Doctoral Dissertation

Essays on Inflation Targeting

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Summary of dissertation

Inflation targeting (IT) regime has become a popular monetary policy framework across countries. Since the early 1990's, advanced countries have adopted an IT regime while developing countries have adopted an IT regime since the late 1990's. As of 2013, fourteen advanced countries and fifteen developing countries have adopted an IT regime to achieve better macroeconomic conditions. The main feature of an IT regime is an explicit inflation target and strong central bank legal commitments to the transparency, accountability, and credibility of price stability in conducting monetary policies (e.g., Mishkin, 2000; Mishkin & Savastano, 2001). Policy makers expect that an IT regime may have favorable effects on macroeconomic stability with low inflation and the stability of inflation and output. There have existed many studies on the economic effects of this regime theoretically and empirically. However, the adoption of IT may have several effects in various contexts. Thus, this dissertation attempts to discuss how the IT adoption relates to three aspects: (i) income velocity (domestic economy); (ii) exchange market pressure (external economy); (iii) central bank credibility (institutional factor). This dissertation is composed of three studies: the first study examines the impact of an IT regime on income velocity, the second study investigates the impact of an IT regime on the exchange market pressure, and the third study analyses the impact of an IT regime on credibility of the central bank.

The first study attempts to examine how inflation targeting relates to the variability of income velocity and its components across 84 developing countries during the period from 1990 to 2013. Developing economies tend to prefer or rely upon monetary policy rule with monetary aggregates due to institutional constraints on monetary policy conduct. Although inflation targeting has been adopted as an alternative monetary policy framework in various developing countries, many developing countries are still adopting monetary aggregates targeting due to unmatured money and financial markets. However, monetary

aggregates targeting often fails to achieve the macroeconomic stability. One crucial condition for monetary aggregates to be effective is the stability of income velocity. Income velocity is more volatile in developing countries than in advanced countries so that stability of income velocity is crucial to achieve macroeconomic stability under monetary aggregates targeting. Taylor (2000) highlights that monetary targeting and inflation targeting can coexist and monetary aggregates would be an appropriate instrument to achieve inflation target in developing countries. If the adoption of IT stabilizes income velocity, monetary authorities can justify monetary aggregates as an appropriate instrument under an IT regime. Thus, the first study attempts to examine the relationship between an IT regime and income velocity in developing countries. The results suggest that inflation targeting would help stabilize income velocity in developing countries. In addition, a decomposition analysis of income velocity generally shows that inflation targeting would reduce the volatilities of inflation, real output growth, and money growth. Our results provide empirical support for the argument that stable income velocity associated with inflation targeting could improve the effectiveness of monetarism, such that monetary aggregates can serve as an appropriate instrument under inflation targeting regime in developing countries.

The second study examines how inflation targeting (IT) relates to the variabilities of exchange market pressure and its components over 101 developing countries, of which 16 are IT countries. Fundamental domestic policies, including monetary policy, may affect a country's external sector. Since foreign exchange markets often induce unstable external conditions, sound monetary arrangement is required for developing economies, which often confront foreign exchange market instability, to absorb exchange market pressures under a globalized world. To capture such market pressures, this study uses the sum of the nominal exchange rate depreciation and the percentage change of international reserves holdings scaled by the base money. Taylor (2001) and Rose (2007) highlight that examining the link

between an IT regime and the external economy is a crucial matter for financial regulators since an IT regime is not only domestically focused policy framework but also related to the exchange rate stability. If IT regime helps stabilize the exchange market pressures, policy makers will achieve the favorable external conditions and macroeconomic stability under an IT regime. Thus, the second study attempts to investigate the relationship between an IT regime and exchange market pressure in developing countries. The empirical results show that an IT regime helps stabilize exchange market pressure, and it reduces the volatility of changes in international reserves. This result reflects the argument that the policy commitment to an IT regime improves the credibility of monetary policy conduct, and thus monetary authorities would not be required to intervene in the foreign exchange market under an IT regime.

The third study examine whether the IT adoption helps improve the credibility of central bank, which could be captured by the central banks' independence and transparency, over 83 advanced and developing countries during the period from 1998 to 2010. The credibility of monetary policy is crucial for macroeconomic and financial stability. Some literatures discuss that the monetary policy credibility is closely related to the institutional structure of central banks and their structural reforms (Eijffinger & Hoeberichts, 2002; Eijffinger et al., 2006). Recently, central banks' institutional reforms on independence and transparency has prevailed in developing countries that often face economic and financial instability as well as political pressures. The conventional theory argues that central bank independent (CBI) reduces the time-inconsistency problem and the inflationary bias. In addition, the recent trend of central bank independence has demanded accountability, legitimacy considerations and guidance, which call for central bank transparency (CBT). CBT also improves the credibility as it allows the market participants to assess the consistency of the central bank's actions with their mandates. At the same time, the adoption

of IT is one of the crucial monetary policy frameworks, which is expected to increase the credibility. Thus, the third study attempts to examine the link between the adoption of IT and the credibility of the central bank, which can be captured by CBI and CBT in both advanced and developing countries and to discuss the differences between them. Our results find that an IT regime helps improve central bank transparency in both advanced and developing countries. More interestingly, our analysis reveals a clear difference in the IT effect on central bank independence between advanced and developing economies. The IT adoption improves independence in advanced countries, but lowers in developing countries. The negative effect of an IT regime on independence in developing countries reflects the argument that monetary authorities in developing countries might still be required to coordinate with other political or governmental institutions in conducting the monetary policy objectives.

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Chapter 1

Introduction

Inflation targeting (IT) regime has become popular as an alternative monetary policy framework since the early 1990's. New Zealand is the first IT adoption country since it has adopted in 1990. As of 2013, fourteen advanced countries and fifteen developing countries have adopted an IT regime to achieve better macroeconomic conditions. The main feature of an IT regime is an explicit inflation target and strong central bank legal commitments to the transparency, accountability, and credibility of price stability in conducting monetary policies (e.g., Mishkin, 2000; Mishkin & Savastano, 2001). An official announcement of an inflation target improves a central bank's credibility and helps to lower inflation and the volatilities of inflation and real output (see, e.g., Bernanke et al., 1999; Svensson, 1997; Mishkin, 1999).

Policy makers expect that an IT regime may have favorable effects on macroeconomic stability with low inflation and the stability of inflation and output. There have existed many studies on the economic effects of this regime theoretically and empirically. On the theoretical front, clear predictions have not been made regarding the effectiveness of IT. Several studies, including Bernanke and Woodford (2005), Caballero and Krishnamurthy (2005), Mishkin (2000, 2004), and Sims (2005), suggest that the current lack of institutional development and inconsistencies among macroeconomic conditions in developing countries could undermine the success of IT and result in worse outcomes. However, a number of other studies, such as Svensson (1997), Mishkin (1999), and Bernanke et al. (1999), argue that as the credibility of central banks is initially very low in emerging economies, the adoption of IT renders monetary policies more credible, thereby contributing to better macroeconomic outcomes in these economies.

Several empirical studies have also been conducted to explore the beneficial effects of the IT adoption and to check the empirical validity of the theoretical arguments. In general, most studies have applied two empirical methodologies such as difference-in-difference (DID) and propensity score matching (PSM) to discuss the effectiveness of an IT regime. Early empirical studies apply the DID approach and most studies do not find evidence that an IT regime can improve economic performance measures, such as inflation, inflation variability, and output volatility in advanced countries. Empirical studies focusing on developing and emerging economies, such as the work of Goncalves and Salles (2008), Batini and Laxon (2007), and Thornton (2016), follow Ball and Sheridan's (2005) DID method. They show the mixed evidence the beneficial impacts of an IT regime in developing and emerging countries.

Because of some drawbacks of the DID approach, the latter studies (e.g., Balima et al., 2017; de Mendonca & de Guimaraes e Souza, 2012; Kadria & Ben Aissa, 2015, 2016; Lin, 2010; Lin & Ye, 2007, 2009; Lucotte, 2012; Samarina et al., 2014; Vega & Winkelried, 2005) apply the PSM method to discuss IT effects in advanced countries, developing countries, or both. Vega and Winkelried (2005) find that an IT regime can reduce inflation and its volatility in advanced and developing economies, suggesting that IT serves as an effective policy approach in both advanced and developing countries. Most studies find different results between advanced and developing countries by indicating that IT reduces inflation and its volatility in developing countries but does not affect advanced economies (Lin & Ye, 2007, 2009; De Mendonca & de Guimaraes e Souza, 2012; Samarina et al., 2014). Several empirical studies, mainly focusing on the IT impacts on inflation, output, and their volatilities generally show that IT is effective in developing countries although less effective in developed countries. However, the IT adoption might have several effects in various contexts. Thus, this dissertation attempts to examine the relationship between an IT regime

and three contents: the first content is how an IT regime relates to the income velocity, the second content is how an IT regime relates to the exchange market pressure, and the third content is how an IT regime relates to the credibility of the central bank.

