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# Factors Leading to Inflation Targeting – The Impact of Adoption

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**Abstract**

This paper examines how the analysis of inflation targeting (IT) adoption is affected by allowing for a structural change after adoption, using panel probit models for 60 countries over the period 1985-2008. Our findings suggest that there is a structural change after IT adoption. Including the post-adoption period when estimating the factors of IT adoption leads to biased results when interested in the question as of what drives countries' decision to adopt IT.

**Keywords**: inflation targeting; panel probit

**JEL Classification**: E42, E52

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## 1. Introduction

Inflation targeting (IT) is a monetary policy strategy that involves the public announcement of medium-term targets for inflation and strong commitment of the central bank to achieving price stability. By the end of 2011, 31 countries had implemented IT. Due to the increasing popularity of IT, it is important to know what drives countries to its adoption.

Several studies analyze empirically the factors leading to IT (e.g., Mishkin and Schmidt-Hebbel, 2001; Hu, 2006; Mukherjee and Singer, 2008). However, their methodological approach does not differentiate between the factors of IT adoption and the factors of IT continuation; as a result, they simultaneously examine both. These studies commonly use the full sample for estimation, i.e. keep observations before and after adoption, until the end of the analyzed period. Such data treatment may cause endogeneity and asymmetry problems, leading to biased results.

This paper examines how the analysis of IT adoption is affected by this choice of the analyzed period. We apply panel probit models on the dataset of Samarina and de Haan (2013) and test whether IT adoption constitutes a structural change, as a result of which country characteristics influence the choice of IT differently before and after its adoption.

When analyzing the decision to apply or not to apply IT at a specific moment in time, one should take into account which monetary strategy a country has so far used (IT or non-IT). The decision to switch from non-IT to IT might not be symmetric to the decision to switch from IT to non-IT. It seems to be institutionally and politically easier to switch from non-IT to IT than vice versa. Hence, we cannot model this process symmetrically. Indeed, the asymmetry is present in real life as we do not observe (at least up to now) any transition from IT to an alternative monetary policy strategy. So far, none of the IT countries has been forced to abandon it. Thus, once a country adopts IT, the self-reinforcing mechanisms make IT enduring.

Our empirical findings indeed suggest that the decision to apply IT is different from the decision to continue IT. The factors related to IT differ significantly between the pre- and post-adoption periods, indicating that IT adoption creates a structural change in institutional and economic characteristics of a country. Most notably, the effect of inflation on the probability of IT adoption is largely overestimated in the model including the post-adoption period compared to the one without this period. Thus, using the full sample for analyzing IT adoption leads to biased parameter estimates. This bias causes an overstatement of the importance of variables that are pushed by the actual implementation of IT.

## 2. Theoretical framework

IT has proven to be a durable monetary policy strategy: so far no country has been forced to give it up.[1] The possible reason for the high durability of IT is its endogeneity.[2] As an explanation of this endogeneity, we refer to the literature on Optimum Currency Areas (Frankel and Rose, 1996; Rose, 2000). In such studies it is argued that countries are more likely to satisfy the criteria for entry into a currency union *ex post* than *ex ante.* That is, even if a currency union is not an optimal choice for a country at the point of its accession, the process of economic and trade integration will transform the economic fundamentals and institutions in such a way that a currency union becomes an optimal regime after all. Consequently, given the self-reinforcing mechanisms and on top of that the asymmetry in political consequences, it becomes more difficult and costly to exit a currency union than to stay in.

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[1] Note that three EU members (Finland, Spain, and Slovakia) abandoned IT when they joined the euro area. However, this decision was caused by the institutional commitment to adopt the euro and to unify their monetary policy conduct with the ECB. Although these EMU countries gave up explicit IT, their new monetary policy strategy under the ECB framework resembles implicit IT (Rose, 2007).

[2] In this paper, endogeneity of IT is understood in a broader economic sense - endogenous means 'having an internal cause or origin'. Thus, when we say that IT is endogenous, we infer that its continuation is internally affected by the institutions and economic conditions that are shaped under the IT regime.

