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

ANTONIA LÓPEZ-VILLAVICENCIO
GATE-CNRS, University Lyon 2, France. (e-mail: lopez@gate.cnrs.fr).
MARC POURROY
University of Poitiers. France. (e-mail: marc.pourroy@univ-poitiers.fr).

October 23, 2018

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 more ancient regimes, adopting a band inflation target and keeping inflation close to the target outperform other IT regimes. We also show that IT is effective even with relatively high inflation target or low independence of the central bank.

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

* *Corresponding author*: Antonia Lopez-Villavicencio, GATE-CNRS and University Lumière Lyon 2. 93, chemin des Mouilles - B.P.167 69131 - ECULLY cedex, France. Phone: + 33 (0) 4 72 86 60 87. Email: `lopez@gate.cnrs.fr`.

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 IT is not randomly allocated across countries, but is instead correlated with other

[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.

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 precise evidence on 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 of 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.[3] Third, as the benefits of explicitly adopting an IT regime are still debated in the literature, our main contribution is to analyse, in detail, the effectiveness of the IT regime under different circumstances. In particular, we alter our original sample by dropping IT countries that present different characteristics of the regime in terms of: i) the initial level of inflation, ii) the inflation level targeted, iii) achieving the announced target, iv) the durability of the regime, v) the independence of the cental bank, vi) the starting dates of IT adoption and, vi) the type of target. By performing this exercises, we try to shed some light into the mechanisms through which IT lowers the ERPT.

Since the ERPT is not an observable variable, our empirical assessment then relies in 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 en-

[3]This is particularly important since while a large part of the literature proposes that explicit IT regimes are generally associated with higher macroeconomic performances (Levin, Natalucci, and Piger (2004); Mishkin and Schmidt-Hebbel (2007)), other studies suggest that there is no evidence that these performances are attributable to IT (see Ball and Sheridan (2003); Lin and Ye (2007) or Angeriz and Arestis (2008)).

sure the robustness of our findings.

Our results can be summarized as follow. 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, more ancient regimes outperform newer regimes, a band targeting regime is more efficient than a point targeting regime and 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 are not directly observable and therefore need 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 of the pass-through based on the following generic specification proposed by Goldberg and Knetter (1997):

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

where p_t denotes consumer prices in period t, e_t is the nominal effective exchange rate, y_t is the demand shifter, p_t^* corresponds to a supply shock variable and $\epsilon_t \sim N(0, G_t)$ is an independent and identically distributed error term.[4] All the variables are expressed in logarithms.[5]

[4]We include 4 lags of the inflation rate to better capture the observed inertial behavior of inflation (inflation persistence) and to avoid underestimating ERPT.

[5]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)).

Note that, in Eq.(1), the ERPT coefficient, θ, is assumed to be time-varying. More specifically, we expand the previous equation, known as the the measurement equation, with the following ERPT shift equation:

$$\theta_t = \theta_{t-1} + C\upsilon_t \tag{2}$$

where the ERPT parameter θ depends on an autoregressive term and $\upsilon_t \sim N(0, Q_t)$. The system (1)-(2) 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:

$$\begin{aligned} \theta_{t|t-1} &= \theta_{t-1|t-1} \\ \Omega_{t|t-1} &= \Omega_{t-1|t-1} + CQC' \\ \Delta p_{t|t-1} &= \alpha + \gamma \sum_{j=1}^{n} \Delta p_{t-j} + \theta_{t|t-1}\Delta e_t + \lambda \Delta p_t^* + \rho \Delta y_t + G\epsilon_t \end{aligned} \tag{3}$$

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

$$\begin{aligned} \hat{\nu}_{t|t} &= \Delta p_t - \Delta p_{t|t-1} \\ \Sigma_{t|t} &= y_t^* \Omega_{t-1|t-1}(\Delta e_t)' + GQG' \end{aligned} \tag{4}$$

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

$$\begin{aligned} \theta_{t|t-1} &= \theta_{t-1|t-1} + \Omega_{t|t-1}(\Delta e)\Sigma_{t|t}^{-1}\hat{\nu}_{t|t} \\ \Omega_{t|t} &= \Omega_{t|t-1} - \Omega_{t|t}(\Delta e)\Sigma_{t|t}^{-1}(\Delta e)'\Omega_{t|t-1} \end{aligned} \tag{5}$$

Equations (3) to (5) are the Kalman filter. The equations denoted by (3) are the one-step predictions. These predictions do not use contemporaneous values of Δp_t; only its past values. Equations (4) and (5) 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.[6] 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 know if 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)).

