Does Inflation Targeting Always Matter for the ERPT? A robust approach

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Abstract

This paper estimates the effects of different forms of inflation targeting (IT) in the exchange rate pass-through (ERPT). To this end, we first estimate the ERPT for a large sample of countries using state-space models. We then consider the adoption of an inflation targeting framework by a country as a treatment to find suitable counterfactuals to the actual targeters. By controlling for self-selection bias and endogeneity of the monetary policy regime, we confirm that the ERPT tends to be lower for countries adopting explicit IT. However, we uncover that older regimes, adopting a range or point with tolerance band and keeping inflation close to the target, outperform other IT regimes. We also show that IT is effective even with a relatively high inflation target or low central bank independence.

JEL Classification: E31; E42; E52; C30.
Keywords: exchange rate pass-through; inflation targeting; state-space model; propensity score matching.

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1 Introduction

It is well documented that exchange rate variations are less than completely associated with changes in prices in recent times. The most common interpretation for this finding is that improvements in monetary policy performance - reflected in stronger nominal anchors and low, stable inflation - result in an endogenous reduction in the exchange rate pass-through to consumer prices.[1] Moreover, the adoption of inflation targeting (IT) is often associated with this stability.

Indeed, it is argued that in the context of a stable and predictable monetary policy environment, nominal shocks –such as exchange rate shocks– play a vastly reduced role in driving fluctuations in prices (Taylor (2000)). Thus, improvements in monetary policy performance–reflected in stronger nominal anchors and low, stable inflation–result in an endogenous reduction in the exchange rate pass-through to consumer prices: when the inflation environment is more stable, firms resist passing exchange rate changes on to prices.[2] Similar arguments are developed in Gagnon and Ihrig (2004), Bailliu and Fujii (2004), Devereux, Engel, and Storgaard (2004), Ihrig, Marazzi, and Rothenberg (2006), Marazzi and Sheets (2007), Bouakez and Rebei (2008), Devereux and Yetman (2010) and Dong (2012) where the size of pass-through is a function of the stance of monetary policy.

Following this strand of the literature, many studies provide evidence that the adoption of an inflation targeting framework is associated with an improvement in overall economic performance (Bernanke and Mishkin (1997); Svensson (1997)). For instance, Mishkin and Schmidt-Hebbel (2007) suggest that exchange rate pass-through (ERPT) seems to be attenuated by the adoption of IT. The basic underlying idea is that adopting IT leads to credibility gains that are responsible for keeping low inflation expectations following an exchange rate appreciation. Consequently, opting for an inflation targeting framework is a means to reduce ERPT since under this regime, (i) inflation is expected to be diminished and stabilized, and (ii) central banks are expected to gain credibility as inflation-fighters. In addition, as shown by Reyes (2007), under inflation targeting regime, central banks respond to an exchange rate appreciation by increasing the interest rate to impede that exchange rate changes feed into inflation.

Most of the previous literature on ERPT and its link with inflation targeting, however, misses some key elements: self selection bias, endogeneity and heterogeneity of the inflation target regime. In the first case, selection bias occurs when

[1]See, for instance, Goldberg and Knetter (1997) and Campa and Goldberg (2005).

[2]In other words, if the increase in costs following a depreciation is perceived as transitory, agents can reduce temporarily their markups, save the menu costs of changing prices and simply wait until the shock reverts. On the contrary, if the shock is perceived as permanent or highly persistent, the price adjustment is inevitable. Since the economy will be subject to more persistent nominal shocks in high inflation regimes, the link between the level of inflation and the pass-through emerges.

IT is not randomly allocated across countries, but is instead correlated with other variables. A difference in ERPT between countries faced with IT (the so-called treated group) and the other countries (the so-called control group) could then be attributable to systematic differences in some variables between the treated and control groups rather than the effect of the treatment itself (IT adoption). In the second case, the adoption of inflation targeting is clearly an endogenous choice (see Mishkin and Schmidt-Hebbel (2001)). For instance, countries with histories of high inflation or expecting future high inflation are more likely to have felt compelled to adopt an inflation targeting framework. The finding that lower ERPT is associated with inflation targeting thus may not imply that inflation targeting causes ERPT. Finally, note that this literature provides no evidence as to which of the different forms and institutional arrangements of IT is more effective at reducing the ERPT.

The objective of this paper is to establish whether and how inflation targeting alter the way exchange rate changes impact prices. We contribute to the literature in different aspects. First, we use the Kalman filter to estimate the ERPT. By doing so, we allow this parameter to vary without imposing assumptions about whether or how it varies. Second, we pay special attention to self selection bias and endogeneity with regard to the monetary policy regime by relying on a methodology that allows us to determine whether a treatment leads to different outcomes than the absence of treatment. To this end, we match treated observations with control observations that share similar characteristics other than the presence of the treatment. That is, we construct a counterfactual for the treatment, based on a set of observable characteristics. This is particularly important since while a large part of the literature proposes that explicit IT regimes are generally associated with higher macroeconomic performance (Levin, Natalucci, and Piger (2004); Mishkin and Schmidt-Hebbel (2007)), other studies suggest that there is no evidence that performance is attributable to IT (see Ball and Sheridan (2003); Lin and Ye (2007) or Angeriz and Arestis (2008)).[3] Third, as the benefits of explicitly adopting an IT regime are still an open debate in the literature, our main contribution is to analyze, in detail, the effectiveness of the IT regime under different circumstances. In particular, we alter our original sample by dropping one at a time from the whole sample IT countries that present different characteristics in terms of the monetary regime. Therefore we first distinguish countries regarding their initial level of inflation. Second, from the original sample, we distinguish observations according to the inflation targeted level. Third, from all IT and Non IT observations, we use different treatments regarding the deviations of actual inflation to the announced target. Fourth, we differentiate by the durability of the regime. Fifth, we formed the treatment with respect to the independence of the central bank. Sixth, observations

[3]Some literature on propensity scores to assess the effect of inflation targeting on inflation or exchange rate volatility can be found in Lin and Ye (2009), Lin (2010), de Mendonca and de Guimarï¿½es e Souza (2012), Samarina, Terpstra, and Haan (2014) or Yamada (2013). However, to the best of our knowledge, our paper is the first one to use this technique for evaluating ERPT.

were differentiated between point or band target. By performing this exercise, we try to shed light into the mechanisms through which IT lowers the ERPT.

Since the ERPT is not an observable variable, our empirical assessment relies on a two-stage procedure. In the first stage, we estimate time-varying coefficients of exchange rate pass through for each economy by means of state space models. In the second step, we explore whether these estimates are related to our proxies of monetary policy objective using a propensity score matching (PSM) methodology. We estimate different models and use several alternative definitions in order to ensure the robustness of our findings.

Our results can be summarized as follows. First, IT significantly reduces the ERPT. Second, this benefit is robust to different structural characteristics. Third, we reveal some important heterogeneities among IT countries. In particular, older regimes outperform newer regimes. Also, allowing for a band or range target is found to be more efficient than a single point targeting regime. Finally, keeping inflation relatively close to the objective, even if this objective is higher than 2 percent, makes a difference for achieving lower pass through.

The rest of the paper is organized as follows. Section 2 describes in detail our methodology. Section 3 presents the data. Section 4 displays our estimation results, and Section 5 concludes the paper.

2 Methodology

The main objective of this paper is to assess whether inflation targeters differ from non-targeters in the response of inflation to shocks in the exchange rate. To this end, we first estimate the ERPT. Instead of using the traditional rolling ERPT estimates, we rely in state space models that allow us to estimate the coefficients for each period of the sample employed in this paper. We then test for differences between targeters and non targeters by adopting a PSM methodology.

2.1 Estimating time-varying ERPT by state space models

The degree of exchange rate pass-through is not directly observable and therefore needs to be estimated before its hypothetical link with a monetary target can be tested. Following Kim (1990) and Sekine (2006), we estimate a varying-parameter model for quarterly data of the pass-through based on the following generic specification proposed by Goldberg and Knetter (1997):

$$\Delta p_t = \alpha + \sum_{j=1}^{4} \gamma_j \Delta p_{t-j} + \theta_t \Delta e_t + \rho \Delta y_t + \lambda \Delta p_t^* + G\epsilon_t \tag{1}$$

where p_t denotes consumer prices in period t, e_t is the nominal effective exchange rate, y_t is the demand shifter (domestic GDP growth), p_t^* corresponds to a supply shock variable (average OECD producer price index) and $\epsilon_t \sim N(0, G_t)$ is an independent and identically distributed error term. We include 4 lags of the inflation rate to better capture the observed inertial behavior of inflation (inflation persistence), to avoid autocorrelation of the residuals and to avoid underestimating the ERPT. All the variables are expressed in logarithms.[4]

Following Campa and Goldberg (2005) or Gopinath, Itskhoki, and Rigobon (2010), among others, we also estimate the following pass-through equation:

$$\Delta p_t = \alpha + \sum_{j=1}^{4} \gamma_j \Delta p_{t-j} + \sum_{j=0}^{4} \theta_{j,t} \Delta e_{t-j} + \rho \Delta y_t + \lambda \Delta p_t^* + G\epsilon_t \tag{2}$$

In Eq. (2), the statistic of interest is the sum of the coefficients on the nominal exchange rate: $\theta_t(n) = \sum_{j=1}^{4} \theta_{j,t}$. These coefficients reflect the impact that the current change in the exchange rate has on the consumer price over time. Therefore, the estimations of Equations (1) and (2) yield short-run (one quarter) and long-run (four quarters) pass-through elasticities, respectively.