Similar mechanisms may be at work for IT. Although some countries do not satisfy initial conditions for IT adoption, they may choose to apply IT anyway in a belief of its effectiveness in controlling inflation. Once IT is in place, country characteristics and institutions subsequently develop in a way that supports the IT framework. As institutions adjust to functioning under IT, it reinforces the decision of the central bank to maintain IT, making it an endogenously determined optimal choice. In this situation, abandoning IT becomes more difficult than keeping this strategy. The decision to give up IT after years of its implementation may undermine the credibility of the central bank and destabilize inflation expectations.

Given the endogeneity of IT, there is an asymmetry in the monetary strategy choice. The (importance of) factors influencing the decision to continue or exit IT are likely to be different from those affecting the decision to adopt or not adopt IT. Ignoring the asymmetry and structural change leads to biased estimation results and inadequate statistical inference.

Therefore, we test the hypothesis:

*IT adoption creates a structural change in economic and institutional conditions. As a result, the factors driving IT adoption are different from those leading to IT continuation.*

Special attention in this analysis is given to inflation, considered to be the most important factor driving IT adoption. Previous studies find that lower inflation increases the probability to adopt IT (see Samarina and de Haan, 2013). At the same time, the implementation of IT helps to maintain low inflation. As inflation after IT adoption is affected by the use of this strategy, the importance of this variable could be overstated. Thus, we expect that the estimated effect of inflation on the probability of IT adoption is overestimated in models that do not distinguish between the pre- and post-adoption periods.

## 3. Methodology

The study employs a panel binary choice model where the dependent variable $y_{it}$ takes the value 1 if country $i$ implements IT in year $t$, and 0 otherwise. We follow the literature and use a random effects probit to account for unobserved cross-country heterogeneity.[3] The estimation is conducted by Maximum Likelihood.

To test whether the explanatory variables influence the probability of IT choice differently before and after IT adoption, we employ a structural break analysis. Let $D(\tau)$ be a time function, where $\tau$ measures the duration of IT in years, starting from 0 in the adoption year. The unrestricted model has the form:

$$Prob\left(y_{it} = 1 \middle| X_{i,t-1,}, D(\tau), \mu_i\right) = \Phi\left(\alpha + \beta X_{i,t-1} + \theta D(\tau) + \lambda(X_{i,t-1} \times D(\tau)) + \mu_i\right), \quad (1)$$

where $y_{it} = 1$ if $y_{it}^* > 0$, $y_{it} = 0$ if $y_{it}^* \leq 0$, $y_{it}^*$ is an unobserved latent variable which describes the decision to adopt IT; $\Phi(.)$ is a cdf of a standard normal distribution; $\alpha$ is a constant term; $\beta$, $\theta$, $\lambda$ are vectors of parameters; $X_{i,t-1}$ is a matrix of explanatory variables, lagged one year, as current decisions of central banks rely on the history of analyzed factors; $(X_{i,t-1} \times D(\tau))$ is a matrix of interaction terms between the explanatory variables and $D(\tau)$; $\mu_i$ are random effects, uncorrelated with the regressors, $\mu_i | X_{i,t-1}, D(\tau) \sim N(0, \sigma_\mu^2)$.

Given that the adjustment of country characteristics to IT implementation is a gradual process, we introduce $D(\tau)$ as a smooth transition function of time. Such specification takes into account that it may take more than one year to accommodate the economic conditions and institutions so as to be compatible with the IT framework. For $\tau > 0$, $D(\tau)$ is the exponential smooth transition function specified as:

$$D(\tau) = 1 - e^{(-\gamma\tau^2)}; \gamma > 0, \quad (2)$$

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[3] Pooled probit specifications do not lead to qualitatively different results. These results are available in Table A.3 in the Annex. A fixed effects model would drop all countries that did not adopt IT and has therefore not been used in previous studies of IT adoption either.

where $\gamma$ is a speed of transition; a smaller value of $\gamma$ implies a slower transition.[4] For the pre-adoption period, $\tau = 0$ and $D(\tau) = 0$, the estimated parameters for the explanatory variables correspond to vector *β*. For the post-adoption period, $\tau > 0$ and $D(\tau) > 0$, the parameters are *β*, *θ*, and *λ*.