The first study examines the IT effect on income velocity. Although an IT regime has become popular even in developing countries, many developing countries are still adopting monetary aggregates targeting due to unmatured money and financial markets. However, monetary aggregates targeting is often ineffective with the frequently failure of macroeconomic stability. It is widely acknowledged that one crucial condition for monetary targeting to be effective is the stable relationship between money aggregates and nominal output, as demonstrated by income velocity in money, i.e., the stability of income velocity (see, e.g., Estrella & Mishkin, 1997; Mishkin, 2006). Unstable income velocity is one of the main reasons for ineffective monetary aggregates targeting (Mishkin, 2006). Income velocity is more volatile in developing countries than in advanced countries (Park, 1970). Thus, stability of income velocity is crucial to achieve macroeconomic stability under monetary aggregates targeting. Taylor (2000) highlights that monetary targeting and inflation targeting can coexist and monetary aggregates would be an appropriate instrument to achieve inflation target in developing countries due to real interest rate uncertainty. If an IT regime helps stabilize income velocity, monetary authorities can justify monetary aggregates targeting as an effective policy measure under an IT regime. Thus, the first study attempts to examine the relationship between an IT regime and income velocity in developing countries.

The second study investigates the impact of an IT regime on the exchange market pressure. Developing countries have often experienced foreign exchange market instability. Since foreign exchange markets are closely related to external conditions of an economy, foreign exchange market turmoil often induce the instability of external economy so that a

sound monetary policy arrangement is important to absorb foreign exchange market pressures for their macroeconomic stability. In the literatures (see Eichengreen et al.,1994; Klaassen & Jager, 2011), exchange market pressure consists of two elements (i) exchange rate depreciation and (ii) losses in international reserves (associated with foreign exchange intervention). Taylor (2001) and Rose (2007) highlight that examining the link between an IT regime and the external economy is a crucial matter for financial regulators since an IT regime is not only domestically focused policy framework but also related to the exchange rate stability. If IT regime helps stabilize the exchange market pressures, policy makers will achieve the favorable external conditions and macroeconomic stability under an IT regime. Thus, the second study attempts to investigate the relationship between an IT regime and exchange market pressure in developing countries.

The third study examines the effect of an IT regime on the credibility of the central bank. Achieving macroeconomic and financial stability requires monetary policy credibility, which is closely related to institutional structure of central banks and their structural reforms. Recently, central banks` institutional reform has prevailed in developing countries that often face economic and financial instability as well as political pressures. In the literatures, central banks` monetary policy credibility is closely related to (i) independence from the government and (ii) transparency to the public (Eijffinger & Hoeberichts,2002; Eijffinger et al., 2006). Some literatures (Garriga, 2016; Dincer & Eichengreen, 2014) constructed these indices to measure the central bank credibility. On the other hand, IT adoption is one of the crucial monetary policy reforms, which is expected to increase the monetary policy credibility. If an IT regime induces central bank credibility, policy makers might achieve favorable macroeconomic outcomes under IT regime. Thus, the third study will also examine the relationship between an IT regime and central bank credibility which is closely related to the institutional structure of central banks, particularly independence and transparency.

This dissertation applies the propensity score matching (PSM) method and entropy balancing method to discuss how the IT adoption relates to the following three contents, particularly in developing countries: income velocity relating to domestic economy; exchange market pressure relating to external economy; and central bank credibility relating to institutional factor. The empirical results in the first study generally suggest that inflation targeting would help stabilize income velocity in developing countries and monetary aggregates can serve as an appropriate instrument under IT regime in developing countries. The results in the second study show that an IT regime helps stabilize exchange market pressure, and it reduces the volatility of changes in international reserves. This result reflects the argument that the policy commitment to an IT regime improves the credibility of monetary policy conduct, and thus monetary authorities would not be required to intervene in the foreign exchange market under an IT regime.

The results in the third study find that an IT regime helps improve central bank transparency in both advanced and developing countries. More interestingly, our analysis reveals a clear difference in the IT effect on central bank independence between advanced and developing economies. The IT adoption improves independence in advanced countries but lowers it in developing countries. The negative IT effect on independence in developing countries reflects the argument in the political economy context that central authorities in developing countries give parts of the power to a central bank by allowing the central bank to fully control monetary policy (an IT regime) and to make it more transparent. However, at the same time central authorities attempt to keep their power by reducing the autonomy or independence of the central bank.

Chapter 2

Inflation targeting and income velocity in developing economies: Some international evidence

2.1 Introduction

Inflation targeting (IT) regimes have recently been prevailed in several countries, including developing countries. The main feature of an IT regime is an explicit quantitative inflation target and strong central bank legal commitments to the transparency, accountability, and credibility of price stability when implementing monetary policies (e.g., Mishkin, 2000; Mishkin & Savastano, 2001). The main argument underlying this concept is that an official announcement of an inflation target improves a central bank's credibility and helps to lower inflation and the volatilities of inflation and real output (see, e.g., Bernanke et al., 1999; Svensson, 1997; Mishkin, 1999). Indeed, as of 2013, fifteen non-OECD countries have adopted the IT regime. Moreover, many developing countries are still pursuing monetary targeting because of institutional constraints, such as the underdevelopment of money and financial markets with strict financial regulations and fiscal dominance with the lack of central bank independence (Roger, 2009). It is widely acknowledged that one crucial condition for monetary targeting to be effective is the stable relationship between money aggregates and nominal output, as demonstrated by income velocity in money, i.e., the stability of income velocity (see, e.g., Estrella & Mishkin, 1997; Mishkin, 2006).

Taylor (2000) argues that an IT regime is not alternative to monetary policies that focus on monetary aggregates.[1] He emphasizes that an IT regime must apply a policy rule to

[1] There is no inconsistency between inflation targeting and monetary aggregates as the instrument in the policy rule, although some discussions indicate that inflation targeting serves as an alternative to monetary aggregate targeting. In fact, monetary aggregates might be applied as a plausible instrument to meet inflation targets due to the presence of real interest rate uncertainty in emerging economies (see, e.g., Taylor, 2000).

achieve the target and suggests that policies with monetary aggregates are preferable in developing countries because of substantial uncertainties related to measuring real interest rates or relatively large shocks in investments and net exports. More importantly, the stability of income velocity is of great importance for monetary aggregates to be a sound instrument in developing countries. Park (1970) notes that income velocity is more volatile in developing economies than in advanced economies because of their unstable economic, social, and political systems; volatile inflation patterns; and high degree of monetization (e.g., Driscoll & Lahiri, 1983; Chowdhury, 1994; Owoye, 1997). Moreover, several studies, including Lin and Ye (2007), indicate that volatile income velocity contributed to the breakdown of monetarism in the 1980s and has rendered monetary aggregate targeting an unreliable monetary framework. Because of unstable income velocity found in developing economies, Lin and Ye's (2007) argument is more persuasive and convincing when applied to discussions of policy effectiveness in developing economies. Thus, the behaviors of income velocity have been of interest to monetary authorities in developing countries pursuing monetary aggregates as an effective form of monetary conduct.

With the importance of stable income velocity and the recent trend of IT regime adoption, a crucial question concerns whether the IT regime can help stabilize income velocity in developing economies. If so, monetary authorities could justify the control of monetary aggregates as an effective policy measure under an IT regime. This study attempts to address such a crucial issue by empirically investigating the relationship between an IT regime and the behaviors of income velocity in developing economies. To the best of our knowledge, few studies have examined the role of income velocity in relation to the effects of the IT regime. Exceptions may include the work of Lin and Ye (2007), who analyze this issue for 22 advanced countries (7 of which are IT countries) by applying the propensity score matching (PSM) method to account for self-selection problems of policy adoption.

Their findings fail to show clear evidence of an IT effect on income velocity variability in advanced countries. Since macroeconomic conditions in developing economies differ from those of advanced economies and stabilizing income velocity is more critical for monetary policy decisions in developing economies, this study extends the work of Lin and Ye (2007) on advanced economies and discusses the IT effects on income velocity variability in developing economies.

