstrap replications to obtain the standard errors of the matching estimator.

3. Data and preliminary analysis

3.1. Data description

We use annual observations from 20 OECD countries over the years 1985 to 2007, including eight inflation-targeting countries – Australia, Canada, Iceland, New Zealand, Norway, Sweden, Switzerland, and the United Kingdom -- and twelve non-inflation-targeting countries.[3] Table 1 lists the targeting countries, their policy adoption years and targets, as well as the twelve control countries.[4] The numerical inflation target typically reflects an annual rate for the consumer price index (CPI) in the form of a range, such as one to three percent (e.g., New Zealand and Canada). Alternatively, the inflation rate target equals a point target with a range, such as a two-percent target plus or minus one percent (e.g., Sweden) or a point target without any explicit range, such as a two-percent target (e.g., the United Kingdom). All targets range between zero and three percent. The performance outcome variables include the levels and variabilities of the inflation

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[3] To limit the variability of economic environments for policy evaluation, we exclude ten OECD member countries form our sample. We exclude seven emerging market countries – the Czech Republic, Hungary, Korea, Mexico, Poland, Slovak Republic, and Turkey -- that adopted inflation targeting through 2006 (see Rose 2007). We also exclude Finland and Spain, even though they adopted inflation targeting in 1993 and 1995. They both adopted the Euro in 1999. Finally, we exclude Luxembourg due to its lack of an independent currency before the euro (see Ball and Sheridan 2005).

[4] The adoption years and targets of the inflation targeting countries come from International Monetary Fund (2005). The sample also confines the analysis generally to the period called the Great Moderation.

and output growth rates. The inflation rate equals the annual percent change of the CPI, while inflation variability equals the three-year moving-average standard deviation. The output growth rate equals the annual growth rate of 2000 base-year constant-price GDP, and output growth variability equals the three-year moving-average standard deviation. Each of the data sets contains 460 observations, of which 103 belong to the treated group and 357 belong to the non-treated group. We take the data for inflation rates and output growth rates from the International Monetary Fund *World Economic Outlook* Database.

Table 2 presents performance of inflation and output growth for the full-sample, the target-adoption year, and pre- and post-inflation targeting (IT) periods for the targeters and the non-targeters as well as the t-statistics testing for equal means between samples. Since no natural break point exists to split the observations of the non-targeting group, we follow Ball and Sheridan (2005) and use the average adoption year of our targeting countries, which is 1995, to split the sample into pre-1995 and post-1995 period to serve as a comparison. Generally, targeters experienced lower inflation, lower inflation variability, higher output growth, and lower growth variability than they did prior to the policy adoption. Comparing columns 2 and 4 in Panel A for targeters, the average inflation rate equals 5.94 percent in the pre-IT period and falls to 2.04 percent in the post-IT period, which falls below the upper inflation target bound of 3 percent in Table 1. The decline in average inflation equals 3.90 percent. The t-statistic (=5.9820) testing for equality of the pre- and post-IT inflation means suggests a significant decline at the 1-percent level (column 3 of Panel B). The other outcomes, the moderation in variability is significant at the 1- and 5-percent levels for inflation and output growth, respectively, and the output growth rate increases significantly at the 5-percent level. The treatment effect assesses how much change we can attribute to the adoption of inflation targeting.

This improvement in macroeconomic performance, however, also appears in the data for the non-inflation-targeting countries, as first noted by Ball and Sheridan (2005). In Table 2, the non-targeters of the industrial countries also experienced significant declines in the inflation rate, inflation and output growth rate variabilities after 1995, and an insignificant increase in the output growth rate.

Comparing targeters and non-targeters indicates that across the four outcomes of economic performance, the non-inflation-targeting countries generally perform better, or, at least, not worse than the targeters. For the full sample, non-targeters exhibit lower inflation and output growth rates and their variabilities, although only the two variability measures are significantly lower. For the pre-inflation targeting (1995) sample, non-targeters achieve higher output growth , although not significantly higher. The other three performance measures show lower values for the non-targeters, but only significantly lower for inflation rate variability. Finally, in the post-inflation targeting (1995) sample, the non-targeters exhibit significantly lower output growth rate and inflation rate and output growth rate variabilities. Now, targeters experience a lower inflation rate, but not significantly lower.

Note that the inflation-targeting countries experience a high mean inflation rate (=4.2352) in the adoption year for inflation targeting. First, Walsh (2009) argues that the OECD industrial countries who adopt inflation targeting do so because they cannot match the inflation improvements of other OECD industrial countries. The inflation difference between the two groups appears pronounced in the adoption year of inflation targeting. The mean inflation rate among the targeters drops substantially from 4.2352 of the year of adoption to 2.0352 in the post-IT period, and to below the 2.1274 value over the period after 1995 of the non-targeters. Second, the 3-percent upper bound of the inflation targets reported in Table 1 importantly falls below the actual mean inflation rate of 4.2352 in the policy adoption year. That is, the timing of monetary policy effects may confound the results of prior studies. This study focuses on the dynamic features of the treatment effect to shed light on the effect of inflation targeting on inflation and output processes over time.

Figure 1 presents inflation trajectories for targeters and non-targeters to illustrate the intuition behind our evaluation of the targeting policy. The horizontal axis captures a rescaled time line, where t_0 equals the year that the countries adopt inflation targeting and equals 1995 for the non-inflation-targeters. The vertical axis measures the mean inflation rate for the two groups. The policy evaluation deals on the right side of the vertical line (at t_0) and asks whether countries become less inflationary after adopting inflation targeting. This Figure provides some evidence of better performance by inflation-targeting countries in the targeters: the mean inflation rate of the countries that start inflation targeting decreases, but only in the year after adopting inflation targeting. In the adoption year, the mean inflation rate actually increases for these inflation-targeting countries. Moreover, the non-inflation-targeting countries experience a continual decline in the inflation rate over the years. Figures 2 to 4 plot trajectories of inflation variability, output growth and its variability for the targeters and non-targeters. Inflation variability in targeting countries exceeds that in non-targeting countries, not only in the adoption year, but also in subsequent years. Targeting countries experience a catch-up effect in output growth rates to non-targeting countries and experience a higher output growth rate variability. We check whether our dynamic *ATT* estimates confirm these graphical inspections.

3.2. Preliminary analysis

We perform preliminary analyses to compare our findings to those in the existing literature that do not consider the timing issues. That is, using equation (2), we find that inflation targeting exhibits no significant treatment effects on the inflation and output growth rates and their variabilities. Following Lin and Ye (2007) and Walsh (2009), the first-stage probit regression that generate the propensity score matches includes lagged values of the inflation rate, the real GDP growth rate, the government budget surplus as a percentage of GDP, openness measured by exports plus imports as a percentage of GDP, and a dummy for a fixed exchange rate regime.[5] The dependent variable takes on the value 1 in the year in which inflation targeting is adopted.