Note that, in Equations (1) and (2), the ERPT coefficient, θ, is assumed to be time-varying. We obtain these coefficients by expanding the previous equation, known as the the measurement equation, with the following ERPT shift equation:

$$\theta_t = \theta_{t-1} + C\upsilon_t \tag{3}$$

where the ERPT parameter θ depends on an autoregressive term and $\upsilon_t \sim N(0, Q_t)$. The system (1)-(3) constitute a state-space model. These type of models can be estimated using the Kalman filter recursive algorithm, which is commonly employed in time-varying coefficient models. The Kalman filter is a method for recursively obtaining linear, least-squares forecasts of unknown coefficients conditional on past information. These forecasts are used then to construct the log likelihood. More precisely, for each time t, the Kalman filter produces the conditional expected state vector $\theta_{t|t-1}$ and the conditional covariance matrix $\Omega_{t|t-1}$; both are conditional on information up to and including time t. Using the model and previous period results, for each t we begin with:

[4] Note that the ERPT equation is specified in first differences because the underlying series are generally found to be integrated of order one and non-cointegrated (see, e.g., Campa and Goldberg (2005)).

$$\begin{aligned}\theta_{t|t-1} &= \theta_{t-1|t-1} \\ \Omega_{t|t-1} &= \Omega_{t-1|t-1} + CQC' \\ \Delta p_{t|t-1} &= \alpha + \gamma \sum_{j=1}^{n} \Delta p_{t-j} + \theta_{t|t-1} \Delta e_t + \lambda \Delta p_t^* + \rho \Delta y_t + G\epsilon_t \end{aligned} \tag{4}$$

The residuals and the mean squared error (MSE) matrix of the forecast error are:

$$\begin{aligned}\hat{\nu}_{t|t} &= \Delta p_t - \Delta p_{t|t-1} \\ \Sigma_{t|t} &= y_t^* \Omega_{t-1|t-1} (\Delta e_t)' + GQG' \end{aligned} \tag{5}$$

In the last step, we update the conditional expected state vector and the conditional covariance with the information in time t:

$$\begin{aligned}\theta_{t|t-1} &= \theta_{t-1|t-1} + \Omega_{t|t-1}(\Delta e) \Sigma_{t|t}^{-1} \hat{\nu}_{t|t} \\ \Omega_{t|t} &= \Omega_{t|t-1} - \Omega_{t|t}(\Delta e) \Sigma_{t|t}^{-1} (\Delta e)' \Omega_{t|t-1} \end{aligned} \tag{6}$$

Equations (4) to (6) are the Kalman filter. The equations denoted by (4) are the one-step predictions. These predictions do not use contemporaneous values of Δp_t; only its past values. Equations (5) and (6) form the update step of the Kalman filter; they incorporate the contemporaneous dependent variable information into the predicted states. In addition, the Kalman filter requires initial values for the states and a covariance matrix for the initial states to start off the recursive process.[5] The previous system of equations can then be estimated by maximum likelihood.

2.2 Assessing the effects of a target with propensity score matching

In order to determine whether countries that have adopted IT present a lower level of ERPT than countries that have not, we must properly control for endogeneity and self selection bias since IT countries may also have lower inflation and pass through rates for other reasons than the adoption of IT. Then, a challenge in evaluating the benefits of IT is to disentangle the direction of causality. Indeed, it could be argued that if IT improves the credibility of monetary policy and the anchoring of inflation expectations, then there would be less of a pass-through effect from exchange rate shocks. As a result of increased credibility and reduced pass-through, inflation targeting may also reinforce monetary policy independence (Mishkin and Schmidt-Hebbel (2007)).

[5] OLS estimates can be used as initial values.

There are a number of ways to account for endogeneity or self-selection bias. The first and more obvious approach is to use an instrument for being a targeter.[6] This standard approach to rely on an instrumental variable that affects the target but does not directly affect inflation is criticized for several reasons. For instance, controlling for the differences across countries through an effective instrument is quite difficult, especially in the presence of limited amount of data. A second, less standard approach,[7] would be to employ the matching and propensity score methodology that was developed precisely for the bias associated with this type of estimation problem. In this paper, we follow this approach and apply the matching methodology to account for the possible estimation bias. As far as we know, this way of proceeding is novel for studying the ERPT and its link with monetary policy.

The idea behind the PSM approach is to determine whether a treatment (in our case the policy goal) leads to different outcomes relative to an absence of the treatment, i.e. by matching treated observations with control observations that share similar characteristics other than the presence of the treatment. Following the matching of observations, we assess the "treatment effect" by measuring the difference in the ERPT between the two groups. That is, we see IT adoption as a "natural experiment," so we seek to reestablish the conditions of a randomized experiment where the IT adoption mimics a treatment.

More in detail, let D be a binary indicator that equals one if a country has adopted IT, zero otherwise. Also, let Y_i^1 denote the ERPT for country i if the country has adopted IT (i.e. if the country is in the treated group) and Y_i^0 if not, all other characteristics of the country being equal. The treatment effect for country i can be written as $Y_i^1 - Y_i^0$, where one outcome is observed and the other one is the counterfactual. We are interested in estimating the average treatment (ATT) effect on the treated countries, that is:

$$ATT = E[Y_i^1|D = 1] - E[Y_i^0|D = 1] \tag{7}$$

[6]Some instruments for IT used in the literature are: i) being an English speaking country and the interaction between this and having high inflation. This identification approach assumes that sharing a common language means that the central bank and government were more likely to be influenced by the same theories about how to effectively fight inflation, ii) a measure of central bank independence since it is argued that central banks that had less historical independence have greater need to become inflation targeters. This implies that they would be vigilant in fighting inflation (Boschen and Weise (2003)) and, iii) benefit entitlements during the 1980s with the idea that higher unemployment benefits may mean the central bank is less concerned about the costs of unemployment and hence focuses more on reducing inflation (MacCulloch, Tella, and Oswald (2001)).

[7]Among the non-standard approaches, it has recently been proposed to study inflation targeting with experimental economics methods, in order to be able to control the factors affecting the results of monetary policy. This is for example the case of Cornand and M'Baye (2018), who applied these methods to the choice of communicating a target by the central bank.

Introducing the control group, we can write the average treatment as:

$$ATT = E[Y_i^1|D=1] - E[Y_i^0|D=0] - E[Y_i^0|D=1] + E[Y_i^0|D=0] \quad (8)$$

where $E[Y_i^1|D=1]$ and $E[Y_i^0|D=0]$ are observed and $E[Y_i^0|D=0] - E[Y_i^0|D=1]$ is the selection bias. Hence, Eq.(8) can only be identified if this selection bias disappears, i.e. if $E[Y_i^0|D=1] = E[Y_i^0|D=0]$.

The PSM methodology deals with this selection problem by pairing each treated observation with control observations that are otherwise similar based on a set of observable characteristics, $\mathbf{X}$. This requires that the treatment satisfies some form of exogeneity, namely the so-called conditional independence assumption. This assumption states that, conditional on a vector of observable characteristics, the variable of interest (the ERPT) is independent of the treatment status. Conditional on this vector $\mathbf{X}$, the expected ERPT in the absence of IT would then be the same for paired countries, that is $E[Y_i^0|D=1,\mathbf{X}] = E[Y_i^0|D=0,\mathbf{X}]$, and the bias would disappear. Under this assumption then ATT effect is written as:

$$ATT = E[Y_i^1|D=1,\mathbf{X}] - E[Y_i^0|D=0,\mathbf{X}] \quad (9)$$

In Eq. (9) $E[Y_i^1|D=1,\mathbf{X}]$ controls for the relevant set of characteristics, $\mathbf{X}$. This set should include variables that are co-determinants of both IT (the treatment) and ERPT (the outcome), and conditioning on all relevant variables may be a challenge. Rosenbaum and Rubin (1983) and Imbens (2004) show that if the hypothesis of conditional independence hold then all biases due to observable components can be removed by conditioning on the propensity score. Therefore, ATT becomes:

$$ATT = E[Y_i^1|D=1,p(\mathbf{X})] - E(Y_i^0|D=0,p(\mathbf{X})] \quad (10)$$

where $E[Y_i^1|D=1,p(\mathbf{X})]$ denotes the fact that we control for the probability of observing the treatment conditional on the set $\mathbf{X}$ of variables. $p(\mathbf{X})$, the propensity score, should reflect a compromise between the potential influence of a variable on the outcome and its ability to improve the matching.