This study applies the PSM method to analyze the behaviors of income velocity in relation to the adoption of the IT regime in 84 developing countries from 1990 to 2013 following the work of Balima et al. (2017), de Mendonca and de Guimaraes e Souza (2012), Lin (2010), Lin and Ye (2007, 2009), Lucotte (2012), Samarina et al. (2014), and Vega and Winkelried (2005). Policy debates have been conducted to determine the countries that have actually adopted the IT regime in an effective manner (Caballero & Krishnamurthy, 2005; Mishkin, 2004; Sims, 2005; Svensson, 1997). Among the various definitions of an adoption year, this study uses the 'loose' and 'strict' type of adoption years following Rose (2007), Lin (2010), and Samarina et al. (2014), with a loose adoption year representing the earliest adoption year in which inflation targets are announced without strong commitments and a strict adoption year representing the latest year in which credible commitments are made to achieve inflation targets with a single inflation target via monetary policies.

In addition, given that income velocity can be decomposed into price levels, real outputs, and money holdings (real output and real money holdings) as in the conventional Fisher equation, we also investigate how the behaviors of each component of income velocity change during pre- and post-IT periods. This decomposition allows us to discuss issues of monetary channels that emerge once an IT regime is adopted by identifying the sources of the behavioral evolution of income velocity. Furthermore, this study attempts to examine heterogeneous features of the performance of an IT regime. Empirical studies, such

as the work of Carare and Stone (2006), Mishkin (2004), and Fraga et al. (2003), indicate that heterogeneity in economic and institutional development should play an important role in determining the performance of an IT regime because emerging economies face differing levels of economic and institutional development compared with those found in advanced economies. Lin and Ye (2009) explore the heterogeneous features of IT effects and show that the performance of an IT regime in terms of inflation and its volatility is more effective in developing countries with favorable preconditions of IT adoption and fiscal positioning but less effective in countries presenting substantial limitations in terms of exchange rate fluctuations. Our study follows the work of Lin and Ye (2009) in evaluating the heterogeneous effects of an IT regime on the volatility of income velocity and related variables of interest.

To check the validity of the results derived from the PSM method, this study further applies the difference-in-difference (DID) approach as an alternative method. The DID approach is also widely used in the IT-related literature (e.g., Ball & Sheridan, 2005; Batini & Laxton, 2007; Goncalves & Salles, 2008; Thornton, 2016; Samarina et al., 2014), although the approach suffers from several critical methodological problems (e.g., the identification of IT adoption years for countries that have never adopted an IT regime). The empirical analysis shows clear evidence supporting the role of an IT regime in stabilizing income velocity in developing countries; however, our results are inconsistent with the findings of Lin and Ye (2007), who do not observe IT effects on income velocity variability in advanced countries. Monetary frameworks in developing countries tend to rely on the control of money aggregates because of the presence of immature money and financial markets along with highly regulated financial operations and stringent credit and interest rate controls. Taylor (2000) stresses that because of the presence of several institutional constraints on monetary policy conduct, monetary authorities in developing economies might prefer or rely on

monetary policy rule with monetary aggregates to achieve an inflation target, particularly under conditions of stable income velocity. Our results on the effects of IT on income velocity provide empirical support for Taylor's (2000) suggestion that monetary aggregates would be appropriate instruments under an IT regime in developing countries.

In addition, our decomposition analysis of income velocity shows that IT would reduce the volatilities of inflation, real output growth, and money aggregate growth. Many empirical studies have examined the relationships between income velocity and macroeconomic conditions, such as money holdings and inflation rates.[2] For example, Owoye's (1997) study on income velocity patterns in 30 less-developed countries shows that income velocity volatility is mainly a result of money growth in most sampled countries and indicates that fluctuations in real output and inflation rates are also central to the determination of income velocity volatility depending on the sampled country. Our empirical findings related to the decomposition of income velocity are partly consistent with the findings of Owoye (1997). IT adoption enables developing countries to satisfy crucial conditions for the effective use of monetary aggregates, which require the presence of money demand stability as well as income velocity stability as argued by Estrella and Mishkin (1997) and Mishkin (2006). Concerning heterogeneous effects, our estimations show that an IT regime is more effective at stabilizing income velocity in developing countries that satisfy favorable preconditions of IT adoption under a floating exchange rate regime.

The rest of this paper is organized as follows. In section 2, a literature review on IT regime adoption is presented. In section 3, we estimate the average treatment (IT) effects on the treated (ATT) by applying PSM methods; present our empirical results on the effects of an IT regime on inflation, inflation volatility, income velocity volatility, real output growth volatility, money growth volatility, and real money balance growth volatility; explore the

[2] See Ezekiel and Adekunle (1969), Park (1970), Melitz and Correa (1970), and Chowdhury (1994) for traditional approaches on income velocity.

heterogeneous effects of adopting an IT regime; and report the results of our alternative DID analysis. In section 4, our conclusions are presented.

2.2 Literature review

The IT regime has been widely adopted by several central banks as a policy measure. Since then many researchers have conducted studies on the economic effects of this regime theoretically and empirically. On the theoretical front, clear predictions have not been made regarding the effectiveness of IT. Several studies, including Bernanke and Woodford (2005), Caballero and Krishnamurthy (2005), Mishkin (2000, 2004), and Sims (2005), suggest that the current lack of institutional development and inconsistencies among macroeconomic conditions in developing countries could undermine the success of IT and result in worse outcomes. However, a number of other studies, such as Svensson (1997), Mishkin (1999), and Bernanke et al. (1999), argue that as the credibility of central banks is initially very low in emerging economies, the adoption of IT renders monetary policies more credible, thereby contributing to better macroeconomic outcomes in these economies.

Several empirical studies have also been conducted to explore the effectiveness of IT regimes to check the empirical validity of the theoretical arguments. In general, the literature has addressed this issue by applying two empirical methodologies: DID and PSM.[3] Early empirical studies, such as the work by Neumann and von Hagen (2002), apply the DID approach. However, such studies can suffer from endogeneity problems because the initial levels of inflation may influence the likelihood of a country adopting an IT regime. Ball and Sheridan's (2005) study on advanced economies solves such endogeneity problems by

[3] Some studies have applied panel estimation techniques, including dynamic panel estimations, to discuss the effectiveness of an IT regime. For example, Mishkin and Schmidt-Hebbel (2007) and Willard (2012) show that an IT regime plays a less significant role in improving macroeconomic performance. In addition, Brito and Bystedt (2010) indicate that an IT regime would not improve economic performance (e.g., inflation and output growth) in developing countries. Moreover, Alpanda and Honig (2014) show that the effects of IT regimes on inflation depend on the degree of central bank independence. Pontines (2013) applies a generalization of the bivariate selection model (Heckman, 1979) to take into account the self-selection problem and presents that an IT regime lowers exchange rate volatility in developing countries but increases it in advanced countries.

considering these initial conditions as an independent variable in DID model specifications, and the authors do not find evidence that an IT regime can improve economic performance measures, such as inflation, inflation variability, and output volatility. Ball's (2010) updated study on the DID approach also fails to identify significant impacts of an IT regime on economic performance (e.g., inflation and output) in advanced economies. Empirical studies focusing on developing and emerging economies, such as the work of Goncalves and Salles (2008), Batini and Laxon (2007), and Thornton (2016), follow Ball and Sheridan's (2005) DID method.

However, Ball and Sheridan's (2005) DID approach suffers from some critical methodological problems. Bertrand et al. (2004) highlight that consistency among the "pre" and "post" periods for every country occurs only when all IT countries have adopted an IT regime at the same time. However, because IT regimes have been adopted by different countries at different times, the "pre" and "post" periods are not consistent for all IT countries; therefore, we must identify adoption timing arbitrarily for non-IT countries. Moreover, as noted by Lin and Ye (2007), the DID method fails to solve self-selectivity problems related to policy adoption. Because of these drawbacks of the DID approach, recent works (e.g., Balima et al., 2017; de Mendonca & de Guimaraes e Souza, 2012; Kadria & Ben Aissa, 2015, 2016; Lin, 2010; Lin & Ye, 2007, 2009; Lucotte, 2012; Samarina et al., 2014; Vega & Winkelried, 2005) apply the PSM approach to discuss IT effects in advanced countries, developing countries, or both. Vega and Winkelried (2005) find that an IT regime can reduce inflation and its volatility in advanced and developing economies, suggesting that IT serves as an effective policy approach in both advanced and developing countries. However, several studies on the framework of the PSM approach present different results on the effectiveness of an IT regime for different country groups.[4] For example, Lin and Ye

[4] Several works have studied the effects of IT regimes on some macroeconomic conditions other than inflation, inflation volatility, and output volatility via the PSM method. For example, Lin (2010) shows that the IT regime

(2007) show a less clear impact of an IT regime on inflation and its volatility in advanced countries, and Lin and Ye (2009) find significant impacts of an IT regime in developing countries. De Mendonca and de Guimaraes e Souza (2012) also find different results between advanced and developing countries by showing that IT reduces inflation and its volatility in developing countries but does not affect advanced economies. Samarina et al. (2014) employ the DID and PSM methods and show that the IT regime reduces inflation in developing countries but not in advanced economies.

