University of Connecticut

*Department of Economics Working Paper Series*

**The Lag in Effect of Inflation Targeting and Policy Evaluation**

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Working Paper 2010-01

January 2010

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This working paper is indexed on RePEc, http://repec.org/

## Abstract

The lag in effect of monetary policy contains vital information for the policy evaluation. Allowing for a time-varying treatment effect, we show that inflation targeting effectively lowers inflation for both developed and developing countries. Developed countries reach their targets rapidly with a two-year lag in effect. Developing countries, however, reduce inflation gradually toward their targets and do not reach their ultimate goal by the end year of 2007.

**Journal of Economic Literature Classification:** C52, E31, E52

**Keywords:** time lag, inflation targeting, time-varying treatment effect, policy evaluation

## 1. Introduction

Macroeconomists know that monetary policy affects prices with a lag, particularly, since Friedman (1961). Friedman and Schwartz (1982, p. 412) report a long-run one-for-one response of inflation to an increase in money growth, with most of the response occurring within four years for the US and the UK. A part of the lag in effect of monetary policy reflects the speed with which monetary policy affects expected inflation.

A credible commitment to an inflation target can more quickly alter inflation expectations, thus shortening the lag in effect. Bernanke *et al*. (1999, p.320) describe a two-year lag between inflation targeting (IT) and its effect on inflation as a common estimate. Batini and Nelson (2002) reaffirm these results, showing that it takes one to four years between changes in monetary policy and the resulting change in inflation. Moreover, this result persists despite changes in monetary policy arrangements in the US and the UK.

Recent empirical research on the evaluation of IT produces mixed results, however. The debate centers on a decline in inflation since the early nineties. Ball and Sheridan (2005) examine the treatment effects of IT in 20 OECD countries, seven of which adopt IT. They discover that after adopting IT, the inflation rate of these countries improves. But, non-targeting countries also experience lower inflation around the same time. Thus, they argue that better inflation performance reflects factors other than the monetary regime and conclude that IT does not lower inflation. Using matching methods or intervention analysis to evaluate IT for developed countries, Lin and Ye (2007) and Angeriz and Arestis (2008), among others, arrive at similar conclusions. In contrast, Gonçalves and Salles (2008) and Lin and Ye (2009) discover that IT significantly lowers inflation in developing countries.

The lag in effect of monetary policy implies different treatment effects at different times

after policy adoption. Ignoring the dynamics of the treatment effect, we argue, contributes to the mixed conclusions in the existing literature.

This paper provides evidence on the nexus between the lagged effects of IT on inflation and the policy evaluation. Our approach uses a time-varying treatment effect technique specifically designed to test for short-run and medium effects in IT adoption. We show that IT effectively lowers inflation for both developed and developing countries. Developed countries reach their targets rapidly in two years, whereas developing countries reduce inflation gradually toward their targets and do not reach their ultimate goal by the end year of 2007.

## 2. What do the data say?

The inflation rate equals the annual percent change of the consumer price index (CPI). We use annual observations from 20 developed and 68 developing countries over the years 1985 to 2007, including 8 and 12 IT countries and 12 and 55 non-IT control countries, respectively, in the developed and developing-country samples.[1] Table 1 lists the targeting countries, their policy adoption years and targets, the inflation rates of targeters in the adoption year, four years after the policy adoption, the end year of the sample, and their mean values, as well as the control countries. The adoption years and targets of the IT countries come from International Monetary Fund (2005).

For developed and developing countries, the numerical inflation target typically reflects an annual rate for the CPI in the form of a range, a point target with a range, or a point target without any explicit range. In developed countries, all targets range between zero and three percent. The average of their mid-points equals 2.19 percent. For developing countries, target ranges generally exceed those for developed countries in level and/or range. The average of their mid-points equals 3.37 percent, much higher than the 2.19-percent average for developed countries.

[1] We exclude five countries that adopt inflation targeting after 2005 – Ghana, Indonesia, Romania, the Slovak Republic, and Turkey, since a two-year experience or less seems too short to tell meaningful treatment effects of inflation targeting for developing countries.

The lagged effects of IT appear in the performance of the inflation rate in Table 1. For the developed countries, the falling inflation rate at the end of second year (= 2.16) reaches the average of the mid-points of the targeted rate (=2.19) and then declines with small deviations to the end of our sample (= 2.17). For developing countries, the inflation rate drops (to 4.77) at the end of the first year, then keeps and falls slowly to the end of our sample (=3.66), which does not reach the average of the mid-points of the targeted rate (=3.37). Thus, a much longer lag length clearly exists between IT monetary policy and inflation for developing countries than for developed countries. We take the data for inflation rates from the International Monetary Fund *World Economic Outlook* Database.

