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THE ROLE OF INFLATION TARGETING ON EXCHANGE RATE VOLATILITY: AN EVIDENCE FROM PROPENSITY SCORE MATCHING APPROACH*

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ABSTRACT

This paper examines the causal effects of inflation targeting on exchange rate volatility across a large panel of 91 (36 inflation targeting) countries over the 1985-2019 period on annual basis. We apply propensity score matching methods to developed, developing, and high-income inflation targeting countries and non-inflation targeting countries. Our results reveal that, on average, adopting the inflation targeting policy exerts lower exchange rate volatility in all sample and developing economies. However, subgroups results demonstrate that inflation targeting regimes may lead to higher exchange rate volatility in developed and high-income economies. The outcome from different degrees of flexibility of exchange rates subgroups points out that the inflation targeting regime has significant and lower exchange rate volatility under free-floating regimes however this policy stance has no discernible effect on floating regimes. Additionally, adopted inflation targeting countries are affected by less damage on exchange rate volatility than those adopting exchange rate targeting regimes.

Keywords: *Propensity Score Matching, Inflation Targeting, Exchange Rate Volatility.*

Jel Codes: *C14, E31, E52, F31.*

1. INTRODUCTION

There has been an environment over the last two decades in the implementation of inflation targeting as a main monetary policy by most economies, emerging economies cause to leave exchange rate peg economies. As a result of the increase in the number of countries adopting inflation targeting, the literature begins to concern debate regarding the effectiveness of the exchange rate monetary policy conducted under inflation targeting frameworks. The inflation targeting regime has an institutional commitment obligation to achieve price stability via the short-term interest rate as their main monetary policy tool. However, especially in developing economies, authorities assert that a case of neglect of the exchange rate may lead to a more open vulnerability in their economies because of a high degree of

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pass-through to domestic prices caused by allowing the exchange rate to swing (Carare and Stone, 2003; Mishkin, 2008).

Through strong nexus between exchange rates and price, it carries crucial importance to obtain stability in the exchange rate and resulting in effective monetary policy. This transmission is associated with several channels. First, the disparity between domestic prices and exchange rates exerts vulnerability. In the case of exchange rate shock occurs, the first impact experiences at the fluctuation in prices of tradable goods and then pass-through domestic prices (Jasova, Moessner and Takats, 2016). Exchange rate fluctuation has direct and indirect effects of passed through to domestic prices. The direct channel consists of changes in domestic prices because of exchange rate fluctuations to cause in changes in import prices. Since exchange rate volatility leads to depreciation in local currency, consumers and firms desire to get the same imported consumption goods, firms and consumers must pay much more in the domestic currency. As further process exchange rate fluctuations raise the domestic price level in reflection of the increased production cost of the sector in connection with that depending on imported input prices at sectors that are priced in foreign currency. The indirect effect of exchange rate fluctuations occurs through a change in the amount of total demand. Import prices that become more expensive for domestic buyers due to depreciation in domestic currency lead to increased money demand. Furthermore, depreciation in domestic currency causes relatively cheaper domestic prices considering export goods for foreign buyers. Higher demand for export goods by foreign buyers and increased money demand by domestic consumers create upward pressure on domestic prices (Karahan, 2017). Severe exchange rate movements create challenge repayment of credits for economies that are under high dependence on global-trade financing. These weak credit conditions of economies that are sourced from the depreciation of the exchange rate cause harmful effects on the business cycles instead of improving international competitiveness (Bruno, Kim and Shin, 2018). Finally, particularly in emerging-developing economies borrowing occurs heavily dependent on foreign currency debt. The case of an increased growth rate in the domestic economy leads to ease financial conditions. Therefore, any drastic exchange rate shock or fluctuations in the exchange rate turn into price instability (Gourinchas and Obstfeld, 2012).

The traditional exchange rate targeting regime still prevails as the dominant monetary policy regime in developing economies even if the success of the inflation targeting regime demonstrates empirical evidence considering the achievement of macroeconomic stability. The main reason behind this is the "fear of floating" case in which developing economies were proposed in the influential study by Calvo and Reinhart (2002). Central banks commit price stability as the main objective to conduct monetary policy. This related idea means that economies with IT regime does not interfere much to stabilize the exchange rate by using central banks' monetary policy tools. Fear of floating occurs due to the esixtence of unhedged foreign-currency-denominated debt that caused restrictions to give fluctuations in exchange rates in economies permission (Pontines, 2013).

Nonetheless, as inflation targeting regimes assure that price commitment in turn improvement of policy credibility, it is expected to absorb the influence of sudden stops in capital flows. Monetary policy carries the greatest importance to achieve in mitigating uncertainty surrounding (Kabundi and Mlachila, 2019). The inflation targeting (IT) regime is a monetary policy framework in which the objective of the central bank is to "target a defined medium-term inflation rate" which is also associated with macroeconomic stability. Result of actualizing deviation from the current inflation rate over the central bank's announced inflation target, the official policy interest rate should adjust in this regime and the mechanism is the main policy instrument where the IT regime is conducted (Ebeke and Azangue, 2015). Maintaining inflation within the target range leads to more credibility in monetary policy stance even if unnoticed output shock, interest rates shock, and exchange rates shock (Kabundi and Mlachila, 2019).

With the transition from the fixed exchange rate to the floating exchange rate regime, interest in exchange rate volatility becomes much more. The first strand of literature is on determinants of exchange rate volatility using various econometric methodologies. The variables impacting exchange rate volatility are financial openness (Calderon and Kubota, 2018), inflation rate and inflation volatility (Mirchandani,2013; Grydaki and Fontas, 2011), interest rate movements (Oaikhenan and Aigheyisi, 2015), and government expenditure (Insah and Chiaraah, 2013; Alagidede and Ibrahim, 2017).