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.[7] 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 presence of limited amount of data. A second, less standard approach,[8] 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 estimation bias arising from the selection on observables problem. 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 goals) leads to different outcomes than the absence of treat-

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

[7] 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)).

[8] 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.

ment, 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 (alternatively, fully flexible) and 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:

$$ATT = E[Y_i^1|D = 1] - E[Y_i^0|D = 1] \tag{6}$$

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

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

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.(7) 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:

$$ATT = E[Y_i^1|D = 1, \mathbf{X}] - E[Y_i^0|D = 0, \mathbf{X}] \tag{8}$$

In Eq. (8) $E[Y_i^1|D = 1, \mathbf{X}]$ 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:

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

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).[9] 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, excepting that one group of countries adopts IT (the "treatment group") and the other does not (the "control group").[10]

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. Therefore, from our 48 countries, 24 or 22 countries are IT according to the chosen classifications.[11]

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

[10] The nearest-neighbor pairs each observation in the treated 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)).

[11] Countries with an IT framework are denoted with a star (*). Dates of adoption are presented in Table (9) in the Appendix. The choice of the countries is also determined by the availability of

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).[12] 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. Regarding the variables related to inflation targeting, we use a dummy variable IT that takes the value 1 for countries that adopted an inflation targeting framework and 0 otherwise.[13] According to Mishkin (2004) or Hammond (2012), a central bank has an IT framework if it full-fills the five following criteria : 1) Price stability is explicitly recognized as the main goal of monetary policy; 2) There is a public announcement of a quantitative target for inflation; 3) Monetary policy is based on a wide set of information, including an inflation forecast; 4) Transparency; and 5) Accountability mechanisms. For the sake of robustness, we follow Rose (2007), Minea and Tapsoba (2014) and Balima, Combes, and Minea (2017) and distinguished between Full-fledge (FF from now on) 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 by academia as the genuine dates from which the central bank began meeting the required criteria to be classified as an ITer. Our sources are Rose (2007), Roger (2009) and Minea and Tapsoba (2014).[14]

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 data. Note that the sample size might occasionally change.

[12]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.

[13]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.

[14]Note that the definition of IT is quite restrictive. Indeed, for inflation targeters, price stability is the main goal of central bank's mandate. Therefore, the USA and countries at the EMU are not consider as ITers. Indeed, the Fed has a dual mandate with two goals: price stability and maximum sustainable employment. Moreover, until January 2012 the Fed had not announced a quantitative target for inflation. The European Central Bank, in turn, has a hierarchical mandate that makes price stability the primary objective. However, in the implementation of its policy, the ECB follows a two pillar approach that focus on all information (real sector activities and monetary aggregates developments) and not only on price developments.

the effectiveness of IT. Therefore, it seems opportune to also evaluate if 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 much more solidly anchored explaining 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 (see Ngo (2018));

- **Deviations of actual inflation from its target:** we are interested not only in 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 announce objective or a a pre-specified target range. Following this argument, we finally alter the sample by excluding observations that deviate 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 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 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 countries with point inflation target and then range inflation target. The sources are different publications of the Central Banks;

The rest of the variables correspond to the controls that we use in the logit or probit estimations: inflation volatility, financial development, political stability, the number of countries having adopted IT, the share of world GDP and trade openness are the set of variables entering the benchmark probit model for the propensity score for inflation targeting. Appendix A reports the exact 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. As expected, ERPT is incomplete in all the cases, the mean value being 0.24 for the whole sample. 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. Moreover, note that the estimated ERPT coefficients increases for a good part of the countries around 2009-2010.

4.2 The Propensity Score for Inflation Targeting

Once the ERPT is calculated, it remains to asses its 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.[15] Table 1

[15]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

presents the logit estimations (i.e. the probability) considering different control variables.[16]

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 indicate that high inflation volatility decreases the likelihood to adopt inflation targeting.[17] 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 also 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.[18] 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 external real 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. [19]

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 C.

include all the possible variables that may have a systematic impact on the ERPT as well as on choice of monetary policy goals.