Table 3 reports probit estimates of propensity scores. All coefficients are significant at least at the 10-percent level and with reasonable signs. These signs conform to the theoretical thinking in the exiting literature as follow. First, Truman (2003) argues that the central bank fear of losing public credibility causes them to adopt inflation targeting only with low inflation rates, which makes the targeted inflation rates easier to reach and/or maintain. Lin and Ye (2007) find that the lagged inflation rate negatively correlates with the probability of adopting inflation targeting for seven industrial countries. Second, a country experiencing rapid economic growth may accept its economic performance and, therefore, may see no need to switch to a monetary framework of inflation targeting. Third, a strong fiscal position enhances the probability of adopting inflation targeting. That is, when the central bank must finance a large fiscal deficit, inflation targeting becomes problematic. Fourth, greater openness to trade reduces the vulnerability of economies to external disturbances. Consequently such countries can more easily adopt inflation targeting along with a floating exchange rate regime. That is, a floating exchange rate regime provides the flexibility for monetary policy to adopt inflation targeting.[6]

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[5] We use the exchange rate classification proposed by Reinhart and Rogoff (2004) and Ilzetzki, Reinhart and Rogoff (2008). They classify exchange rate regimes into six categories – de facto peg, de facto crawling peg, managed floating, freely floating, freely falling, and dual market. Following Lin and Ye (2007), we consider the first two categories as fixed exchange rate regimes.

[6] When examining the data, we find that the targeting countries generally exhibit better fiscal positions, higher openness, and more flexible exchange rate regimes than the non-targeting countries.

This probit regression achieves a reasonable overall fit with pseudo-R^2 of 0.29. The common support region shows that the estimated propensity scores fall between 0.0199 and 0.8575 among the treated units. We exclude 66 out of 357 control units whose estimated propensity scores fall below the lowest score of 0.0199 to assure that our treated and control units share the same support. This leaves 291 units to conduct matching and the *ATT* estimates. Finally, following the algorithm proposed by Becker and Ichino (2002), we verify that our data conform to the balancing property. That is, in each of the five equally spaced blocks of propensity scores, the average propensity scores of the treated and control units as well as the means of each of our five covariates used in the probit model do not differ significantly between the two groups.

Table 4 reports the estimated *ATT*s of equation (2) on inflation and output growth in both level and variability. Each column in the Table uses a different matching method. Consistent with the findings of Lin and Ye (2007) and Walsh (2009), the estimation results suggest that inflation targeting does not significantly affect the inflation and output growth rates or their variabilities, except the *ATT* on output growth at the 10-percent level when using the radius matching at r = 0.005. Although we use different inflation targeting sample countries and a much longer sample period, generally, the magnitudes and signs of the treatment effect on inflation and its variability closely approximates the estimates in Lin and Ye (2007) and the positive *ATT* estimates of output growth and its variability closely approximate those in Walsh (2009).[7] Different industrial targeting countries and sample periods do not influence much of the *ATT*s under different

[7] Both Lin and Ye (2007) and Walsh (2009) evaluate the treatment effect of inflation targeting in seven industrial countries – Australia, Canada, Finland, New Zealand, Spain, Sweden, and United Kingdom, that adopted this policy in the 1990s for the years 1985-1999. As noted in Footnote 3, Finland and Spain adopted inflation targeting in 1993 and 1995, respectively, and both adopted Euro in 1999. We replace the two countries with Iceland, Norway, and Switzerland, who adopted inflation targeting in the early 2000s (see Table 1). We evaluate the treatment effect of inflation targeting in eight industrial countries over a much longer period 1985-2007.

matching methods and the view of window-dressing of inflation targeting.

The ineffectiveness of inflation targeting generally reflects a long-run average effect. This paper considers whether future inflation and output growth (and their trajectories) change right after adopting the inflation target. Our methodology examines short-run and medium to long-run effects of this monetary strategy. The next section presents the estimation results of the *ATT* for inflation and output growth in level and variability, using the dynamic specifications of equations (3) and (4).

4. Dynamic treatment effects of inflation targeting

Table 5 presents five-period *ATT* estimates from the adoption year (ATT_0) to the fourth year (ATT_4) after the adoption, reflecting how inflation targeting might affect inflation, inflation variability, output growth, and growth variability with lagged short-run effects under the seven different matching algorithms. The results are consistent and robust.

For the treatment effect on inflation, we expect a lower inflation rate. Inflation targeting, however, actually increases the inflation rate significantly in the adoption year. Each of the estimated ATT_0*s* across the seven matching methods generates a positive effect with the average equal to 1.45 percent in terms of the annual inflation rate. A significant negative effect on the inflation rate emerges generally at the 5-percent level in the first year after adoption. The estimated ATT_1*s* range from -0.54% to -1.33%. Targeting countries become, on average, -0.85 percent less inflationary the first year after they adopt inflation targeting. The inflation gap shrinks in the second year and widens in the third year, although none of these effects are significant. After three years of adoption, the ATT_4 becomes volatile across different matching methods. All effects are negative after the adoption year, but only the first-year effects are significantly negative. The evidence from matching suggests that inflation targeting lowers inflation starting the first year after the policy adoption.

The treatment effects on inflation variability exhibit a different story from the inflation rate. In the adoption year, the estimated *ATT_0s* deliver positive, but insignificant, values. That is, the treatment does not lower the inflation rate variability. More than this, in the first year after adoption, the magnitude of the coefficient, ATT_1, increases consistently and significantly in the seven matching methods. A robust and narrow range of the seven estimates falls between 0.6073 and 0.6899. In addition, in the second year after adoption, the inflation variability gap (ATT_2) becomes even larger in magnitude and more significant.[8] In the third and the fourth year, the estimated *ATT*s (ATT_3 and ATT_4) fall to small levels quantitatively, nearly half negative, although none prove significant. Thus, no beneficial effect of inflation targeting emerges for inflation rate variability.

Conceptually, under an inflation targeting framework, the central bank places increased weight on inflation stabilization and reduces its concern for maintaining real economic stability. Thus, a trade-off occurs between the inflation and output growth rates, or the output cost of lowering inflation, particularly, in the short-run. Hutchison and Walsh (1998) find that the short-run trade-off in New Zealand started to rise in the early 1990s around the time of the central bank reform. Once the central bank's disinflationary policy obtains credibility, however, it may receive a credibility bonus that should reduce the output cost of lowing inflation. Goncaives and Carvalho (2009) show that inflation targeters suffer smaller output losses during disinflations when compared to non-targeters. In an early study, Barro (1995) finds that an increase in the annual inflation rate significantly associates with a decline in the annual growth rate of GDP for around 100 countries.

[8] A one-year significant decline in the mean inflation rate can generate a multiple-year increase in inflation rate variability, when the measure of variability equals a three-year moving average. Note that the story on output growth rate variability differs.

We follow the same procedures to evaluate the treatment effect on output growth. In the adoption year (ATT_0), the output growth rate falls, although insignificantly, compared to the pre-targeting level (-1.30 percent, on average, across different matching techniques). Targeters experience significantly lower output growth in the first year after adoption (ATT_1 = -1.43 percent, on average). The credibility bonus emerges in the second year after adoption, where the output growth rate falls (-0.39 percent, on average), but the decrease is insignificant. The targeters enjoy higher output growth in the third and fourth years after adoption, although these effects are also insignificant.