Studies of the role of the inflation targeting framework demonstrate after the adoption of the regime, exchange rate pass-through of countries has decreased (Gagnon and Ihrig, 2004; Coulibaly and Kempf, 2010). The findings of Taguchi and Sohn (2014) suggest that switching to an inflation targeting regime does not lead to discernible change concerning reducing exchange rate pass-through through developing economies.

Few studies examine the effectiveness of monetary policy role on exchange rate volatility. The study by Edwards (2006) is an important study to focus on this type of evaluation. This study examines seven inflation targeting countries using GARCH models to test the role of IT adoption on multilateral exchange rate volatility over the period 1985-2005. Results assert that after implementation of inflation targeting exerts reducing exchange rate pass-through to inflation. Rose (2007) examines exchange rate volatility as compare between inflation targeting countries and control groups amongst developed and developing and emerging market economies. This study offers that the inflation targeting regime is effective in getting lower exchange rate volatility and inflation targeting countries seem to be less likely to experience “sudden stops” of capital inflows. Berganza and Broto (2012) estimate the impact of inflation targeting on exchange rate volatility for emerging economies during the period 1985 to 2005. Countries in inflation targeting regimes perform much more fluctuation in exchange rates than alternative regimes. The result of the study of Berganza and Broto (2012) on this issue raises an important argument that the presence of a higher degree of exchange rate flexibility in inflation targeting countries does not produce effectively in getting reduced exchange rate stability. Ouyang, Rajan, and Li (2016) discuss the impact of IT by evaluating the self-selection problem related to monetary policy

selection, which has been neglected in previous studies to analyze the effectiveness of the inflation targeting regime. Furthermore, the paper's impact of IT regime on real exchange rate volatility evaluate in dividing into two parts "relative tradable prices across countries as well as sectoral prices of tradable and nontradable within countries" over the period 2006 to 2012. Findings draw attention to this difference while developed economies in inflation targeting regimes suffer from more volatility in exchange rate because of external prices, but for developing economies in inflation targeting regimes experience decreasing exchange rate volatility through internal prices stability. Results from Lin (2010) are consistent with the study of Ouyang et al. (2016) using propensity score matching approaches to evaluate nominal and real exchange rate volatility. Finding demonstrate that nominal and real exchange rate fluctuation does not increase in developing economies after the implementation of inflation targeting against those adopting alternative regimes. However, developed economies face increased exchange rate volatility compared to economies that have not implementing IT regime.

The aim of this study is to analyze the causal impact of IT implementation on volatility in exchange rates utilizing the propensity score matching method (PSM). A self-selection problem occurs if economies' policy choice has a non-random process. We use the PSM approach to study the effect of IT regime on exchange rate volatility. This paper examines the treatment impacts of inflation targeting on volatility in the real effective exchange rates in economies that implement this framework. Furthermore, after analyzing all influence of IT on exchange rate volatility, our paper seeks to answer if this outcome has a different influence among developing, developed, high-income economies. Additionally, given the importance of the degree of flexibility of exchange rate this paper examines the impact of exchange rate volatility of under inflation-targeting within the context of floating and free-floating IT countries and adopting fixed exchange rate regimes.

Section two explains the employed methodology, section three demonstrates sample coverage and the dataset, section four provides our estimation outcomes, section five indicates the robustness analysis of our outcomes, and section six concludes.

2. METHODOLOGY

The primary goal of this article is to compare IT economies and non-IT economies regarding exchange rate volatility using the treatment effect approach, namely PSM methodology. We consider the implementation of IT by economies as a treatment. The treated group belongs to economies conducting IT regimes, whereas the control group denotes that not adopting inflation targeting countries. IT policy assessment is employed the average treatment effect which is measured as follows:

$$ATT = E(Y_{i1}|IT_i = 1) - E(Y_{i0}|IT_i = 1) \quad (1)$$

The effect of treatment utilizes Y ∈ 0, 1 which is IT on an outcome y of exchange rate volatility. IT_i refers a dummy indicator that stands for whether economies conduct monetary policy as an inflation

targeting regime or not. If the country i conducts inflation targeting regime, IT is equal to 1 and 0 if not. Thus, $[Y_{i1}|IT_i=1]$ demonstrates the result relevance actually observed in the identical economy change in exchange rate volatility after country i has adopted inflation targeting, and $[Y_{i0}|IT_i = 1]$ indicates the assessment of the result that would have been seen if a treatment economy had not implemented IT regime. Equation (1) therefore corresponds that the Average Treatment Effect (ATT) on the ITers demonstrates the divergence between the result obtained after the adopted IT and the possible result that the unit would have achieved if it had never been adopted IT.

Unfortunately, the problem of missing data encounters in the related equation of the second term, $E(Y_{i0}|IT_i = 1)$. Because, in reality, each unit become either an inflation targeter or a non-inflation targeter, it is not possible to observe both for all population. In another way, we cannot detect the exchange rate volatility of a treatment country had it not implemented such a regime. The effect of this problem disappears when treatment is conditionally randomized. However, the transition process of economies to inflation targeting is not a monetary policy choice involving a random process, i.e., regardless of their economic structure. From the point of view of choosing the IT regime while we face a self-selection problem in assessing the role of the IT regime on the consequences of IT on any variable of interest. The decision to implement the IT framework demonstrates that is endogenous to the main reason is if economies desire to conduct monetary policy as an IT framework explicitly, they should fulfill some prerequisites on institutional infrastructures. These related factors which IT's role on real exchange rate volatility which causes a self-selection problem are impossible to identify as control variables (e.g., Dehejia and Wahba, 2002; Heckman, Ichimura, Todd, 1997). As choosing in the IT framework is nonrandom, a set of observable variables also impacts the outcome variable, namely the "self-selection" problem which makes a biased estimation of the ATT. The "Selection on observables" problem is in solution as to employ propensity score matching method.