The restricted model has the form:

$$Prob\left(y_{it} = 1 \middle| X_{i,t-1}, \mu_i\right) = \Phi\left(\alpha + \beta X_{i,t-1} + \mu_i\right). \tag{3}$$

The estimation procedure is the following: first, we estimate the restricted model; then, we fit the unrestricted model and use a Wald test to test for the joint significance of the interaction terms and $D(\tau)$. Testing for a structural break implies the following null and alternative hypotheses:

$H_0$: there is no structural break, i.e. all interaction terms with $D(\tau)$ plus $D(\tau)$ itself have jointly insignificant coefficient estimates;

$H_1$: there is a structural break after IT adoption, i.e. either the coefficient of $D(\tau)$ or at least one of the interaction terms are significantly different from zero.

## 4. Data

We use the dataset of Samarina and de Haan (2013). It consists of 60 countries over the period 1985-2008, out of which 30 countries implemented IT and 30 countries did not. Table A.1 (Annex) provides the list of countries with IT adoption dates. We conduct estimations for official adoption dates according to the central banks' documents.[5]

We include those 6 variables that are found significant by Samarina and de Haan (2013). These are: inflation, output volatility, flexible exchange rate regime dummy, exchange rate

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[4] As a robustness check, we use a different specification of $D(\tau)$, namely $D(\tau) = e^{-\rho/\tau}$, where $\rho \geq 0$ and a larger value of $\rho$ means a slower transition. The results with this specification (and different values of $\rho$) are qualitatively similar to the ones with $D(\tau)$ specified in equation (2). These results are available in Samarina and Sturm (2013).

[5] Alternative dates for soft IT and full-fledged IT adoption are used in a robustness check and available on request.

volatility, government debt and financial development.[6] Table A.2 (Annex) describes the explanatory variables.

## 5. Empirical results

Table 1 presents the estimation results of random effects probit models using official adoption dates. We report average partial effects at $\bar{\mu} = 0$. In the function $D(\tau)$ we set $\gamma = 1$, which implies a transition half-life (i.e. when $D(\tau) = 0.5$) of 10 months.

The Wald test statistics indicate that all interaction terms with $D(\tau)$ plus $D(\tau)$ itself are jointly significant in the unrestricted models. Thus, we reject the null hypothesis in favor of the alternative that there is a structural break after IT adoption.

Our results point to substantial differences between restricted and unrestricted models in terms of significance and magnitude of partial effects for the explanatory variables. In the unrestricted models we find significant but smaller effects (in absolute sense) for inflation and the exchange rate variables. Especially for inflation this points to a large overestimation bias in the restricted model. Furthermore, the estimate of government debt turns significant and those of financial development and output volatility insignificant in the unrestricted models. All three change signs.

Since we cannot estimate $\gamma$ directly, we conduct a robustness analysis to check how sensitive the results are to the choice of $\gamma$. Figure 1 shows the estimated partial effects for each explanatory variable across different values of $\gamma$ that are used to measure half-lives of transition. On the graphs the half-life of transition varies from 45 months (i.e. $\gamma = 0.05$) to 6 months (i.e. $\gamma = 3$). We find that the outcomes – with the exception of inflation – do not vary

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[6] The dataset contains 6 additional variables that have also been used in previous studies (e.g., Hu, 2006; Mukherjee and Singer, 2008): output growth, fiscal balance, trade openness, external debt, market-based financial structure and an index of actual central bank instrument independence. Including these variables as well does not change the conclusions. Results are available in Samarina and Sturm (2013).