Income velocity variability is our main focus, and several studies have empirically tested whether an IT regime can help stabilize income velocity. Exceptions include the work of Lin and Ye (2007), who apply the PSM approach to investigate the impacts of an IT regime on the volatility of income velocity in advanced countries. Their empirical results show no evidence that an IT regime contributes to the stability of income velocity. However, their study focuses only on the effectiveness of an IT regime in advanced countries, and to the best of our knowledge, no comprehensive studies have been conducted on this issue with regard to developing countries. Since income velocity is more volatile in developing countries than advanced countries (Park, 1970) and volatile income velocities render targeting monetary aggregates an unreliable monetary framework (Lin & Ye, 2007), the effectiveness of an IT regime in stabilizing income velocity should be crucial for monetary policies applied in developing countries.

reduces levels of real and nominal exchange rate volatility while increasing international reserves in developing countries, although it intensifies exchange rate instability and reduces international reserves in advanced economies. Lucotte (2012) indicates that IT regimes have a positive significant effect on tax revenue collection in developing countries. Kadria and Ben Aissa (2015, 2016) evaluate the time-varying treatment effects of IT adoption using the propensity score matching approach and conclude that an IT regime can help reduce budget deficits in emerging economies. In addition, Kadria and Ben Aissa (2015) show that the positive effect of an IT regime on exchange rate volatility diminishes over time in emerging countries. Balima et al. (2017) show that IT adoption reduces levels of sovereign debt risk.

2.3 Empirical analysis

2.3.1 Methodology and data

Following Ball and Sheridan (2005), previous empirical studies on IT regimes have applied the DID method (Goncalves & Salles, 2008; Batini & Laxon, 2007; Thornton, 2016). However, as noted in the previous section, the DID method can suffer from identification problems related to the time of IT regime adoption among non-IT countries as well as from self-selectivity problems related to policy adoption (Bertrand et al., 2004; Lin & Ye, 2007). Recently, several studies have employed the PSM framework to mitigate such problems (e.g., Balima et al., 2017; de Mendonca & de Guimaraes e Souza, 2012; Lin, 2010; Lin & Ye, 2007, 2009; Lucotte, 2012; Samarina et al., 2014; Vega & Winkelried, 2005). The PSM method is a statistical matching technique that estimates the effect of a treatment by taking into account observed covariates that predict receiving the treatment and it attempts to mitigate biases resulting from the presence of confounding variables in estimates of treatment effects obtained from simple comparisons of the outcomes between units with treatment versus those without treatment.

A country's decision to adopt an IT regime can be endogenous since the policy approach is often influenced by various macroeconomic, financial, and institutional conditions. We also apply the PSM method to investigate the effectiveness of an IT regime for developing countries. The PSM method involves the application of a two-step procedure. As a first step, this study estimates the propensity score of each country studied, which is the conditional probability that a country will adopt an IT regime based on the country's characteristics:

$$P(X) = \text{Prob}(D = 1|X) = E(D|X), \quad (1)$$

where D is a treatment or IT dummy that takes a value of one when a country uses an IT regime and a value of zero otherwise and X is the matrix of the country's characteristics. Following the work of Lin and Ye (2007), we apply a probit model to estimate propensity scores.

Concerning the IT dummy used a dependent variable, a clear consensus has not been reached on the exact date by which each country has implemented an IT regime, although the correct identification of adoption years is crucial to evaluating the effects of an IT regime. Vega and Winkelried (2005) propose two types of IT adoption dates, soft and full-fledged adoption dates, and they define soft IT as a simple announcement of numerical inflation targets and a transition to a complete IT regime (i.e., the partial adoption of an IT regime) and full-fledged IT as a complete IT regime (i.e., the explicit adoption of an IT regime in the absence of nominal anchors other than inflation targets). Similarly, Rose (2007) proposes two types of adoption dates (default and conservative dates) that are nearly consistent with the adoption dates of Vega and Winkelried (2005). In this study, we use two types of adoption years ('loose' and 'strict' adoption years) that correspond to the soft and full-fledged adoption dates proposed by Vega and Winkelried (2005), respectively, as in the studies of de Mendonca and de Guimaraes e Souza (2012) and Samaria et al. (2014). Table 2.1 shows a list of IT countries with loose and strict adoption years, and Table 2.2 presents the non-IT countries included in our sample.

The probit model applies several variables that are expected to drive IT regime selection following de Mendonca and de Guimaraes e Souza (2012), Lin and Ye (2007), and Samaria et al. (2014).[5] The model includes the one-year lagged inflation rate. Some studies,

[5] As noted by Lin and Ye (2007), finding an appropriate statistical model that explains the probability of IT adoption is not the main goal of estimating propensity scores. Under conditional independence assumptions, the exclusion of variables that systematically affect the likelihood of IT adoption but do not affect outcome variables, such as inflation and its volatility, is not problematic in the case of probit regressions (see Persson, 2001, for a more detailed explanation).

including Truman (2003), Lin and Ye (2009), Masson et al. (1997), and Minella et al. (2003), suggest that a country tends to adopt an IT regime when its inflation rate is at a reasonably low level because announcing a target far from the actual inflation rate can lose the credibility of its central bank. We also consider the real per capita GDP growth rate to capture a country's level of economic development, which is expected to be a precondition of IT adoption (Truman, 2003; Lin & Ye, 2007). The model also incorporates broad money growth into the model because high levels of broad money growth are expected to decrease the likelihood of IT adoption because of the presence of strong inflationary pressures. In addition, fiscal balance is also included in the model. As noted in Mishkin (2004) and de Mendonca and de Guimaraes e Souza (2012), under a government's balanced budget, debt monetization or government budget financing by a central bank are not needed, particularly for developing countries. Thus, sound fiscal conditions can be a precondition for the adoption of an IT regime. However, studies on fiscal theory of price levels initiated by Woodford (2001) suggest that the determination of price levels is a fiscal phenomenon; therefore, the control of money is not sufficient for determining paths of inflation. In this case, the presence of sound fiscal conditions implies less inflationary pressure, which can reduce the motivations for IT adoption.

To control for economic conditions related to external trade and finance, we incorporate the fixed exchange rate regime dummy, trade openness, and financial openness in the probit model. Some studies, including Hu (2006), find that the flexibility of exchange rates would enhance a country's motivations for adopting IT regimes. The exchange rate nominal anchor should be subordinate to IT because the rigidity of exchange rates is not suitable for IT policies in the long-run (Brenner & Sokoler, 2010). In addition, trade openness or integration with international markets reduces the inflation biases of central banks (Romer, 1993; Rogoff, 2003), which might not necessitate the adoption of an IT

regime. Moreover, financial integration can affect the nature of central bank monetary conduct, including motivations to adopt IT policies in the midst of globalization processes (de Mendonca & de Guimaraes e Souza, 2012; Mishkin, 2004; Samarina et al., 2014; Truman, 2003). Furthermore, we include time trends in the probit model following de Mendonca and de Guimaraes e Souza (2012) and Samarina et al. (2014).

Data on inflation, real GDP per capita, broad money, imports and exports were obtained from the World Bank's World Development Indicators (WDI), whereas data on fiscal balance were obtained from the World Economic Outlook (WEO). Trade openness is calculated from the ratio of the sum of exports and imports to GDP. We use the de facto exchange rate arrangement classification developed by Reinhart and Rogoff (2004) to define the dummy of a fixed exchange rate regime, which takes a value of one when a country adopts a fixed exchange rate regime (categories 1 to 3) and a value of zero otherwise.[6] To measure the degrees of financial openness, we use the Chinn-Ito capital account openness index developed by Chinn and Ito (2008). Some developing countries have experienced periods of hyper-inflation or hyper-growth of broad money. Because the presence of such outlier values may significantly influence the estimates, two techniques are commonly used to remove outliers. The first approach involves fully excluding countries that have experienced extremely high inflation rates (the inflation rate exceeds a specified level) in at least one year over the course of the sample period. The second approach involves discarding only the observations occurring in periods that show extremely high inflation rates. Samarina et al. (2014) use the first approach, whereas Goncalves and Salles (2008) and Lin and Ye

[6] In general, two different classifications are used as measures of exchange rate regimes. As a de jure classification, the International Monetary Fund publishes the self-reported exchange rate regime statuses of member countries. However, a country's actual choice of exchange rate regimes often differs from its self-reported status. Thus, many studies use the de facto classification developed by Reinhart and Rogoff (2004). Although countries, particularly developing countries, facing 'fear to floating' conditions (Calvo & Reinhart, 2002) may officially announce the adoption of a floating regime, they often involve foreign market intervention; therefore, in practice, their actual regimes can be viewed as managed exchange rate regimes. Hence, we also use a de facto exchange rate regime classification.