Conventional thinking of the Phillips-curve tradeoff between the inflation rate and the output gap focuses on levels. Taylor (1994) argues that the policy tradeoff more appropriately relates to a tradeoff between the variabilities of the output growth and inflation rates. Fuhrer (1997) demonstrates that the short-run tradeoff between the inflation and output growth rates implies a long-run tradeoff between their variabilities. The optimal monetary policy (that minimizes variability of the central bank's targets of the level of inflation and the level of real output relative to potential) implies dramatic increases in the output growth rate variability, when policy attempts to make the inflation rate variability too small. His empirical results suggest that balanced responses to inflation and output are consistent with balanced preferences over inflation and output variability. Cecchetti and Ehrmann (1999) observe that while the variability of inflation falls more in the inflation targeting countries than in the non-targeters, output variability falls far less in the former than in the latter. When the targeting countries increase their revealed aversion of inflation variability, they suffer increases in output volatility. Erceg (2002) argues that inflation targeting reflects the perceived monetary policy frontier of the economy, the policymaker's tradeoff between the volatilities of inflation and real activity. Adopting a narrow inflation target range may induce considerable volatility in real activity. Arestis *et al*. (2002) report mixed evidence for individual targeting countries. The adoption of inflation targets results in a more favorable monetary policy tradeoff in New Zealand, the UK, and Sweden, meaning a substantial decrease in the output gap volatility for a given inflation volatility. No change occurs in Canada, and a decrease in the inflation rate variability accompanied by an increase in output gap volatility across Australia and Finland. When the authors compare the ratio of output gap volatility to inflation volatility between inflation-targeting and non-inflation-targeting countries, the ratio in the non-inflation-targeting countries exceeds that in the inflation-targeting countries.

In the adoption year, the effects of inflation targeting on output growth variability are trivial (-0.05, on average), either positive or negative, and insignificant. The variability increases sharply in the next two years after inflation targeting begins. All ATT_1 are significant, ranging from 0.5360 to 0.7226, and the average effect across different matching techniques equals 0.63 percent. The variability becomes even larger at the second year after the policy adoption. The ATT_2 estimates range from 0.6334 to 1.0967 and prove significant and averages 0.81 percent, an obvious cost of targeting inflation. In the third and fourth years after adoption, we find positive, but insignificant, effects

Table 6 reports cumulative treatment effects of inflation targeting, where $\sum_0^t \mathrm{ATT}$, *t=1. 2, 3, 4,* equals a cumulative treatment effect taking the t-year period from the adoption year to the t^{th} year, and $\sum_5^H \mathrm{ATT}$ equals the cumulative effect of a longer period from the fifth year to the end of our sample.

The cumulative treatment effect on inflation becomes negative across the seven matching methods after we accumulate across the adoption year and the first two years after adoption (i.e., $\sum_0^2 \mathrm{ATT}$) and eventually becomes positive in some cases at the end of our sample (i.e., $\sum_5^H \mathbf{ATT}$).

No significant effect of inflation targeting on inflation occurs in either the short run or the medium to long term. In contrast, the cost of inflation targeting emerges significantly in higher inflation variability, lower output growth, and higher growth variability in the short-run. Cumulative output growth becomes positive and the inflation rate and output growth rate variability generally become negative in the medium to long term. These effects are not significant, however. The long-run treatment effects in Table 4 imply only one weakly significant effect, significantly higher output growth at the 10-percent level with the smallest radius matching technique.

We plot the short-run cumulative trajectory for the inflation and output growth rates in Figure 5 and for the inflation and output growth rate variabilities in Figure 6. We can see clearly in Figure 5 that inflation-targeting countries experience lower inflation rates than their matched counterparts that do not adopt inflation targeting, beginning in the second year after adoption of inflation targeting. Targeters experience a lower level of output growth in the early year of inflation targeting relative to non-targeters. The targeters gradually catch up, nearly matching non-targeters in the fourth year after adoption. Figure 6 shows that targeters exhibit a higher inflation variability gap with respect to their counterparts, increasing until the second year and decreasing after the second year. The output growth variability gap increases at a decreasing rate, since the adoption year. In sum, adopting inflation targeting lead to higher inflation and output growth variabilities as well as lower output growth, and does not lead to lower inflation in the short run. No gain, but pain. In the long run, we see no significant differences in the economic performances of the targeter and non-targeters. Lastly, our *ATT* estimates shown in Figures 5 and 6 match closely with the prior inspections in Figures 1 to 4 for the four outcomes, suggesting that our econometric specifications used to evaluate inflation targeting are appropriately modeled.

Several reasons may explain why other studies do not find significant effects of inflation targeting on inflation and its variability or output and its variability. First, different time horizons may explain different findings. For example, Lin and Ye (2007) and Walsh (2009) use long-period (15 years from 1985 to 1999) data evaluating inflation targeting and find no significant effects for the industrial countries in the OECD. We report the same in Table 4 over an even longer period (23 years from 1985 to 2007). Our methodology also checks whether the outcome trajectory differ in a short period of 4 years following the adoption of inflation targeting for eight industrial countries in the OECD. Considering the lagged effects of this monetary policy, we show that for targeters, the inflation gain, output growth loss, and the inflation and output growth rate variabilities increases come in the years after the initial targeting (see Tables 5 and 6 as well as Figures 5 and 6), suggesting that the effects of inflation targeting are short-lived. The evidence shows the importance of considering the timing of the performance outcomes, not just the overall result, when evaluating inflation targeting.

Second, the specific countries examined influence the outcomes. For example, Ball and Sheridan (2005), Lin and Ye (2007), and Walsh (2009) show that the available evidence for a group of developed countries does not support the view that adopting inflation targeting brings the inflation rate and its variability down or affect the output growth rate and its variability. Using the same econometric methods, Goncalves and Salles (2008) and Lin and Ye (2009) find that developing countries that adopt inflation targeting significantly lower both the inflation rate and its variability. The differences between developed and developing countries relate to motivation. If the motivation aims at reducing a high inflation rate, then inflation targeting lowers inflation, as argued by Neumann and von Hagen (2002) and Mishkin and Schmidt-Hebbel (2007). This may explain the motivation of developing countries – adopting policy to achieve real results of lower inflation. If the monetary authorities choose inflation targeting to maintain their already low inflation rates or to converge to a lower rate, rather than to squeeze high inflation rates down, then we will not observe significant effects from the adoption of inflation targeting. This may capture the motivation of developed countries. Truman (2003) argues that because central banks cherish their public credibility, they may only adopt inflation targeting when inflation rates are low, which makes the targeted inflation rate easier to reach and/or maintain. Thus, studies that use developing countries, which usually experience high inflation rates, find significant negative effects on the inflation rate and its variability. In contrast, studies that examine developed countries, which usually experience low inflation rates, find no significant effects as shown in Table 4 in this study.

5. Conclusion

This paper evaluates inflation targeting through dynamic treatment effects for eight industrial countries -- Australia, Canada, Iceland, New Zealand, Norway, Sweden, Switzerland, and the United Kingdom during the period 1985 to 2007. We begin by considering the average effects, if any, of inflation targeting on the inflation and output growth rates and their variabilities in our longer sample period. Our initial results, based on the treatment effect on the treated, generally find no significant effects of inflation targeting on the four macroeconomic performance measures. Subsequent analysis reveals that this conclusion does not prove robust to short-run specifications of the treatment effect. We find that, at the early stage of the monetary policy, the treatment effects exhibit time-varying and significant outcomes at different times for different outcomes. This result demonstrates the misspecification (misinterpretation or information missed) of the treatment estimates, if researchers neglect the dynamic adjustment process in the early years following the policy adoption.