2.1. Matching on Propensity Scores

As proposed by Caliendo and Kopeining (2008), when we evaluate inference by employing matching methods through propensity score estimation, related problem is tackled with this difficulty. The main idea of the matching approach is to decide non-ITers economies to mimic a randomized experiment to decrease the biased estimates in the ATT with the observable data set. State of "unconfoundedness" (Rosenbaum and Rubin, 1983), "selection on observables" (Heckman and Robb, 1985), or "conditional independence" (Lechner,1999), potential results are not dependent of the target IT regime has chosen conditional on the dependent variable, X. The hypothesis means that, in this state, systematic variation in the exchange rate volatility between ITers and non-ITers with the same evaluation of covariates X can only associated with the implementation of IT. Under this notion, Equation (1) rewrite as:

$$ATT = E[Y_{i1}|IT_i = 1, X_i] - E[Y_{i0}|IT_i = 0, X_i] \quad (2)$$

where $(Y_{i1}|IT_i = 1, X_i)$ indicates the exchange rate volatility in the ith economy implemented by IT regime, under state X_i. The expression $(Y_{i0}\lfloor IT_i = 0, X_i)$ denotes the exchange rate volatility in the ith economy which still sustained its monetary stance under the same circumtances X_i. To put it another way, for the right-hand term $E[Y_{i1}|IT_i = 1, X_i]$ is changed with $[Y_{i0}\lfloor IT_i = 0, X_i]$, which is noticeable.

However, this approach encounters a high-dimension problem at matched these characteristics as the amount of covariates in X raises. Due to the high-dimensionality problems would be also difficult to employ in estimating ATT. To cope with this related difficulty, Rosenbaum and Rubin (1983) suggest that one can pair the ITers and non-ITers on their propensity scores, which are the likelihood of IT regime implementation conditional on X.

$$P(X_i) = Pr[IT = 1|X_i] \quad (3)$$

where $P(X_i) = Pr[IT = 1|X_i]$ refers the propensity scores. Under the same assumption, if equation (2) is rewritten conditional on a propensity score range:

$$ATT = E[Y_{i1}|IT = 1, P(X_i)] - E[Y_{i0}\lfloor IT_i = 0, P(X_i)] \quad (4)$$

The PSM method guarantees to overcome biased ATT estimation through common support statement. The common support condition indicates the equation as:

$$0 < P(X_i) = \Pr(|IT_i = 1|X_i) < 1 \quad (5)$$

After providing the common support condition, the ATT denotes the average exchange rate volatility over the common support, adequately weighted by the propensity score allocation of participants in the sample.

To cope with the self-selection problem, we employ five PSM methods - nearest-neighbor matching, kernel matching, stratification matching, local linear regression matching, and radius matching- in order to evaluate the role of the IT regime on exchange rate volatility. Findings from various matching approaches assert the "robustness" of propensity score estimated treatment effect on IT and increases the quality of analysis (Lucotte, 2012). In our article, we utilize four PSM approaches commonly used in the literature:

(i) The first one states to the N nearest-neighbor matching estimator with replacement. This estimator entails of pairing each ITers with N non-ITers components according to results of the closest propensity. Thus findings reduce the variance of the estimator as raises the number of neighbors. Unfortunately, the weakness of the neighborhood matching, findings may lead to decreased quality owing to using on average poorer pairs.

(ii) In the case of the closest neighbor being remote, findings estimated from nearest-neighbor matching do not document the true results of ATT. The radius matching estimator deal with this problem by impressiving a threshold on the maximum propensity score gap. To reduce the problem sourced by increased variance because of decreased matching, we use three calipers; a "wide radius" (r=0.05), a "medium radius" (r=0.03), and a "tight radius" (r=0.01).

(iii) By contrast with neighbor and radius matching methods which establish counterfactual matching as utilized from a few ITers observations, the kernel matching approach considers matching weighted averages of all non-ITers to ITers. Each non-ITers observation has a weight that depends on the distance from the participants in terms of propensity.

(iv) Local linear matching as recommended by Heckman et al (1997) carries a similar shape as the kernel matching process excluding for the weighting function. Unlike the kernel matching processes, local linear matching is analogous to regression on a linear term in the propensity score of ITers. Employing this approach may be more suitable in the absence of a strong common support situation.

(v) Measurement of stratification matching is based on the partition of the common support of the propensity score into a set of intervals. The evaluation depends on the mean difference within each interval in exchange rate volatility between participants (ITers) and non-participants (non-ITers) (Caliendo and Kopeinig, 2008).

3. SAMPLE COVERAGE AND DATA DESCRIPTION

3.1. The Sample Versus Outcome Variables

The data set for this article lies of 91 countries over the period from 1985 to 2019 on yearly. In this paper, the IT regime which adopts a full-fledged regime dummy corresponds to a treatment effect variable. Our main interest variable in this paper is exchange rate volatility. By following Lin (2010), we first get twelve monthly observations of real effective exchange rates for each year. After, effective exchange rates use taking the form of natural logarithms. Next, the estimation for each economy over an interval of 12 months is calculated as a standard deviation.

Among our full sample, 36 countries are inflation targeting economies as treatment groups that have implemented inflation targeting by the end of 2019, and 55 countries are a member of the non-targeting countries (control group). We split the sample into developed, developing, and high-income economies to evaluate the effectiveness of IT on exchange rate volatility. This paper identifies country groups based on the "IMF's country classification". Appendix 1 lists our analyzed sample economies with adoption years and Appendix 2 presents non-inflation targeting economies. The pooled sample contains all 91 economies for 36 inflation targeters. In the subsample of developed economies there are 32 (12 inflation targeters), case of developing-emerging economies is 59 (24 inflation targeters). The subsample of high-income economies includes 38, with 15 targeted economies.