## 3. What do the dynamic treatment effects say?

Using propensity score matching, the intertemporal average treatment effect on the treated (*ATT*) of every period at and after the adoption year of IT depends on the following equation:

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

where $\Pi_{it}$ and $\Pi_{jt}$ equal the values of the inflation rate at period $t$ for countries $i$ in the targeting group $T$ and $j$ in the control group $C$, respectively. $P_i$ and $P_j$ equal the predicted probabilities of adopting IT for countries $i$ and $j$. $N_t$ equals the number of treated units. The match for each treated unit $i \in T \cap S_p$ equals a weighted average of the outcomes of non-treated countries, $S_p$ is the region of common support, and $w(p_i, p_j)$ equals the weight function. In this study, t equals 0, 1, 2, 3, 4, denoting the adopting year (t=0) and four years after (t=1…4).

We also estimate the cumulative average treatment effect in a period from the adopting year to the fourth year or from any year ($\tau$) since the policy adoption to the end of our sample ($T$) as follows:

$$ATT_{\tau}^{T} = \frac{1}{N_T} \sum_{i \in T \cap S_p} \left[ \sum_{\tau}^{T} \Pi_{it} - \sum_{\tau}^{T} \sum_{j \in C} w(P_i, P_j) \Pi_{jt} \right]. \quad (2)$$

This estimator provides an effect of IT in the short-run, the medium, or the long-run. When $\tau$ =0, the $ATT_{\tau}^{T}$ equals the long-run effect.

For the developed countries, the data set contains 460 observations, of which 103 belong to the treated group and 357 belong to the non-treated group. For the developing countries, the data set contains 1,329 observations, of which 109 belong to the treated group and 1,220 belong to the non-treated group.

The first-stage probit regression that generates 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. Based on the common support region, we exclude 66 out of 357 and 434 out of 1,220 control units whose estimated propensity scores fall below the lowest scores for the developed and developing countries, respectively. This leaves 291 and 786 units to conduct matching and the *ATT* estimates.

Table 2 reports the estimated intertemporal effect ($ATT_1$), short-run ($\sum_0^4 ATT$), medium ($\sum_5^T ATT$**),** and long-run ($\sum_0^T ATT$**)** cumulative effects for developed and developing countries. Each column uses a different matching method – three-nearest-neighbor matching, caliper matching at the tolerance level of 0.03, kernel matching, and local-linear matching to obtain results.

For developed countries, IT increases the inflation rate significantly in the adoption year. Consistent with the basic message of Table 1, however, the estimation results suggest that IT lowers inflation significantly in the first year after the policy adoption. The inflation gap shrinks in the second year and widens in the third year, although insignificantly. Since targeters achieve their

inflation target in two years, inflation rates beyond the second year prove irrelevant and, thus, no more treatment effect emerges in the short run, the medium term, or the long run. No long-run treatment effect found in the literature also reflects the fact that, at the end of 2007, the average inflation rate of 2.17 for targeters matches closely to that of 2.03 for non-targeters.

Developing countries tell a totally different story. IT significantly lowers the inflation rate since the adoption year, except for two insignificant estimates when using the 3-nearest-neighbor matching. Targeters generally choose to reach their inflation targets gradually. In this study, eight years (from 2000 of the average adoption year to 2007 at the end of our sample) do not permit enough time to achieve the long-run outcome. The inflation rate of 3.66 in 2007 still exceeds the 3.37 percent average of the target range mid-points. The significant treatment effect or the above three-percent difference between targeters and non-targeters reflects that more than 3-percent gap exists in the two mean inflation rates (3.66 in targeters vs. 7.01 in non-targeters) in 2007. The evidence is more suggestive that developing countries adopt IT policy.

## 4. Conclusion

Our results show that developed and developing countries experience different time profiles when adopting IT. Thus, time lags play an important role in evaluating this policy. Developed countries lower inflation and reach their targets rapidly in two years. In contrast, developing countries reduce inflation gradually toward their targets and do not reach their ultimate goal by the end year of our sample in 2007. In sum, the lag in effect of IT proves shorter for developed relative to developing countries.

