Examining the Success of the Central Banks in Inflation Targeting Countries: The Dynamics of Inflation Gap and the Institutional Characteristics

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Abstract

This paper analyzes the performance of central banks in 27 inflation targeting countries by examining their success in achieving their explicit inflation targets. For this purpose, we decompose the inflation gap, the difference between actual inflation and inflation target, into predictable and unpredictable components. We argue that the central banks are successful if the predictable component in the inflation gap diminishes over time. The predictable component of inflation gap is measured by the conditional mean of a time-varying autoregressive model. Our results find considerable heterogeneity in the success of these IT countries in achieving their targets at the start of this policy regime. Our findings also suggest that the central banks of the IT adopting countries started targeting inflation implicitly before becoming an explicit inflation targeter. The panel data analysis suggests that the relative success of these countries in reducing the gap is influenced by their institutional characteristics particularly by fiscal discipline and macroeconomic performance.

Keywords: Inflation targeting, inflation gap, predictability, time-varying autoregressive model, institutional characteristics

JEL Classification Numbers: E31, E37, E52, E58, C32, C53.

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1 Introduction

Explicit inflation targeting (IT) is increasingly being adopted as one of the primary methods of conducting monetary policy. The Reserve Bank of New Zealand initiated inflation targeting in 1990. Since then, the number of countries that have adopted this policy has risen to 27[1]; the last of which was Serbia in 2009. One very impressive feature of inflation targeting regime is that no country has left the inflation targeting family unlike other monetary policy strategies like the exchange rate or monetary targeting (Mihov and Rose (2008)). Under the IT regime, a central bank estimates and makes public a projected, or 'target', inflation rate and then attempts to steer actual inflation towards the target through the use of interest rate changes and other monetary policy tools.

The increasing popularity of this monetary policy strategy has evinced keen interest among researchers. The literature on inflation targeting, however, is divided over the efficacy of inflation targeting. There is one strand of literature where researchers argue that IT strategy curbs inflation expectations due to the credibility, accountability and transparency of central banks (Bernanke and Mishkin (1997), Mishkin and Schmidt-Hebbel (2001), Levin et al. (2004), Mishkin and Schmidt-Hebbel (2007), Baxa et al. (2014)). The opposite view takes the stand that the apparent success of IT regime in most of the countries has been mainly due to favorable shocks affecting the global economy and these economies would have witnessed low and stable inflation even in the absence of an IT regime (Johnson (2002), Ball and Sheridan (2003), Lin and Ye (2007), Genc et al. (2007), Cecchetti and Hakkio (2009))

Most of the existing studies on IT regime examine its efficacy by examining the behavior of inflation after the adoption of this regime. Surprisingly, there is no comprehensive study that takes into account the success of these IT countries in achieving their targets[2]. The objective of our paper is to examine the effectiveness of the central banks in IT countries in meeting their targets. We also examine whether the success in achieving their explicit inflation targets is associated with the institutional strength of these countries.

The success in achieving the target announced publicly by the central bank is crucial

[1]Countries operating a fully fledged inflation targeting regime are: Armenia, Australia, Brazil, Canada, Chile, Colombia, the Czech Republic, Ghana, Guatemala, Hungary, Iceland, Indonesia, Israel, Mexico, New Zealand, Norway, Peru, Philippines, Poland, Romania, Serbia, South Africa, South Korea, Sweden, Thailand, Turkey and the United Kingdom (Hammond (2012)).

[2]One exception is Neuenkirch and Tillmann (2014) who evaluate the central banks' response to inflation gap for a sample of five inflation targeting countries.

if the IT central bank wants to gain credibility. There are different reasons why actual inflation may differ from the target. At the time of the adoption of the IT regime, the central banks want to anchor inflationary expectations over medium to long-horizon. Therefore, the short-term gap between actual inflation and target may not reflect the inability of the central banks to hit their target. However, the central bank will lose credibility if the gap is non-zero for a considerable period of time. The gap may also arise because of unpredictable shocks, but the impact of these unpredictable shocks should not persist for a long period. We use this feature of inflation targeting and propose to test the effectiveness of the IT countries in meeting their target by decomposing the gap between actual inflation and the target into predictable and unpredictable components. If the IT regime is perfectly successful in meeting its target, then any gap between the actual and the targeted inflation should be unpredictable (Bernanke and Mishkin (1997)). This implies that a successful IT regime should bring down the predictable component of the inflation gap to zero over the medium-horizon if they are successful in bridging the gap that was predictable in advance. The hypothesized relationship between the predictable component of inflation gap and the success of the IT regime is motivated by the monetary policy effectiveness literature where researchers like Benati and Surico (2008) and Boivin and Giannoni (2006) among others have shown that the aggressive policy stance towards inflation causes a decline in inflation predictability. The empirical evidence presented in D'Agostino and Surico (2012) for the twentieth century also supports the above hypothesis where they find that the inflation forecasts based on money growth and output growth were significantly more accurate than the naïve forecasts only during the regimes associated with neither a clear nominal anchor nor a credible commitment to fight inflation.

We examine the success of the IT countries in meeting their target by estimating the predictable component of inflation gap from a time-varying autoregressive model. The conditional expectation of this TVP-AR model is the predictable component of the inflation gap. The TVP-AR model takes into account the fact that the capability of the central bank to achieve its target varies over time and is affected by institutional characteristics like fiscal situation, central bank independence and financial market depth among others. Our approach is able to capture the gradual transition of actual inflation to its target over time. Moreover, we perform a panel analysis to examine the relationship between inflation gap and institutional characteristics of these countries.

We find considerable heterogeneity in the success of the IT countries in bridging the gap between actual inflation and the target in the years immediately after the adoption of the

IT regime. We find that the predictable component of inflation gap was close to zero for the countries with relatively low level and volatility of inflation even at the beginning of this regime. However, we find that the predictable component of inflation converged to zero implying higher degree of success in achieving the target for almost all the IT countries after few years of the adoption of IT. Interestingly, we also find that the predictable component of inflation gap started declining few years before these countries publicly joined the IT regime. This implies that the central banks of the IT adopting countries started targeting inflation implicitly before becoming an explicit inflation targeter.

Our findings that in addition to cross-country heterogeneity, there is also significant time-variation in the success of the IT countries in achieving their targets can reconcile the two conflicting views on the effectiveness of IT. The finding that the IT countries have been successful in achieving their target is consistent with the literature that suggests that IT regime leads to a gradual build up in the credibility of the central banks (Neumann and von Hagen (2002), Carare and Stone (2006), Creel and Hubert (2010), de Mendonça and de Guimarães e Souza (2012)). The finding that there is considerable cross-country heterogeneity in the performance of the central banks immediately after the adoption is consistent with the literature which suggests the countries that started with high inflation benefitted more from this regime (Levin et al. (2004), Mishkin and Schmidt-Hebbel (2007) and Batini and Laxton (2007)). Our panel data analysis suggests that the relative success of these countries in achieving their targets is influenced by their institutional characteristics. In particular, we find that high debt-GDP ratio constrains the ability of the central bank to bridge the gap between inflation and target. We also find that financial development indicators and macroeconomic performance significantly affect the inflation gap in these IT countries.

2 Data Description

One of the contributions of our paper is to create a comprehensive database of explicit inflation targets for all the IT countries. Table 1 shows the list of countries that have adopted IT regime. It includes information on the date of adoption, the initial target and the target at the end of the 2013. If there is a range for the target, we consider midpoints of target ranges. Israel and Poland have the highest gap between the two periods' target level, 14.5 to 2 and 8.25 to 2.5 percent, respectively. Figure 1 represents the target level at the date of adoption compared to the target level in 2013. Panel (a) shows the target level

at the adoption date and panel (b) depicts the level in 2013. In general, the target level has been decreasing over the past 25 years.

Table 1 also shows the type of target path for each IT country. The literature has classified the behavior of inflation targets into two categories: 'convergence' and 'stationary' target path. Convergence rates relate to the inflation targeters in which initial target levels were high, gradually converging to a lower level. Stationary rates indicate a constantly low level of inflation. In addition, we classify each country into industrial or emerging market economies based on their level of economic development. Ruge-Murcia (2014) finds that Canada is an exception, where the price-level itself is stationary.

The data on consumer prices have been obtained from the IMF's International Financial Statistics and FRED from 1980 through 2013 on a quarterly basis. The data on inflation targets have been obtained from the central banks' websites, and other studies (Mishkin and Schmidt-Hebbel (2001), Batini and Laxton (2007), Hammond (2012) and Leyva (2008))[3]. Figure 2 presents the annual inflation rates and targets for our samples. The vertical lines indicate the date of IT adoption. A visual inspection suggests that over medium to long-horizons though there are significant and protracted gap between actual and the inflation target at the beginning of the IT regime for most of the countries, this gap seems have narrowed down over time.

Table 2 shows the descriptive statistics of the inflation rates for all 27 countries. Inflation targeters like Colombia, Ghana, Poland, Romania and Serbia have the highest pre-IT inflation levels; the average of those is above 20 percent. However, the mean of post-IT inflation is significantly low. A substantial gap exists between the means before and after the policy. This gap for Colombia, Ghana, Poland, Romania and Serbia is 15.09, 11.96, 20.36, 17.08 and 18.47 percent, respectively.

Conventionally, inflation variability is measured by the standard deviation of inflation. Table 2 also presents the standard deviation for pre- and post-IT. A significant reduction in the standard deviation is noted after the adoption of IT. This dramatic reduction in the standard deviation can be seen in targeters such as Brazil, Ghana, Peru, Romania, Serbia and Turkey. Overall, Figure 2 and Table 2 depict the existence of a lower mean and standard deviation in the post-IT period.

[3]More details on inflation target data are available upon request.

3 A Time-Varying Parameter Model for Inflation Gap

In this section, we propose to test the success of the IT countries in achieving their inflation targets. There are different ways to assess the success of the IT regimes in achieving their targets. The simplest method is to look at the inflation gap between actual inflation and the target over time. Figure 2 plots inflation and inflation targets for all the countries together. We observe two main features of this data. First, the difference between the target and actual inflation is time-varying. Secondly, this gap is not just a white noise. This implies that there is a predictable component in the inflation gap and this predictability varies over time. The predicability of the inflation gap can arise due to several reasons. First, interest rate smoothing behavior by the central bank can lead to a gradual adjustment towards the target. Secondly, there is a lag in monetary policy transmission and this lag tends to be higher for prices than real economic activity. Thirdly, the central bank may have a medium-run horizon and they want to achieve the target not in the very short term.