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

[17]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.

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

[19]Note that 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))

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
No. 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).

4.3 ERPT and Inflation Targeting

Having proved that all the prerequisite required for the use 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.

Table 2: **Impact of inflation targeting on ERPT. Average treatment (ATT) effect on the treated countries.**

PSM	Nearest neighbor(1)	Nearest neighbor(5)	Kernel	Local-linear	Radius (.05)
Treatment= FF IT criteria					
ATT	-0.124*	-0.140***	-0.128***	-0.167***	-0.124***
	(-1.99)	(-2.92)	(-3.14)	(-4.04)	(-2.93)
Nbr. Treated	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)
Nbr. Treated	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)
Nbr. Treated	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)
Nbr. Treated	415 /914	415/914	415/914	415/914	415/914
Alternative IT criteria: Soft IT					
ATT	-0.121**	-0.0951**	-0.126***	-0.149***	-0.128***
	(-2.35)	(-2.14)	(-3.33)	(-3.99)	(-3.25)
Nbr. Treated	436 / 1011	436 / 1011	436 / 1011	436 / 1011	436 / 1011

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 1, 5 and 10%. A high t-value indicates a significant gap between treated and controls, (4) Nbr. Treated is the number of treated observations over the sample size.

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.[20] Moreover, the table also shows that our results are robust to change 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. However, 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 (seen 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 to 3 and 5 years.[21] As seen, ATTs are not significant in the estimation for

[20]For the sake of completness we also atler 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 date. The estimated ATT for this alternative IT definition was similar to the estimated ATT for IT FF.

[21]By defining a treatment group with countries that will adopt IT during the following 3 years we

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	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	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	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	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 1, 5 and 10%. A low p-value indicates a significant gap between treated and controls.

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 more ancient regimes outperforms recent ones. 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 the independency of the central bank. Using the median level of alternative indicators, we exclude from the treatment group observations with high levels of independency. 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.

consider that some inflation targeters were targeting inflation before the announcement of official targets.

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	-0.0215***	-0.0224***	-0.0165***	-0.0184***	-0.0167***
	(-2.76)	(-3.51)	(-3.98)	(-4.52)	(-4.00)
N. Treated	98	98	98	98	98
Treatment= target at most 4% of inflation					
ATT	-0.0118*	-0.0127***	-0.0112***	-0.0132***	-0.0111***
	(-1.95)	(-2.58)	(-2.77)	(-3.14)	(-2.61)
N. Treated	261	261	261	261	261
Treatment= target at most 6% of inflation					
ATT	-0.0194***	-0.0140**	-0.0147***	-0.0175***	-0.0144***
	(-3.22)	(-2.55)	(-3.59)	(-4.44)	(-3.70)
N. Treated	314	314	314	314	314
Treatment= target at most 8% of inflation					
ATT	-0.0154**	-0.0141***	-0.0142***	-0.0172***	-0.0141***
	(-2.35)	(-2.75)	(-3.48)	(-4.09)	(-3.26)
N. Treated	321	321	321	321	321

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 1, 5 and 10%. A low p-value indicates a significant gap between treated and controls.

Finally, knowing that the central bank could explicitly announce a numerical point or band target for inflation to the public, we alter our sample by dropping each regime from the treatment group. Table 8 shows that IT adoption significantly reduces the ERPT in both cases. However, the magnitude of the estimated ATTs is stronger in band compared to point target. Thus, if IT adoption reduces the link between exchange rate shocks and inflation, a band IT outperforms any other objective. This result suggests that more discretion within the IT framework is not detriment to reduce exchange rate shocks on prices.