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**Table 1: Inflation Targeting Countries and Control Countries**

**Developed Countries**

| Targeting Countries | Adoption Year* | Inflation Target | $t_0$ | $t_1$ | $t_2$ | $t_3$ | $t_4$ | $t_{2007}$ |
|---|---|---|---|---|---|---|---|---|
| Australia | 1993 | 2-3 | 1.81 | 1.89 | 4.63 | 2.61 | 0.25 | 2.33 |
| Canada | 1991 | 1-3 | 5.62 | 1.49 | 1.86 | 0.13 | 2.18 | 2.14 |
| Iceland | 2001 | 2.5 | 6.63 | 4.84 | 2.09 | 3.22 | 4.02 | 5.02 |
| New Zealand | 1990 | 1-3 | 6.09 | 2.61 | 0.98 | 1.31 | 1.75 | 2.37 |
| Norway | 2001 | 2.5 | 3.03 | 1.28 | 2.45 | 0.44 | 1.55 | 0.76 |
| Sweden | 1993 | 2(+/-1) | 4.82 | 2.15 | 2.56 | 1.02 | 1.80 | 1.67 |
| Switzerland | 2000 | <2 | 1.55 | 0.98 | 0.64 | 0.63 | 0.80 | 0.73 |
| United Kingdom | 1992 | 2 | 4.29 | 2.49 | 2.07 | 2.62 | 2.44 | 2.34 |
| Mean value | | | 4.23 | 2.21 | 2.16 | 1.49 | 1.84 | 2.17 |

**Control Countries**

| | | |
|---|---|---|
| Austria | Germany | Japan |
| Belgium | Greece | Netherlands |
| Denmark | Ireland | Portugal |
| France | Italy | United States |

**Developing Countries**

| Targeting Countries | Adoption Year* | Inflation Target | $t_0$ | $t_1$ | $t_2$ | $t_3$ | $t_4$ | $t_{2007}$ |
|---|---|---|---|---|---|---|---|---|
| Brazil | 1999 | 4.5(±2.5) | 4.85 | 7.05 | 6.83 | 8.42 | 14.7 | 3.63 |
| Chile | 1999 | 2-4 | 3.33 | 3.84 | 3.56 | 2.48 | 2.81 | 4.40 |
| Colombia | 1999 | 5(±0.5) | 10.8 | 9.22 | 7.96 | 6.34 | 7.13 | 5.54 |
| Czech Republic | 1998 | 3(±1) | 10.6 | 2.25 | 3.82 | 4.69 | 1.81 | 2.80 |
| Hungary | 2001 | 3.5(±1) | 9.22 | 5.26 | 4.63 | 6.78 | 3.55 | 7.93 |
| Israel | 1997 | 1-3 | 9.00 | 5.43 | 5.19 | 1.25 | 1.11 | 0.51 |
| Korea | 1998 | 2.5-3.5 | 7.51 | 0.81 | 2.25 | 4.06 | 2.76 | 2.53 |
| Mexico | 2001 | 3(±1) | 6.36 | 5.03 | 4.54 | 4.68 | 3.98 | 3.96 |
| Peru | 2002 | 2.5(±1) | 0.19 | 2.25 | 3.33 | 1.62 | 2.00 | 1.78 |
| Philippines | 2002 | 5-6 | 2.94 | 3.47 | 5.97 | 7.65 | 6.23 | 2.8 |
| Poland | 1999 | 2.5(±1) | 7.3 | 10.1 | 5.5 | 1.9 | 0.8 | 2.49 |
| South Africa | 2000 | 3-6 | 5.37 | 5.7 | 9.17 | 5.80 | 1.39 | 7.09 |
| Thailand | 2000 | 0-3.5 | 1.55 | 1.66 | 0.63 | 1.80 | 2.76 | 2.22 |
| Brazil | 1999 | 4.5(±2.5) | 4.85 | 7.05 | 6.83 | 8.42 | 14.7 | 3.63 |
| Mean value | | | 6.07 | 4.77 | 4.87 | 4.42 | 3.92 | 3.66 |

**Control Countries**

| | | | | |
|---|---|---|---|---|
| Algeria | Costa Rica | Honduras | Maldives | Solomon Islands |
| Argentina | Cote d'Ivoire | Hong Kong | Mauritania | Sri Lanka |
| Bangladesh | Dominican Republic | India | Mauritius | St. Lucia |
| Bhutan | Egypt, Arab Rep. | Iran, Islamic Rep. | Nepal | Swaziland |
| Bolivia | El Salvador | Jamaica | Nicaragua | Syrian Arab Rep. |
| Botswana | Ethiopia | Jordan | Nigeria | Tonga |
| Bulgaria | Fiji | Kenya | Pakistan | Trinidad and Tobago |
| Burundi | Gambia, The | Lao PDR | Papua New Guinea | Tunisia |
| Cape Verde | Guatemala | Lesotho | Paraguay | Uganda |
| Chad | Guyana | Madagascar | Rwanda | Vanuatu |
| China | Haiti | Malawi | Samoa | Vietnam |

**Notes:** $t_0$, $t_1$, $t_2$, $t_3$, and $t_4$ denote the adoption year and four years after, $t_{2007}$ equals the year of 2007.