We study the success of IT regime by decomposing inflation gap into two components: a predictable and an unpredictable component. The predictable component of the inflation gap should disappear over time if the IT regime is successful in achieving its target. Admittedly, if a central bank announces its target, it is not expected to hit the target within a quarter, but we anticipate the inflation gap, that is forecastable, to disappear over medium to long-horizon. Actual inflation may always turn out to be different than the target because of unanticipated shocks, but a successful and credible central bank should not let this deviation persist.

The hypothesized relationship between the predictable component of inflation gap and effectiveness of the IT regime is motivated by the monetary policy effectiveness literature where researchers like Benati and Surico (2008) and Boivin and Giannoni (2006) among others have shown that the aggressive policy stance towards inflation causes a decline in inflation predictability. The empirical evidence presented in D'Agostino and Surico (2012) also support the above hypothesis. They find that the inflation forecasts based on money growth and output growth were significantly more accurate than the naïve forecasts only during the regimes associated with neither a clear nominal anchor nor a credible commitment to fight inflation. Therefore, in case of a perfectly successful IT regime, the only difference between the actual inflation and the target will be the unforecastable news in the data.

We measure the predictable component of inflation gap in a very parsimonious way. We fit an ARMA(p,q) model to inflation gap for all the IT countries. We find that AR(1) best approximates the inflation gap data for all the IT countries using the BIC. There are alternative ways to estimate AR(1) model in our example. We can fit the following fixed coefficient model:

$$\pi_t^{dev} = \alpha + \beta \pi_{t-1}^{dev} + v_t \tag{1}$$

In the above model, the systematic part or the predictable component is the conditional mean, $\alpha + \beta \pi_{t-1}^{dev}$, and the unsystematic component is the error term, v_t. If monetary policy is perfectly successful in achieving its target, then $\alpha = \beta = 0$. Intercept represents the bias and the slope coefficient, β measures the persistence of shock to inflation gap. The problem with a fixed coefficient model is that it would not be able to capture the time variation in success of the IT central banks as it restricts the coefficients. The fixed coefficient model will restrict both the intercept and the slope coefficient to be constant across time. This implies that the behavior of the central bank for the full sample has remained fixed and the persistence property of the shocks affecting the inflation gap has also remained the same. To take care of the problems associated with a fixed coefficient model, we modify the above model and allow the coefficients to vary with time. In particular, we allow the coefficients to follow a random walk. Our time-varying parameter (TVP) model becomes:

$$\pi_t^{dev} = \alpha_t + \beta_t \pi_{t-1}^{dev} + v_t \tag{2}$$

The subscript t signifies time-varying coefficients. There are alternative approaches of modeling time variation that includes structural break as well as Markov switching in the reaction function coefficients. The usual test of time variation has a low power against the alternative, that is, it is difficult to distinguish between different forms of time variation. As in Boivin and Giannoni (2006), we note that structural break models are very special cases of time variation and does not allow for the gradual evolution of monetary policy. Moreover, time-varying parameter model may also be used as a good approximation of multiple breaks in the reaction function coefficients [4].

[4]Stock and Watson (2002) and Boivin and Giannoni (2006) discuss merits of the TVP model over other forms of structural break.

The state-space representation of the above model is given by:

$$\begin{aligned} Y_t &= F_t\theta_t + v_t, \qquad v_t \sim \mathcal{N}(0, V_t) \\ \theta_t &= G_t\theta_{t-1} + w_t, \quad w_t \sim \mathcal{N}(0, W_t) \end{aligned} \tag{3}$$

The system matrices are:

$$F_t = \begin{pmatrix} 1 & Y_{t-1} \end{pmatrix}, \quad V_t = \sigma_v^2 \tag{4}$$

$$G_t = I_2, \quad W_t = \begin{pmatrix} \sigma_\alpha^2 & 0 \\ 0 & \sigma_\beta^2 \end{pmatrix} \tag{5}$$

where $\theta_t = (\alpha_t, \beta_t)'$. Y_t is π_t^{dev} and we assume the initial state, θ_0, is normally distributed with the mean m_0 and variance G_0 and the sequences v_t and w_t are independent of θ_0. We use Kalman filtering algorithms to obtain the means and variances of the conditional distributions of the unobservable states given the data. Giovanni et al. (2009) argue that a naïve use of the Kalman filter causes numerical instability issues. One way to overcome this problem is to define more robust algorithms. We utilize a singular value decomposition-based algorithm proposed by Wang et al. (1992). Given observed data, $\{\pi_1^{dev}, \ldots, \pi_T^{dev}\}$, we find the optimal 'signal extraction' and the optimal 'h-step ahead prediction' of states and data. [5]

Figure 3 shows the time-varying conditional expectations of the inflation deviation from its target. The residuals which are the unpredictable component from our model are also plotted along with the predictable component which is the conditional mean. The vertical line represents the date of adoption of the IT regime. For comparison, we also estimate the conditional mean three years prior to the adoption. Since the inflation targets prior to adoption are not available, we use the initial inflation target for each country. In many cases, these targets were known in advance since the countries announce them prior to the official adoption of IT regime.

We observe some clear and interesting patterns in our estimated results. First, we find that there is considerable heterogeneity in the success of the IT countries in bridging the gap between actual inflation and the target in the years immediately after the adoption of the IT regime. We find that the conditional mean of the inflation gap was close to zero for countries with relatively low level and volatility of inflation even at the beginning of

[5] For details, see Zivot and Yollin (2012).

this regime. For example, we can clearly observe that the conditional mean in Australia, Canada, Chile, New Zealand and Sweden hovered around zero for most of the time period after the adoption of the IT regime. On the other hand, there are countries like Brazil, Colombia, Guatemala, Iceland, Mexico among others where the conditional mean was not close to zero during the initial years of this regime. However, we find that the predictable component of inflation converged to zero implying higher degree of success in achieving the target for almost all the IT countries after few years of the adoption of IT.

Interestingly, we also find that the predictable component of inflation gap starts declining few years before these countries publicly joined the IT regime. Since the targets are not available prior to the date of adoption, we use the target level announced at the time of the adoption of IT. The results imply that the central banks of the IT adopting countries started targeting inflation implicitly before becoming an explicit inflation targeter. Usually, the countries make an announcement about their intention to move to full-fledged inflation targeting at a future date. There is usually a time lag involved between the announcement and the formal move to new regime. Our results that the predictable component starts declining before the formal date of adoption may reflect this time lag. Secondly, we find that for most of the countries, the residuals or the unpredictable component in the TVP-AR model is significant. This implies that the naïve way of just looking at inflation gap and not making the distinction between the predictable and the unpredictable component would not provide us the proper understanding into the effectiveness of the IT regime in meeting its target.

Our findings that in addition to cross-country heterogeneity, there is also significant time-variation in the success of the IT countries in achieving their targets can reconcile the two conflicting views on the effectiveness of IT. The finding that the IT countries have been successful in achieving their target is consistent with the literature suggesting that the IT regime leads to a gradual build up in the credibility of the central banks (Neumann and von Hagen (2002), Carare and Stone (2006), Creel and Hubert (2010), de Mendonça and de Guimarães e Souza (2012)). The finding that there is considerable cross-country heterogeneity in the performance of the central banks immediately after the adoption is consistent with the literature which suggests the countries that started with high inflation tended to have benefited more from the IT regime in terms of lower level and volatility of inflation over a medium to long-horizon. Our estimates also suggest that the conditional mean of inflation gap for these emerging economies has gradually declined over time was not very close to zero at the beginning of the IT regime.

Our approach estimates the conditional mean of inflation gap using information from only the past values of inflation gap. It is conceivable that the expansion of information set in the calculation of conditional mean may provide us a different estimate. However, it should be noted that our estimated conditional mean consistently show a clear pattern for all the countries and even if information set is expanded, we should be able to find similar pattern in the data. Moreover, a complex model is more prone to mis-specifiation especially since we are estimating the conditional mean of all the IT countries.

To dig deeper into the behavior of predictable component, we look at the evolution of the intercept, α, and the slope, β, separately. Figure 4 shows the time-variation in α and β coefficients. The left graphs show the intercept coefficients over time, α_t, and the right graphs present the time-varying AR coefficients, β_t. The vertical lines in each panel indicate the date of the adoption of IT.

The results for time-varying intercept and slope coefficients suggest that the estimated intercepts are driving the results in countries where the predictable component of inflation was significant at the beginning of the IT regime. This was not the case for the countries with low level and volatility of inflation. These are also the countries with very low conditional mean or the predictable component. [6]

4 Institutional Characteristics and Inflation Targeting Effectiveness

It has been argued in the literature that the success of IT depends on the institutional strength of the country that adopts this regime. Mishkin and Schmidt-Hebbel (2001) suggest that the success of full-fledged inflation targeting is based on five pillars: the absence of other nominal anchors, an institutional commitment to price stability, the lack of fiscal dominance, policy instrument independence and accountability. In this section, we examine this hypothesis by investigating whether the success of IT countries in achieving their targets is determined by the strength of their institutions. To do so, we examine

[6]It should be noted that the persistence parameter beta for inflation gap is different than the inflation persistence parameter that has attracted widespread attention from researchers. One of the implications of that strand of research is that higher credibility of a central bank is associated with lower persistence implying that a shock to inflation disappears quickly as inflationary expectations are anchored. For example, see Cogley et al. (2010), Tillmann (2012) among others.

the role of fiscal situation, central bank independence, financial market development and macroeconomic outcomes. Fiscal stance is measured by the debt-GDP ratio. We measure the financial market development using domestic private credit to the real sector by deposit money banks. We obtain the data on these variables from the International Financial Statistics published by the International Monetary Fund. Financial depth and financial sophistication are measured by stock market capitalization to GDP and Central Bank Assets to GDP, respectively. The data are obtained from the World Bank. The central bank independence measure is calculated by the turnover rate of the central bank governor's tenure (Cukierman et al. (1994)). The rapid turnover signifies less autonomy and instability in the policy regime. This index is the inverse measure of central bank independence. The details of the construction of this index is provided in Appendix A. We also use GDP per capita as the measure of macroeconomic outcomes in our analysis. Since we are interested in the relationship between inflation gap and institutional characteristics, we only consider the post-IT sample period for each country.