To obtain ATT, we proceed in two steps. We first estimate the propensity score by a benchmark probit equation explaining the likelihood of a country receiving the treatment. To this end, we consider a number of potential structural, political, and economic determinants of IT (or any other treatment).[8] We then use a matching algorithm to pair the observations based on observable characteristics. We employ four matching algorithms: nearest neighbor, kernel, local linear, and radius matching. These different approaches all match observations with similar characteristics, differentiating one group of countries which adopt IT (the "treatment group") and

[8] As a robustness exercises we also estimate logit models for the benchmark equation.

the other group that does not (the "control group").[9]

Applying these matching methods requires that two hypotheses must be satisfied. The first is the conditional independence assumption stating that, conditional to the vector of observable variables $\mathbf{X}$, the outcome variable is independent of the IT adoption. The second is the common support condition, which ensures that there is sufficient overlap in the characteristics of the treated and untreated groups to find adequate matches.

3 Data and descriptive statistics

We consider a sample of 48 advanced and emerging economies that have and have not adopted explicit IT between 1982 and 2016: Argentina, Australia*, Austria, Belgium, Brazil*,Canada*, Chile*, Colombia*, Costa Rica, Denmark, Finland*, France, Germany, Greece, Hong Kong, China, Hungary*, India, Indonesia*, Ireland, Israel*, Italy, Japan, Korea*, Latvia, Malaysia, Mexico*, Netherlands, New Zealand*, Norway*, Peru*, Philippines*, Poland*, Portugal, Romania*, Russia, Singapore, Slovak Republic*, Slovenia, South Africa*, Spain*, Sweden*, Switzerland*, Thailand*, Turkey*, The United Kingdom* and The United States.[10]

Following Rose (2007), Minea and Tapsoba (2014) and Balima, Combes, and Minea (2017) we classify an observation as IT distinguishing between Full-fledge (FF henceforth) and Soft starting dates of IT. The difference between the two dates captures the fact that some central banks first adopted "soft or informal" IT (see Vega and Winkelried (2005)), in which the central bank's reaction, following a deviation of inflation from its targeted level, is slower compared to its reaction under an explicit "full-fledged or formal" IT. Consequently, soft IT are those dates declared by central banks themselves, while full-fledged IT starting dates are those considered the dates from which the central bank began meeting the required criteria to be classified as an ITer. Under these two classifications for our sample of 48 countries, 24 countries are IT by the end of the period.

However, given that any classification into inflation targeters is somewhat subjective, we also used a "Flawed" IT classification. This category includes all the countries present in "soft" and "full-fledged IT list", as well as three countries for

[9] The nearest-neighbor pairs each observation in the treatment group with the closest observation (in term of propensity score) from the control group. We consider the nearest (N=1) and the five-nearest neighbors (N=5). The radius method (see Dehejia and Wahba (2002)) matches each treated with untreated located at some distance. We use a wide (r=0.05) radius. Finally, the kernel and local-linear method compare the outcome of each treated observation to a weighted average of the outcomes of all control observations, with the highest weight being placed on the control observations with the closest propensity scores to the treated observation (see Heckman, Ichimura, and Todd (1998)).

[10] ITers are denoted with a star, *. Note that the sample size might occasionally change.

which there is no consensus in the literature: Japan, India and the United States. Indeed, almost all the studies devoted to IT exclude these three countries, including recent studies such as Ardakania, Kishorb, and Song (2018) or Ilzetzki, Reinhart, and Rogoff (Forthcoming). The main argument used not to consider these countries as ITers comes from the importance given to price stability. According to the IT definition by Mishkin (2004) or Hammond (2012): "price stability is effectively recognized as the main goal of monetary policy". In the US, the Fed has a dual mandate which gives a strong weight to the maximum sustainable employment objective, while in Japan the BoJ announced an inflation target, but, according to many commentators, focuses mostly on the exchange rate. This definition is called into question by other works. For instance, Bundick and Smith (2018) show that the structure of inflation expectations in the US has changed since the announcement of an inflation target in January 2012. In Japan, the announcement of a quantified target of inflation (2%) was one of the goals of the Abenomics in 2013. Papers such as ichi Fukuda and Soma (2019) or Okimoto (2019) show that this announcement has had a significant effect on inflation expectations and on inflation trend, meaning that IT adoption has a strong impact on the Japanese economy. The case of India is different. Indeed, since this country adopted inflation targeting in 2016 the only reason that other studies do not include India in the IT group is that this is a recent event.[11] To take into account the lack of consensus on these three countries, we present the three definitions.

We use a dummy variable IT that takes the value 1 for countries that adopted an inflation targeting framework and 0 otherwise.[12] Dates of adoption for each of the three classifications are presented in Table (9) in the Appendix.

The variables entering the estimation of the exchange rate pass through are: (i) the consumer price index (P), (ii) the nominal effective exchange rate defined as domestic currency per unit of foreign currency (E, source BIS), (iii) the GDP (Y, source IFS), and (iv) the OECD producer price index as a proxy for supply factors (P^*, source OECD).[13] All the series are seasonally adjusted. We work with the year-to-year differences of the variables expressed in logarithm terms.

For the second step, namely, the PSM estimation, we work with annual data in order to consider a broad set of variables that define an economy. We therefore annualised the ERPT found in the first step by taking the annual mean value of the four quarters.

[11] On India, see for example Mohan and Ray (2019) and Ito (2019).

[12] In other words, the dummy variable takes on the value one starting in the period in which the country adopted this inflation target (and for all subsequent years), and zero otherwise.

[13] An increase in the nominal exchange rate implies a depreciation. Therefore, a positive relationship is expected between exchange rate changes and inflation, since a depreciation of the currency should be followed by an increase in inflation.

Now, one of the basic underlying principles to adopt IT is to gain credibility and to keep low inflation expectations following an exchange rate appreciation. However, IT can have different characteristics that could, in principle, lead to heterogeneity in the effectiveness of IT. Therefore, it seems beneficial to also evaluate whether the success of IT holds when changing the composition of the treatment group. In particular, we exclude from the treatment group countries according to:

- **Level of inflation:** An expanding body of arguments hold that ERPT is higher in a high and unstable inflation environment. On the contrary, when the inflation environment is more stable, expectations of inflation become firmly anchored which may explain why firms resist passing exchange rate changes on to prices. We therefore alter our benchmark treatment sample by dropping countries that have more than 3, 5, 10 and 15 percent inflation;

- **Targeted inflation rate:** With the objective of keeping longer-term inflation expectations firmly anchored, most central banks now target an inflation rate of 2 per cent. However, the recent experience with the effective lower bound on nominal interest rates has renewed interest in the benefits of inflation targets above 2 per cent. We evaluate whether an increase in the inflation target would be detrimental to achieving low ERPT by choosing from the original sample different treatments according to the announced target (see Ngo (2018));

- **Deviations of actual inflation from its target:** we are interested not only on the effects of having formally adopted an inflation target, but also in the effects of having successfully hit the declared target. Indeed, according to Bordo and Siklos (2015), credibility is crucially dependent on the relationship between observed and some estimate of the inflation rate that the central bank targets, either a numerical announcement objective or a ~~a~~ pre-specified target range. Following this argument, we finally alter the original sample by excluding observations that deviate more or less from the target.

- **Regime duration:** It is suggested that older regimes are more likely to deliver better outcomes than newer regimes (Mihov and Rose (2007)). The main argument is that monetary policy could work with lags in building credibility. To explore this possibility, we first exclude from the whole sample IT countries with more than 3 years under IT and then countries with less than 5 years;

- **Central Bank Independence:** analogous to the previous point, it could be argued that a monetary policy environment which is supported by an institutional framework that allows the central bank to pursue a credible and independent policy contributes to explain why even sizeable depreciations of the nominal exchange rate exert small effects on prices. To test this hypothesis, we abstract from countries with higher independence of the central bank with respect to the median of the sample. The idea in this case is to identify if an independent authority is necessary to achieve a better outcome for IT countries. We used Cukierman, Webb, and Neyapti (1992) CBI indicator, coded by Crowe and Meade (2007), Bodea and Hicks (2015) and Garriga (2016b);

- **Band, range or point inflation targeting:** The debate related to band versus point IT focuses on the advantages and drawbacks of each regime. The main argument in favor of the adoption of a band IT regime is that the band can signal to the public that the central bank may fail to achieve its numerical objective in a context of uncertainty. The higher the uncertainty on inflation expectations, the wider the band must be to avoid too large a deviation of inflation from the target (see Peter, Roger, and Heenan (2006) or Hammond (2012)). Range targets are also believed to better communicate the uncertainly and, therefore, the realism of the inflation forecast and economic fundamentals (Mishkin and Westelius (2008)). Point targets, in turn, are defended because they are supposed to better anchor inflation expectations and hence, reducing the costs associated with imperfect knowledge which can lead to higher macroeconomic performance (e.g. Orphanides and Williams (2007)). In this case, we exclude from the treatment group observations that allow for a range target or point target band and then observations with strict point inflation target. The sources come from various central bank publications;

The rest of the variables correspond to the controls that we use in the logit or probit estimations for the propensity score for inflation targeting: inflation volatility, financial development, political stability, the number of countries having adopted IT, the share of world GDP and trade openness. Appendix A summarizes the definition and source of all the variables.