(2009) use the second approach. We applied the latter approach by excluding only the observations of outliers based on inflation and broad money growth rates above 70 percent. We consider 84 developing countries, of which 15 countries are IT countries, for the period from 1990 to 2013.

As a second step, we estimate the ATT by using propensity scores estimated from the probit model in the first step according to the following equation:

$$\mathrm{ATT} = \mathrm{E}[\mathrm{Y_{i1}}|\mathrm{D_i} = 1] - \mathrm{E}[\mathrm{Y_{i0}}|\mathrm{D_i} = 1], \qquad (2)$$

where $\mathrm{D_i}$ is the IT dummy for country i; $\mathrm{Y_{i1}}$ and $\mathrm{Y_{i0}}$ are potential outcomes of the IT and non-IT regimes (two counterfactual situations), respectively; $\mathrm{Y_{i0}}|\mathrm{D_i} = 1$ is the value of the outcome of our interest that would have been observed of the IT country had not adopted an IT regime; and $\mathrm{Y_{i1}}|\mathrm{D_i} = 1$ is the value of the outcome that is actually observed in the same country. A crucial problem concerns the difficulty of estimating the ATT because of the unobservable value of $\mathrm{E}[\mathrm{Y_{i0}}|\mathrm{D_i} = 1]$. When a country's choice of IT regime is random, the ATT can be estimated from differences in the sample means of the outcome variable between the groups of the IT and non-IT countries.

However, as noted for the first step, IT regime selection is not random in the sense that such a choice is systematically correlated with a set of observable covariates that also affect the outcome variable, thereby creating problems in the selection of observables (e.g., Dehejia & Wahba, 2002; Heckman et al., 1998). To mitigate such a problem, we apply the PSM method following Lin and Ye (2007, 2009) and Lin (2010), who use a control group of non-IT countries to mimic a randomized experiment. Once the propensity score $\mathrm{p(X)}$ is

given, the ATT is estimated under two main assumptions, i.e., conditional independence and common support assumptions[7], as follows:

$$\mathrm{ATT} = \mathrm{E}[\mathrm{Y_{i1}}|\mathrm{D_i} = 1, \mathrm{p}(\mathrm{X_i})] - \mathrm{E}[\mathrm{Y_{i0}}|\mathrm{D_i} = 0, \mathrm{p}(\mathrm{X_i})] \quad (3)$$

By utilizing the propensity scores estimated via the probit model, we apply four PSM methods that are commonly used in the literature to estimate the ATT. The first matching method is the nearest-neighbor matching without replacement, which matches each treated observation to the n control observations that have the closest propensity scores, but each control observation is used no more than one time as a match for a treated observation. We use two nearest-neighbor matching estimators: $\mathrm{n} = 1$ and $\mathrm{n} = 3$. The second method involves radius matching, where each treated observation is matched with control observations with estimated propensity scores that fall within a specified radius. We use two radius matching estimators: $\mathrm{r} = 0.05$ and $\mathrm{r} = 0.1$. The next method involves kernel matching method, which matches each treated observation to control observations with weights inversely proportional to the distance between the treated and control observations. We use two kernel matching methods: Gaussian and Epanechnikov. The latter matching

[7] The PSM method applied in this study is based on the method presented in Lin and Ye (2007, 2009). An initial assumption indicates that the assignment of treatments (IT regime selection) is independent of potential outcomes conditional on the observed covariates X, i.e., $\mathrm{Y_0}, \mathrm{Y_1} \perp \mathrm{D}|\mathrm{X}$. As suggested by Lin and Ye (2007, 2009) and Rosenbaum and Rubin (1983), under the conditional independence assumption, the average treatment effect (ATE) is equal to the average treatment effect on the treated (ATT), and $\mathrm{ATT} = \mathrm{E}[\mathrm{Y_{i1}}|\mathrm{D_i} = 1] - \mathrm{E}[\mathrm{Y_{i0}}|\mathrm{D_i} = 1]$ is rewritten as $\mathrm{ATT} = \mathrm{E}[\mathrm{Y_{i1}}|\mathrm{D_i} = 1, \mathrm{X_i}] - \mathrm{E}[\mathrm{Y_{i0}}|\mathrm{D_i} = 0, \mathrm{X_i}]$. Heckman et al. (1998) note that the ATT can be estimated consistently under a weaker independence assumption of $\mathrm{E}[\mathrm{Y_{i0}}|\mathrm{D_i} = 1, \mathrm{X_i}] = \mathrm{E}[\mathrm{Y_{i0}}|\mathrm{D_i} = 0, \mathrm{X_i}]$, which requires that the outcomes of non-IT countries are independent of IT adoption decisions based on the observed covariates X. Such a weaker assumption generally yields different values of ATE and ATT. However, as the number of observed covariates increases, the $\mathrm{ATT} = \mathrm{E}[\mathrm{Y_{i1}}|\mathrm{D_i} = 1, \mathrm{X_i}] - \mathrm{E}[\mathrm{Y_{i0}}|\mathrm{D_i} = 0, \mathrm{X_i}]$ equation becomes more difficult to estimate. To solve this high-dimensional set of observed covariates, Rosenbaum and Rubin (1983) recommend that treatment and control observations be matched based on propensity scores $\mathrm{p}(\mathrm{X_i})$, which are estimated from the probit model. The second assumption ($0 < \mathrm{p}(\mathrm{X_i}) < 1$) suggests that every observation comes with a non-zero probability of IT regime adoption, which requires the presence of comparable control observations for each treated observation.

method involves applying the regression-adjusted local linear matching approach developed by Heckman et al. (1998).

2.3.2 Empirical results

Our main interest is to determine how IT adoption affects income velocity variability in developing countries. By definition, income velocity is composed of price levels, real outputs, and broad money (or real output and real money balance). Thus, we attempt to evaluate IT effects by estimating the treatment effect of an IT regime on the volatility of income velocity as well as on the volatilities of its components to discuss sources of income velocity variability. Similar to the works of Lin and Ye (2007, 2009), we measure the volatilities of income velocity, inflation, output growth, broad money growth, and real money balance growth as the standard deviation of variables over the previous seven years.[8] Concerning the timing of IT adoption, we use two different IT adoption years as noted in the previous subsection. We identify developing countries based on the IMF's country classification.[9]

2.3.2.1 Estimating propensity scores

The distribution of measured baseline covariates should be performed independent of the treatment assignments conditional on the true propensity score. Thus, we should confirm that our probit model is adequately specified by examining whether the distribution of observed covariates is similar between the treated and control observations with the same estimated propensity score. We conduct balancing tests that generally support the balancing

[8] Our volatility measures are calculated by the standard deviation of the gap between the current variable and its seven-year moving average over the past seven years.

[9] To ensure that the treatment and control groups are comparable, Lin and Ye (2009) and Lin (2010) exclude some non-IT countries with substantially different features (e.g., real GDP per capita) from IT countries. We also follow their method by constructing a different dataset by excluding some non-IT countries whose real GDP per capita levels are lower than those of the smallest IT country. The estimated results generally coincide with the results of the original dataset (see Table 2.8).

properties for our covariates.[10] Once the probit model is specified, we first estimate the propensity scores. As discussed in the previous subsection, we expect to find negative coefficient signs for the one-year lagged inflation rate, broad money growth, trade openness, fixed exchange rate regime, and fiscal balance and positive coefficient signs for the real per capita GDP growth rate and financial openness.

Table 2.3 presents the estimation results of the probit model for the loose IT and strict IT regimes.[11] Most estimates are generally consistent with our expected signs except for the coefficient on broad money growth, which shows insignificant results. The estimation results indicate that countries with higher inflation rates for the previous period, sound fiscal conditions, higher levels of trade openness, and a fixed exchange rate regime are less likely to adopt an IT regime. In addition, countries with higher GDP per capita growth and more financial openness are more likely to adopt an IT regime. These results generally coincide with the findings of previous studies (e.g., de Mendonca & de Guimaraes e Souza, 2012; Lin & Ye, 2007).

[10] Once the balancing condition ($D \perp X|p(X)$) is satisfied, a conclusion can be made as to whether the treatment and control groups with similar propensity scores follow the similar distribution of observed characteristics (covariates) independent of the treatment status. Tables 2.9 and 2.10 present the mean values of the covariates of the treatment and control groups and the p-value of a balancing test for the loose and strict IT regimes, respectively. We report three balancing tests for income velocity volatility (the test results for other outcome variables are available on request). The null hypothesis of the balancing test is that the mean values of the covariates are similar for both the treatment and control groups. For the balancing tests of the strict IT regime, the mean values of all variables of both the IT and non-IT countries after matching become similar with the evidence that the p-values fail to reject the null hypothesis. However, the balancing test results for the loose IT regime are less convincing for some covariates. The null of identical means is rejected at the 1 percent significance level for financial openness under the nearest-neighbor matching condition (p-value of 0.09) as well as under lagged inflation and GDP per capita growth based on radius (p-values of 0.06 and 0.04) and kernel matching (p-values of 0.07 and 0.05). Thus, matching generally helps reduce the bias in distributions of observables for the IT and non-IT country groups.