To examine the impact of institutions on the deviation of actual inflation from the target, we consider a dynamic fixed-effects specification:

$$Y_{it} = X_{i,t}\beta_1 + W_{it}\beta_2 + \eta_i + \lambda_t + \epsilon_{i,t} \tag{6}$$

where $Y_{it} = \pi_{it}^{dev} = \pi_{it} - \pi_{it}^*$. X_{it} includes strictly exogenous regressors, W_{it} are predetermined regressors including lags of Y. η_i is the country-specific characteristics and λ_t is the time-specific effect. $X_{i,t}$ is a $(K-1)*1$ vector of regressors and $\epsilon_{i,t} \sim \mathcal{N}(0, \sigma_\epsilon^2)$ is a random disturbance. We assume the following:

$$\begin{aligned}
&\sigma_\epsilon^2 \geq 0 \\
&E(\epsilon_{i,t}, \epsilon_{j,s}) = 0 \quad i \neq j \quad or \quad t \neq s \\
&E(\eta_i, \epsilon_{j,t}) = 0 \\
&E(X_{i,t}, \epsilon_{j,s}) = 0
\end{aligned} \tag{7}$$

In our analysis, we regress inflation gap on a set of regressors including its own lag, GDP growth, money growth, central bank independence index, central bank assets to GDP ratio, stock market capitalization to GDP and private credit to GDP ratio. In addition of

inflation gap, we also consider cumulative inflation gap as a dependent variable because central banks may not try to achieve their target every period because of the noise in the aggregate inflation data, but instead they may want to focus on cumulative deviation as consistent deviation from the target may affect its credibility.

Table 3 summarizes the estimation results for the panel analysis. Our panel estimation includes both the individual and time-specific effects. We also use Panel Corrected Standard Errors (PCSE) introduced by Beck and Katz (1995). The results are economically meaningful and signs on the coefficients are consistent with the existing findings in the literature. To control for the lag dependence, we include the lag of dependent variable as explanatory variables. The results suggest significant dependence of inflation and cumulative inflation gap on their past. This is consistent with the findings of the previous section.

Higher debt-GDP ratio is a measure of increased debt burden and has bearing on the conduct of the monetary policy. We find that higher debt burden is associated with higher inflation gap and this relationship is significant at all levels of significance. This relationship remains robust to the use of cumulative deviation as a dependent variable. This finding is consistent with the fiscal dominance theory which suggests that fiscal indiscipline constrains monetary policy and may affect the central bank's ability to function prudently. We observe that the inverse of central bank independence index measured by the central bank governor's turnover ratio has a positive impact on the inflation deviation and cumulative inflation deviation. It implies that greater central bank autonomy lowers the inflation gap and cumulative inflation deviation. The independence of central banks is one of the preconditions for adopting inflation targeting. There is a consensus in the central banking literature that greater central bank independence is associated with lower and more stable inflation (Mishkin and Schmidt-Hebbel (2001) and Batini and Laxton (2007)).

The variable real money growth is used as an indicator of inflationary pressure in the economy. We find that an increase in real money growth is associated with lower inflation gap and cumulative inflation gap. This is a counterintuitive result. One proposed explanation of this counterintuitive sign is that in many emerging economies real money growth reflects the level of financial development. This is especially true in countries where dollarization is a strong feature of the economy. In this scenario, finding a negative coefficient on real money growth is not surprising. We also find that higher GDP growth is associated with higher inflation gap. Higher inflation due to higher

GDP growth will lead to an increase of inflation gap in countries with stationary target rates.

We also examine the relationship between financial market depth indicators and inflation gap. For this purpose, we look at two measures of financial soundness: central bank assets to GDP and private credit to GDP ratios. We don't find significant relationship between central bank assets to GDP ratio and inflation gap. However, we find that private credit to GDP ratio positively and significantly affects inflation and cumulative inflation gap. If private credit is just an indicator of financial market depth, then we would have expected inflation gap to go down in response to higher private credit to GDP ratio. However, it has been argued that in many emerging economies a rapid increase in private credit may indicate overheating the economy and in that case it's not surprising that we find positive relationship with inflation and cumulative inflation gap.

Overall, our results from the panel analysis are largely consistent with the literature where researchers have argued that for the success of inflation targeting regime, stable and strong institutional set up is required. We find that the success of IT countries in terms of achieving their targets is strongly associated with the extent of fiscal discipline and macroeconomic performance.

5 Concluding Remarks

This paper examines the effectiveness of inflation targeting countries in terms of their success in achieving their explicit inflation targets. Keeping in mind that there are unanticipated shocks that can affect actual inflation, we propose to test the effectiveness of the central bank by decomposing the inflation gap, the difference between actual inflation and inflation targets, into predictable and unpredictable components. We argue that the predictable component of inflation gap, which we measure by the conditional mean of a time-varying parameter autoregressive model should converge to zero if the IT regime is successful in achieving the target. Our results find considerable heterogeneity in the success of these IT countries in achieving their targets at the start of this policy regime. We find that countries like Canada and New Zealand have been consistently successful, whereas there was a gradual decline in the predictable component of inflation gap in some emerging market economies like Colombia, Guatemala and Turkey. Interestingly, we also find that the predictable component of inflation gap started declining few years before these countries publicly joined the IT regime. This implies that the central banks of the IT

adopting countries started targeting inflation implicitly before becoming an explicit inflation targeter. Our panel data analysis suggests that the relative success of these countries in achieving their targets is influenced by their institutional characteristics particularly by fiscal discipline and macroeconomic performance.

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Appendix A

In this appendix, we explain how to construct the central bank independence measure. Cukierman et al. (1994) develop four measures of central bank independence and measure their correlation with the inflation outcomes. The legal index, the rate of turnover of central bank governors, an index based on a questionnaire answered by specialists and an aggregation of the legal index with the turnover rate. They conclude that the legal independence is negatively related to the inflation in industrial countries, but not in developing countries. We consider the turnover of central bank governors as an index for central bank independence. We use the turnover index because this index is more accurate than the legal index or questionnaire based criterion in the emerging market economies. This index is more accurate in those countries because of the fact that the legal index is based on central bank laws and it doesn't reflect the central bank independence.

We construct the index based on the findings of Cukierman et al. (1994) by assuming that above a threshold, a rapid turnover of central bank governors determines a higher dependence and a lower $ICBI$. If the political authorities frequently choose a new governor, they have the opportunity to pick those who favor the nominators' will. Frequent turnover reflects firing those who challenge the government. This is true especially in developing countries. Therefore, the measure for this index is in accordance with the electoral cycle for the central banks. If the turnover of central bank governor is four years the index will be .25, and so on.

Using the turnover index, we find the central bank independence for all inflation targeters. Table A1 presents the average annual turnover rates in our sample countries for two time periods, 1980–1999 and 2000–2013. The average annual turnover rates are calculated from the ratio of governor changes to the number of years in that period. The average turnover rate during 1980–1999 ranges from a minimum of 0.0 to a maximum of 0.2. An average turnover of 0.0 indicates no change in the last 20 years. Canada, Colombia, the Czech Republic, Hungary and the United Kingdom are the few examples of totally

independent structures. However, countries like Chile, Poland and Turkey have the highest rates of dependency. The central banks' independence has increased from the period 1980–1999 to 2000– 2013. In the first period, there are five countries with totally independent central banks; whereas, after 2000 it has risen to 13 countries. In general, the average annual turnover rate reduced significantly in 15 countries, i.e. the degree of central bank independence has been increasing over time.

Table A1: Average Annual Turnover Rates of the central bank governors for inflation targeters, 1980–2013

Countries	1980–1999	2000–2013	Countries	1980–1999	2000–2013
United States	0.05	0.07	Mexico	0.10	0.14
Armenia	0.10	0.07	New Zealand	0.15	0.07
Australia	0.05	0.00	Norway	0.15	0.00
Brazil	0.05	0.07	Peru	NA	0.14
Canada	0.00	0.00	Philippines	0.15	0.07
Chile	0.20	0.07	Poland	0.20	0.14
Colombia	0.00	0.07	Romania	0.15	0.00
Czech	0.00	0.00	Serbia	NA	0.21
Ghana	0.15	0.21	South Africa	0.05	0.00
Guatemala	NA	NA	South Korea	0.10	0.00
Hungary	0.00	0.00	Sweden	0.10	0.14
Iceland	0.10	0.00	Thailand	0.15	0.00
Indonesia	0.05	0.00	Turkey	0.20	0.00
Israel	0.15	0.14	UK	0.00	0.00

Note: Average number of changes a year

Table 1: Inflation targeting countries in the world, 1989–2013

Countries	Adoption Date	Target (adoption date)	Target (2013)	Group	Target Path
Armenia	*2006Q1*	4	4	EME	Convergence
Australia	*1993Q2*	2.5	2.5	IND	Stationary
Brazil	*1999Q2*	8	4.5	EME	Convergence
Canada	*1991Q1*	4	2	IND	Stationary
Chile	*1999Q3*	3	3	EME	Stationary
Colombia	*1999Q3*	5	3	EME	Convergence
Czech	*1997Q4*	6	2	EME	Stationary
Ghana	*2002Q1*	12	8	EME	Convergence
Guatemala	*2005Q1*	5	4.5	EME	Convergence
Hungary	*2001Q2*	7	3	EME	Convergence
Iceland	*2001Q1*	3.5	2.5	IND	Stationary
Indonesia	*2005Q3*	5	4.5	EME	Convergence
Israel	*1992Q1*	14.5	2	EME	Stationary
Mexico	*2001Q1*	5	3	EME	Stationary
New Zealand	*1989Q4*	4	2	IND	Stationary
Norway	*2001Q1*	2.5	2.5	IND	Stationary
Peru	*2002Q1*	2.5	2	EME	Stationary
Philippines	*2002Q1*	4.7	4	EME	Stationary
Poland	*1998Q1*	8.25	2.5	EME	Stationary
Romania	*2005Q3*	7.5	2.5	EME	Convergence
Serbia	*2006Q3*	8	4	EME	Convergence
South Africa	*2000Q1*	3	4.5	EME	Stationary
South Korea	*1998Q2*	9	3	EME	Stationary
Sweden	*1993Q1*	2	2	IND	Stationary
Thailand	*2000Q2*	1.75	3	EME	Stationary
Turkey	*2006Q1*	5	5	EME	Convergence
UK	*1992Q3*	3	2	IND	Stationary

Note: EME and IND indicate Emerging Market and Industrial Economies, respectively.
Source: Adoption dates and inflation targets are taken from the central banks' web pages. Country group and target path are based on Schmidt-Hebbel (2009).