4 Results

4.1 The time-varying ERPT estimates

Figures 1 and 2 show the estimated ERPT varying coefficients. It has to be added so that the varying-parameter estimation techniques based on the Kalman filter may be uncertain in some cases. However, being an unobservable variable, this is the case for almost any ERPT coefficient in the empirical literature. Alternatively to the Kalman filter, to capture the decline in exchange rate pass-through, most of the research is done by splitting the sample or by rolling regressions. However, as suggested by Sekine (2006), these estimation techniques are based on the assumption that underlying parameters are not altered within the estimated sample periods, and thus they do not necessarily provide precise parameter shifts. Moreover, it is often the case with rolling regressions that the timing of parameter shifts crucially depends on the size of windows. We therefore compared our state-space ERPT estimates with those obtained by rolling regressions.[14] In general, both estimation methods provide coefficients that follow a similar path. However, the state-space results suggest that the changing nature in pass-through is more gradual compared with those obtained by rolling regressions. We believe in gradual changes in pass-through for at least two reasons: First, rolling regressions tend to yield different coefficients depending on whether or not a specific sample is in the window. Second, the time-varying parameter model tends to yield gradual changes in the pass-through because of smoothing. As suggested by Sims (2001), it is smoothed series that give a more precise estimate of actual time variation.

Therefore, even though there are concerns about the limitations of the Kalman filter, our estimates provide some similarities with alternative techniques and previous research in several points: i) there is substantial heterogeneity in the magnitude of the estimated exchange rate pass-through across countries, ii) the ERPT is incomplete in all the cases, the mean value being 0.24 for the whole sample, iii) the figures also shows that it declines over time in various countries. However, the decreasing ERPT found in the literature is not a generalized feature for our set of countries, iv) emerging economies have, in general, higher ERPT than advanced countries and v) ERPT is not constant over time.[15]

4.2 The Propensity Score for Inflation Targeting

Once the ERPT is calculated, it remains unclear whether there is a link with the monetary policy goal. As a first step to produce the propensity score specifications for IT, we estimate the probability of observing Full Fledge IT for all the countries of our sample. We therefore explore economic, fiscal, external, financial, and institutional characteristics highlighted by the literature as preconditions for IT adoption.[16] Table 1 presents the logit estimations considering different control variables.[17] We also estimate the propensity score for our two alternative definitions: Soft and Flawed IT. Changing the dates and the composition of the sample does not alter the results.[18]

As seen, the variables help in capturing the specificities of the treatment since all estimated parameters are significant. Indeed, contrary to our intuition, the results

[14]All the values are available upon request to the authors.

[15]Table C in the appendix provides the mean value of the ERPT obtained by the state-space model. For comparison purposes, we also present the results from OLS regressions.

[16]It is worth noting that when estimating the propensity score, our goal is not only to find the best statistical model to explain the probability of IT adoption but also to achieve the best matching. Indeed, to respect the conditional independence assumption, the propensity score estimates should include all the possible variables that may have a systematic impact on the ERPT as well as on choice of monetary policy goals.

[17]All variables used in the logit regression are lagged in order to ensure that they are not affected by the treatment.

[18]All the results are available under request to the authors.

Table 1: Propensity score for inflation targeting. Independent variable: IT dummy

	Baseline Model (1)	Baseline Model (2)	Adding Structure (3)	Adding Financial (4)	Adding Fiscal (5)
Dependent var.	FF IT	Soft IT	FF IT	FF IT	FF IT
Inflation vol.	-0.21**	-0.18**	-0.24**	-0.32***	-0.14
	(0.08)	(0.07)	(0.10)	(0.11)	(0.10)
Market Dev.	0.00***	0.01***	0.01***	0.01***	0.00***
	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)
Political stability	0.15***	0.14***	0.29***	0.16***	0.23***
	(0.04)	(0.04)	(0.06)	(0.04)	(0.05)
IT number	0.10***	0.09***	0.11***	0.12***	0.11***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
GDP Share	-3.67***	-3.77***	-2.80***	-2.18***	-2.49***
	(0.48)	(0.47)	(0.52)	(0.36)	(0.50)
Trade openness	-1.51***	-1.54***	-1.25***	-0.59***	-1.39***
	(0.19)	(0.18)	(0.22)	(0.21)	(0.20)
Econ. Development			-0.07**		
			(0.04)		
Energy dependence			-0.05***		
			(0.02)		
Remittances			0.17**		
			(0.07)		
Income			-0.00***		
			(0.00)		
Credit				0.01***	
				(0.00)	
Broad money				-0.04***	
				(0.00)	
Debt to GDP					-0.03***
					(0.00)
Fiscal deficit					0.03
					(0.02)
Constant	3.19***	3.51***	2.65**	0.29	2.93***
	(0.93)	(0.90)	(1.19)	(0.99)	(1.03)
Pseudo R2	0.25	0.23	0.23	0.33	0.28
N. of Obs.	1015	1015	799	981	914

Notes: *,**,*** denotes significance at the 1 5 and 10%, respectively. “FF” denotes full fledged inflation targeting. Soft and full fledged are defined as in Minea and Tapsoba (2014).

indicate that high inflation volatility decreases the likelihood to adopt inflation targeting.[19] This result is in line with studies by Lucotte (2012), Minea and Tapsoba (2014), Ebeke and Fouejieu (2015) and Balima, Combes, and Minea (2017) among others, who show that high or volatile inflation is negatively associated with the probability of adopting IT. GDP share and trade openness is also found to negatively affect IT adoption. In the first case, note that small countries are more likely to fix because they have a higher propensity to trade internationally and are less likely to trade using the nation unit of account, while the major currencies (the US dollar, the Euro and the Yen) are not ITers.[20] The usual explanation behind the negative sign in the case of trade openness is that many economies are dependent on foreign trade and exposed to real external shocks. As such, countries tend to limit exchange rate movements. Consequently, open economies often prefer to have exchange rate pegs rather than inflation targeting with flexible exchange rates (see, for instance Fatas, Mihov, and Rose (2007)). On the contrary, political stability, captured by the democracy score, market or financial development and the number of countries with IT increases the probability of targeting inflation. [21]

We next proceed to verify that the independence condition holds, i.e., that the value of the various control variables does not significantly differ between the treatment and control groups once the matching is computed. Results, using different matching algorithms, indicate that no significant difference remains in the data after any of the matching procedures for the benchmark and the majority of alternative models. Details on the validation procedure are presented in Appendix D.

4.3 ERPT and Inflation Targeting

Having proved that all the prerequisites of our method hold, we estimate the impact of the monetary regime on the ERPT. In order to do so, we perform the matches and estimate the average treatment effects –IT– on the treated countries.

Let us first focus on the estimated average effect of FF IT. As seen in Table 2, the results show that IT significantly decreases the ERPT in ITers compared to the control group (i.e. non ITers). Indeed, depending on the matching algorithm and the control variables considered, the reduction is estimated to lie between 0.12 and 0.17 percentage points.

[19]It has been argued that economies with high prior inflation are more likely to adopt IT (Mishkin and Schmidt-Hebbel (2001) and Goncalves and Salles (2008)). We should expect then high and unstable inflation to be a prerequisite for IT (i.e. a positive sign of inflation volatility in the probit model). However, Mishkin and Schmidt-Hebbel (2001) and Mishkin (2000) also highlight that industrial countries and some emerging country inflation targeters started IT at initial inflation close to stationary low levels.

[20]On the relation between country size and monetary regime choice, see also Levy Yeyati, Sturzenegger, and Reggio (2010) and Rose (2014).

[21]We add a set of variables that may affect IT adoption as long as we do not reduce too much the number of treated observations (see columns (4), (5) and (6) in Table (1))

It is important to remark that many countries, particularly emerging ones, adopted initially partial IT, shifting only later, and often quite gradually, to full-fledged IT. Therefore, analogous to our previous analysis, we estimate the average treatment effect for the Soft classification adoption date. Results are also presented in Table 2. As seen, under this criteria, countries with IT also present a significant lower ERPT compared to the control group.[22] Moreover, Table 2 also shows that our results are robust to changes in the PS definition: in addition to the baseline variables, we add variables related to the structure of the economy, the financial sector or the fiscal position of the country while computing the PS index. The estimated ATT based on these additional variables is negative, significant and of similar to the baseline estimation.

4.4 The heterogenous effectiveness of Inflation Targeting

Our analysis confirms previous results regarding the effectiveness of IT to reduce the link between inflation and exchange rate shocks, even after controlling for endogeneity and self-selection bias. We now investigate if the effectiveness of IT holds to different characteristics of the regime.

First, we account for the inflation level. Indeed, the ERPT should be lower in a more stable inflation environment. In addition, many ITers used IT initially as a price stabilization device, adopting the new regime at initially moderate and even high inflation levels and pre-announcing a sequence of annually declining inflation targets. By dropping observations according to different actual inflation levels, Table 3 shows that IT adoption statistically affect the pass-through at any level of inflation.