[11] For the robustness checks of our empirical results, we follow the work of Lin and Ye (2009) and examine whether the results are sensitive to alternative specifications of the probit model by adding government debt to GDP ratio and the turnover rate of central bank governors, which are obtained from Ali Abbas et al. (2010) and Cukierman et al. (1992), respectively. The turnover index was supplemented with data from Crowe and Meade (2007) and Dreher et al. (2008). In addition, we also check whether our results are robust to different sample periods by estimating the original probit model over the alternative sample period from 1990 to 2007. These robustness checks do not undermine our results (see the estimated results of the probit models and the ATTs in Tables 2.11 and 2.12, respectively).

2.3.2.2 Average treatment effects

Once the propensity scores are estimated, we estimate the ATT by applying matching methods. We first attempt to ensure the sharing of the same support or to confirm the highly and reasonably comparability between the treatment and control groups. As in the works of Lin and Ye (2007, 2009) and Thornton and Vasilakis (2017), we reconstruct the dataset that satisfies the common support assumption by sorting all observations based on estimated propensity scores and discarding control units with propensity scores that fall below the lowest treatment unit value and exceed the highest treatment unit value. Table 4 reports the matching results for the loose and strict IT regimes based on the modified samples. The first seven columns of Table 2.4 report the results of the loose IT regime, and the last seven columns show the results of the strict IT regime. We present the estimated ATTs of the seven types of matching methods with analytical standard errors and bootstrapped standard errors. Many studies have generally highlighted the effectiveness of IT regimes in terms of inflation levels in developing countries, whereas other studies, such as Thornton (2016), doubt their effectiveness. The first row of Table 4 highlights the important role of an IT regime in reducing the inflation level, although less clear negative effects are observed under a loose IT regime. This result is consistent with the findings of Samarina et al. (2014), Lin and Ye (2009) and de Mendonca and de Guimaraes e Souza (2012) on the IT effects in developing countries.

The main concern in this study is on the variabilities of income velocity and its components as the outcome variables, which allows us to discuss the role of stable income velocities in the monetary policy frameworks of developing countries. The second row of Table 4 shows the ATT results of the IT regime in terms of income velocity volatility, and the last four rows present the ATT estimates of the IT regime for volatilities in inflation, output growth, money growth, and real money balance growth. The estimated results show

that income velocity volatility is negatively significant irrespective of the choice of the IT regime, which indicates that IT adoption helps stabilize income velocity in developing countries. In addition, the results clearly show that IT adoption reduces volatilities of inflation and output growth in loose and strict IT regimes. Moreover, IT adoption reduces volatilities of money growth and real money balance growth in a loose IT regime, whereas the estimated ATTs are negative, although insignificant for a strict IT regime. The decomposition analysis generally shows that a reduction in income velocity volatility originates from all of its components (inflation, real output growth, money growth, and real money balance growth), although less clear results on money growth and real money balance growth in the case of a strict IT regime. Our results on the role of IT policies in stabilizing income velocity variability in developing countries stands in sharp contrast with the findings of Lin and Ye (2007), who showed an insignificant link between IT adoption and income velocity volatility in advanced countries.

Historically, as a solution after the collapse of the Bretton Woods system in the mid-1970s, many countries initiated a monetary targeting framework. Inspired by monetarists' quantity theory of money, central banks, mainly those in advanced countries, started to apply monetary aggregates as intermediate targets through their monetary policy conduct (Argy et al., 1990; Mishkin, 2006; Woodford, 2008). During this period, the success of monetary targeting required the presence of a strong relationship between targeted monetary aggregates and inflation and/or nominal income, i.e., income velocity, along with stability in money demand (Estrella & Mishkin, 1997; Mishkin, 2006). An early study by Ritter (1959) also stresses that income velocity instability generates ineffective monetary policies. However, many countries experienced periods of volatile income velocity with the unstable money demand in the 1980s, thereby inducing the breakdown of monetarism and monetary targeting (Lin & Ye, 2007). Roger (2009) notes that many advanced countries started to

abandon monetary targeting in the 1980s and all advanced countries had abandoned it by the late 1990s.

However, developing economies adopted monetary targeting in the 1980s and 1990s, and some are still pursuing this monetary framework. According to historical arguments on monetary frameworks, stable income velocity is central to successful monetary targeting in developing economies. Early studies, such as Park (1970) and Melitz and Correa (1970), show international variations in income velocity, with Park (1970) finding that less-developed countries are generally characterized by higher levels of income velocity variability than advanced countries because of their unstable economic, social, and political systems; volatile inflation patterns; and the large degree of monetization (see, e.g., Driscoll & Lahiri, 1983; Chowdhury, 1994; Owoye, 1997). Owoye (1997) investigates sources of income velocity volatility in less-developed countries and shows that income velocity volatility is mainly a result of money growth in most sampled countries, and fluctuations of real output and inflation rates are also central in determining income velocity volatility depending on sampled countries. As the IT regime has recently become more popular, some developing countries have also adopted it as a monetary policy framework. With the importance of stable income velocity and the current trend of the adoption of an IT regime, one crucial question concerns whether an IT regime can help stabilize income velocity in developing economies. If so, then monetary targeting can serve as a reliable framework. Our estimation results support the effectiveness of an IT regime in decreasing income velocity variability and could provide monetary authorities in developing countries with the justification of the control of monetary aggregates as an effective policy measure applied under an IT regime.

More importantly, our analysis results can also be linked to Taylor's (2000) argument for policy consistency. Recent discussions on IT in emerging economies suggest that an IT

regime serves as an alternative to monetary aggregate targeting. However, Taylor (2000) argues that there is no inconsistency between IT and monetary aggregates as an instrument of policy rule and suggests that an IT regime does not serve as an alternative to policies that focus on monetary aggregates. Taylor (2000) also describes a policy rule for achieving targets under an IT regime. As a policy rule, an instrument can involve a short-term overnight interest rate, although monetary bases or other monetary aggregates can also be used as instruments. As noted by Poole (1970), the choice of a policy rule between interest rates and monetary bases (or other monetary aggregates) as instruments is essential. Monetary aggregates would be the preferred instrument when considerable uncertainty is involved in measuring real interest rates or when relatively significant shocks to investment or net exports occur. Moreover, when income velocity is relatively stable, monetary aggregates would be the better instrument. Taylor (2000) stresses that the preference for the interest rate as the instrument primarily reflects income velocity uncertainty, but developing economies often face the circumstances where real interest rate is difficult to measure and the overnight nominal interest rate is not a good policy measure.[12] In addition, developing countries experience several institutional constraints on monetary policy conduct (e.g., the underdevelopment of money and financial markets with strict financial regulations). Thus, monetary authorities in developing economies might prefer or rely on monetary policy rules with monetary aggregates to achieve inflation targets, particularly under conditions of stable income velocity. Our results showing the IT effects on income velocity provide empirical support for Taylor's (2000) suggestion that monetary aggregates will be the appropriate instrument under an IT regime.

[12] Taylor (2000) notes that such circumstances may be present in emerging countries. In a high inflation period, measuring the real interest rate and risk premiums is difficult. In a high growth period, determining and measuring the equilibrium real interest rate is also difficult.

Concerning the sources of the IT role in reducing income velocity variability, our estimation results generally show that IT adoption would reduce volatilities of inflation and real output growth irrespective of the choice of the loose or strict IT regimes. This finding implies that an IT regime contributes to price stability as well as macroeconomic stability in developing countries. In addition, the estimation results suggest that an IT regime also helps stabilize volatilities of money growth and real money balance growth, i.e., the stability of money demand, in developing countries, although the results of a strict IT regime show less clear evidence. Based on our results showing favorable IT effects on income velocity variability, the findings of the decomposition analysis are generally consistent with the results of Owoye (1997), who shows that volatility in income velocity is related to money growth, inflation, and real outputs. In addition, our decomposition analysis supports the notion that IT adoption offers substantial economic benefits of macroeconomic stabilization by securing real outputs and inflation stability. Moreover, our results on IT effects suggest that IT adoption enables developing countries to satisfy crucial conditions necessary to support the effective role of monetary aggregates, which require the presence of income velocity stability as well as money demand stability as argued by Estrella and Mishkin (1997) and Mishkin (2006).