Table 2: Descriptive statistics of inflation

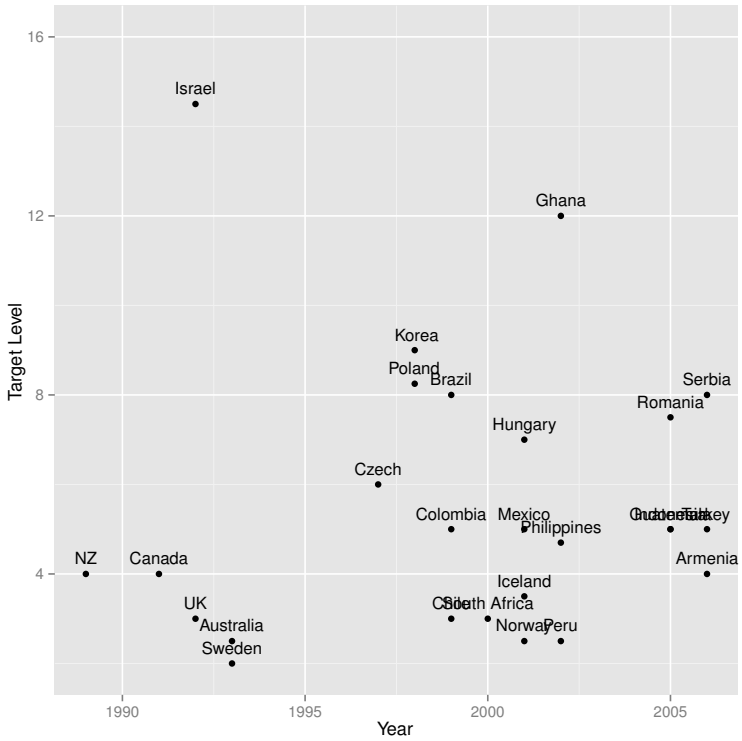
Countries	Period	Mean	St Dev	Countries	Period	Mean	St Dev
	Pre-IT	10.70	23.20		Pre-IT	10.41	4.57
Armenia	Post-IT	5.54	2.66	New Zealand	Post-IT	2.31	1.40
	Whole	*8.69*	*18.14*		*Whole*	*4.50*	*4.49*
	Pre-IT	6.49	3.07		Pre-IT	4.69	3.04
Australia	Post-IT	2.62	1.30	Norway	Post-IT	1.81	1.11
	Whole	*4.10*	*2.85*		*Whole*	*3.58*	*2.86*
	Pre-IT	12.25	14.11		Pre-IT	13.05	13.87
Brazil	Post-IT	6.32	2.49	Peru	Post-IT	2.66	1.49
	Whole	*7.72*	*7.39*		*Whole*	*7.52*	*10.78*
	Pre-IT	5.77	2.73		Pre-IT	9.82	8.86
Canada	Post-IT	1.96	1.15	Philippines	Post-IT	4.23	1.85
	Whole	*3.12*	*2.51*		*Whole*	*7.87*	*7.68*
	Pre-IT	14.43	6.95		Pre-IT	24.23	8.40
Chile	Post-IT	3.03	2.14	Poland	Post-IT	3.87	2.82
	Whole	*9.55*	*7.84*		*Whole*	*9.62*	*10.56*
	Pre-IT	20.26	4.28		Pre-IT	22.52	11.98
Colombia	Post-IT	5.17	2.10	Romania	Post-IT	5.44	1.90
	Whole	*13.82*	*8.33*		*Whole*	*13.21*	*11.85*
	Pre-IT	10.72	4.12		Pre-IT	26.53	21.23
Czech	Post-IT	3.12	2.62	Serbia	Post-IT	8.06	3.15
	Whole	*5.14*	*4.58*		*Whole*	*18.83*	*18.64*
	Pre-IT	24.82	12.38		Pre-IT	11.19	3.65
Ghana	Post-IT	12.86	4.42	South Africa	Post-IT	5.71	2.63
	Whole	*20.03*	*11.58*		*Whole*	*8.94*	*4.20*
	Pre-IT	11.05	9.32		Pre-IT	5.73	3.54
Guatemala	Post-IT	5.70	2.90	South Korea	Post-IT	2.89	1.23
	Whole	*9.64*	*8.48*		*Whole*	*4.38*	*3.05*
	Pre-IT	14.17	7.40		Pre-IT	6.85	2.56
Hungary	Post-IT	4.87	1.75	Sweden	Post-IT	1.37	1.34
	Whole	*10.66*	*7.48*		*Whole*	*3.39*	*3.26*
	Pre-IT	9.15	8.86		Pre-IT	4.26	2.55
Iceland	Post-IT	5.65	3.32	Thailand	Post-IT	2.63	1.87
	Whole	*7.63*	*7.2*		*Whole*	*3.61*	*2.43*
	Pre-IT	10.00	9.10		Pre-IT	45.02	24.88
Indonesia	Post-IT	7.02	3.64	Turkey	Post-IT	7.98	1.71
	Whole	*9.20*	*8.18*		*Whole*	*31.62*	*26.73*
	Pre-IT	16.86	1.84		Pre-IT	5.85	2.32
Israel	Post-IT	4.49	3.99	UK	Post-IT	2.17	0.91
	Whole	*7.11*	*6.27*		*Whole*	*3.48*	*2.36*
	Pre-IT	16.20	8.68				
Mexico	Post-IT	4.31	0.83				
	Whole	*9.64*	*8.33*				

Note: 'Pre-IT' refers to the period before the inflation targeting is adopted by each county.'Whole' refers to the entire sample.
Source: Authors' calculation.

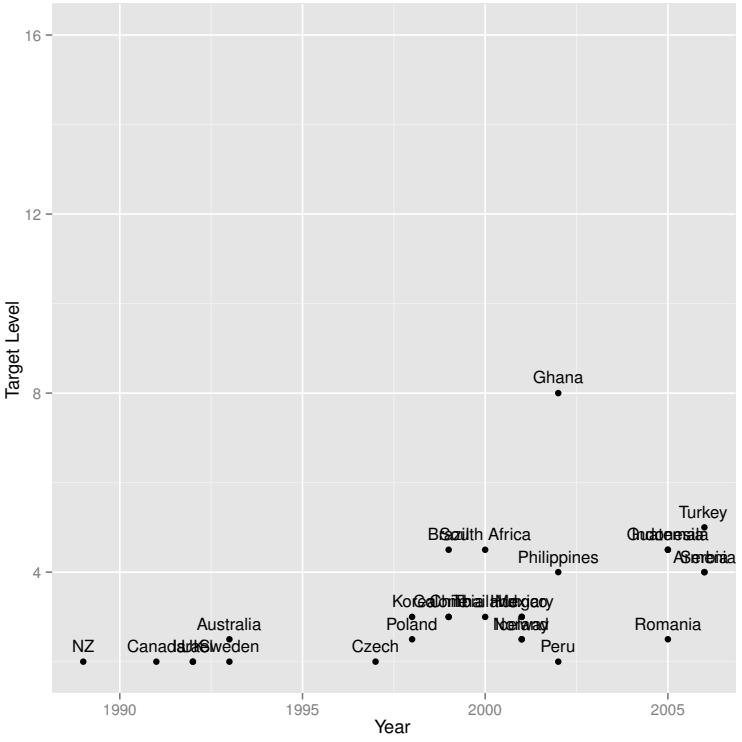
Table 3: Institutional characteristics and inflation gap: Panel estimation results

	Dependent variable:	
	π^{dev}	π^{dev}_{csum}
	(1)	(2)
π^{dev}_{t-1}	0.419^{***}	
	(0.075)	
π^{dev}_{t-2}	-0.180^{***}	
	(0.062)	
$\pi^{dev}_{csum,t-1}$		1.224^{***}
		(0.074)
$\pi^{dev}_{csum,t-2}$		-0.340^{***}
		(0.066)
$Money_g$	-0.064^{**}	-0.070^{***}
	(0.025)	(0.026)
$PCredit/GDP$	0.010^{**}	0.011^{***}
	(0.004)	(0.003)
GDP_g	22.939^{***}	12.457
	(7.995)	(8.361)
$ICBI$	1.634	1.400
	(2.452)	(1.977)
$CBAssets/GDP$	0.005	0.009
	(0.023)	(0.024)
$Debt/GDP$	0.026^{***}	0.029^{***}
	(0.008)	(0.008)
Note:	*p<0.1; **p<0.05; ***p<0.01	

The dependent variables are inflation gap, π^{dev}, and the cumulative inflation gap, π^{dev}_{csum}. The regressors are lagged dependent variables, real money growth, $Money_g$, private credit to GDP ratio, $PCredit/GDP$, real GDP growth, GDP_g, the inverse measure of central bank independence, $ICBI$, central bank assets to GDP ratio, $CBAssets/GDP$, and the government debt to GDP, $Debt/GDP$. Note that the robust standard errors are reported in parentheses, according to the Beck and Katz (1995) method, a.k.a. Panel Corrected Standard Errors (PCSE).