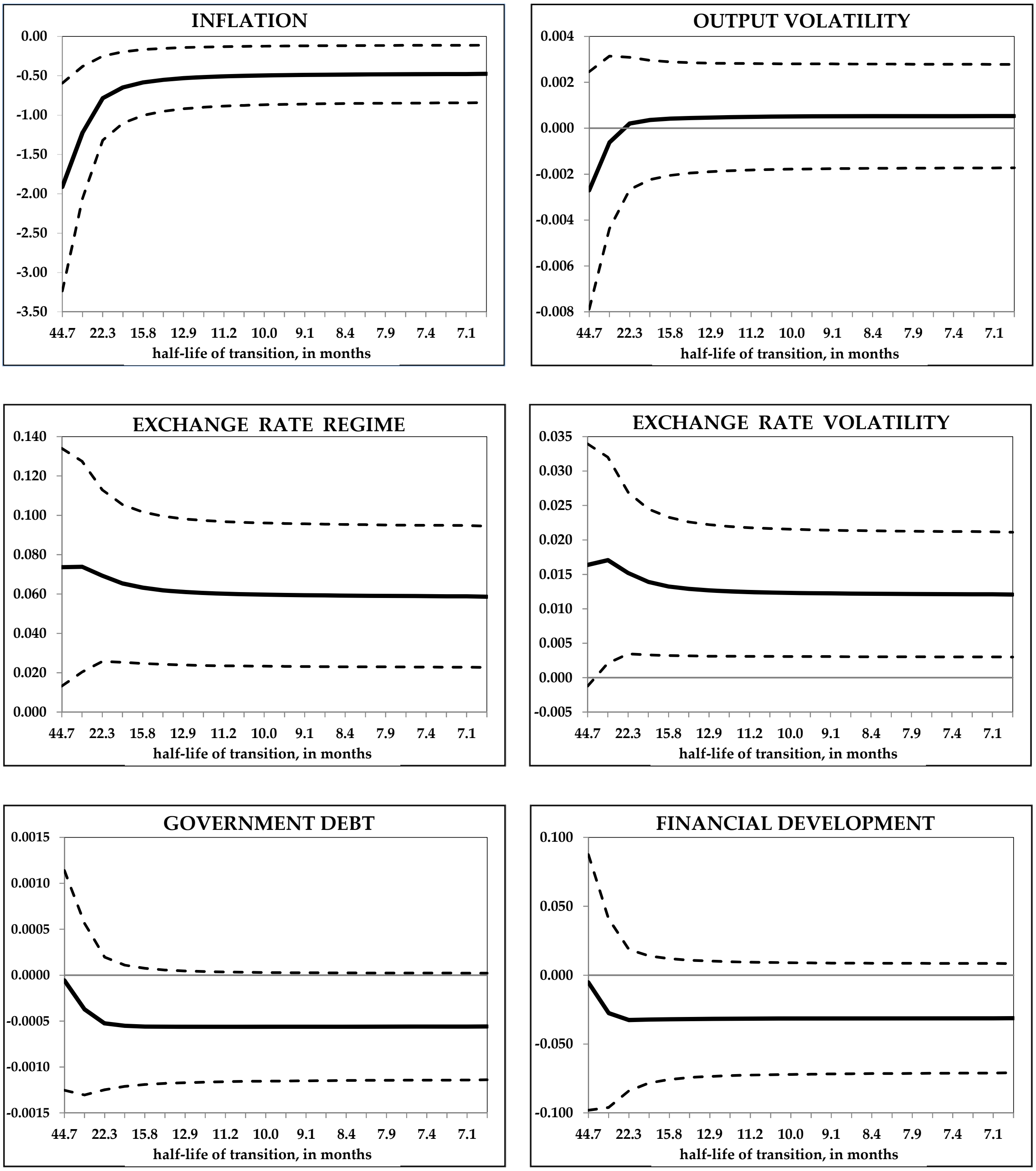
substantially across $\gamma$ in terms of sign and significance of the estimated effects. For inflation, the estimated effects become much smaller (in absolute value) as transition is allowed to go faster. Moreover and as to be expected, the slower is the transition to IT (corresponding to a higher half-life of transition), the closer our estimates get to the restricted model. However, even for a very slow transition, the results from the unrestricted models remain significantly different from the restricted.

**Table 1. Estimation results – random effects probit**

| Variables | Restricted | Unrestricted, $D(\tau)=1-e^{-\tau^2}$ |
|---|---|---|
| Inflation | -3.483*** | -0.496*** |
| | (1.050) | (0.190) |
| Output volatility | -0.006* | 0.0005 |
| | (0.003) | (0.001) |
| Flexible exchange rate regime | 0.094*** | 0.060*** |
| | (0.035) | (0.019) |
| Exchange rate volatility | 0.015* | 0.012*** |
| | (0.009) | (0.005) |
| Government debt | 0.001 | -0.001* |
| | (0.001) | (0.0003) |
| Financial development | 0.118** | -0.032 |
| | (0.050) | (0.021) |
| Observations | 1009 | 1009 |
| Log-likelihood | -240.0 | -128.6 |
| Wald test *p*-value | | 0.00 |

*Notes*: The Table reports average partial effects and their standard errors (in brackets). Interaction terms are included in the unrestricted model, but not reported. ***, **, and * indicate the significance at 1%, 5%, and 10% level, respectively. Wald test *p*-value indicates the significance level for rejecting the null hypothesis of joint insignificance of interaction terms and $D(\tau)$.