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	-0.301***	-0.255***	-0.224***	-0.285***	-0.226***
	(-3.92)	(-4.13)	(-4.36)	(-5.31)	(-4.14)
N. Treated	153 / 805	153 / 805	153 / 805	153 / 805	153 / 805
Treatment= Inflation at objective +/- 5%					
ATT	-0.252***	-0.227***	-0.228***	-0.276***	-0.224***
	(-3.66)	(-3.94)	(-4.59)	(-5.31)	(-4.39)
N. Treated	173 / 825	173 / 825	173 / 825	173 / 825	173 / 825
Treatment= Inflation at objective +/- 20%					
ATT	-0.293***	-0.260***	-0.254***	-0.300***	-0.250***
	(-3.81)	(-4.06)	(-4.09)	(-6.50)	(-4.37)
N. Treated	220 / 872	220 / 872	220 / 872	220 / 872	220 / 872
Treatment= Inflation at objective +/- 50%					
ATT	-0.132**	-0.154***	-0.182***	-0.217***	-0.179***
	(-2.34)	(-2.71)	(-3.56)	(-4.74)	(-3.48)
N. Treated	277 / 929	277 / 929	277 / 929	277 / 929	277 / 929
Treatment= Inflation at objective +/- 100%					
ATT	-0.161**	-0.155***	-0.148***	-0.176***	-0.147***
	(-2.40)	(-2.91)	(-3.46)	(-3.93)	(-3.25)
N. Treated	316 / 968	316 / 968	316 / 968	316 / 968	316 / 968

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 1, 5 and 10%. A low p-value indicates a significant gap between treated and controls.

5 Conclusions

Estimates of the exchange rate pass-through have decline in recent years. The main explanations for this decline is that expectations of inflation have become much more solidly anchored due to a 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

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	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	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	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	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 1, 5 and 10%. A low p-value indicates a significant gap between treated and controls.

the macroeconomic effects of inflation targeting. More importantly, we conduct a detail 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, ancient 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 in an inflation-targeting framework monetary policy is delegated to an independent central bank, monetary authorities do not need to implement a high level of independency to achieve lower ERPT.

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= targeting 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	152 / 809	152 / 809	152 / 809	152 / 809	152 / 809
Treatment= targeting 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	169 / 826	169 / 826	169 / 826	169 / 826	169 / 826
Treatment= targeting 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	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 1, 5 and 10%. A low p-value indicates a significant gap between treated and controls.

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= point inflation target					
ATT	-0.087	-0.140***	-0.128***	-0.152***	-0.126***
	(-1.26)	(-2.66)	(-2.97)	(-3.65)	(-3.30)
N. Treated	267 / 924	267 / 924	267 / 924	267 / 924	267 / 924
Treatment= range inflation target					
ATT	-0.351***	-0.279	-0.233**	-0.324**	-0.233*
	(-2.71)	(-1.55)	(-2.02)	(-2.03)	(-1.93)
N. Treated	74 / 731	74 / 731	74 / 731	74 / 731	74 / 731

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 1, 5 and 10%. A low p-value indicates a significant gap between treated and controls.