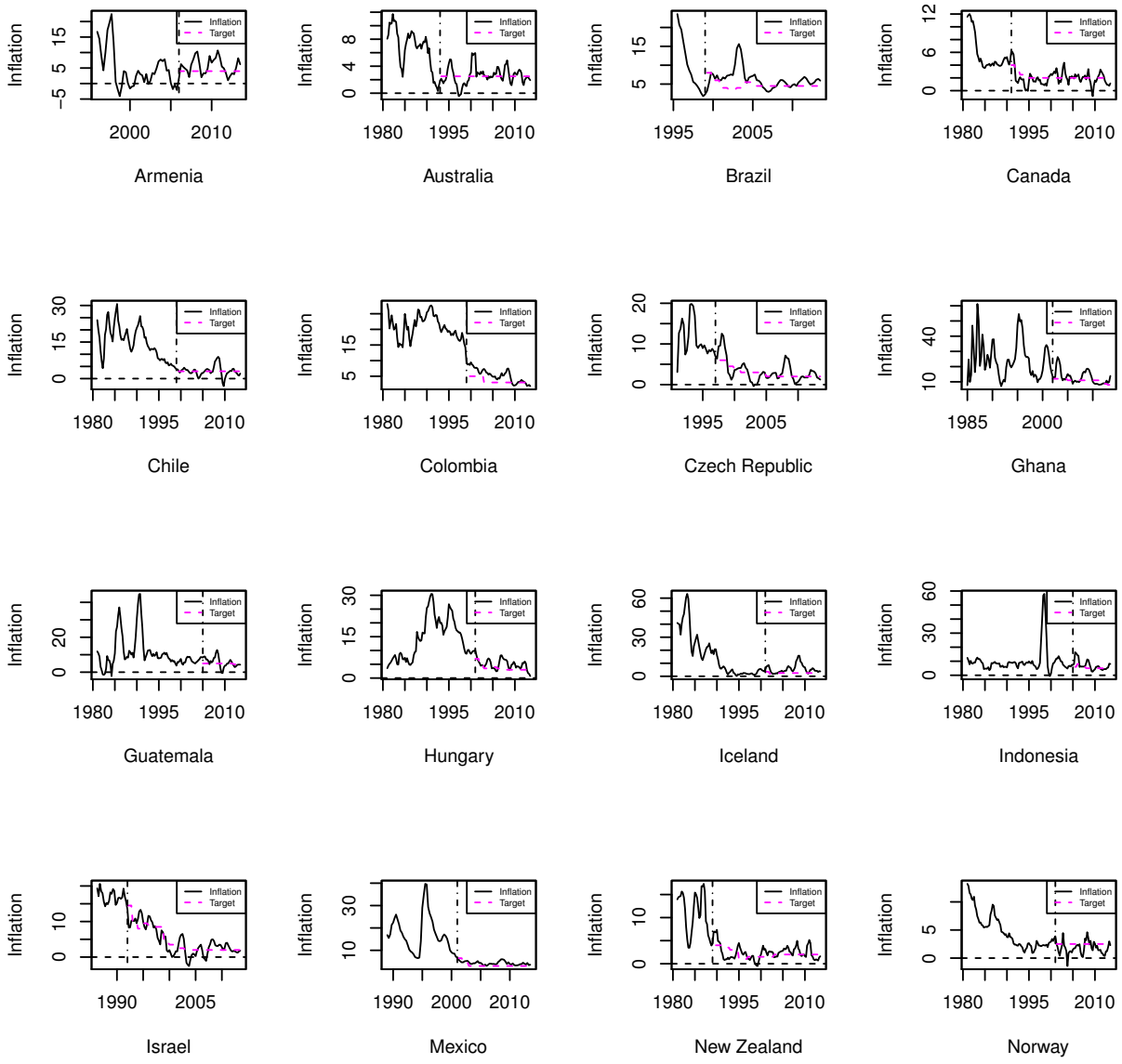


(a) Target Level at the Adoption Date



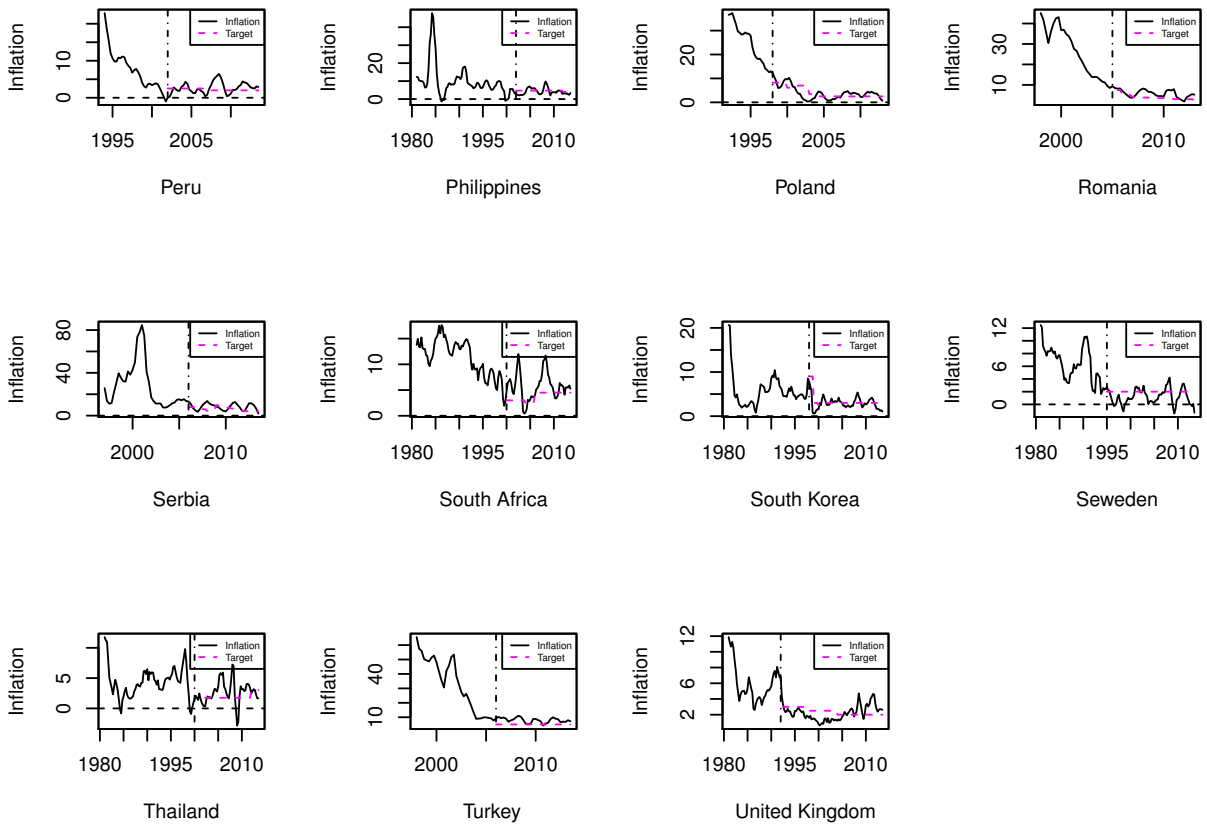
(b) Target Level in 2013

Figure 1: Target level at the adoption date and 2013



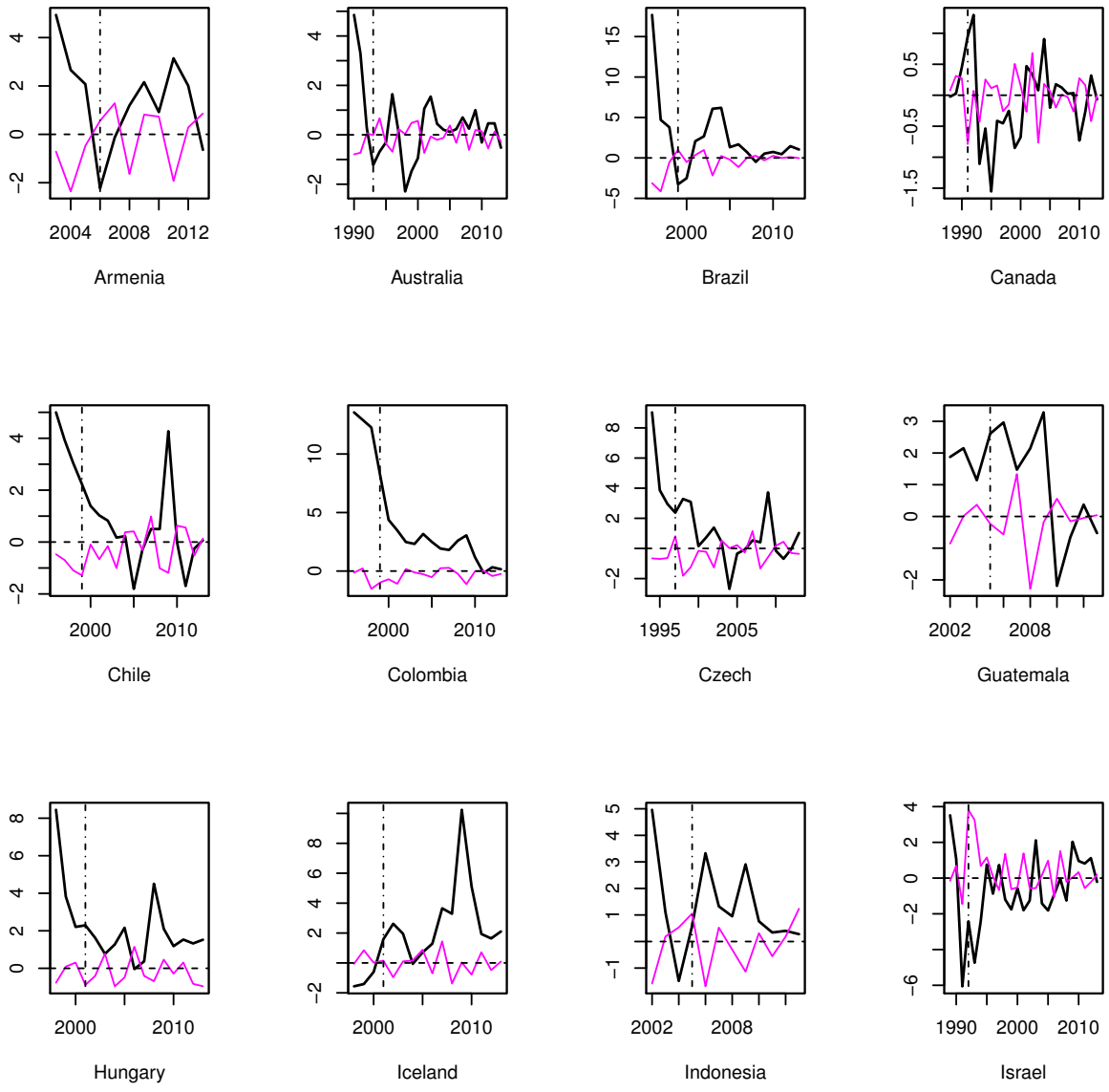
(a)

Figure 2: Annual inflation rates and targets in inflation targeting countries, 1980–2013
Source: Authors' calculations, based on data from the IMF's International Financial Statistics and central banks' websites.