As the aim further assesses the impact of IT in exchange rate volatility, we also consider the control group by using only exchange rate pegs. While economies conduct monetary policy regimes as an inflation targeting, they allow fluctuation in exchange rates. Therefore, all inflation targeting countries adopts floating exchange rate. However, most emerging economies do not conduct for exchange rates to move freely. In this paper, we follow a classification series of "Annual Reports on Exchange Arrangements and Exchange Restrictions published by the International Monetary Fund" (IMF, 2018). In order to get further results, we aim to answer the impact of IT on exchange rate volatility by employing consideration to discern de facto exchange rate regime classification. According to IMF classification, in our sample, 19, 8, and 23 IT country observations fall into the floating, free-floating, and fixed exchange rate regimes, respectively.

3.2. The Conditioning Variables

Relying on the existing literature we consider a set of five indicators as control variables by using determinants of the exchange rate volatility and affect likelihood adoption of IT regime to analyze the average treatment effect of IT role on exchange rate volatility and estimation of the propensity score. The covariates, in our paper, consist of current account balance, openness, growth in GDP, international reserves, and land area per capita.

The first variable is land population. Land area per capita corresponds to population density as the *logarithm of the ratio of land area to population*. The fact that countries have a very dense population causes their specialization in primary products to be low. This related case leads to more exposure to terms-of-trade shocks (Bleaney and Tian, 2011) and therefore we expect that land area per capita impacts positively this probability of IT implementation. The second variable is that the current account balance is measured by the *ratio of the sum of net exports of goods and services* which depicts the degree of external sustainability. We anticipate that current account imbalances create a negative effect on the transition to this monetary policy framework and exchange rate stabilization. The third conditioning variable is "reserves in months of imports" is associated with international exchange reserves. The excess of foreign exchange reserves is important for the reliability of the monetary policy stance, as it provides space for the parity not to experience instability in case of shock. Therefore, we expect that international reserves have a positive effect on the probability of IT regime adoption. The fourth variable is the rate of GDP growth that demonstrates the business cycle condition for economies. The impact of the selected inflation targeting regime in this indicator is less obvious. One argument is that economic growth is less likely to choose inflation targeting since a faster economic growth rate creates a lack of credibility environment. The adverse argument is related to higher real GDP growth having a more likely effect on the inflation targeting implementation. The reason is that this variable indicates the market size in the domestic economy. Thus, a higher economic growth rate also offers the existence of a profitable investment environment. The fifth variable is openness that is measured as export plus imports to GDP, which represented the *total trade as a percentage of GDP*. The degree of economic openness causes a

restrictive effect on exchange rate stability. According to the "theory of optimum currency areas" (Mundell, 1961) offering low trade openness is more suitable for fixed exchange rate regimes and more trade openness is not favorable to inflation targeting policy choices. However, the probit estimation result shows that the influence of trade openness on inflation targeting adoption choice is more likely to favor inflation targeting except for the exchange rate pegging control group. This negative type of sign is expected for this control group subsample because higher openness trade causes adverse external shocks. Therefore, the choice of a fixed exchange rate on trade makes a country less likely to have exchange rate volatility through fewer surrounding external shocks (Lin and Ye, 2012). Data sources of our study variables are the IMF database and World Bank Development Indicator.

4. EMPIRICAL RESULTS

Table 1 denotes the causal effect of conducted inflation targeting framework for IT economies through evaluation of the likelihood of implementing inflation targeting analyzed macroeconomic variables and this estimation is also associated with the impact on exchange rate volatility. All estimated coefficients are statistically significant in the analyzed sample. We reach that countries with higher population densities make economies more likely to implement inflation targeting policies. However, the findings from developing and emerging market economies, if economies have less population density, economies tend more to adopt an inflation targeting framework. Moreover, countries under current account imbalances are accompanied by less probability of implementing IT in the all sample, developed, high-income, developing, free-floating IT, adopted by exchange rate peg control subsamples. As expected, better international reserve conditions (namely, reserves in months of imports) raise the IT implementation probability. The estimates on the higher economic growth rate coefficients are positive but insignificant except for the floating inflation targeting country groups. The results suggest the notion that countries with lower real GDP growth rates are less expected to implement inflation targeting. Finally, estimation shows that the more openness to trade creates pooled, developing, and emerging less tending to implement the IT policy since a more open economy would support an exchange rate targeting regime for faster trade integration.

Table 1. Probit Estimates of the Probability of Implemented of IT

Variables	Pooled	Developed	Developing	High Income
lnland_pop	0.083***	0.278***	-0.090**	0.105***
	(0.022)	(0.034)	(0.036)	(0.029)
cab	0.0151***	0.0051	0.0167***	0.002
	(0.004)	(0.010)	(0.005)	(0.005)
rim	0.015***	0.103***	0.028***	0.023**
	(0.006)	(0.016)	(0.007)	(0.009)
gdpg	0.001	0.028	0.000	0.014
	(0.007)	(0.018)	(0.009)	(0.012)
topn	-0.003***	-0.002**	-0.003***	-0.007 ***
	(.000)	(.001)	(.001)	(.001)
_cons	-0.288***	0.318**	-01.192***	0.218
	(0.111)	(0.157)	(0.192)	(0.152)
Number of obs	3220	1120	2100	1540

Untreated obs	2628	863	1765	1228
Treated obs	592	257	335	312

Table 1. (Continued) Probit Estimates of the Propensity Scores

Variables	Floating IT	Free Floating IT	Only Exchange Rate Peg (Untreated)
lnland_pop	-0.032	0.255***	0.027
	(0.039)	(0.032)	(0.023)
cab	-0.001	0.017**	0.040***
	(0.005)	(0.006)	(0.005)
rim	0.047***	-0.030***	0.004
	(0.008)	(0.010)	(0.008)
gdpg	0.0203**	-0.016	-0.007
	(0.010)	(0.012)	(0.008)
topn	-0.005***	-0.009***	0.0009
	(0.001)	(0.001)	(0.001)
_cons	-1.338***	0.645***	-0.339***
	(0.201)	(0.188)	(0.131)
Number of obs	2625	2310	2605
Untreated obs	2634	2103	1500
Treated obs	261	207	565

Note: The brackets represent standard errors. 10%, 5% and 1% significance levels demonstrate *, **, ***, respectively.