Our dynamic treatment effect leads to different results with respect to how the policy of inflation targeting affects the inflation and output growth rates and their variabilities. That is, we find significant effects on each of the four variables, differing from those findings of previous studies. The treatment effect of inflation targeting on inflation is significantly positive in the inflation targeting adoption year. Thus, the policy exhibits a reverse effect when adopted. The significant negative effect emerges only in the first year after the adoption year. Thus, a one-year time lag exists in experiencing the benefits of this monetary policy. No free lunch exists, however. The treatment effect on output growth is significantly negative in the first year after policy adoption. Moreover, both the inflation and output growth rate variabilities are significantly higher in the next two years after the policy adoption. Apparently, to lower the inflation rate, the policy must accept the costs of a lower output growth rate in addition to higher inflation and output growth rate variabilities in the short run.

Our results require careful interpretation. The evidence that inflation targeting worsened the output growth rate as well as the inflation and output growth rate variabilities, as most critics of inflation targeting stress, tells only the short-run costs of inflation targeting. The critics concerns do not materialize in the long-run.

References:

Acemoglu, D., Johnson, S., Querubin, P., and Robinson, J. A., (2008) "When does policy reform work? The case of central bank independence," *Brookings Papers on Economic Activity*, 351-417.

Angeriz, A. and Arestis, P. (2008) "Assessing inflation targeting through intervention analysis," *Oxford Economic Papers* 60, 293-317.

Arestis, P., Caporale, G. M., and Cipollini, A. (2002) "Does inflation targeting affect the trade-off between output gap and inflation variability," *Manchester School* 70(4), 528-545.

Ball, L. and Sheridan, N. (2005) "Does inflation targeting matter?" in Ben S. Bernanke and Michael Woodford (eds), *The Inflation Targeting Debate*, Chicago: University of Chicago Press, 2005, 249-276.

Barro, R. J., 1995. Inflation and economic growth. *Bank of England Quarterly Bulletin*, May, 166-176.

Becker, S. O. and Ichino, A. (2002) "Estimation of average treatment effects based on propensity scores," *Stata Journal* 2, 358-377.

Bernanke, B.S. and Woodford, M. (2005) *The Inflation Targeting Debate*, Chicago: University of Chicago Press.

Bernanke, B.S., Laubach, T., Mishkin, F.S. and Posen, A. (1999) *Inflation Targeting: Lessons from the International Experience*, Princeton University Press: Princeton.

Blinder, A. S., Ehrmann, M., Fratzscher, M., Haan, J., and Jansen, D. (2008) "Central bank communication and monetary policy: A survey of theory and evidence," *Journal of Economic Literature* 46(4), 910-945.

Caliendo, M. and Kopeinig, S. (2008) “Some practical guidance for the implementation of propensity score matching,” *Journal of Economic Surveys* 22, 31-72.

Cecchetti, S. C. and Ehrmann, M. (1999) “Does inflation targeting increase output volatility? An international comparison of policymakers’ preferences and outcomes,” *National Bureau of Economic Research Working Paper 7426.*

De Loecker, J. (2007) “Do exports generate higher productivity? Evidence from Slovenia,” *Journal of International Economics* 73, 69-98.

Dueker, M. J. and Fischer, A. M. (2006) “Do inflation targeters outperform non-targeters?” Federal Reserve Bank of St. Louis *Review* 88(5), 431-450.

Erceg, C. J. (2002) “ The choice of an inflation target range in a small open economy,” *American Economic Review Papers and Proceedings* 92(2), 85-89.

Fatás, A., Mihov, I., and Rose, A. K., (2007) “Quantitative goals for monetary policy,” *Journal of Money, Credit and Banking* 39, 1163-1176.

Faust, J. and Svensson, L. E. O. (2001) “Transparency and credibility: Monetary policy with unobserved goals,” *International Economic Review* 42(2), 369-397.

Friedman, M. (1948) “A monetary and fiscal framework for economic stability,” *American Economic Review* 38(3), 245-264.

Friedman, M. (1961) “The lag in effect of monetary policy,” *Journal of Political Economy* 69(5), 447-466.

Fuhrer, J. C. (1997) “Inflation/output variance trade-offs and optimal monetary policy,” *Journal of Money, Credit and Banking* 29(2), 214-234.

Goncalves, C. E. S., and Salles, J. M. (2008) “Inflation targeting in emerging economies: What do the data say?” *Journal of Development Economics* 85, 312-318.

Gonçalves, C. and Carvalho, A. (2009) "Inflation targeting matters: Evidence from OECD economics' sacrifice ratios," *Journal of Money, Credit and Banking* 41, 233-243.

Goodhart, C. A. E. (2001) "Monetary transmission lags and the formulation of the policy decision on interest rates," Federal Reserve Bank of St. Louis *Review* 83(4), 165-181.

Hutchison, M. M. and Walsh, C. E. (1998) "The output-inflation tradeoff and central bank reform: Evidence from New Zealand," *Economic Journal* 108, 703-725.

Ilzetzki, E., Reinhart, C., and Rogoff, K. (2008) "Exchange rate arrangements entering the 21st century: Which anchor will hold?" manuscript.

International Monetary Fund, 2005. Does inflation targeting work in emerging markets? IMF *World Economic Outlook*. Washington D.C.: International Monetary Fund.

Issing, O. (2005) "Communication, transparency, accountability: Monetary policy in the twenty-first century," Federal Reserve Bank of St. Louis *Review* 87(2), 65-83.

Laporte, A. and Windmeijer, F. (2005) "Estimation of panel data models with binary indicators when treatment effects are not constant over time," *Economics Letters* 88, 389-396.

Leuven, E. and Sianesi, B. (2003) PSMATCH2: Stata module to perform full Mahalanobis and propensity score matching, common support graphing, and covariate imbalance testing. http://ideas.repec.org/c/boc/bocode/s432001.html Version 3.0.0.

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 really make a difference in developing countries," *Journal of Development Economics* 89, 118-123.

Mishkin, F.S. (2007) *Monetary Policy Strategy*, The MIT Press, Cambridge, Massachusetts.

Mishkin, F.S. and Schmist-Hebbel, K. (2007) *Monetary Policy under Inflation Targeting*, Banco Central de Chile.

Neumann, M. J. M. and von Hagen, J. (2002) "Does inflation targeting matter?" The Federal Reserve Bank of St. Louis *Review* 84, 127-148.

Reinhart, C. and Rogoff, K. (2004) "The modern history of exchange arrangements: A reinterpretation," *Quarterly Journal of Economics* 119, 1-48.

Rose, A. K. (2007) "A stable international monetary system emerges: Inflation targeting is Bretton woods, reversed," *Journal of International Money and Finance* 26, 663-681.

Rosenbaum, P. and Rubin D. (1983) "The central role of the propensity score in observational studies for causal effects," *Biomertrika* 70, 41-50.

Smets, F. (2003) "Maintaining price stability: low long is the medium term?" *Journal of Monetary Economics* 50, 1293-1309.

Svensson, L. E. O. (1997) "Inflation forecast targeting: Implementing and monitoring inflation targets," *European Economic Review* 41, 1111-1146.

Svensson, L. E. O. (1999) "Inflation targeting: Some extensions," *Scandinavian Journal of Economics* 101, 337-361.

Svensson, L. E. O. (2009) "Transparency under flexible inflation targeting: Experience and challenges," *Sveriges Riksbank Economic Review* 1, 5-44.

Taylor, J. B. (1994) "The inflation-output variability trade-off revisited," In *Goals, Guidelines, and Constrains Facing Monetary Policymakers,* Federal Reserve Bank of Boston Conference Series No. 38, 21-38.

Truman, E. (2003) *Inflation Targeting in the World Economy*, Washington, District of Columbia: Institute for International Economics.