(b)

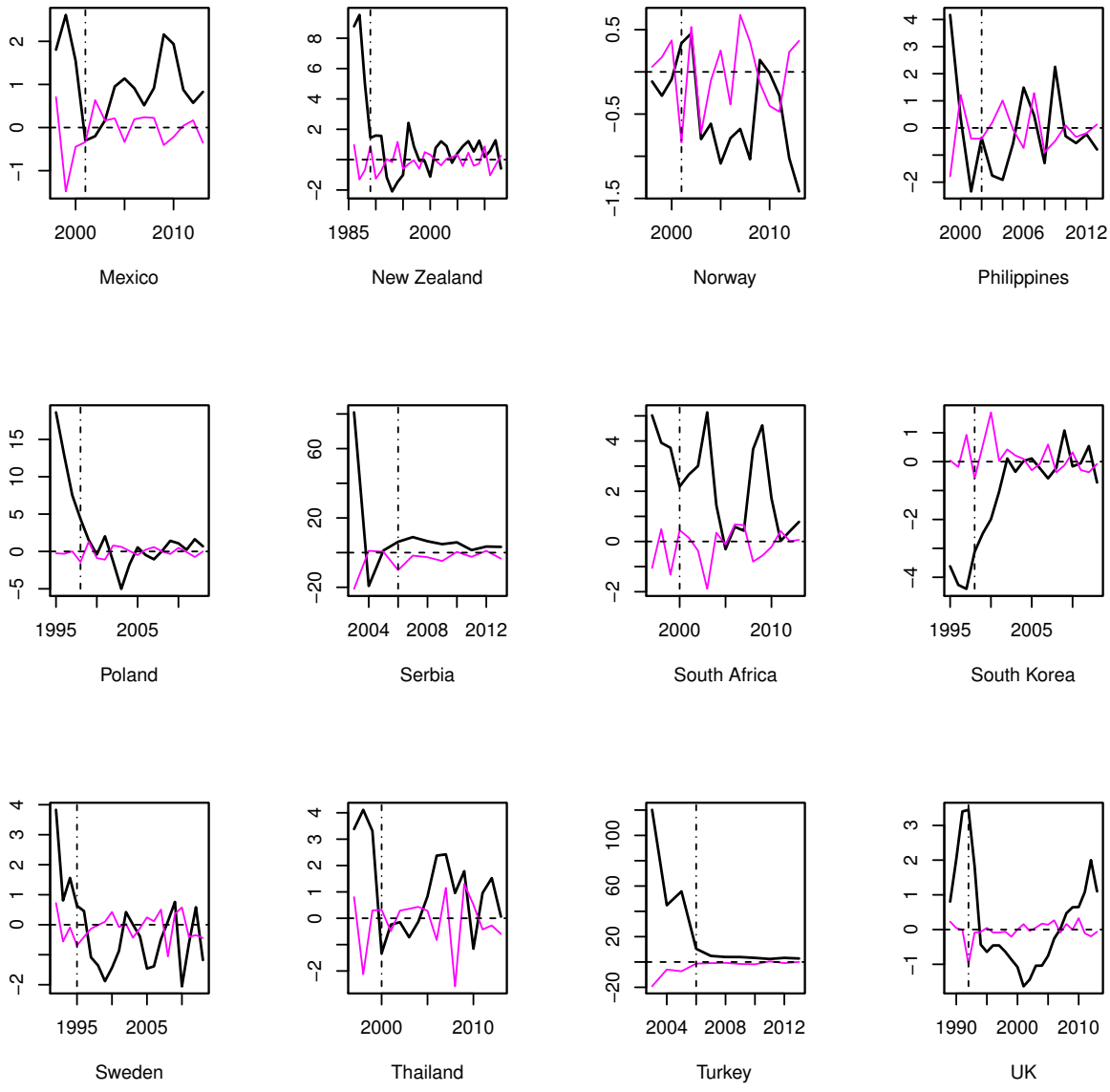
Figure 2: Annual inflation rates and targets in inflation targeting countries, 1980–2013
Source: Authors' calculations, based on data from IMF's International Financial Statistics and central bank websites.



(a)

Figure 3: Time-varying conditional expectations of inflation gap and residuals from the TVP-AR model

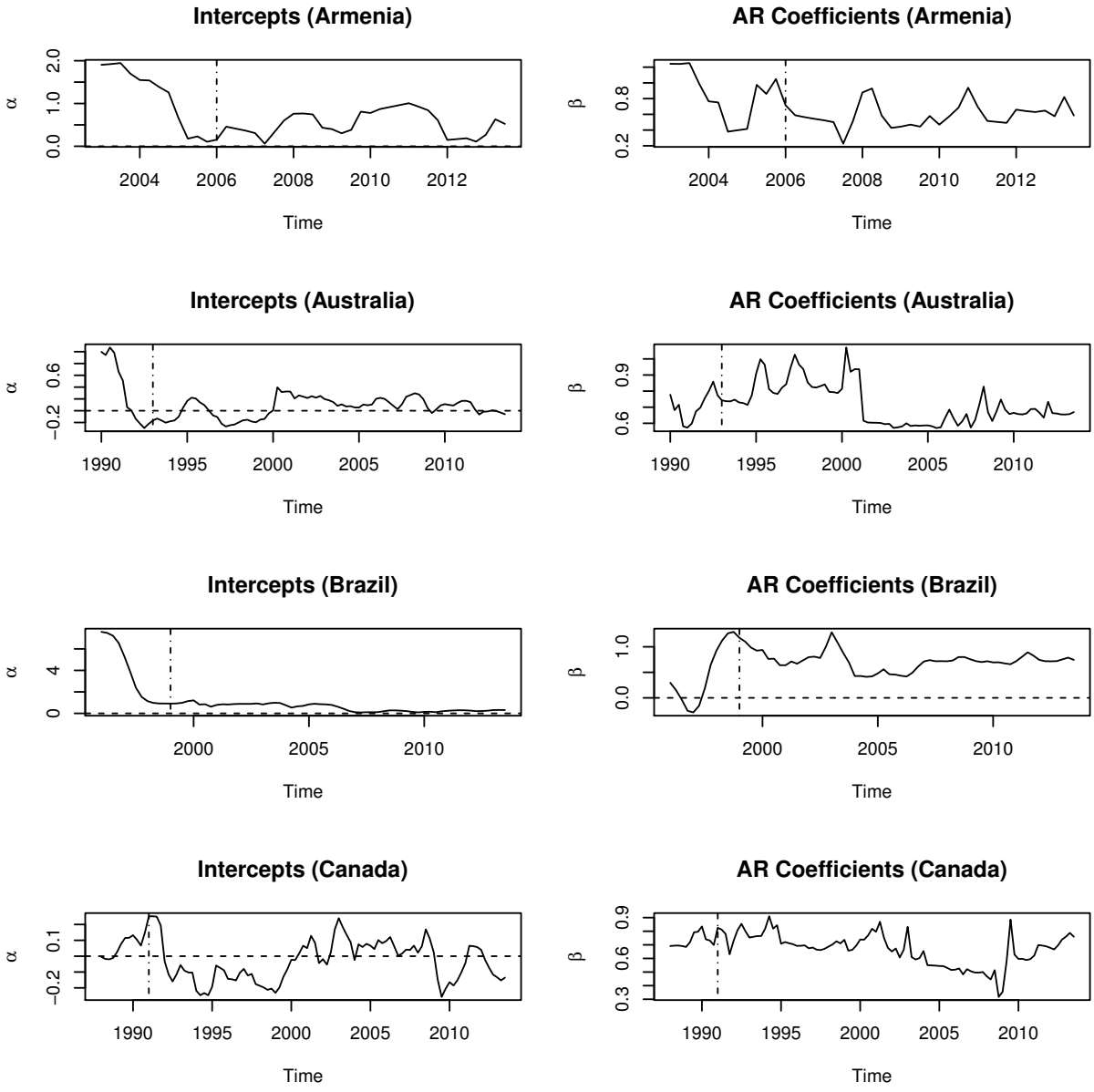
Source: Authors' calculations.



(b)

Figure 3: Time-varying conditional expectations of inflation gap and residuals from the TVP-AR model

Source: Authors' calculations.



(a)