2.3.3 Heterogeneity in treatment effects

Substantial heterogeneity social and economic development is known to occur in developing countries. Many studies have shown that the causes and consequences of IT adoption can be associated with various economic and institutional characteristics of developing countries (e.g., Carare & Stone, 2006; Fraga et al., 2003; Fry et al., 2000; Masson et al., 1997; Minella et al., 2003; Mishkin, 2004; Mishkin & Savastano, 2001; Svensson, 2002; Lin & Ye, 2009). Thus, examining the heterogeneous effects of IT adoption on income velocity variability is critical for conducting policy evaluations of developing countries. Lin and Ye (2009) analyze

the crucial heterogeneities of average treatment effects of IT adoption on inflation and its variability, and our study also evaluates four possible sources of heterogeneity following Lin and Ye (2009). As a first possible source, IT effects can depend on whether a country satisfies the precondition of IT adoption, which is captured by the estimated propensity score. The second source concerns time lagged effects of IT adoption based on the argument that it often takes some time for monetary policy to be effective. The third and fourth sources concern the roles of fiscal conditions and exchange rate arrangements in determining the effects of IT adoption, respectively. Mishkin (2004) and Mishkin and Savastano (2001) note that the performance of an IT regime would be influenced by government fiscal positions and levels of exchange rate flexibility.

Table 2.5 presents the estimated results of the four sources of heterogeneous effects of loose and strict IT regimes on our outcome variable of income velocity volatility. The first column shows the results of the OLS regression of income velocity volatility on the IT regime, which presents the consistent finding of the negative coefficient with the matching analysis of the previous subsection. In the second column, we include the estimated propensity score and interaction term of the IT regime and the difference between the estimated propensity score and its sample mean to evaluate how IT effects are dependent on the precondition of IT adoption. The results show that coefficients on the IT dummy are negative for the loose and strict IT regimes, whereas those on the interaction term are negative, although less significant for the strict IT regime. These results imply that the treatment effect of the IT regime for the mean of the propensity score is significantly negative with the estimated coefficients of -0.07 and -0.06 for the loose and strict IT regimes, respectively. More importantly, the coefficient on the interaction term highlights the presence of heterogeneity. The negative coefficient suggests that the effectiveness of an IT regime is more apparent for countries with high estimated propensity scores that reflect

more favorable preconditions for IT adoption. IT would lead to an additional reduction in income velocity volatility (standard deviation) of 0.03 points for every 10 percent increase in the propensity score.

To examine the role of the time length on IT effects, the third column includes the interaction term of the IT dummy and the time length (year) from IT adoption.[13] The results show that the coefficient on the interaction term is significantly negative for the loose IT regime, and it is negative but less significant for the strict IT regime. The effectiveness of the IT regime is dependent on the time length since the IT adoption; therefore, IT is likely to become effective at reducing income velocity variability over time. In addition, we test the role of exchange rate arrangements in heterogeneous IT effects by including a fixed exchange rate dummy and an interaction term for the IT dummy and a fixed exchange rate dummy in the model. The estimation results shown in the fourth column illustrate that the coefficient on the interaction term is significantly positive irrespective of whether loose or strict IT regimes are involved. The treatment effect on income velocity volatility would be zero when a country adopts a fixed exchange rate regime. IT reduces income velocity volatility under a flexible exchange rate regime, but it fails to influence volatility under a fixed exchange rate regime. An IT regime would be effective in reducing income velocity volatility only under a floating exchange rate regime. Moreover, we examine the role of a fiscal disciple by incorporating fiscal balance and its interaction term with the IT dummy. The fifth column shows that the coefficient on the interaction term is insignificant for the loose and strict IT regimes; thus, no evidence is observed for the heterogeneous effects on IT regime performance.

[13] As in Lin and Ye (2009), this study does not include the time length variable in the regression because the value of the time length variable is the same as the interaction term of the IT dummy and time length.

2.3.4 Alternative method

In addition to the PSM method, we also apply the DID method as an alternative approach. The PSM method can serve as an appropriate method of addressing selection biases in observed covariates in the adoption of an IT regime. However, as noted in the literature (e.g., Pearl, 2000), the PSM method is limited because it controls only for observed covariates and unobserved covariates or factors may induce hidden bias. In addition, the PSM method requires the use of large samples with substantial common regions of treatment and control groups. The DID method can properly address selection biases originating from time-invariant unobserved characteristics by differentiating between the pre-period and post-period, and it can also be used to estimate treatment effects by comparing pre- and post-treatment differences from the outcomes of treatment and control groups.

The main assumption of the DID method is that the outcomes of treatment and control groups would follow the same time trends in the absence of treatment. When the parallel trend assumption holds and we can credibly rule out the presence of any other time-variant changes that may confound the treatment, the DID method is a trustworthy approach to apply. However, a crucial methodological problem related to the DID method identified in our study concerns the identification of adoption dates for non-IT countries that have never adopted an IT regime. Another problem may be related to potential violations of the parallel time trend condition because the timing of IT adoption varies across IT countries. Although the DID method can suffer from such issues, we attempt to ascertain the empirical validity of our baseline results derived from the matching analysis. The DID approach is widely used in the IT-related literature (e.g., Ball & Sheridan, 2005; Batini & Laxton, 2007; Goncalves & Salles, 2008; Thornton, 2016; Samarina et al., 2014). Following previous work, we apply the DID method as follows:

$$X_{i,post} - X_{i,pre} = \beta_0 + \beta_1 X_{i,pre} + \beta_2 IT_i + \varepsilon_i, \quad (4)$$

where X denotes the outcome of interest; $X_{i,pre}$ and $X_{i,post}$ are the outcomes of country i for the pre- and post-IT adoption periods, respectively; IT_i is the IT adoption dummy; and ε_i is the error term. As outcomes, we use the level of inflation and the volatilities of income velocity, inflation, real output growth, money growth, and real money balance growth for the pre- and post-IT periods. The level of inflation for the two periods is calculated from its average over 10 years before and after IT adoption. The volatilities of income velocity and of other variables are measured from their standard deviation for 10 years before and after IT adoption as in the work of Thornton (2016).[14] Following previous work, including that of Ball and Sheridan (2005), we include the initial (pre-IT) outcome level as an independent variable.[15] We exclude some countries with missing data for the 10-year pre- and post-IT periods as well as outliers based on inflation and money growth data.

Table 2.6 presents the average outcome variables of the pre- and post-IT periods, and Table 7 shows the estimated effects of the loose and strict IT regimes on our outcome variables. Our analysis of income velocity volatility suggests that IT adoption helps stabilize income velocity irrespective of the choice of the IT regime. This result of our DID approach is consistent with the PSM analysis shown in the previous subsection. Concerning the components of income velocity, our DID approach generally shows that coefficients on the IT dummy are negative, although less significant for some cases, thus revealing results that

[14] As in the works of Goncalves and Salles (2008), Thornton (2016), and Samarina et al. (2014), we use the IT adoption year to separate the pre- and post-periods for IT countries. However, non-IT countries do not have an IT adoption year because they have not adopted an IT regime. To measure the outcomes of pre- and post-periods for non-IT countries, we consider the hypothetical IT adoption year by taking the average of the adoption year for all IT countries. Hypothetical adoption years are designated as 2001 and 2002 for the loose and strict IT regimes, respectively.

[15] The correlation between IT and $X_{i,pre}$ would lead to a bias because a high $X_{i,pre}$ value could affect the likelihood of a country adopting an IT regime. Another issue occurs when $X_{i,pre}$ is very high because a more significant reduction in the variable may simply reflect a mean reversion rather than a direct contribution from the IT regime. See, e.g., Ball and Sheridan (2005, 2010), Goncalves and Salles (2008), and Samarina et al. (2014).

are consistent with the findings of the PSM method. Thus, our PSM results are robust, and an IT regime would generally reduce the volatilities of each component of income velocity.

2.4 Conclusion

This study has applied the PSM method to examine whether IT helps stabilize income velocity variability. The PSM method has commonly been used to eliminate self-selection bias, although it may suffer from issues related to small samples as well as hidden biases derived from unobserved covariates or factors (Pearl, 2000). Thus, to confirm the empirical validity of our PSM results, this study has also applied another method widely used in IT-related studies, the DID method. The empirical results of both methods have indicated that IT would help stabilize income velocity in developing countries. Thus, our findings have shown clear support for Taylor's (2000) argument that monetary authorities in developing economies would prefer using monetary policy rule with monetary aggregates to achieve inflation targets under stable income velocity. In addition, our empirical results regarding IT effects on income velocity have highlighted that monetary authorities can pursue monetary aggregates as an effective policy measure under an IT regime. Moreover, our decomposition analysis of income velocity variability has provided evidences that IT lessens volatilities of inflation, real output growth, and money growth. Furthermore, our analysis of heterogeneous effects has revealed that an IT regime would be effective in reducing income velocity volatility under the favorable preconditions of IT adoption and floating exchange rate regime application. The time length also influences the effectiveness of an IT regime, and IT is likely to become more effective in lowering income velocity volatility over time.