Second, the good performance of IT seems to be more related to keeping inflation close to the target than to the target rate itself. Indeed, Table 8 shows the ATT when we exclude observations according to the targeted inflation rate. As seen, the ERPT is significantly lower for countries targeting different inflation rates than for non ITers. In other words, the results show that countries which adopt IT manage to reduce the ERPT, even when the targeted inflation rate is higher than 2 percent. This result shows that there is not difference, at least in terms of reducing the impact of exchange rate shocks on inflation, between a target of 2% and a higher target. Indeed, many central banks target an inflation rate near two percent. However, some economists claim that a four percent target would ease the constraints on monetary policy arising from the zero bound on interest rates, with the result that economic downturns would be less severe (See, for instance, Ball (2014)). Our results when the treatment is target at least 4% of inflation show that a four percent

[22] For the sake of completeness we also alter our IT sample by considering Ilzetzki, Reinhart, and Rogoff (2017) list of IT countries. This list is almost the same as IT FF but it excludes Switzerland and differs on some starting dates. The estimated ATT for this alternative IT definition was similar to the estimated ATT for IT FF.

inflation does not imply a significantly higher ERPT than a two percent. However, note that IT is extremely effective when the authorities achieve an inflation level close to their target. This positive effect, however, stabilizes for large deviations from the objective, becoming comparable to the ATT in our baseline specification (see Table 5).

Table 6 shows the results when we exclude observations according to the duration of the regime, i.e. our treatment groups become observations of countries that will adopt IT in less than three years, that have adopted IT for less than 3 years and more than 3 and 5 years.[23] As seen, ATTs are not significant in the estimation for countries that will adopt IT in the near future or countries with less than 3 years with IT. That is, there is no significant difference between IT during the first years of adoption compared to countries without IT. On the contrary, estimated ATTs are stronger –and even by roughly 0.1 pp– in older regimes compared to the benchmark case. Such differences unveil that the length of exposure to IT is an important determinant of the success to reduce the ERPT. In accordance with Mihov and Rose (2007), since no inflation targeter has been forced to leave its IT under duress, we can affirm that this result is not driven by having only "good performers".

We now look at central bank independence. Using the median level of three alternative indicators based on Crowe and Meade (2007), Bodea and Hicks (2015) and Garriga (2016b), we exclude from the treatment group observations with high levels of independence. Table 7 reveals that IT adoption reduces the ERPT even for observations with independence of the central bank lower than the median, the difference respect to non ITers being significant at conventional levels. In other words, countries with more independent central banks do not outperform other ITers in terms of lower ERPT.

Finally, trying to contribute to the debate regarding the benefits of limits of uncertainly that the central bank transmits to the public, we alter our sample by dropping first i) only observations that allow for a band or range and then ii) only observations with a strict point target, from the treatment group. Table 8 shows that IT adoption significantly reduces the ERPT when the central bank allows for uncertainty regarding the target. In fact, note that the difference between IT with point target and not IT is not significant in the estimated ATT. Thus, if IT adoption reduces the link between exchange rate shocks and inflation, a more "flexible" target outperforms any other objective. This result suggests that more discretion within the IT framework is not detriment to reduce exchange rate shocks on prices.[24]

[23]By defining a treatment group with countries that will adopt IT during the following 3 years we consider that some inflation targeters were targeting inflation before the announcement of official targets.

[24]Given that in some cases, the number of observations in each regime is small and, therefore, the results should be taken with precaution, we estimated Equation (1) with different interaction variables by dynamic GMM for robustness purposes. The results confirm our finding using propensity

score matching techniques.

5 Conclusions

Estimates of the exchange rate pass-through have declined in recent years. The main explanations for this decline is that expectations of inflation have become more anchored due to a more stable and predictable monetary policy environment, supported by the adoption of inflation targeting from several monetary authorities around the world.

This paper has employed state-space models to estimate the time-varying exchange rate pass-through for a large sample of countries. Moreover, by using PSM as a method to control for self-selection bias, we analyse to what extent explicit IT is relevant for the declining ERPT by comparing observations which differ only with respect to whether the country adopts an inflation targeting framework. We therefore overcome a main limitation of the empirical literature that tries to document the macroeconomic effects of inflation targeting. More importantly, we conduct a detailed analysis of the heterogenous effectiveness of IT in reducing the ERPT.

The main results are as follows. First, monetary policy that incorporates explicit targets achieve lower exchange rate pass-through than non ITers. This finding is robust to a wide set of alternative specifications and to self-selection bias. Second, among the different characteristics of IT, older regimes, adopting a band inflation target and keeping inflation relatively close to the objective outperform any other IT regime. Third, IT reduces the ERPT at any level of initial inflation or targeted inflation rate. Finally, even though monetary policy is delegated to an independent central bank in an inflation-targeting framework, monetary authorities do not need to implement a high level of independency to achieve lower ERPT.