Figure 1: **Exchange rate pass through**

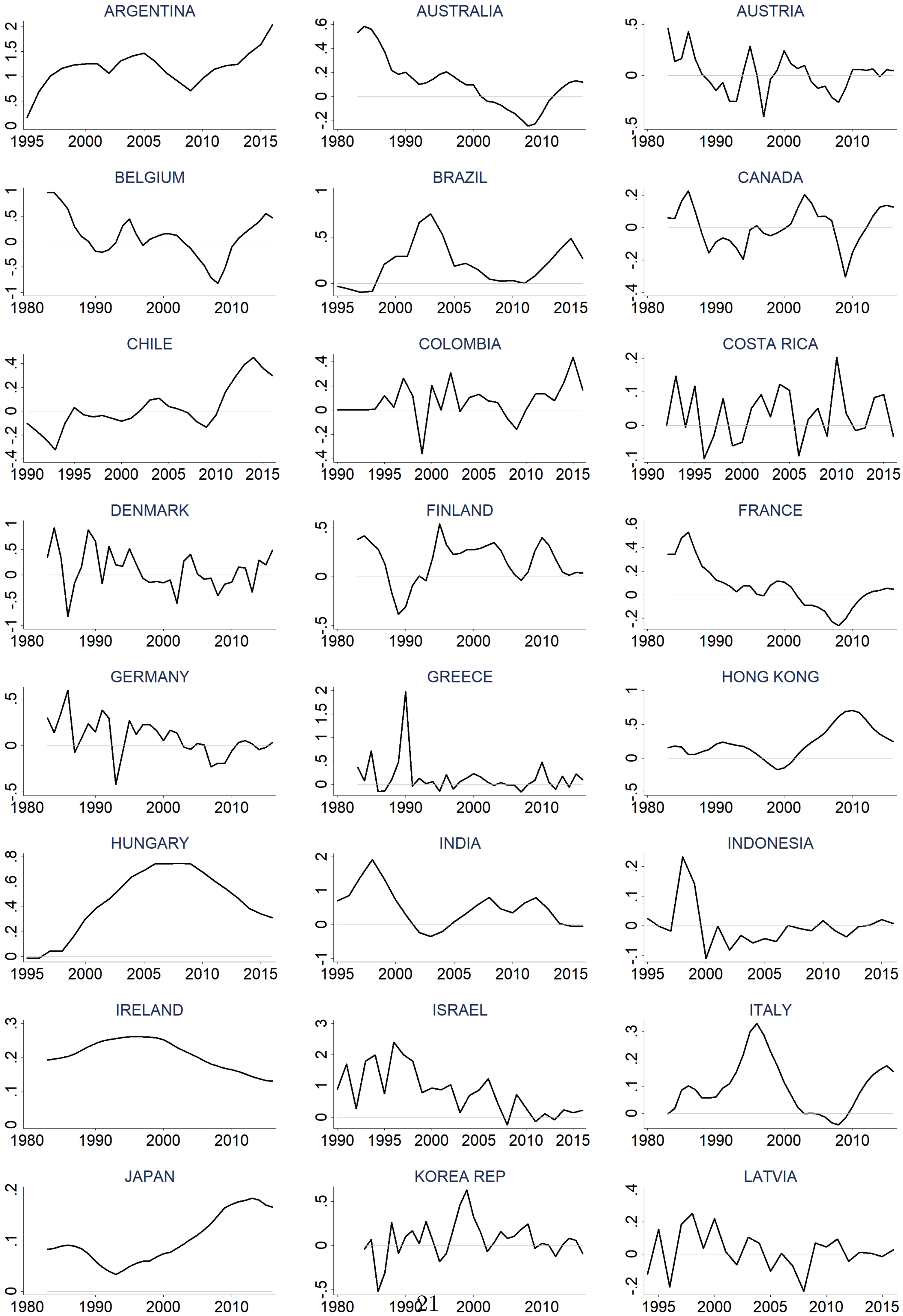
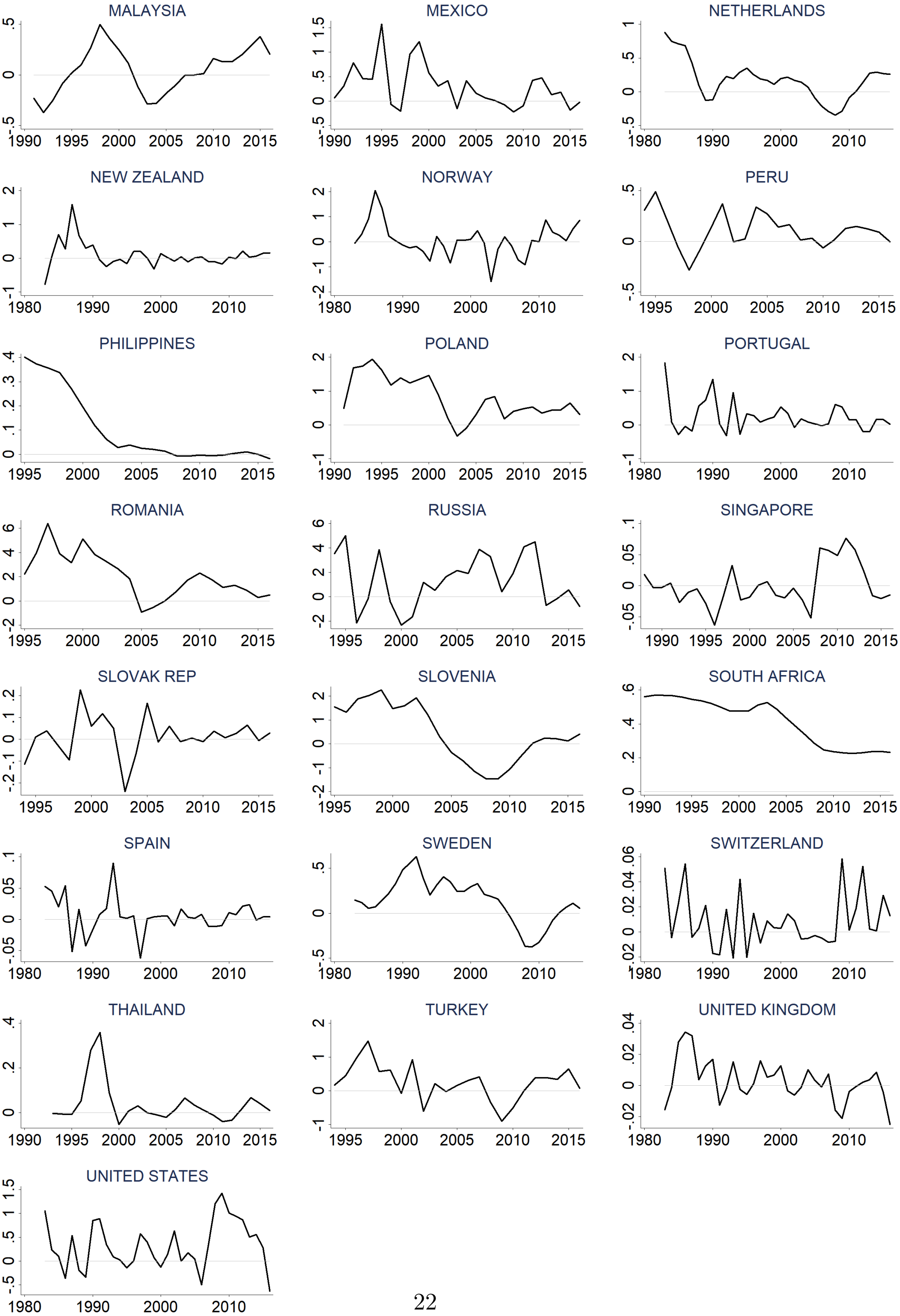