4.2. Matching Results from Average Treatment Effect on Population (ATE)

Table 2 documents matching results for ATE, the first three columns report the matching estimations from the nearest neighbor matching. The fourth column shows the finding from Kernel matching. The consequences indicate that those countries implementing an inflation targeting regime have relatively higher volatility in the real exchange rates for high-income economies than alternative regimes. The analysis of developing economies indicates that adopted IT frameworks seem to be more successful through lower volatility in exchange rates compared to non-IT countries.

Panel A in table 2 reports the finding from the full sample that ATEs indicate a significant effect on volatility in exchange rate except five-nearest neighbor matching. Matching results for the pooled sample are statistically significant ranging from 0.002 to 0.005 and negative. More specifically, this finding suggests that, if a country conducts an IT regime, its volatility in the exchange rate drop on average by at least 0.002 percent. Put simply, the implementation of the IT regime exerts mitigates affect volatility in the exchange rate for the pooled sample. In the analysis of developed economies in Panel B, the results do not exert a distinct effect on economies that adopted IT framework compared to non-IT developed economies. Put simply, finding from developed economies assure that the average treatment effect on the population is not statistically significant for developed economies. Panel C indicates that the results from emerging-developing economies associated with IT regimes lead to a significant change in exchange rate volatility regarding reducing impact even if one nearest-neighbor matching is insignificant. The matching findings demonstrate that IT regimes have negative, and they range from 0.004 to 0.007 and are statistically significant. In other words, all the matching functions strongly suggest that economies adopting the IT framework achieve a less harmful effect with lower

volatility in the exchange rate at least an average of 0.004. Findings from high-income economies, Panel D, suggest that inflation targeting regimes are statistically significant ATEs. In other words, matching approaches suggest that economies that implemented IT framework achieve a positive effect with respect to volatility in the exchange rate by at least an average of 0.004 percentage points. More specifically, economies choosing the IT framework get higher exchange rate volatility than non-IT high-income economies.

Table 3 summarizes the ATEs on the population on exchange rate volatility that captures floating, free-floating ITers and exchange rate peg as control groups that used Neighbor Matching (one to one, one to three, one to five nearest neighbor matching) and Kernel Matching (bwidth=0.06). In the results from all sample with only accepting floating as ITers , Panel A, demonstrate that IT policy creates lower exchange rate volatility but an insignificant effect. Panel B in table 3, suggests that the role of IT become has increased the efficiency of the monetary policy which indicates getting lower exchange rate volatility and is statistically significant regardless of matching algorithms. To be more precise, the observed outcomes for these country groups support those economies under an IT framework in which no interference from any central bank on exchange rate volatility, obtaining lower exchange rate volatility, which corresponds to an average at most 0.011. On another front, we may strongly claim that the IT framework exerts less exchange rate fluctuation under freely floating, on average by at least 0.006 percent. Findings from Panel C argue that exchange rate fluctuations under an exchange rate targeting framework have significantly higher than that under inflation targeting frameworks on average.

Table 2. Estimates of ATE of Real Exchange Rate Volatility - *Level of Economic Development and Pooled Sample*

Dependent Variable: REERVOL	Nearest Neighbor Matching			Kernel Matching
	nn=1	nn=3	nn=5	
Panel A				
Pooled	-0.005**	-0.005**	-0.002	-0.003*
Sample	(0.002)	(0.002)	(0.002)	(0.001)
Observations	2,342	2,342	2,342	2,342
Panel B				
Developed	0.00001	0.00001	0.00015	0.00014
Economies	(0.001)	(0.001)	(0.0009)	(0.0006)
Observations	894	894	894	894
Panel C				
Developing	-0.004	-0.006**	-0.007***	-0.004*
Economies	(0.003)	(0.003)	(0.002)	(0.002)
Observations	1,448	1,448	1,448	1,448
Panel D				
High Income	0.004**	0.004***	0.004***	0.004***
Economies	(0.001)	(0.001)	(0.001)	(0.001)

Observations	1,017	1,017	1,017	1,017

Note: Bootstrapped standard errors are reported in parentheses which are based on 1000 replication of the data. A 0.06 fixed bandwidth and an Epanechnikov kernel are used for kernel matching. *, **, and *** indicate the significance level of 10%, 5%, and 1%, respectively.

Table 3. Estimates of ATE of Real Exchange Rate Volatility- *The Degree of Flexibility of the Exchange Rate Regime*

Dependent Variable: REERVOL	Nearest Neighbor Matching			Kernel Matching
	nn=1	nn=3	nn=5	
Panel A				
For only including floating as ITers	0.002 (0.004)	0.001 (0.003)	0.001 (0.003)	0.002 (0.003)
Observations	1,846	1,846	1,846	1,846
Panel B				
For only including free-floating as ITers	-0.011*** (0.001)	-0.009*** (0.001)	-0.009*** (0.001)	-0.006*** (0.001)
Observations	1,635	1,635	1,635	1,635
Panel C				
For only including exchange rate regime adoption as control groups	-0.004*** (0.001)	-0.004*** (0.001)	-0.004*** (0.001)	-0.002 (0.001)
Observations	1,553	1,553	1,553	1,553

Note: Bootstrapped standard errors are reported in parentheses which are based on 1000 replication of the data. A 0.06 fixed bandwidth and an Epanechnikov kernel are used for kernel matching. *, **, and *** indicate the significance level of 10%, 5%, and 1%, respectively.