Vega, M. and Winkelried, D. (2005) “Inflation targeting and inflation behavior: A successful story?” *International Journal of Central Banking* 1, 153-175.

Walsh, C. E. (1995a) “Optimal contracts for independent central banker,” *American Economic Review* 85, 150-167.

Walsh, C. E. (1995b) “Is New Zealand’s Reserve Bank Act of 1989 an optimal central bank contract?” *Journal of Money, Credit and Banking* 27, 1179-1191.

Walsh, C. E. (2009) “Inflation targeting: What have we learned?” *International Finance*, forthcoming.

Table 1: Inflation targeting countries and control countries

Targeting countries	Adoption year*	Inflation target (percent)
Australia	1993	2-3
Canada	1991	1-3
Iceland	2001	2.5
New Zealand	1990	1-3
Norway	2001	2.5
Sweden	1993	2(+/-1)
Switzerland	2000	<2
United Kingdom	1992	2
Control countries		
Austria	Germany	Japan
Belgium	Greece	Netherlands
Denmark	Ireland	Portugal
France	Italy	United States

* This year indicates when countries de facto adopted inflation targeting. Official adoption dates may vary.

Table 2. Economic performance of targeters (IT) and non-targeters(NIT), 1985-2007

Panel A. Mean values of inflation, output growth, and variability

	Targeters			
	Full sample	**Pre-IT**	**Adoption year**	**Post-IT**
Inflation	3.8481	5.9361	4.2352	2.0352
Inflation variability	1.3744	2.0490	1.2444	0.8102
Output growth	2.7761	2.4759	1.2818	3.1579
Growth variability	1.3170	1.4910	1.0818	1.1884
Observations	184	81	8	95

	Non-targeters			
	Full sample	**Pre-1995**	**1995**	**Post-1995**
Inflation	3.2992	4.7531	2.8228	2.1274
Inflation variability	0.8681	1.2633	0.8252	0.5423
Output growth	2.7242	2.6773	2.9921	2.7409
Growth variability	1.1394	1.3394	1.8884	0.9103
Observations	276	120	12	144

Panel B. t statistic test for equal means

	Full sample-IT v.s. Full sample-NIT	**Pre-IT v.s. Pre-1995**	**Post-IT v.s. Pre-IT**	**Post-1995 v.s. Pre-1995**	**Post-IT v.s. Post-1995**
Inflation	1.4272	1.5312	-5.9820***	-5.9337***	-0.5925
	[0.1545]	[0.1278]	[0.0000]	[0.0000]	[0.5542]
Inflation variability	2.5864**	1.8618*	-3.0122***	-6.1033***	3.7759***
	[0.0104]	[0.0658]	[0.0034]	[0.0000]	[0.0002]
Output growth	0.2822	-0.6793	2.3923**	0.2628	1.8294*
	[0.7780]	[0.4979]	[0.0181]	[0.7929]	[0.0686]
Growth variability	2.2782**	1.1599	-2.2300**	-5.2353***	3.1003***
	[0.0234]	[0.2481]	[0.0272]	[0.0000]	[0.0023]

Note: The post-IT (or post-1995) period does not include the adoption year (or 1995). p-values are in brackets.
*** denotes 1-percent significance level.
** denotes 5-percent significance level.
* denotes 10 -percent significance level

Table 3. Probit estimates of propensity scores

	Coefficient	Standard error
Inflation rate	-0.1153 ***	0.0378
Real GDP growth rate	-0.0824 *	0.0431
Budget surplus	0.0447 **	0.0018
Openness	0.0082 ***	0.0229
Fixed exchange rate dummy	-1.6647 ***	0.2089
Constant term	0.0964	0.2397
No. of observation	460	
Pseudo R^2	0.2938	
Common support region	[0.0199, 0.8575]	

*** denotes 1-percent significance level.
** denotes 5-percent significance level.
* denotes 10 -percent significance level

Table 4. Treatment effects of inflation targeting

	1 Nearest-neighbor matching	3 Nearest-neighbor matching	Radius matching			Kernel matching	Local linear regression matching
			r=0.03	*r=0.01*	*r=0.005*		
Treatment effect on inflation							
ATT	-0.3041	-0.1828	0.0043	0.0841	0.0587	-0.0610	-0.2981
	[0.329]	[0.542]	[0.986]	[0.777]	[0.864]	[0.796]	[0.283]
Treatment effect on inflation variability							
ATT	0.1057	-0.0328	0.0651	-0.0149	0.0496	0.0713	0.1207
	[0.440]	[0.811]	[0.527]	[0.950]	[0.724]	[0.376]	[0.271]
Treatment effect on output growth							
ATT	0.2059	0.2900	0.3762	0.6822	0.6757*	0.2706	0.1927
	[0.574]	[0.378]	[0.146]	[0.136]	[0.079]	[0.280]	[0.656]
Treatment effect on growth variability							
ATT	0.2412	0.0842	0.1754	0.1524	0.1517	0.1391	0.2249
	[0.145]	[0.560]	[0.218]	[0.239]	[0.421]	[0.280]	[0.335]
No. of treated	103	103	95	82	69	103	103
No. of control	291	291	291	291	291	291	291

Notes: We employ Gaussian kernel function with the bandwidth of 0.06 for kernel and local linear regression matching. p-values are in brackets.