Figure 1: **Exchange rate pass through**

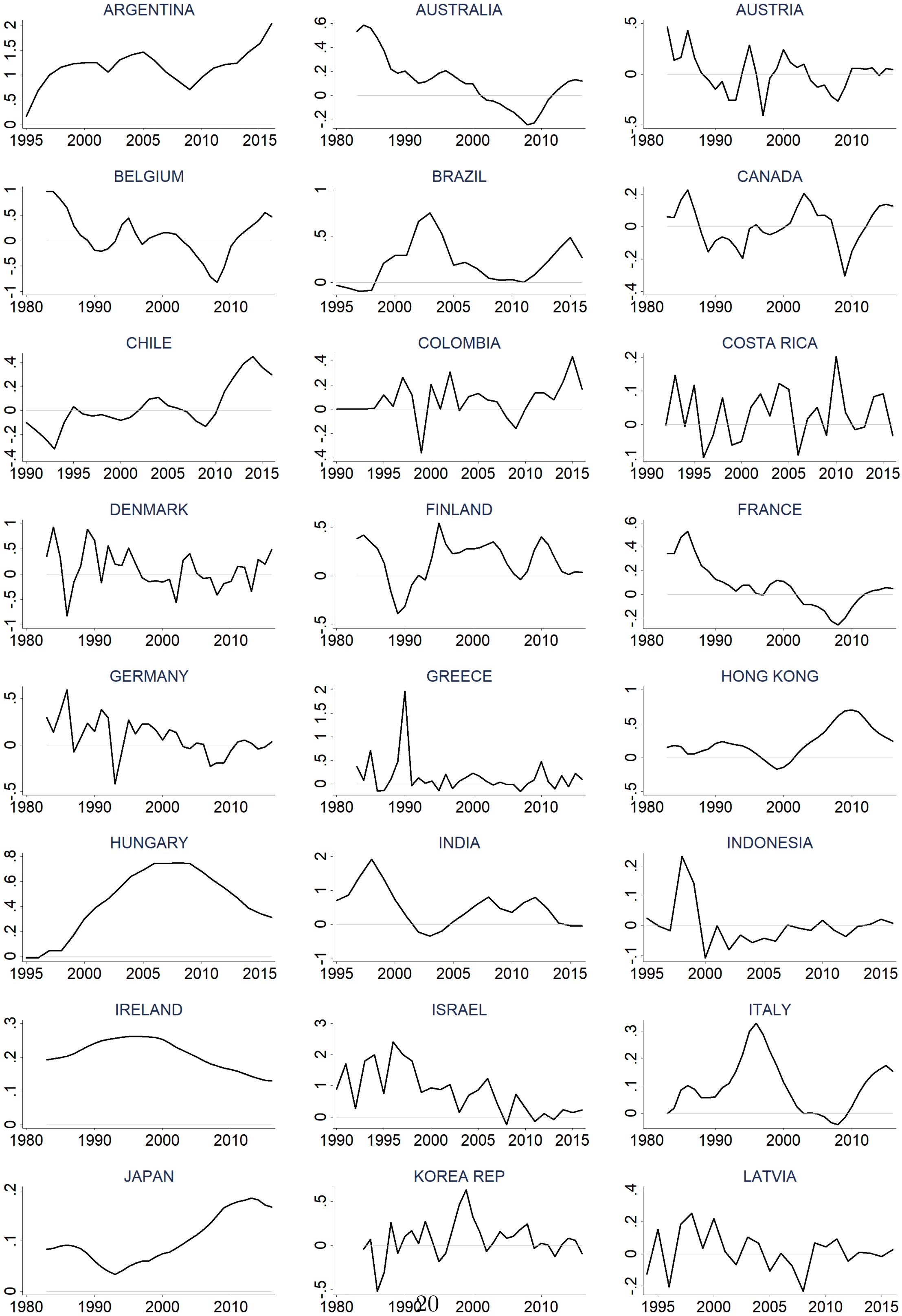

Figure 2: **Exchange rate pass through (cont.)**

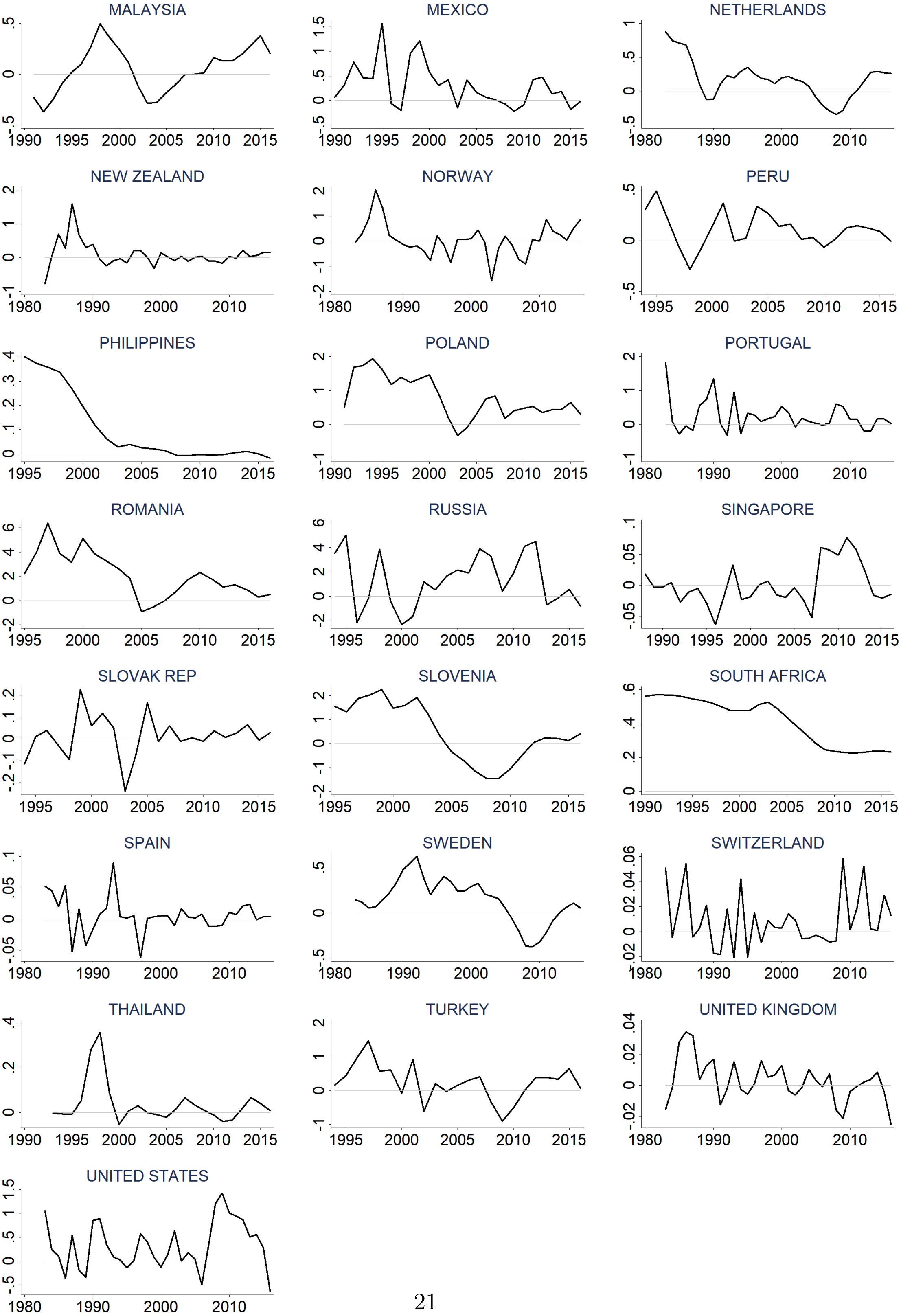

Table 2: **Average treatment effect of inflation targeting on ERPT.**

PSM	Nearest neighbor(1)	Nearest neighbor(5)	Kernel	Local-linear	Radius (.05)
Baseline PSM, treatment is IT, FF criteria					
ATT	-0.124*	-0.140***	-0.128***	-0.167***	-0.124***
	(-1.99)	(-2.92)	(-3.14)	(-4.04)	(-2.93)
N. Treated/N. Obs.	415 /1011	415/1011	415/1011	415/1011	415/1011
Alternative PSM:					
ATT adding structure	-0.157**	-0.170***	-0.180***	-0.330***	-0.180***
	(-2.25)	(-3.14)	(-3.95)	(-6.73)	(-4.06)
N. Treated/N. Obs.	415 /799	415/799	415/799	415/799	415/799
ATT adding finance	-0.158*	-0.174***	-0.184***	-0.214***	-0.180***
	(-1.92)	(-2.80)	(-3.46)	(-3.26)	(-3.41)
N. Treated/N. Obs.	415 /981	415/981	415/981	415/981	415/981
ATT adding fiscal	-0.153**	-0.196***	-0.173***	-0.209***	-0.172***
	(-2.01)	(-3.18)	(-3.51)	(-3.24)	(-3.14)
N. Treated/N. Obs.	415 /914	415/914	415/914	415/914	415/914
Alternative IT criteria: Soft IT					
ATT	-0.166***	-0.129***	-0.129***	-0.164***	-0.128***
	(-3.01)	(-2.63)	(-3.03)	(-4.12)	(-3.26)
N. Treated/N. Obs.	436 / 1011	436 / 1011	436 / 1011	436 / 1011	436 / 1011
Alternative IT criteria: Flawed IT					
ATT	-0.115**	-0.150***	-0.163***	-0.194***	-0.164***
	(-2.18)	(-3.47)	(-4.25)	(-4.79)	(-3.94)
N. Treated/N. Obs.	343/973	343/973	343/973	343/973	343/973
Alternative outcome variable: long term ERPT					
ATT	-0.211**	-0.248***	-0.267***	-0.269***	-0.268***
	(-2.08)	(-2.82)	(-3.29)	(-3.46)	(-3.46)
N. Treated/N. Obs.	304 / 919	304 / 919	304 / 919	304 / 919	304 / 919

Notes: (1) Observed coefficient is treatment effect (the difference between the treated and controls). When ERPT is higher for the controls than the treated, observed coefficient shows a negative value, (2) t-statistics are presented in parenthesis. Standard errors are bootstrapped (using 500 iterations), (3) *,**,*** denotes significance at the 10, 5 and 1%. A high t-value indicates a significant gap between treated and controls, (4) N. Treated/N. Obs. is the number of treated observations over the sample size.

Table 3: **Impact of inflation targeting on ERPT. Average treatment (ATT) effect on the treated countries. Level of inflation**

PSM	Nearest neighbor(1)	Nearest neighbor(5)	Kernel	Local-linear	Radius (.05)
Treatment= targeting when inflation is less than 3%					
ATT	-0.137**	-0.109**	-0.092***	-0.096***	-0.093***
	(-2.24)	(-2.17)	(-2.76)	(-2.75)	(-2.73)
N. Treated/N. Obs.	180 / 832	180 / 832	180 / 832	180 / 832	180 / 832
Treatment= targeting when inflation is less than 5%					
ATT	-0.123**	-0.147***	-0.138***	-0.172***	-0.135***
	(-2.08)	(-3.21)	(-3.51)	(-3.31)	(-3.40)
N. Treated/N. Obs.	270 / 922	270 / 922	270 / 922	270 / 922	270 / 922
Treatment= targeting when inflation is less than 10%					
ATT	-0.104*	-0.124**	-0.125***	-0.164***	-0.123***
	(-1.87)	(-2.52)	(-2.91)	(-3.58)	(-3.05)
N. Treated/N. Obs.	340 / 992	340 / 992	340 / 992	340 / 992	340 / 992
Treatment= targeting when inflation is less than 15%					
ATT	-0.189***	-0.139***	-0.128***	-0.165***	-0.127***
	(-3.35)	(-2.81)	(-2.95)	(-3.81)	(-3.09)
N. Treated/N. Obs.	346 / 998	346 / 998	346 / 998	346 / 998	346 / 998

Notes: (1) Observed coefficient is treatment effect (the difference between the treated and controls). When ERPT is higher for the controls than the treated, observed coefficient shows a negative value, (2) Standard errors are bootstrapped (using 500 iterations), (3) *,**,*** denotes significance at the 10, 5 and 1%. A low p-value indicates a significant gap between treated and controls. (4) N. Treated/N. Obs.is the number of treated observations over the sample size.