4.3. Matching Results from Average Treatment Effect on the Treated (ATT)

Table 4 demonstrates the estimated average treatment effects on the treated level of economic development using the various matching methods. Taken as a whole, the results from the model demonstrate that inflation targeting can provide a significant change in the volatility in the exchange rates for those countries that select IT regimes except in the subsample developed economies. Considering the pooled sample, exchange rate fluctuations have little effect in economies that adopt inflation targeting countries irrelevant to the estimator. Findings from developing and emerging market economies offer the highest reduction in the exchange rate volatility, which indicates an average of at least 0.006 average points. The findings of the sample of developed economies do not assert any change in implemented inflation targeting framework with respect to dropped exchange rate volatility.

All matching findings from the pooled sample suggest that the ATT is adverse and statistically substantial ranging from 0.004 to 0.007. This evidence strongly asserts that the exchange rate becomes less fluctuated on average by at least 0.004 percent under inflation targeting regimes for those economies that implement an IT regime. In other words, if non-inflation targeting countries had adopted inflation targeting, their fluctuations in the exchange rate would have been at least an average of 0.004 percent

lower. In the observed outcome from developed economies, the effectiveness of IT has not successful change in lower exchange rate volatility and insignificant results whatever using matching approaches.

The case of developing economies strongly asserts exchange rate fluctuations become decreased rate by at least 0.007 percent. Observed findings from all matching approaches report that the IT monetary system delivers a substantial effect to get reduce exchange rate volatility ranging from 0.007 to 0.009 and is statistically significant regardless of matching estimations. In other words, the IT policy outperforms and drops the exchange rate volatility more than all alternative regimes. The matching results in the analyzed country groups demonstrate that a dropped in exchange rate volatility occurs much more reducing effect amongst different developed economies. For exchange rate volatility in high-income economies, findings report a rise of at most 0.003 percentage at significantly except for one-to-one and three-nearest neighbor matching and stratification matching approaches. Adopting IT does not help to reduce the exchange rate volatility set of high-income economies.

Table 5 reports the ATT effects that examine the degree of flexibility of exchange rate utilized from a variety of matching approaches. Findings all matching results from that adopting IT monetary system not freely floating suggest that efficacy of IT on exchange rate volatility does not lead to noticeable impact as statistically. This outcome confirms our hypothesis, implying that if economies interfere with the exchange rate system under the IT monetary system, monetary policy cannot be effective in reducing the volatility in the exchange rate.

Outcomes from the freely floating inflation targeter subsamples document that treatment impact on exchange rate volatility has harmful and statistically substantial. This would strongly argue that IT adoption causes a larger magnitude of decreased exchange rate volatility, ranging from 0.009 to 0.023. In other words, we infer that if non-IT economies had conducted inflation targeting policy as freely floating, i.e., implying that central banks do not charge any intervention on the exchange rate, their fluctuations regarding exchange rate would have been on average at most by 0.023 lower. Furthermore, we conclude that an inflation-targeting regime that does not interfere with the exchange rate can implement a much more effective monetary policy.

In the analysis of control groups that conduct exchange rate targeting, the results exert similar to compared to implemented alternative monetary policies, such as monetary targets, and hybrid regimes. There is a strong and robust demonstration that the IT monetary system indicates that fluctuation of the exchange rate is exposed to less ratio on average by at least 0.003 percent over non-exchange rate targeting regime counterparts considering all matching approaches. On another front, if non-exchange rate targeting policy economies had conducted an inflation targeting framework, their exchange rate volatility would have been on average at most 0.005 lower.

Table 4. Estimates of ATT of Exchange Rate Volatility- *Level of Economic Development and Pooled Sample*

Dependent Variable: REERVOL	Nearest Neighbor Matching			Kernel Matching	Stratification Matching	Local Linear Regression Matching	Radius Matching		
	nn=1	nn=3	nn=5				r=0.01	r=0.03	r=0.05
[1] ATT for Pooled Sample	-0.007***	-0.007***	-0.006***	-0.004***	-0.005***	-0.005***	-0.005***	-0.004***	-0.004***
	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
OBS	2,344	2,344	2,344	2,344	3,255	2,344	2,344	2,344	2,344
[2] ATT for Developed Economies	0.001	0.0001	0.0002	0.0003	0.0001	0.0007	0.0001	0.0002	0.0005
	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
OBS	894	894	894	894	1,120	894	894	894	894
[3] ATT for Developing Economies	-0.008*	-0.007*	-0.009***	-0.008***	-0.009***	-0.006**	-0.008***	-0.008***	-0.007***
	(0.004)	(0.004)	(0.003)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)
OBS	1,450	1,450	1,450	1,450	2,100	1,450	1,450	1,450	1,450
[4] ATT for High Income Economies	0.003	0.002	0.002*	0.003**	0.002	0.003**	0.003**	0.003**	0.003**
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
OBS	1,017	1,017	1,017	1,017	1,541	1,017	1,017	1,017	1,017

Note: The brackets represent bootstrapped standard errors which are based on 1000 replication of the data. Kernel matching estimation uses the form of Epanechnikov kernel and fixed bandwidth is 0.06. In the local linear regression matching estimation utilizes 0.08 fixed bandwidth. *, **, and *** imply the significance level of 10%, 5%, and 1%, respectively.