Figure 4: Filtered Time-Varying Coefficients

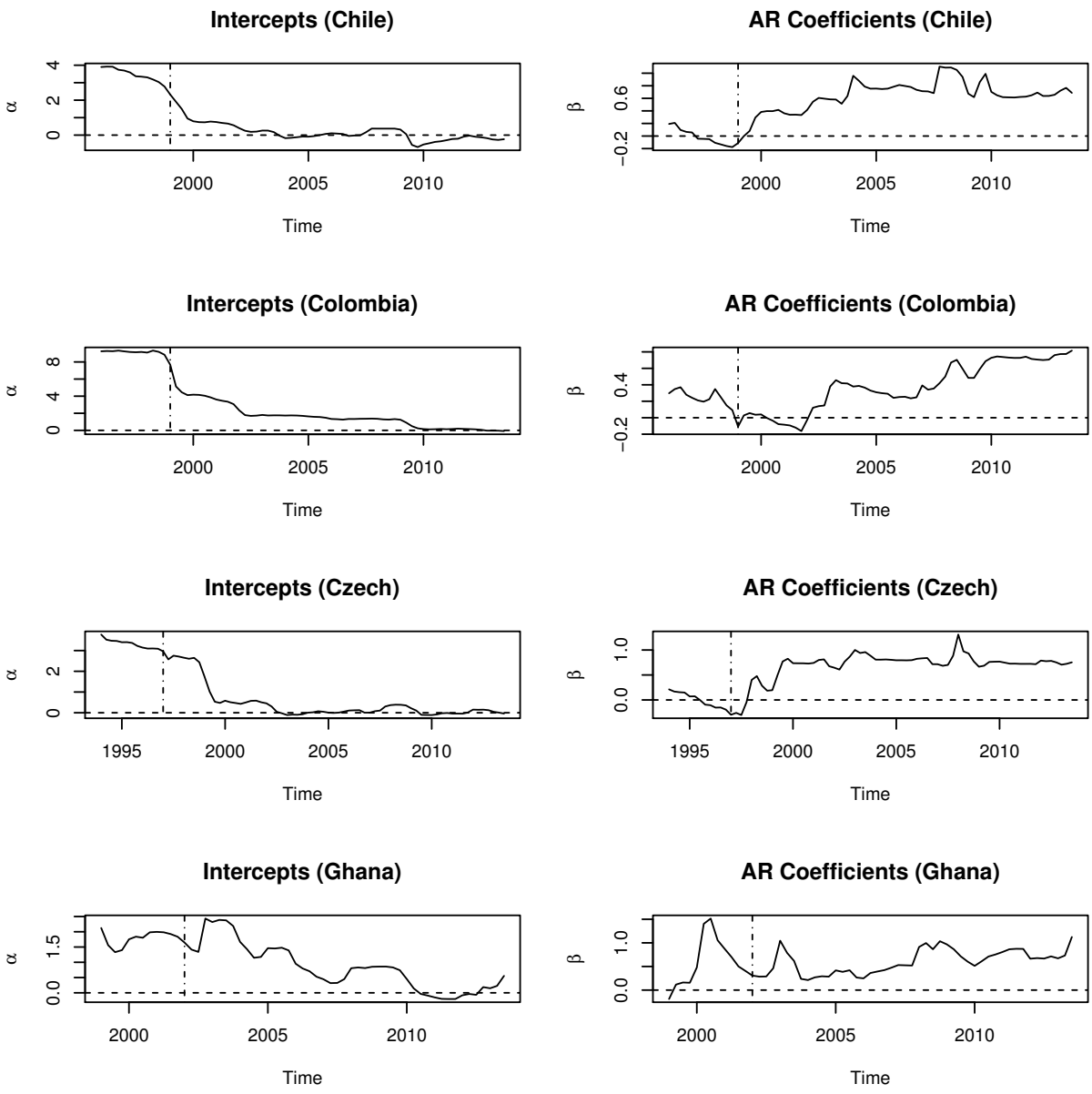


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Figure 4: Filtered Time-Varying Coefficients

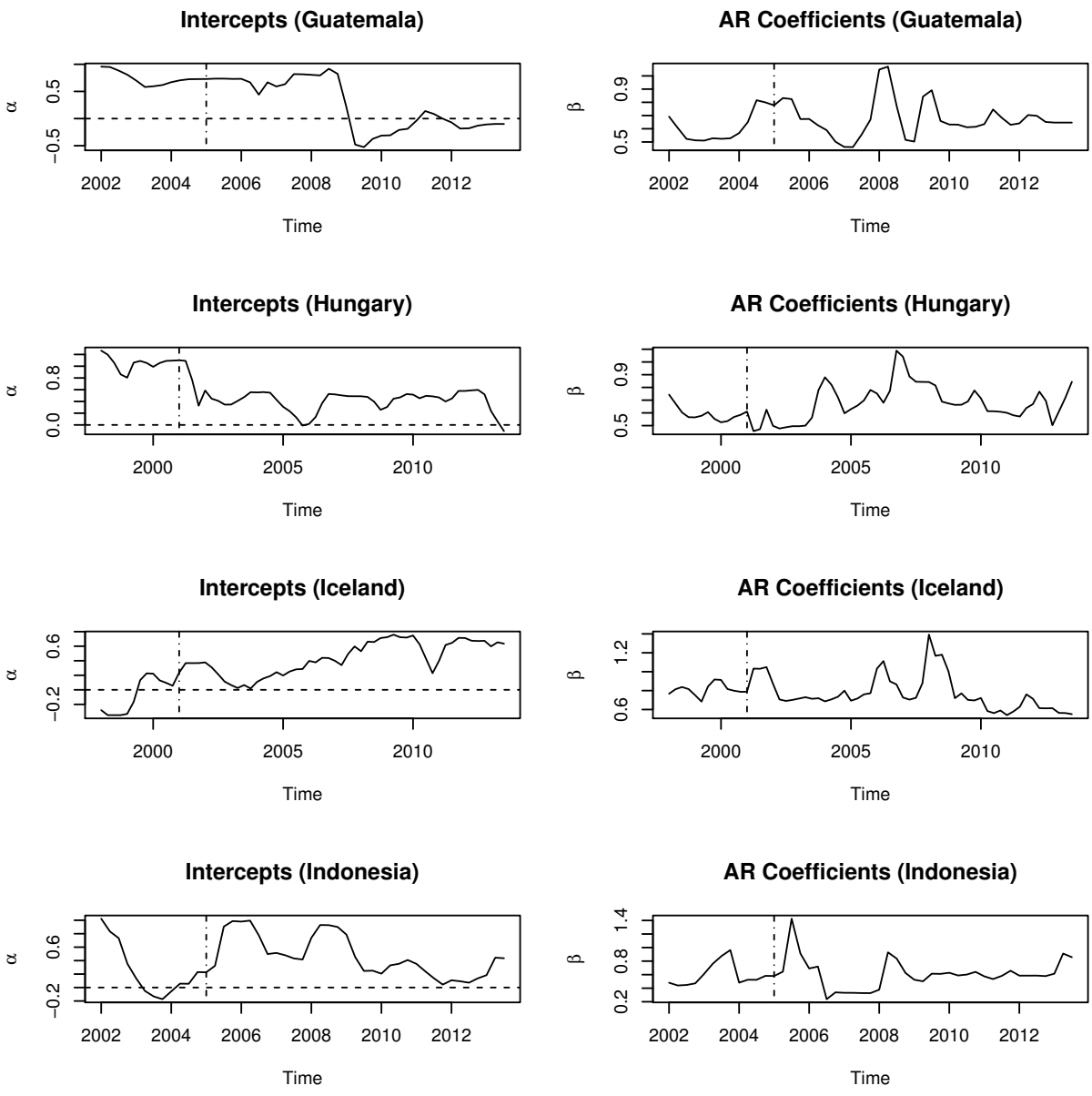

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Figure 4: Filtered Time-Varying Coefficients