* denotes 10 -percent significance level

Table 5. Dynamic treatment effects of inflation targeting

	1 Nearest-neighbor matching	3 Nearest-neighbor matching	Radius matching			Kernel matching	Local linear regression matching
			r=0.03	*r=0.01*	*r=0.005*		
Treatment effect on inflation							
ATT_0	1.4812** [0.041]	1.1707* [0.079]	1.6309** [0.028]	1.2209** [0.026]	1.6862** [0.050]	1.6489*** [0.004]	1.2762** [0.020]
ATT_1	-1.1758** [0.024]	-0.8174** [0.011]	-0.6402** [0.076]	-0.6219* [0.063]	-1.3348** [0.022]	-0.5381* [0.089]	-0.8525** [0.047]
ATT_2	-0.6266 [0.478]	-0.7995 [0.390]	-0.5571 [0.322]	-0.5202 [0.445]	-0.3677 [0.599]	-0.3850 [0.494]	-0.7103 [0.632]
ATT_3	-0.8717 [0.243]	-1.2704 [0.118]	-1.0901 [0.141]	-0.7542 [0.310]	-0.5728 [0.485]	-1.0239 [0.139]	-1.2890 [0.147]
ATT_4	-1.1632 [0.289]	-0.6261 [0.439]	-0.2679 [0.567]	-0.4208 [0.695]	-1.5222 [0.364]	-0.6496 [0.227]	-0.9803 [0.274]
Treatment effect on inflation variability							
ATT_0	0.6349 [0.316]	0.4168 [0.521]	0.5521 [0.311]	0.2647 [0.579]	0.5748 [0.248]	0.4853 [0.352]	0.4875 [0.304]
ATT_1	0.6150** [0.022]	0.6899** [0.029]	0.6164** [0.031]	0.6082*** [0.005]	0.6213*** [0.001]	0.6073** [0.031]	0.6239** [0.041]
ATT_2	1.0134*** [0.002]	0.8369*** [0.007]	0.8837*** [0.009]	0.8705*** [0.005]	1.2194*** [0.000]	0.8400*** [0.002]	0.8885*** [0.000]
ATT_3	0.0198 [0.949]	-0.1558 [0.722]	0.0573 [0.658]	-0.0722 [0.896]	-0.2705 [0.614]	0.1119 [0.562]	0.1580 [0.387]
ATT_4	0.2215 [0.766]	-0.0930 [0.781]	-0.0265 [0.918]	0.2926 [0.583]	-0.4463 [0.529]	0.0907 [0.514]	0.1426 [0.694]
Treatment effect on output growth							
ATT_0	-1.3278 [0.330]	-1.4991 [0.205]	-1.2495 [0.331]	-1.2311 [0.329]	-0.9472 [0.528]	-1.4427 [0.162]	-1.3724 [0.242]
ATT_1	-2.2457*** [0.002]	-1.5203*** [0.009]	-1.0104** [0.046]	-1.2666** [0.036]	-1.7439** [0.012]	-1.1083** [0.027]	-1.0912** [0.011]
ATT_2	-0.9588 [0.418]	-0.6187 [0.415]	-0.1649 [0.882]	0.0678 [0.947]	-0.0384 [0.958]	-0.4645 [0.525]	-0.5344 [0.588]
ATT_3	1.3720 [0.434]	1.1096 [0.216]	1.0957 [0.321]	1.8926 [0.175]	2.3470 [0.113]	0.9550 [0.330]	0.8257 [0.565]
ATT_4	1.3738 [0.204]	1.6860 [0.181]	2.1007 [0.112]	3.1284 [0.147]	2.7112 [0.161]	1.0231 [0.205]	0.9415 [0.566]
Treatment effect on growth variability							
ATT_0	-0.0887 [0.889]	-0.2284 [0.653]	0.0468 [0.916]	-0.0775 [0.823]	-0.0770 [0.897]	0.0031 [0.994]	0.1026 [0.830]
ATT_1	0.6903** [0.040]	0.5360** [0.045]	0.6260*** [0.003]	0.6008*** [0.002]	0.5958* [0.079]	0.6287*** [0.003]	0.7226*** [0.005]
ATT_2	1.0967*** [0.002]	0.6879** [0.026]	0.8417*** [0.000]	0.8194*** [0.001]	0.7976*** [0.001]	0.6334*** [0.002]	0.7719*** [0.001]
ATT_3	0.7299 [0.311]	0.8423 [0.261]	0.8966 [0.256]	1.1533 [0.289]	0.9890 [0.256]	0.8034 [0.255]	0.8703 [0.358]
ATT_4	0.4827 [0.281]	0.2440 [0.348]	0.4625 [0.362]	0.2621 [0.724]	0.2904 [0.552]	0.4898 [0.211]	0.6302 [0.404]

Notes: See Table 4.
*** denotes 1-percent significance level.
** denotes 5-percent significance level.
* denotes 10 -percent significance level

Table 6. Cumulative treatment effects of inflation targeting

	1 Nearest-neighbor matching	3 Nearest-neighbor matching	Radius matching			Kernel matching	Local linear regression matching
			r=0.03	*r=0.01*	*r=0.005*		
Treatment effect on inflation							
$\sum_0^1$ **ATT**	0.1526	0.1766	0.4953	0.2994	0.1756	0.5554	0.2118
	[0.815]	[0.759]	[0.345]	[0.615]	[0.814]	[0.174]	[0.710]
$\sum_0^2$ **ATT**	-0.1070	-0.1487	0.1445	0.0535	0.0126	0.2419	-0.0955
	[0.829]	[0.716]	[0.788]	[0.936]	[0.979]	[0.446]	[0.840]
$\sum_0^3$ **ATT**	-0.2982	-0.4291	-0.1641	-0.1328	-0.1224	-0.0745	-0.3939
	[0.216]	[0.317]	[0.663]	[0.826]	[0.792]	[0.823]	[0.305]
$\sum_0^4$ **ATT**	-0.4712	-0.4685	-0.1824	-0.1792	-0.3482	-0.1895	-0.5112
	[0.274]	[0.233]	[0.621]	[0.667]	[0.485]	[0.499]	[0.150]
$\sum_5^H$ **ATT**	-0.1981	-0.0015	0.1085	0.2442	0.3907	0.0205	-0.1629
	[0.640]	[0.997]	[0.695]	[0.436]	[0.420]	[0.938]	[0.597]
Treatment effect on inflation variability							
$\sum_0^1$ **ATT**	0.6249*	0.5533*	0.5843**	0.4364*	0.5980*	0.5463**	0.5557**
	[0.086]	[0.087]	[0.038]	[0.082]	[0.076]	[0.029]	[0.031]
$\sum_0^2$ **ATT**	0.7544***	0.6479***	0.6841***	0.5667***	0.7845***	0.6442***	0.6666***
	[0.001]	[0.006]	[0.000]	[0.004]	[0.000]	[0.000]	[0.000]
$\sum_0^3$ **ATT**	0.5707**	0.4469**	0.5274***	0.4192**	0.5410**	0.5111***	0.5395***
	[0.016]	[0.015]	[0.004]	[0.023]	[0.024]	[0.001]	[0.001]
$\sum_0^4$ **ATT**	0.5009**	0.3389**	0.4296**	0.3044**	0.3817***	0.4271***	0.4601***
	[0.034]	[0.014]	[0.022]	[0.040]	[0.002]	[0.002]	[0.003]
$\sum_5^H$ **ATT**	-0.1451	-0.2689	-0.1379	-0.2091	-0.2212	-0.1545	-0.0947
	[0.341]	[0.124]	[0.201]	[0.247]	[0.368]	[0.147]	[0.444]
Treatment effect on output growth							
$\sum_0^1$ **ATT**	-1.7868***	-1.5097**	-1.1300***	-1.2488**	-1.3456**	-1.2755**	-1.2318*
	[0.005]	[0.018]	[0.001]	[0.020]	[0.031]	[0.023]	[0.085]
$\sum_0^2$ **ATT**	-1.5108**	-1.2127**	-0.8083**	-0.8538**	-0.9534*	-1.0052**	-0.9993*
	[0.017]	[0.028]	[0.024]	[0.046]	[0.089]	[0.014]	[0.088]
$\sum_0^3$ **ATT**	-0.7901	-0.6321	-0.3322	-0.2200	-0.1917	-0.5151	-0.5430
	[0.245]	[0.381]	[0.364]	[0.666]	[0.724]	[0.296]	[0.385]
$\sum_0^4$ **ATT**	-0.3573	-0.1685	0.0970	0.3200	0.2764	-0.2074	-0.2461
	[0.521]	[0.745]	[0.830]	[0.562]	[0.636]	[0.604]	[0.708]
$\sum_5^H$ **ATT**	0.5636	0.5811	0.5318	0.9024	1.0015	0.5743	0.4714
	[0.308]	[0.257]	[0.258]	[0.125]	[0.118]	[0.114]	[0.248]
Treatment effect on growth variability							
$\sum_0^1$ **ATT**	0.3007	0.1538	0.3364	0.2616	0.2594	0.3159	0.4126
	[0.384]	[0.627]	[0.118]	[0.445]	[0.407]	[0.136]	[0.208]
$\sum_0^2$ **ATT**	0.5661*	0.3318*	0.5048**	0.4290*	0.4208*	0.4217**	0.5324*
	[0.069]	[0.060]	[0.018]	[0.055]	[0.063]	[0.023]	[0.077]
$\sum_0^3$ **ATT**	0.6070**	0.4594**	0.6028**	0.5961**	0.5520**	0.5172***	0.6169**
	[0.034]	[0.040]	[0.043]	[0.015]	[0.033]	[0.002]	[0.035]
$\sum_0^4$ **ATT**	0.5822**	0.4163**	0.5780***	0.5422**	0.5098**	0.5117***	0.6195**
	[0.011]	[0.045]	[0.003]	[0.021]	[0.042]	[0.002]	[0.020]
$\sum_5^H$ **ATT**	0.0247	-0.1266	-0.0489	-0.0845	-0.1403	-0.0973	-0.0256
	[0.852]	[0.208]	[0.520]	[0.757]	[0.686]	[0.372]	[0.474]