**Fig. 1. Average partial effects for $D(\tau) = 1 - e^{(-\gamma\tau^2)}$.**




*Notes:* Solid lines show the estimated partial effects for each explanatory variable, while dashed lines are 95% confidence intervals around the partial effects.

## 6. Conclusion

In this paper we test whether country characteristics influence the probability to apply IT differently before and after adoption. We find that there is a structural change in economic and institutional characteristics occurring during and after IT adoption. The factors leading to IT adoption differ significantly between the periods before and after adoption due to the asymmetry and endogeneity of IT. Importantly, the effect of inflation on the probability of IT adoption is largely overestimated in the model including the post-adoption period. Hence, using the full sample for analyzing the factors of IT adoption produces biased parameter estimates.

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## ANNEX

### Table A.1. List of countries with IT adoption dates

| IT countries (30) | | | | | |
|---|---|---|---|---|---|
| Armenia | 2006 | Hungary | 2001 | Romania | 2005 |
| Australia | 1993 | Iceland | 2001 | Slovakia | 2005 |
| Brazil | 1999 | Indonesia | 2005 | South Africa | 2000 |
| Canada | 1991 | Israel | 1992 | South Korea | 1998 |
| Chile | 1991 | Mexico | 2001 | Spain | 1995 |
| Colombia | 2000 | New Zealand | 1990 | Sweden | 1993 |
| Czech Republic | 1998 | Norway | 2001 | Switzerland | 2000 |
| Finland | 1993 | Peru | 2002 | Thailand | 2000 |
| Ghana | 2007 | Philippines | 2002 | Turkey | 2006 |
| Guatemala | 2005 | Poland | 1999 | United Kingdom | 1993 |

| Non-IT countries (30) | | | | | |
|---|---|---|---|---|---|
| Austria | Greece | Netherlands | Bulgaria | Estonia | Pakistan |
| Belgium | Ireland | Portugal | China | India | Panama |
| Denmark | Italy | United States | Costa Rica | Latvia | Singapore |
| France | Japan | Argentina | Cyprus | Lithuania | Sudan |
| Germany | Luxemburg | Bolivia | Egypt | Malaysia | Venezuela |

Sources: Samarina and de Haan (2013)

### Table A.2. Variables and their description

| Analyzed variable | Description |
|---|---|
| Inflation | CPI inflation rate, transformed as $\frac{\pi/100}{1+\pi/100}$ |
| Output volatility | Annual standard deviation of monthly Industrial Production growth rates |
| Flexible exchange rate regime | 1 – floating exchange rate regime, 0 – otherwise |
| Exchange rate volatility | Annual standard deviation of monthly percentage changes in REER |
| Government debt | Central government debt (in % GDP) |
| Financial development | Private credit by banks and other financial institutions/GDP |

Source: for data sources, see Samarina and de Haan (2013)

**Table A.3. Estimation results – pooled probit**

| Variables | Restricted | Unrestricted, $D(\tau)=1-e^{-\tau^2}$ |
|---|---|---|
| Inflation | -2.651*** | -0.323** |
| | (0.652) | (0.131) |
| Output volatility | -0.002 | 0.001 |
| | (0.006) | (0.001) |
| Flexible exchange rate regime | 0.236*** | 0.053*** |
| | (0.058) | (0.016) |
| Exchange rate volatility | 0.055*** | 0.011*** |
| | (0.017) | (0.004) |
| Government debt | -0.002 | -0.001** |
| | (0.002) | (0.0003) |
| Financial development | -0.082 | -0.030* |
| | (0.080) | (0.018) |
| Observations | 1009 | 1009 |
| Log-likelihood | -468.8 | -132.2 |
| Wald test *p*-value | | 0.00 |

*Notes*: The Table reports average marginal effects and their robust standard errors (in brackets). Interaction terms are included in the unrestricted model, but not reported. ***, **, and * indicate the significance at 1%, 5%, and 10% level, respectively. Wald test *p*-value indicates the significance level for rejecting the null hypothesis of joint insignificance of interaction terms and $D(\tau)$.