Table 5. Estimates of ATT of Real Exchange Rate Volatility- *The Degree of Flexibility of the Exchange Rate Regime*

Dependent Variable: REERVOL	Nearest Neighbor Matching			Kernel Matching	Stratification Matching	Local Linear Regression Matching	Radius Matching		
	nn=1	nn=3	nn=5				r=0.01	r=0.03	r=0.05
[1] ATT for only including floating as ITers	-0.002	-0.000	-0.0003	-0.0005	-0.0008	-0.0001	-0.001	-0.0007	-0.0004
	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
OBS	1,848	1,848	1,848	1,848	2,625	1,848	1,848	1,848	1,848
[2] ATT for only including free-floating as ITers	-0.023***	-0.015***	-0.014***	-0.010***	-0.010***	-0.009***	-0.012***	-0.010***	-0.009***
	(0.005)	(0.004)	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.002)
OBS	1,636	1,636	1,636	1,636	2,345	1,636	1,636	1,636	1,636
[3] ATT for only including exchange rate regime adoption as control groups	-0.004*	-0.003*	-0.003**	-0.005***	-0.004***	-0.005***	-0.004***	-0.005***	-0.005***
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
OBS	1,555	1,555	1,555	1,555	2,065	1,555	1,555	1,555	1,555

Note: Bootstrapped standard errors are reported in parentheses which are based on 1000 replication of the data. A 0.06 fixed bandwidth and an Epanechnikov kernel are used for kernel matching. 0.08 fixed bandwidth is used for local linear regression matching. *, **, and *** indicate the significance level of 10%, 5%, and 1%, respectively.

5. ROBUSTNESS CHECK: "HIDDEN BIAS"

Regarding the analyzed causal effectiveness of inflation targeting, we may face a "hidden bias" problem in which the source is the presence of preexisting unobserved characteristics that play a role in the regime selection and the main interest (real exchange rate volatility) variable. Rosenbaum (2002) offer sensitivity analysis to solve deciding unmeasured confounding variable which affects IT regime selection. Inflation targeting may be sensitive to "hidden bias" originated from the existence of preexisting unmeasured characteristics that impact the regime choice and the outcome variable. Sensitivity analysis as suggested by Rosenbaum (2002) provide deals to determine how unmeasured confounding variables affect IT regime selection.

We check the matching results considering the appearance of a "hidden bias problem" using Rosenbaum bounds sensitivity analysis. Findings for all our analyzed samples reveal strong and robust evidence in view of insensitivity to unobserved characteristics. Table 6 documents the pooled sample from the one-nearest-neighbor matching. The critical value of increases Γ up to 3 indicates that there support our results in terms of significant effect. This corresponds that the matching estimations do not show sensitivity to the hidden bias. To put it another way, we assert that the selection of IT policy is not effective a role in the outcome variable, and thus accomplishing that ATT for the effectiveness of IT is robust to the being of unmeasured variables.

Table 6. Rosenbaum Bounds of Pooled Sample of Exchange Rate Volatility

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	.000187	.000187	-.002674	-.002674	-.004039	-.001415
1.5	1.4e-14	.635917	-.006061	.000249	-.007697	.001494
1.6	1.1e-16	.83306	-.006659	.000722	-.008354	.001935
1.7	0	.939246	-.007232	.001154	-.008976	.002366
1.8	0	.982075	-.007759	.001539	-.009596	.002755
1.9	0	.995611	-.008295	.001902	-.010238	.00313
2.0	0	.999088	-.008806	.002253	-.010838	.003508
2.5	0	1	-.01129	.003776	-.013714	.005122
2.6	0	1	-.011757	.004052	-.014261	.005387
2.7	0	1	-.012214	.004314	-.014763	.005648
2.8	0	1	-.012648	.004571	-.015278	.005907
2.9	0	1	-.01308	.004803	-.015774	.006163
3.	0	1	-.013543	.005029	-.016269	.006417

Notes: From one-neighborhood-matching estimates of treatment effect on exchange rate volatility. sig+ : upper bound significance level. sig-: lower bound significance level. t-hat + : upper bound Hodges–Lehmann point estimate. t-hat − : lower bound Hodges–Lehmann point estimate. CI + : upper bound confidence interval (a = 0.9). CI − : lower bound confidence interval (a = 0.9).

6. CONCLUSION

The increasing transformation of economies into international trade with liberalization policies since the 1980s causes more pressure on exchange rates. The exchange rates are allowed for fluctuating in the inflation targeting regime. While developing countries' economies fear fluctuations, on the other hand, the regime offers the opportunity to defend against shocks by using domestic dynamics. Macroprudential policies occur to provide financial stability after the global crisis experienced recently. This paper examines the effectiveness of inflation targeting on the fluctuations of exchange rate for the whole sample, developing economies, high-income economies, and different degrees of exchange rate flexibility over the 1985 to 2019 period considering self-selection in a particular monetary policy. The study reveals the following main outcomes:

(i) Developing economies after the implementation of IT on average have relatively less exchange rate volatility exposed in comparison to non-IT counterparts.

(ii) The existence of a less flexible degree of the exchange rate in the case of an IT regime leads to substantial implications for the success of the inflation targeting regime to achieve less fluctuation in the exchange rate. To be more specific, reducing the degree of exchange rate flexibility in inflation targeter economies overshadows the success created by the inflation targeting environment and causes the monetary policy to lose its effectiveness.

(iii) Inflation targeting regime creates different effects among developing economies and developed country groups on exchange rate volatility. To put it another way, while the effectiveness of the IT framework on stabilization exchange rate volatility leads to higher volatility for developed economies after inflation targeting adoption developing economies achieve less fluctuation in exchange rate volatility.

(iv) IT also obtain the same effects on high-income country groups like developed economies, that has similar characteristics to developed economies, regarding more exchange rate volatility.

A central fear of developing economies is whether the inflation regime will remain insensitive to external shocks because of the flexible exchange rate regimes. There is a probability that the fluctuation in exchange rates regarding the sustainability of the external balance will cause a sudden stop to capital movements. Matching results regarding the whole sample find indicates that the fluctuations in the exchange rate have reached a significant decrease, albeit small, after switching to inflation targeting. Furthermore, while developed economies adopt a fully flexible floating exchange rate regime, the degree of flexibility in developing economies is smaller. Our findings obtained for this sub-sample group show important inference that the cost of intervention creates much more weight against the benefits of intervention under the inflation regime. Beyond operational costs related to reserves holdings and sterilization efforts, there occur a potential risk of losing the effectiveness of monetary policy in any stabilizing effort event on the exchange rate. Finally, our findings suggest strong evidence that especially

for developing and emerging market economies IT regime is successful to decline the detrimental effects of exchange rate fluctuations..