Notes: See Table 4.
*** denotes 1-percent significance level.
** denotes 5-percent significance level.
* denotes 10 -percent significance level

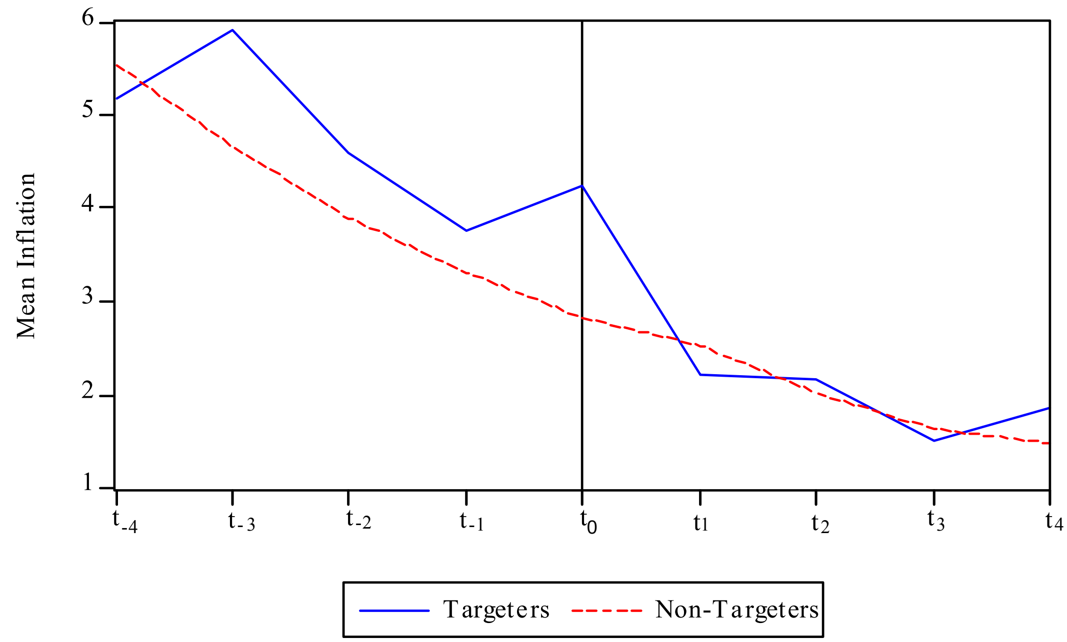

Figure 1. Inflation trajectory for targeters and non-targeters

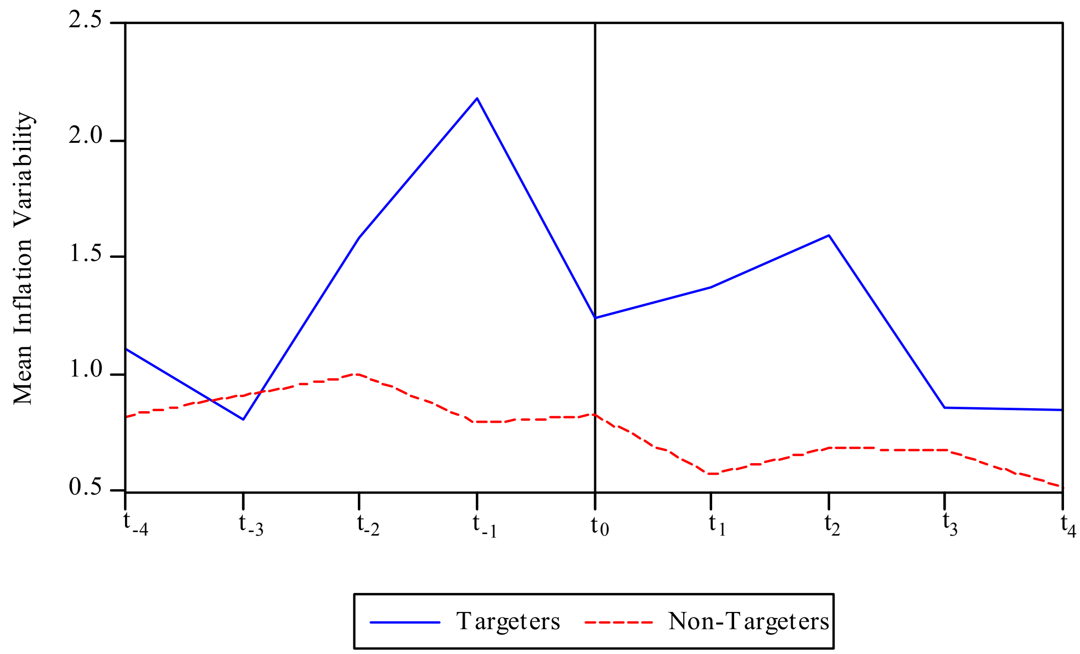

Figure 2. Inflation variability trajectory for targeters and non-targeters

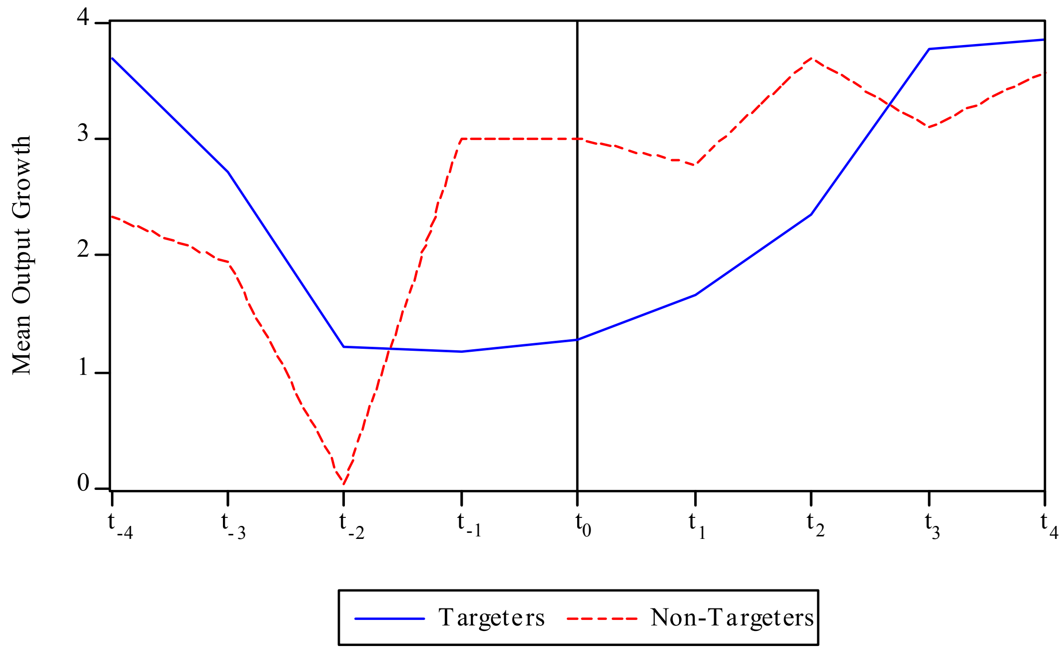