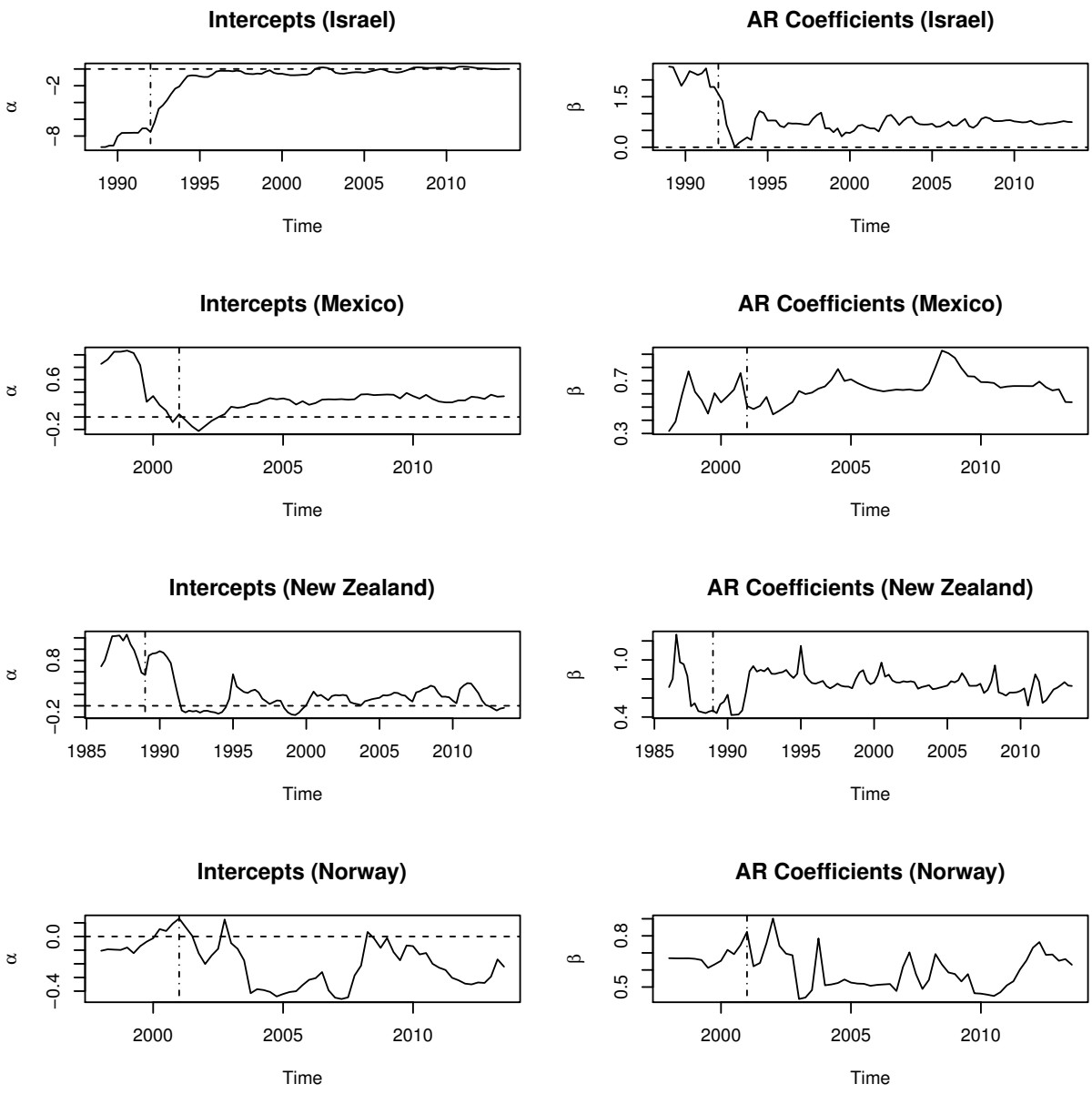

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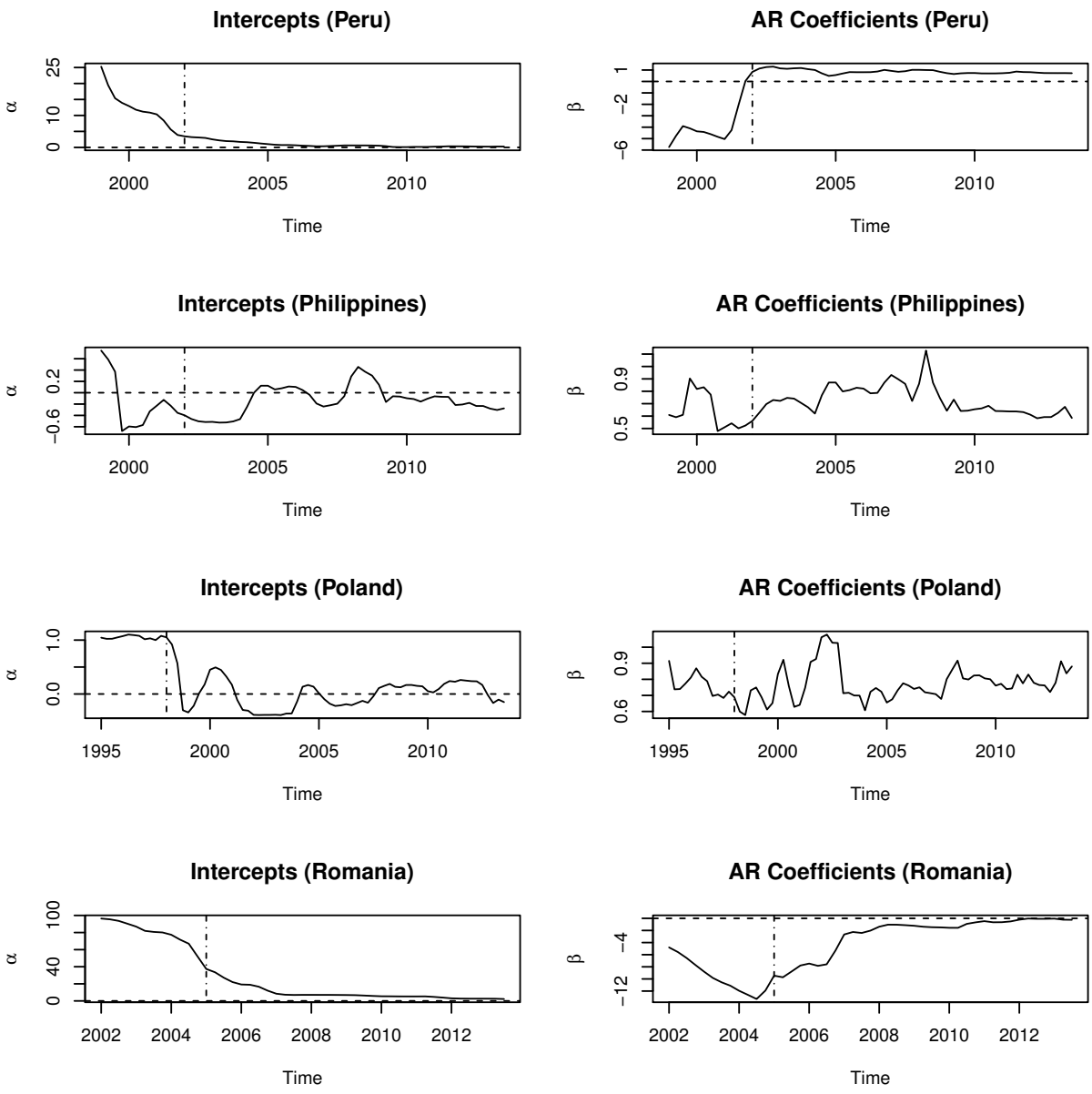
Figure 4: Filtered Time-Varying Coefficients



(e)

Figure 4: Filtered Time-Varying Coefficients

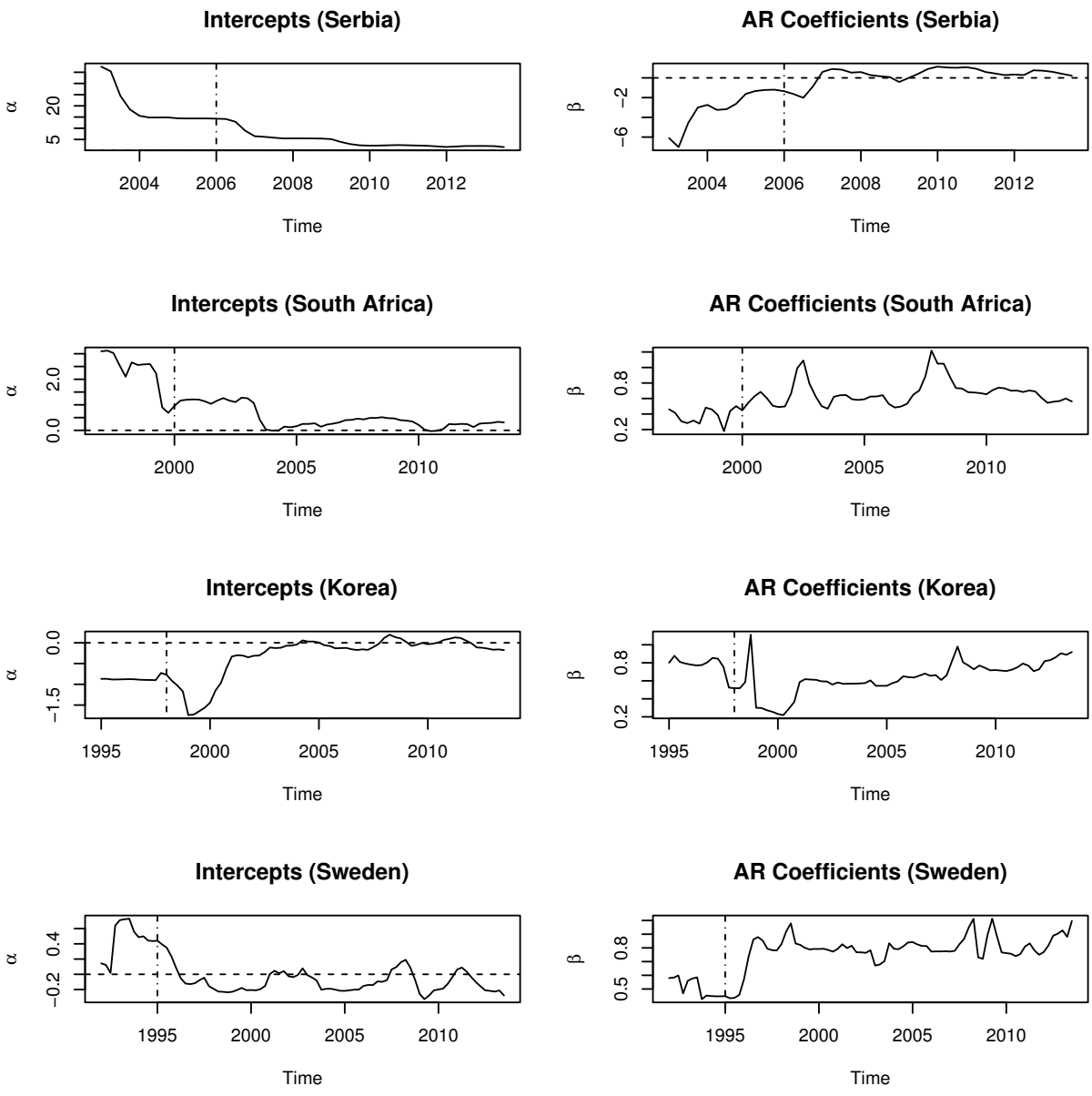


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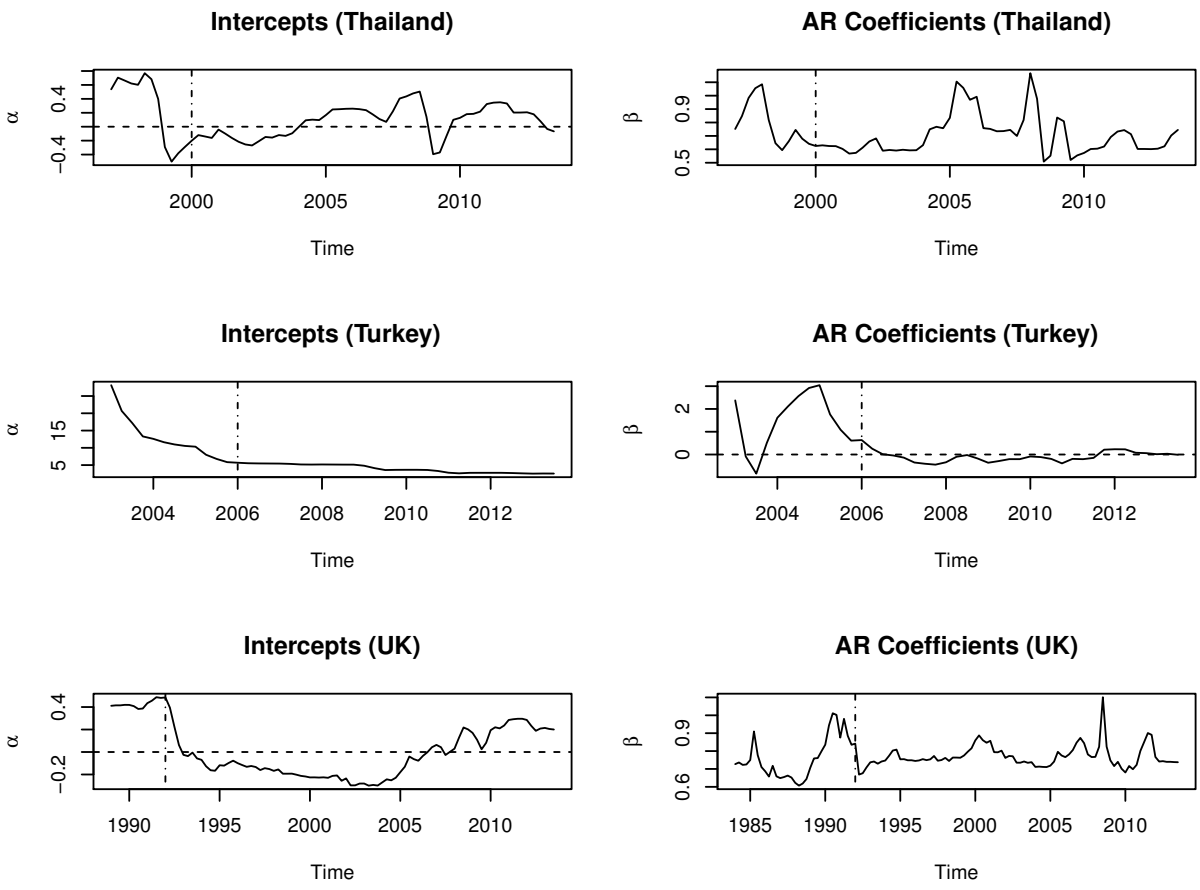
Figure 4: Filtered Time-Varying Coefficients



(g)

Figure 4: Filtered Time-Varying Coefficients