Figure 2: **Exchange rate pass through (cont.)**



References

ANGERIZ, A., AND P. ARESTIS (2008): "Assessing inflation targeting through intervention analysis," *Oxford Economic Papers*, 60(2), 293–317.

BAILLIU, J., AND E. FUJII (2004): "Exchange Rate Pass-Through and the Inflation Environment in Industrialized Countries: An Empirical Investigation," Staff Working Papers 04-21, Bank of Canada.

BALIMA, W. H., J.-L. COMBES, AND A. MINEA (2017): "Sovereign debt risk in emerging market economies: Does inflation targeting adoption make any difference?," *Journal of International Money and Finance*, 70, 360 – 377.

BALL, L., AND N. SHERIDAN (2003): "Does Inflation Targeting Matter?," NBER Working Papers 9577, National Bureau of Economic Research, Inc.

BERNANKE, B. S., AND F. S. MISHKIN (1997): "Inflation Targeting: A New Framework for Monetary Policy?," *Journal of Economic Perspectives*, 11(2), 97–116.

BODEA, C., AND R. HICKS (2015): "International Finance and Central Bank Independence: Institutional Diffusion and the Flow and Cost of Capital," *The Journal of Politics*, 77(1), 268–284.

BORDO, M. D., AND P. L. SIKLOS (2015): "Central Bank Credibility and Reputation: An Historical Exploration," NBER Working Papers 20824, National Bureau of Economic Research, Inc.

BOSCHEN, J. F., AND C. L. WEISE (2003): " What Starts Inflation: Evidence from the OECD Countries," *Journal of Money, Credit and Banking*, 35(3), 323–349.

BOUAKEZ, H., AND N. REBEI (2008): "Has exchange rate pass-through really declined? Evidence from Canada," *Journal of International Economics*, 75(2), 249 – 267.

CAMPA, J. M., AND L. S. GOLDBERG (2005): "Exchange Rate Pass-Through into Import Prices," *The Review of Economics and Statistics*, 87(4), 679–690.