Figure 3. Output growth trajectory for targeters and non-targeters

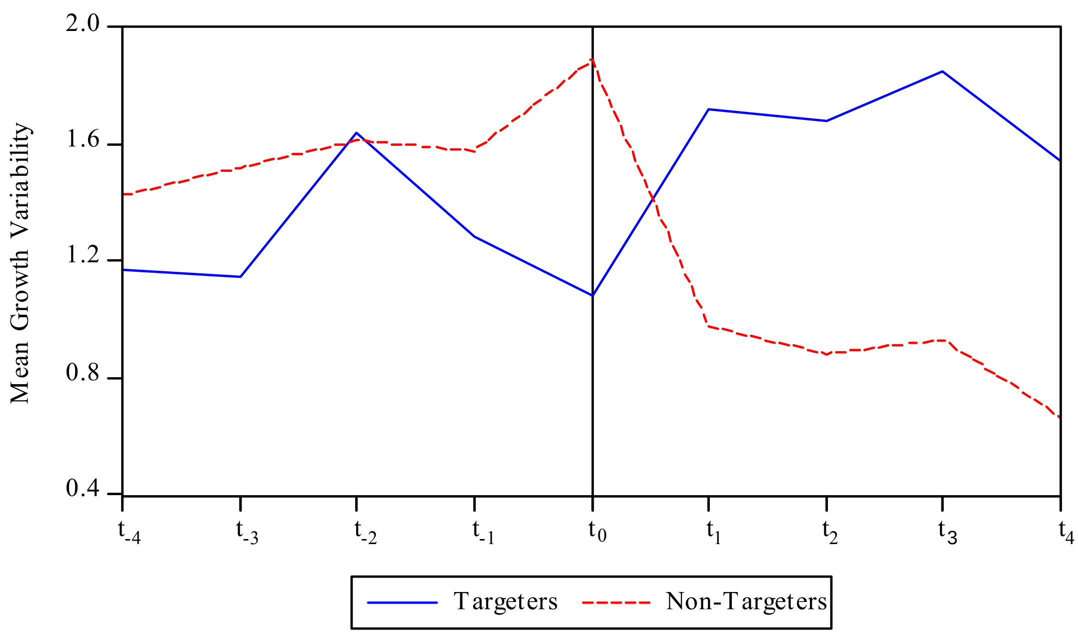

Figure 4. Growth variability trajectory for targeters and non-targeters

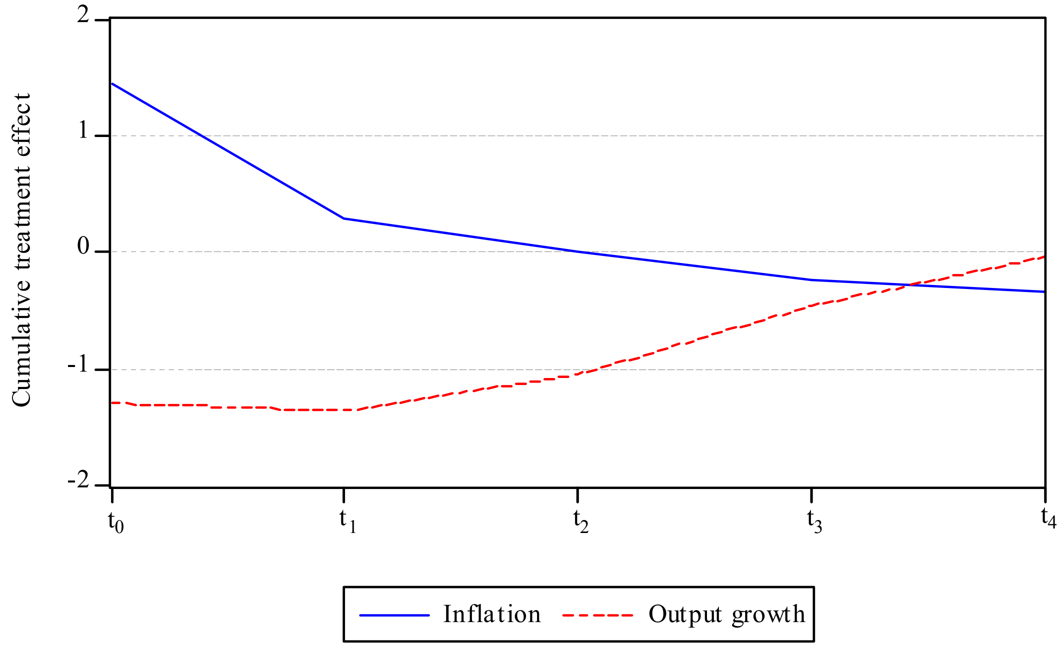

Figure 5. Cumulative trajectory for inflation and output growth

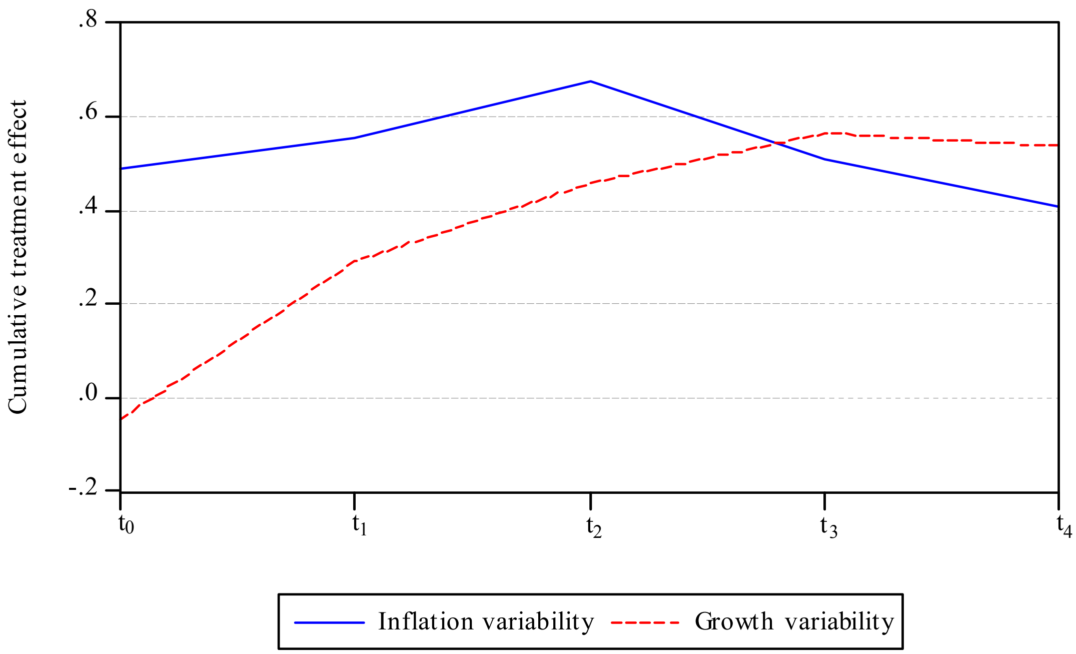

Figure 6. Cumulative trajectory for inflation variability and growth variability