Table 4: **Impact of inflation targeting on ERPT. Average treatment (ATT) effect on the treated countries. Targeted inflation level**

PSM	Nearest neighbor(1)	Nearest neighbor(5)	Kernel	Local-linear	Radius (.05)
Treatment= target at most 2% of inflation					
ATT	-0.223***	-0.194***	-0.156***	-0.177***	-0.154***
	(-3.55)	(-3.17)	(-3.98)	(-4.55)	(-4.07)
N. Treated/N. Obs.	98 / 773	98 / 773	98 / 773	98 / 773	98 / 773
Treatment= target at most 4% of inflation					
ATT	-0.130**	-0.140**	-0.102**	-0.119***	-0.1000**
	(-2.09)	(-2.53)	(-2.56)	(-2.91)	(-2.39)
N. Treated/N. Obs.	261 / 936	261 / 936	261 / 936	261 / 936	261 / 936
Treatment= target at most 6% of inflation					
ATT	-0.0713	-0.118***	-0.129***	-0.156***	-0.129***
	(-1.22)	(-2.59)	(-3.22)	(-4.11)	(-2.93)
N. Treated/N. Obs.	314 / 989	314 / 989	314 / 989	314 / 989	314 / 989
Treatment= target at most 8% of inflation					
ATT	-0.107*	-0.127**	-0.124***	-0.153***	-0.121***
	(-1.83)	(-2.48)	(-2.88)	(-3.64)	(-2.86)
N. Treated/N. Obs.	321 / 996	321 / 996	321 / 996	321 / 996	321 / 996
Treatment= target at least 2.5% of inflation					
ATT	-0.184*	-0.133*	-0.116*	-0.120**	-0.115
	(-1.84)	(-1.75)	(-1.79)	(-1.99)	(-1.60)
N. Treated/N. Obs.	152 / 785	152 / 785	152 / 785	152 / 785	152 / 785
Treatment= target at least 4% of inflation					
ATT	-0.206	-0.235**	-0.239**	-0.243**	-0.230**
	(-1.44)	(-2.06)	(-2.25)	(-2.27)	(-2.19)
N. Treated/N. Obs.	73 / 720	73 / 720	73 / 720	63 / 720	63 / 720

Notes: (1) Observed coefficient is treatment effect (the difference between the treated and controls). When ERPT is higher for the controls than the treated, observed coefficient shows a negative value, (2) Standard errors are bootstrapped (using 500 iterations), (3) *,**,*** denotes significance at the 10, 5 and 1%. A low p-value indicates a significant gap between treated and controls. (4) N. Treated/N. Obs.is the number of treated observations over the sample size

Table 5: **Impact of inflation targeting on ERPT. Average treatment (ATT) effect on the treated countries. Measure of credibility**

PSM	Nearest neighbor(1)	Nearest neighbor(5)	Kernel	Local-linear	Radius (.05)
Treatment= inflation at objective					
ATT	-0.257***	-0.247***	-0.252***	-0.262***	-0.251***
	(-3.62)	(-4.18)	(-5.06)	(-5.46)	(-5.28)
N. Treated/N. Obs.	157 / 832	157 / 832	157 / 832	157 / 832	157 / 832
Treatment= inflation at objective +/- 1pp					
ATT	-0.295***	-0.216***	-0.217***	-0.234***	-0.219***
	(-5.00)	(-4.35)	(-4.79)	(-5.77)	(-4.74)
N. Treated/N. Obs.	244 / 919	244 / 919	244 / 919	244 / 919	244 / 919
Treatment= inflation at objective +/- 2pp					
ATT	-0.190***	-0.182***	-0.145***	-0.169***	-0.144***
	(-2.88)	(-3.47)	(-3.43)	(-4.19)	(-3.33)
N. Treated/N. Obs.	297 /972	297 /972	297 /972	297 /972	297 /972
Treatment= inflation at objective +/- 3pp					
ATT	-0.101*	-0.150***	-0.131***	-0.157***	-0.129***
	(-1.72)	(-2.98)	(-3.11)	(-3.74)	(-3.05)
N. Treated/N. Obs.	310 / 985	310 / 985	310 / 985	310 / 985	310 / 985

Notes: (1) Observed coefficient is treatment effect (the difference between the treated and controls). When ERPT is higher for the controls than the treated, observed coefficient shows a negative value, (2) Standard errors are bootstrapped (using 500 iterations), (3) *,**,*** denotes significance at the 10, 5 and 1%. A low p-value indicates a significant gap between treated and controls. (4) N. Treated/N. Obs.is the number of treated observations over the sample size, (5) pp = percentage point, measured relative to the point target or centre of the target band. Inflation is assumed to be "at objective" if the observed inflation rate is within the target band or within a +/- 0.25 pp band around the point target.

Table 6: **Impact of fully fledge inflation targeting on ERPT. Average treatment (ATT) effect on the treated countries. Duration of regime**

PSM	Nearest neighbor(1)	Nearest neighbor(5)	Kernel	Local-linear	Radius (.05)
Treatment = country will adopt IT in less than three years					
ATT	0.195*	0.133	0.106	0.106	0.107
	(1.77)	(1.56)	(1.42)	(1.36)	(1.38)
N. Treated/N. Obs.	89/1011	89/1011	89/1011	89/1011	89/1011
Treatment = country has adopted IT for less than 3 years					
ATT	-0.118	-0.113	-0.055	-0.077	-0.052
	(-1.28)	(-1.05)	(-0.84)	(-1.14)	(-0.77)
N. Treated/N. Obs.	71 / 723	71 / 723	71 / 723	71 / 723	71 / 723
Treatment = country has adopted IT for at least 3 years					
ATT	-0.135*	-0.139**	-0.158***	-0.211***	-0.161***
	(-1.80)	(-2.24)	(-2.99)	(-4.40)	(-2.97)
N. Treated/N. Obs.	288 / 940	288 / 940	288 / 940	288 / 940	288 / 940
Treatment = country has adopted IT at least for 5 years					
ATT	-0.218***	-0.217***	-0.217***	-0.256***	-0.214***
	(-2.59)	(-2.91)	(-3.37)	(-5.22)	(-3.27)
N. Treated/N. Obs.	240 / 892	240 / 892	240 / 892	240 / 892	240 / 892

Notes: (1) Observed coefficient is treatment effect (the difference between the treated and controls). When ERPT is higher for the controls than the treated, observed coefficient shows a negative value, (2) Standard errors are bootstrapped (using 500 iterations), (3) *,**,*** denotes significance at the 10, 5 and 1%. A low p-value indicates a significant gap between treated and controls. (4) N. Treated/N. Obs.is the number of treated observations over the sample size.

Table 7: **Impact of inflation targeting on ERPT. Average treatment (ATT) effect on the treated countries. Central bank independence**

PSM	Nearest neighbor(1)	Nearest neighbor(5)	Kernel	Local-linear	Radius (.05)
Treatment = IT with independence lower than median, Garriga Index					
ATT	-0.249***	-0.235***	-0.264***	-0.305***	-0.263***
	(-3.22)	(-3.98)	(-4.94)	(-5.95)	(-4.94)
N. Treated/N. Obs.	152 / 809	152 / 809	152 / 809	152 / 809	152 / 809
Treatment = IT with independence lower than median, Crowe & Meade Index					
ATT	-0.145**	-0.214***	-0.214***	-0.230***	-0.215***
	(-2.02)	(-3.92)	(-4.36)	(-4.99)	(-4.19)
N. Treated/N. Obs.	169 / 826	169 / 826	169 / 826	169 / 826	169 / 826
Treatment = IT with independence lower than median, Bodea & Hicks Index					
ATT	-0.216**	-0.190**	-0.211***	-0.254***	-0.209***
	(-2.33)	(-2.50)	(-3.41)	(-4.68)	(-3.58)
N. Treated/N. Obs.	160 / 817	160 / 817	160 / 817	160 / 817	160 / 817

Notes: (1) Observed coefficient is treatment effect (the difference between the treated and controls). When ERPT is higher for the controls than the treated, observed coefficient shows a negative value, (2) Standard errors are bootstrapped (using 500 iterations), (3) *,**,*** denotes significance at the 10, 5 and 1%. A low p-value indicates a significant gap between treated and controls. (4) N. Treated/N. Obs.is the number of treated observations over the sample size.

Table 8: **Impact of inflation targeting on ERPT. Average treatment (ATT) effect on the treated countries. Type of IT objective**

PSM	Nearest neighbor(1)	Nearest neighbor(5)	Kernel	Local-linear	Radius (.05)
Treatment = strict point target (without tolerance band)					
ATT	-0.0805	-0.0891	-0.0885*	-0.0972**	-0.0903*
	(-0.84)	(-1.36)	(-1.83)	(-2.01)	(-1.84)
N. Treated/N. Obs.	58 / 733	58 / 733	58 / 733	58 / 733	58 / 733
Treatment = not a single target value (either a range or a point with tolerance band)					
ATT	-0.159**	-0.120**	-0.110**	-0.131***	-0.113**
	(-2.16)	(-2.12)	(-2.37)	(-2.87)	(-2.37)
N. Treated/N. Obs.	278 / 953	278 / 953	278 / 953	278 / 953	278 / 953

Notes: (1) Observed coefficient is treatment effect (the difference between the treated and controls). When ERPT is higher for the controls than the treated, observed coefficient shows a negative value, (2) Standard errors are bootstrapped (using 500 iterations), (3) *,**,*** denotes significance at the 10, 5 and 1%. A low p-value indicates a significant gap between treated and controls. (4) N. Treated/N. Obs.is the number of treated observations over the sample size.