CORNAND, C., AND C. K. M'BAYE (2018): "Does Inflation Targeting Matter ? An Experimental Investigation," *Macroeconomic Dynamics*.

CROWE, C., AND E. E. MEADE (2007): "The Evolution of Central Bank Governance around the World," *Journal of Economic Perspectives*, 21(4), 69–90.

CUKIERMAN, A., S. B. WEBB, AND B. NEYAPTI (1992): "Measuring the Independence of Central Banks and Its Effect on Policy Outcomes," *World Bank Economic Review*, 6(3), 353–398.

Dehejia, R. H., and S. Wahba (2002): “Propensity Score-Matching Methods for Nonexperimental Causal Studies,” *The Review of Economics and Statistics*, 84(1), 151–161.

Devereux, M. B., C. Engel, and P. E. Storgaard (2004): “Endogenous exchange rate pass-through when nominal prices are set in advance,” *Journal of International Economics*, 63(2), 263–291.

Devereux, M. B., and J. Yetman (2010): “Price adjustment and exchange rate pass-through,” *Journal of International Money and Finance*, 29(1), 181–200.

Dong, W. (2012): “The role of expenditure switching in the global imbalance adjustment,” *Journal of International Economics*, 86(2), 237 – 251.

Ebeke, C. H., and A. Fouejieu (2015): “Inflation Targeting and Exchange Rate Regimes in Emerging Markets,” IMF Working Papers 15/228, International Monetary Fund.

Fatas, A., I. Mihov, and A. K. Rose (2007): “Quantitative Goals for Monetary Policy,” *Journal of Money, Credit and Banking*, 39(5), 1163–1176.

Gagnon, J. E., and J. Ihrig (2004): “Monetary policy and exchange rate pass-through This article is a U.S. Government work and is in the public domain in the U.S.A,” *International Journal of Finance & Economics*, 9(4), 315–338.

Garriga, A. (2016a): “Central Bank Independence in the World: A New Data Set,” Harvard Dataverse.

Garriga, A. C. (2016b): “Central Bank Independence in the World: A New Data Set,” *International Interactions*, 42(5), 849–868.

Goldberg, P. K., and M. M. Knetter (1997): “Goods Prices and Exchange Rates: What Have We Learned?,” *Journal of Economic Literature*, 35, 1243–1272.

Goncalves, C. E. S., and J. M. Salles (2008): “Inflation targeting in emerging economies: What do the data say?,” *Journal of Development Economics*, 85(1-2), 312–318.

Hammond, G. (2012): *State of the art of inflation targeting*. Centre for Central Banking Studies, Bank of England, 4 edn.

Heckman, J. J., H. Ichimura, and P. E. Todd (1998): “Matching As An Econometric Evaluation Estimator: Evidence from Evaluating a Job Training Programme,” *Review of Economic Studies*, 64(4), 605–654.

Ihrig, J. E., M. Marazzi, and A. D. Rothenberg (2006): “Exchange-rate pass-through in the G-7 countries,” International Finance Discussion Papers 851, Board of Governors of the Federal Reserve System (U.S.).

Ilzetzki, E., C. M. Reinhart, and K. S. Rogoff (2017): "Exchange Arrangements Entering the 21st Century: Which Anchor Will Hold?," NBER Working Papers 23134, National Bureau of Economic Research, Inc.

Imbens, G. W. (2004): "Nonparametric Estimation of Average Treatment Effects Under Exogeneity: A Review," *The Review of Economics and Statistics*, 86(1), 4–29.

Kim, Y. (1990): "Exchange Rates and Import Prices in the United States: A Varying-Parameter Estimationof Exchange-Rate Pass-through," *Journal of Business and Economic Statistics*, 8(3), 305–315.

Levin, A. T., F. M. Natalucci, and J. M. Piger (2004): "The macroeconomic effects of inflation targeting," *Review*, (Jul), 51–80.

Levy Yeyati, E., F. Sturzenegger, and I. Reggio (2010): "On the endogeneity of exchange rate regimes," *European Economic Review*, 54(5), 659–677.

Lin, S., and H. Ye (2007): "Does inflation targeting really make a difference? Evaluating the treatment effect of inflation targeting in seven industrial countries," *Journal of Monetary Economics*, 54(8), 2521–2533.