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

**Table 2: Dynamic Treatment Effects of Inflation Targeting on Inflation**

| | Nearest-Neighbor Matching | Radius Matching | Kernel Matching | Local Linear Regression Matching |
|---|---|---|---|---|
| **Developed Countries** | | | | |
| $ATT_0$ | 1.1707* | 1.6309** | 1.6489*** | 1.2762** |
| | [0.079] | [0.028] | [0.004] | [0.020] |
| $ATT_1$ | -0.9916** | -0.6402** | -0.5381* | -0.8525** |
| | [0.023] | [0.076] | [0.089] | [0.047] |
| $ATT_2$ | -0.7995 | -0.5571 | -0.3850 | -0.7103 |
| | [0.390] | [0.322] | [0.494] | [0.632] |
| $ATT_3$ | -1.2704 | -1.0901 | -1.0239 | -1.2890 |
| | [0.118] | [0.141] | [0.139] | [0.147] |
| $ATT_4$ | -0.6261 | -0.2679 | -0.6496 | -0.9803 |
| | [0.439] | [0.567] | [0.227] | [0.274] |
| $\sum_0^1 ATT$ | 0.1766 | 0.4953 | 0.5554 | 0.2118 |
| | [0.759] | [0.345] | [0.174] | [0.710] |
| $\sum_0^2 ATT$ | -0.1487 | 0.1445 | 0.2419 | -0.0955 |
| | [0.716] | [0.788] | [0.446] | [0.840] |
| $\sum_0^3 ATT$ | -0.4291 | -0.1641 | -0.0745 | -0.3939 |
| | [0.317] | [0.663] | [0.823] | [0.305] |
| $\sum_0^4 ATT$ | -0.4685 | -0.1824 | -0.1895 | -0.5112 |
| | [0.233] | [0.621] | [0.499] | [0.150] |
| $\sum_5^T ATT$ | -0.0015 | 0.1085 | 0.0205 | -0.1629 |
| | [0.997] | [0.695] | [0.938] | [0.597] |
| $\sum_0^T ATT$ | -0.1828 | 0.0043 | -0.0610 | -0.2981 |
| | [0.542] | [0.986] | [0.796] | [0.283] |
| **Developing Countries** | | | | |
| $ATT_0$ | -2.0395 | -2.4556*** | -2.6354** | -2.6654** |
| | [0.366] | [0.010] | [0.012] | [0.015] |
| $ATT_1$ | -4.7213** | -3.6739*** | -3.8212*** | -3.7588*** |
| | [0.037] | [0.001] | [0.000] | [0.000] |
| $ATT_2$ | -2.7631 | -3.5522*** | -3.4407*** | -3.3200*** |
| | [0.263] | [0.005] | [0.000] | [0.001] |
| $ATT_3$ | -3.4126* | -3.0580*** | -3.8301*** | -3.7192*** |
| | [0.063] | [0.002] | [0.000] | [0.000] |
| $ATT_4$ | -5.1243** | -4.2098*** | -4.2182*** | -4.2890*** |
| | [0.047] | [0.002] | [0.000] | [0.001] |
| $\sum_0^1 ATT$ | -3.3804** | -3.0648*** | -3.2283*** | -3.2121*** |
| | [0.035] | [0.000] | [0.000] | [0.000] |
| $\sum_0^2 ATT$ | -3.1746** | -3.2272*** | -3.2991*** | -3.2481*** |
| | [0.025] | [0.000] | [0.001] | [0.000] |
| $\sum_0^3 ATT$ | -3.2341** | -3.1849*** | -3.4319*** | -3.3659*** |
| | [0.015] | [0.000] | [0.000] | [0.000] |
| $\sum_0^4 ATT$ | -3.6122*** | -3.3899*** | -3.5891*** | -3.5505*** |
| | [0.002] | [0.000] | [0.000] | [0.000] |
| $\sum_5^T ATT$ | -3.9820*** | -3.8367*** | -4.5733*** | -4.3411*** |
| | [0.006] | [0.000] | [0.000] | [0.001] |
| $\sum_0^T ATT$ | -3.7615*** | -3.5703*** | -3.9864*** | -3.8696*** |
| | [0.000] | [0.000] | [0.000] | [0.000] |

**Notes:** p-values are in brackets.
*** denotes 1-percent significance level.
** denotes 5-percent significance level.
* denotes 10 -percent significance level