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APPENDICES

Appendix 1. Inflation Targeting Economies with Adopted Years

Countries	Inflation Targeting Year	Economic Classification	Exchange Rate Arrangement
Australia	1994	Developed, High Income	Free Floating
Canada	1992	Developed, High Income	Free Floating
Czech Republic	1998	Developed, High Income	
Iceland	2001	Developed, High Income	
Israel	1998	Developed, High Income	
Japan	2013	Developed, High Income	Free Floating
Korea	1998	Developed, High Income	
New Zealand	1990	Developed, High Income	
Sweden	1995	Developed, High Income	Free Floating
Switzerland	2000	Developed, High Income	
United Kingdom	1992	Developed, High Income	Free Floating
United States	2012	Developed, High Income	
Armenia	2006	Developing	Floating
Brazil	1999	Developing	Floating
Chile	1999	Developing, High Income	Floating
Colombia	1999	Developing	
Dominican Republic	2012	Developing	
Ghana	2007	Developing	Floating
India	2015	Developing	Floating
Indonesia	2015	Developing	Floating
Mexico	2001	Developing	Free Floating
Moldova	2010	Developing	Floating
Paraguay	2011	Developing	Floating
Peru	2002	Developing	Floating
Philippines	2002	Developing	Floating
Poland	1999	Developing, High Income	Free Floating
Romania	2005	Developing	Floating
Russia	2015	Developing	Free Floating
South Africa	2000	Developing	Floating
Thailand	2000	Developing	Floating
Turkey	2006	Developing	Floating
Uganda	2011	Developing	Floating
Ukraine	2015	Developing	Floating
Uruguay	2007	Developing, High Income	Floating
Georgia	2012	Developing	Floating
Hungary	2001	Developing	Floating

Appendix 2. Non-Inflation Targeting Economies

Non-IT Countries	Economic Classification	Exchange Rate Arrangement
Algeria	Developing	
Bahamas, The	Developing, High Income	Exchange Rate Peg
Bolivia	Developing	Exchange Rate Peg
Burundi	Developing	Exchange Rate Peg
Cameroon	Developing	Exchange Rate Peg
Cote d'Ivoire	Developing	
Dominica	Developing	
Fiji	Developing	Exchange Rate Peg
Gabon	Developing	Exchange Rate Peg
Gambia, The	Developing	
Grenada	Developing	Exchange Rate Peg
Lesotho	Developing	Exchange Rate Peg
Malawi	Developing	
Malaysia	Developing	
Morocco	Developing	Exchange Rate Peg
Iran, Islamic Rep.	Developing	Exchange Rate Peg
Equatorial Guinea	Developing	Exchange Rate Peg
China	Developing	
Belize	Developing	Exchange Rate Peg
Antigua and Barbuda	Developing, High Income	Exchange Rate Peg
Croatia	Developing, High Income	Exchange Rate Peg
Nicaragua	Developing	Exchange Rate Peg
North Macedonia	Developing	Exchange Rate Peg
Nigeria	Developing	
Pakistan	Developing	
Papua New Guinea	Developing	
Saudi Arabia	Developing High Income	Exchange Rate Peg
Sierra Leone	Developing	
St.Kitts and Nevis	Developing	Exchange Rate Peg
St.Lucia	Developing	Exchange Rate Peg
St.Vincent	Developing	
and the Grenadines		Exchange Rate Peg
Togo	Developing	Exchange Rate Peg
Trinidad and Tobago	Developing High Income	Exchange Rate Peg
Tunisia	Developing	
Zambia	Developing	
Austria	Developed, High Income	
Belgium	Developed, High Income	
Cyprus	Developed, High Income	
Denmark	Developed, High Income	Exchange Rate Peg
France	Developed	

Germany	Developed, High Income	
Greece	Developed, High Income	
Ireland	Developed, High Income	
Italy	Developed	
Malta	Developed, High Income	
Netherlands	Developed, High Income	
Norway	Developed, High Income	
Portugal	Developed, High Income	
Singapore	Developed, High Income	Exchange Rate Peg
Spain	Developed, High Income	
Slovak	Developed, High Income	
Slovenia	Developed, High Income	
Finland	Developed, High Income	
Latvia	Developed, High Income	
Luxembourg	Developed, High Income	

KATKI ORANI/ CONTRIBUTION RATE AÇIKLAMA	**AÇIKLAMA / EXPLANATION**	**KATKIDA BULUNANLAR / CONTRIBUTORS**
Fikir veya Kavram / Idea or Notion	Araştırma hipotezini veya fikrini oluşturmak / Form the research hypothesis or idea	Res. Asst. Güntülü Özlem YÜKSEL Assoc. Prof. İsmail Onur BAYCAN
Tasarım / Design	Yöntemi, ölçeği ve deseni tasarlamak / Designing method, scale and pattern	Res. Asst. Güntülü Özlem YÜKSEL Assoc. Prof. İsmail Onur BAYCAN
Veri Toplama ve İşleme / Data Collecting and Processing	Verileri toplamak, düzenlenmek ve raporlamak / Collecting, organizing and reporting data	Res. Asst. Güntülü Özlem YÜKSEL Assoc. Prof. İsmail Onur BAYCAN
Tartışma ve Yorum / Discussion and Interpretation	Bulguların değerlendirilmesinde ve sonuçlandırılmasında sorumluluk almak / Taking responsibility in evaluating and finalizing the findings	Res. Asst. Güntülü Özlem YÜKSEL Assoc. Prof. İsmail Onur BAYCAN
Literatür Taraması / Literature Review	Çalışma için gerekli literatürü taramak / Review the literature required for the study	Res. Asst. Güntülü Özlem YÜKSEL Assoc. Prof. İsmail Onur BAYCAN

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