Lucotte, Y. (2012): "Adoption of inflation targeting and tax revenue performance in emerging market economies: An empirical investigation," *Economic Systems*, 36(4), 609–628.

MacCulloch, R. J., R. D. Tella, and A. J. Oswald (2001): "Preferences over Inflation and Unemployment: Evidence from Surveys of Happiness," *American Economic Review*, 91(1), 335–341.

Marazzi, M., and N. Sheets (2007): "Declining exchange rate pass-through to U.S. import prices: The potential role of global factors," *Journal of International Money and Finance*, 26(6), 924 – 947.

Mihov, I., and A. K. Rose (2007): "Is Old Money Better than New? Duration and Monetary Regimes," CEPR Discussion Papers 6529, C.E.P.R. Discussion Papers.

Minea, A., and R. Tapsoba (2014): "Does inflation targeting improve fiscal discipline?," *Journal of International Money and Finance*, 40(C), 185–203.

Mishkin, F. S. (2000): "Inflation Targeting in Emerging-Market Countries," *American Economic Review*, 90(2), 105–109.

——— (2004): "Can Inflation Targeting Work in Emerging Market Countries?," NBER Working Papers 10646, National Bureau of Economic Research, Inc.

Mishkin, F. S., and K. Schmidt-Hebbel (2001): "One Decade of Inflation Targeting in the World: What Do We Know and What Do We Need to Know?," NBER Working Papers 8397, National Bureau of Economic Research, Inc.

——— (2007): "Does Inflation Targeting Make a Difference?," NBER Working Papers 12876, National Bureau of Economic Research, Inc.

Mishkin, F. S., and N. J. Westelius (2008): "Inflation Band Targeting and Optimal Inflation Contracts," *Journal of Money, Credit and Banking*, 40(4), 557–582.

Ngo, P. (2018): "The Risk Of Hitting The Zero Lower Bound And The Optimal Inflation Target," *Macroeconomic Dynamics*, 22(02), 402–425.

Orphanides, A., and J. C. Williams (2007): "Inflation Targeting under Imperfect Knowledge," in *Monetary Policy under Inflation Targeting*, ed. by F. S. Miskin, K. Schmidt-Hebbel, N. L. S. Editor), and K. S.-H. (Se, vol. 11 of *Central Banking, Analysis, and Economic Policies Book Series*, chap. 4, pp. 077–123. Central Bank of Chile.

Peter, M., S. Roger, and G. M. Heenan (2006): "Implementing Inflation Targeting; Institutional Arrangements, Target Design, and Communications," IMF Working Papers 06/278, International Monetary Fund.

Reyes, J. (2007): "Exchange Rate Passthrough Effects and Inflation Targeting in Emerging Economies: What is the Relationship?," *Review of International Economics*, 15(3), 538–559.

Roger, S. (2009): "Inflation Targeting at 20 - Achievements and Challenges," IMF Working Papers 09/236, International Monetary Fund.

Rose, A. K. (2007): "A stable international monetary system emerges: Inflation targeting is Bretton Woods, reversed," *Journal of International Money and Finance*, 26(5), 663–681.

——— (2014): "Surprising similarities: Recent monetary regimes of small economies," *Journal of International Money and Finance*, 49(PA), 5–27.

Rosenbaum, P. R., and D. B. Rubin (1983): "The Central Role of the Propensity Score in Observational Studies for Causal Effects," *Biometrika*, 70(1), 41–55.

Sekine, T. (2006): "Time-varying exchange rate pass-through: experiences of some industrial countries," BIS Working Papers 202, Bank for International Settlements.

Svensson, L. E. O. (1997): "Inflation forecast targeting: Implementing and monitoring inflation targets," *European Economic Review*, 41(6), 1111–1146.

Taylor, J. B. (2000): "Low inflation, pass-through, and the pricing power of firms," *European Economic Review*, 44(7), 1389–1408.

Vega, M., and D. Winkelried (2005): "Inflation Targeting and Inflation Behavior: A Successful Story?," *International Journal of Central Banking*, 1(3).

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: Ful 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)

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

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 Conditional independence assumption

Table 10: **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 Openess							
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 10, 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 intial 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 biais 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 aslo 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).