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A Variables and definition:

Broad Money: money-to-GDP ratio (Broad money % of GDP)
Source: World Bank (FM.LBL.BMNY.GD.ZS) and IMF IFS (35L..ZK)

Central Bank Independence Dummy variable taking the value 1 if the country is IT and has indepedence greater than median, according to Bodea and Hicks (2015), Crowe and Meade (2007) and Garriga (2016b) indices . *Source: Author's calculations based on Garriga (2016a)*

Credit: Domestic credit to private sector (% of GDP)
Source: World Bank (fs.ast.prvt.gd.zs)

Debt to GDP: General government gross debt (% of GDP)
Source: World Bank WEO and IMF (GGXWDG.NGDP)

Economic Development: measured by primary sector share of GDP
Source: World Bank (nv.agr.totl.zs)

Energy Dependence: Fuel imports (% of merchandise imports)
Source: World Bank (tm.val.fuel.zs.un)

Exchange Rate Variation (Δe): Quarterly year-to-year difference of the log nominal effective exchange rate. Domestic currency per unit of foreign currency: an increase implies a nominal depreciation.
Source: BIS- Bank of International Settlements

Fiscal Deficit: General government net lending/borrowing (gdp%)
Source: World Bank WEO and IMF (GGXCNL.NGDP)

GDP Growth (Δy): Quarterly seasonally adjusted year-to-year difference of the log GDP in real terms.
Source: IMF- International Financial Statistics

GDP Share: The share of world GDP (domestic current US$ GDP over world current US$ GDP, %,)
Source: Author's calculations & World Bank (ny.gdp.mktp.cd)

Income: GDP per capita, PPP (constant 2011 international USD)
Source: World Bank (ny.gdp.pcap.pp.kd)

Inflation (Δp): Quarterly seasonally adjusted year-to-year difference of the log consumer price index.

Source: IMF- International Financial Statistics

Inflation Targeting: Full Fledged : Dummy variable that takes on the value one if in a given year the country operates under IT, and zero otherwise. The default IT variable corresponds to the full-fledge definition: countries that make an explicit commitment to meet a specified inflation rate or range within a specified time frame, regularly announce their targets to the public, and have institutional arrangements to ensure that the central bank is accountable for meeting the target.
Source: Rose (2007), Roger (2009) and Minea and Tapsoba (2014)

Inflation Targeting: Soft Dummy variable that takes on the value one starting in the period in which the country officially announced the adoption of IT (and for all subsequent years), and zero otherwise. Under soft IT, the inflation target may coexists with other nominal anchors.
Source: Rose (2007), Roger (2009) and Minea and Tapsoba (2014)

Inflation Targeting: Flawed Dummy variable that takes on the value one if in a given year the country operates under IT, and zero otherwise. Flawed IT is based on Full Fledged IT but also assumed the USA, Japan and India adopt IT since 2012, 2013 and 2016, respectively.
Source: Bundick and Smith (2018), Okimoto (2019) ,Mohan and Ray (2019) and Ito (2019)

IT Number: Number of countries that have adopted IT at the period t
Source: Author's calculations

Inflation Volatility: Standard deviation of the annualized montly inflation rates of years t and $t-1$.
Source: Author's calculations based on the consumer price index provided by the IMF- International Financial Statistics

Market Development: Financial development measure by market capitalization of listed domestic companies (% of GDP)
Source: World Bank.

Political Stability: Polity2 index taking values from -10 (very autocratic) to +10 (very democratic) and constructed by subtracting the democracy score from the autocracy score
Source: Polity IV Project (Polity2)

Remittances: "Personal remittances, received (% of GDP)"
Source: World Bank (bx.trf.pwkr.dt.gd.zs)

Supply Shocks (Δp^{*}): Quarterly seasonally adjusted year-to-year difference of the average OECD producer price index.
Source: IMF- International Financial Statistics

Trade Openness: Log of the sum of exports and imports of goods and services measured as a share of the GDP.
Source: World Bank (ne.trd.gnfs.zs)

B IT data-set composition

Table 9: **IT data-set composition**

Country	IT Full-Fledge	IT Soft	IT Flawed
New Zealand	1990	1990	1990
Canada	1992	1991	1991
Chile	2000	1991	1991
Israel	1997	1992	1992
Australia	1995	1993	1993
Finland*	1994	1993	1993
Sweden	1995	1993	1993
United Kingdom	1993	1993	1993
Spain*	1995	1995	1995
Korea Republic	1998	1998	1998
Brazil	1999	1999	1999
Mexico	2001	1999	1999
Poland	1999	1999	1999
Colombia	2000	2000	2000
South Africa	2000	2000	2000
Switzerland	2000	2000	2000
Thailand	2000	2000	2000
Hungary	2002	2001	2001
Norway	2001	2001	2001
Peru	2002	2002	2002
Philippines	2002	2002	2002
Slovak Republic*	2005	2005	2005
Indonesia	2006	2005	2005
Romania	2006	2005	2005
Turkey	2006	2006	2006
United States	-	-	2012
Japan	-	-	2013
India	-	-	2016

Notes: The starting date is the current year of adoption if it took place from January to June, the following year if it took place form July to December. The ending date is 2016 for all countries but Finland, Slovak Republic and Spain which adopted the Euro in 1999, 2009 and 1999 respectively.

C Estimated ERPT coefficients by country

Table 10: Estimated ERPT coefficients by country

	State-space	**OLS**
Argentina	1.16	1.00
Australia	0.11	0.16
Austria	0.01	0.08
Belgium	0.10	0.28
Brazil	0.21	0.33
Canada	0.01	0.01
Chile	0.03	0.00
Colombia	0.07	0.32
Costa Rica	0.03	0.00
Denmark	0.10	0.32
Finland	0.16	0.17
France	0.07	0.22
Germany	0.08	0.25
Greece	0.15	0.89
Hong Kong	0.23	0.23
Hungary	0.44	0.49
India	0.49	0.83
Indonesia	0.08	0.19
Ireland	0.21	0.29
Israel	0.81	0.71
Italy	0.10	0.17
Japan	0.10	0.12
Korea, Rep.	0.06	0.24
Latvia	0.20	0.00
Malaysia	0.05	0.31
Mexico	0.29	0.97
Netherlands	0.17	0.32
New Zealand	0.09	0.42
Norway	0.07	-0.12
Peru	0.11	0.22
Philippines	0.10	0.31
Poland	0.79	2.00
Portugal	0.84	1.08
Romania	2.07	3.80
Russia	1.31	1.58
Singapore	0.10	0.17
Slovak Rep.	0.01	0.60
Slovenia	0.45	1.40
South Africa	0.41	0.43
Spain	0.01	0.18
Sweden	0.14	0.20
Switzerland	0.01	0.19
Thailand	0.04	0.36
Turkey	0.24	1.24
United Kingdom	0.00	0.06
United States	0.32	0.20
Emerging counties	0.37	0.71
Advanced countries	0.13	0.2

D Conditional independence assumption

Table 11: **Conditional independence assumption**

	Treated	Control	Nearest 1 neighbor	Nearest 5 neighbor	Kernel	Local-linear	Radius (.05)
	Mean		**Pval**				
Inflation vol.							
Unmatched	0,63	0,85	0,04	0,04	0,04	0,04	0,04
Matched	0,63	0,59	0,448	0,372	0,41	0,45	0,42
GDP Share							
Unmatched	0,14	0,41	0,00	0,00	0,00	0,00	0,00
Matched	0,14	0,15	0,567	0,32	0,50	0,57	0,51
Market Dev.							
Unmatched	77,27	76,99	969	0,97	0,97	0,97	0,97
Matched	77,27	78,96	0,861	0,301	0,40	0,86	0,38
Political stab.							
Unmatched	8,83	8,02	0,00	0,00	0,00	0,00	0,00
Matched	8,83	8,71	0,524	0,935	0,62	0,52	0,61
IT number							
Unmatched	21,55	13,50	0,00	0,00	0,00	0,00	0,00
Matched	21,55	21,51	0,942	0,84	0,82	0,94	0,83
Trade Openness							
Unmatched	4,16	4,25	0,042	0,04	0,04	0,04	0,04
Matched	4,16	4,14	0,63	0,225	0,60	0,63	0,63
All variables: average			**Mean**				
R&R's Residual Bias			2.66	1.94	1.98	2.81	2.03
R&R's Bias Reduction			88.79	89.01	90.11	88.79	90.04
Rubin's B			9.31	7.14	7.74	9.55	7.81
Rubin's R			0.65	0.74	0.54	0.71	0.51

In Table 11, the mean is reported only for the Nearest neighbor (1) matching algorithm, the mean under other algorithms being very close. The difference between the Unmatched Treated and Unmatched Control is the initial biased, while the difference between the Matched Treated and Matched Control is minimized during the matching process. The absence of sample bias (also known as conditional independence assumption) is validated by testing the difference between the variable average for the treatment group and the control group. In the absence of bias, their should be not significant difference between the two groups means, indicated by a large p-value. An overall evaluation of the conditional independence assumption is given by Rosenbaum and Rubin's standardised percentage bias, which is the average gap between the Treated and Control group expressed as a percentage of the square root of the sample variance. In our case R&R's standardised percentage bias has been reduced by about 90% thanks to the matching process, resulting in a bias after matching (R&R's Residual Bias) of about 2%, which is small enough to accept the absence of Conditional dependence. In addition to the latter statics relative to the covariate balancing, the PS balancing can also be tested, either in mean (Rubin's B) or in variance (Rubin's R). Rubin's B is a measure of the average PS gap between the Treated group and Control groups. As a rule of thumb, the balancing hypothesis is accepted for values below 25. Last, Rubin's R is the ratio the Treated group PS index variance to the Control group PS index variance. The acceptance threshold is generally assumed to be from 0.5 to 2 and is validated for our five matching algorithms. R&R's Bias and Rubin's B and R are bootstrapped (using 500 iterations).