Table 2.1. Inflation targeting developing countries and starting years

Country	Starting Year	
	Inflation targeting (loose)	Inflation targeting (strict)
Armenia	2006	2006
Brazil	1999	1999
Chile	1991	2000
Colombia	2000	2000
Ghana	2003	2007
Guatemala	2005	2006
Hungary	2001	2001
Indonesia	2005	2006
Mexico	1995	2001
Peru	2002	2002
Philippines	2002	2002
Poland	1999	1999
Thailand	2000	2000
Turkey	2002	2006
South Africa	2000	2000

Note: Targeting dates are taken from De Mendonca and De Guimaraes e Souza (2012), Thornton (2016), Rose (2007), and Lin and Ye (2009).

Table 2.2. Control group countries

United Arab Emirates	Gabon	Oman
Argentina	Gambia, The	Pakistan
Antigua and Barbuda	Grenada	Papua New Guinea
Burundi	Guyana	Qatar
Benin	Honduras	Rwanda
Burkina Faso	India	Saudi Arabia
Bangladesh	Jamaica	Sudan
Bahrain	Jordan	Senegal
Bahamas, The	Kenya	Solomon Islands
Belize	St. Kitts and Nevis	Sierra Leone
Bolivia	St. Lucia	Suriname
Botswana	Sri Lanka	Swaziland
Central African Republic	Morocco	Seychelles
China	Madagascar	Chad
Cote d'Ivoire	Maldives	Togo
Cameroon	Mali	Trinidad and Tobago
Congo, Rep.	Myanmar	Tunisia
Cabo Verde	Mauritius	Uruguay
Costa Rica	Malawi	St. Vincent and the Grenadines
Dominica	Malaysia	Venezuela, RB
Algeria	Niger	Vanuatu
Ecuador	Nigeria	
Egypt, Arab Rep.	Nicaragua	
Fiji	Nepal	

Table 2.3. Estimates of propensity scores (probit model)

	Loose IT	Strict IT
Inflation (lag)	-0.008	-0.051***
	(0.007)	(0.010)
GDP per capita growth	3.947***	3.168***
	(1.122)	(1.134)
Broad money growth	0.002	-0.001
	(0.005)	(0.007)
Fiscal balance	-0.015*	-0.032***
	(0.009)	(0.011)
Fixed exchange rate regime	-1.750***	-1.930***
	(0.140)	(0.150)
Trade openness	-0.007***	-0.008***
	(0.002)	(0.002)
Financial openness	0.159***	0.224***
	(0.042)	(0.045)
No. of obs.	1393	1393
Pseudo-R^2	0.37	0.46

Notes: Constant terms and year trend are included but not reported. Robust standard errors are presented in parenthesis. *, **, and *** indicate the significant level of 10 %, 5 %, and 1 %, respectively.

Table 2.4. Estimates of the treatment effects

	Loose IT							Strict IT						
	Nearest-neighbor	3-nearest-neighbor	Radius		Kernel		Local linear	Nearest-neighbor	3-nearest-neighbor	Radius		Kernel		Local linear
			r=0.05	r=0.10	Gaussian	Epanechn				r=0.05	r=0.10	Gaussian	Epanechn	
Inflation	-1.498	-2.271	-1.372	-1.412	-1.392	-1.342	-1.363	-1.283	-1.996	-1.720	-1.692	-1.745	-1.748	-1.650
	(0.972)	(1.282)*	(0.950)	(0.926)	(0.919)	(0.952)	(1.395)	(0.684)*	(1.069)*	(1.035)*	(0.989)*	(0.984)*	(1.038)*	(0.261)
	[0.907]*	[1.316]*	[1.089]	[1.053]	[1.107]	[1.082]	[1.125]	[0.689]*	[0.806]*	[0.573]***	[0.553]***	[0.513]***	[0.555]***	[0.534]***
Income velocity volatility	-0.193	-0.151	-0.135	-0.137	-0.140	-0.136	-0.140	-0.118	-0.070	-0.065	-0.071	-0.072	-0.064	-0.064
	(0.034)***	(0.040)***	(0.038)***	(0.036)***	(0.036)***	(0.038)***	(0.053)***	(0.031)***	(0.042)*	(0.047)	(0.045)	(0.045)	(0.047)	(0.049)
	[0.032]***	[0.038]***	[0.028]***	[0.031]***	[0.030]***	[0.029]***	[0.029]***	[0.030]**	[0.032]**	[0.028]**	[0.027]***	[0.028]***	[0.029]**	[0.025]**
Inflation volatility	-3.013	-3.396	-3.069	-3.075	-3.053	-3.070	-3.081	-3.050	-2.317	-2.289	-2.250	-2.276	-2.299	-2.221
	(0.478)***	(0.542)***	(0.400)***	(0.390)***	(0.386)***	(0.400)***	(0.685)***	(0.478)***	(0.623)***	(0.478)***	(0.457)***	(0.455)***	(0.480)***	(0.758)***
	[0.503]***	[0.585]***	[0.495]***	[0.481]***	[0.449]***	[0.476]***	[0.484]***	[0.485]***	[0.629]***	[0.491]***	[0.438]***	[0.445]***	[0.484]***	[0.452]***
Real output growth volatility	-2.228	-2.574	-2.374	-2.452	-2.447	-2.383	-2.430	-1.836	-1.645	-1.758	-1.800	-1.803	-1.753	-1.735
	(0.360)***	(0.403)***	(0.258)***	(0.251)***	(0.249)***	(0.259)***	(0.557)***	(0.346)***	(0.475)***	(0.319)***	(0.305)***	(0.304)***	(0.320)***	(0.645)***
	[0.374]***	[0.506]***	[0.399]***	[0.425]***	[0.398]***	[0.413]***	[0.388]***	[0.378]***	[0.430]***	[0.346]***	[0.346]***	[0.316]***	[0.343]***	[0.316]***
Money growth volatility	-1.626	-1.429	-1.116	-1.173	-1.177	-1.120	-1.152	-0.635	-0.114	-0.265	-0.272	-0.293	-0.259	-0.340
	(0.513)***	(0.547)***	(0.569)**	(0.558)**	(0.554)**	(0.570)**	(0.631)*	(0.509)	(0.633)	(0.681)	(0.657)	(0.654)	(0.682)	(0.774)
	[0.524]***	[0.620]***	[0.543]***	[0.515]**	[0.546]**	[0.524]**	[0.511]**	[0.499]	[0.637]	[0.577]	[0.534]	[0.573]	[0.620]	[0.573]
Real money balance growth volatility	-1.971	-1.359	-1.259	-1.291	-1.310	-1.263	-1.344	-1.248	-0.370	-0.620	-0.662	-0.670	-0.587	-0.709
	(0.527)***	(0.578)**	(0.564)**	(0.553)**	(0.549)**	(0.565)**	(0.603)**	(0.529)**	(0.634)	(0.676)	(0.653)	(0.651)	(0.677)	(0.773)
	[0.528]***	[0.562]**	[0.496]**	[0.500]***	[0.503]***	[0.518]**	[0.492]***	[0.554]**	[0.638]	[0.564]	[0.554]	[0.540]	[0.610]	[0.533]

Notes: 0.06 fixed bandwidth is used for kernel and local linear regression matching. The analytical standard errors are shown in parentheses and the bootstrapped standard errors are shown in brackets (they are based on 500 replications of the data). *, ** and *** indicate the significant level of 10 %, 5% and 1%, respectively.

Table 2.5. Heterogeneity in the treatment effects

	(1)	(2)	(3)	(4)	(5)
Loose IT					
IT	-0.105***	-0.072***	-0.082***	-0.229***	-0.148***
	(0.017)	(0.027)	(0.030)	(0.032)	(0.026)
PS		0.181**	0.102*	0.205***	0.079
		(0.075)	(0.058)	(0.061)	(0.051)
IT*(PS-PS_avg)		-0.305***			
		(0.094)			
IT*Time			-0.009**		
			(0.004)		
Fixed exchange rate regime				0.017	
				(0.024)	
IT*Fixed exchange rate regime				0.238***	
				(0.044)	
Fiscal balance					0.005**
					(0.002)
IT*Fiscal balance					-0.007
					(0.005)
No of obs.	1325	1325	1325	1325	1325
Strict IT					
IT	-0.104***	-0.056*	-0.061*	-0.155***	-0.089***
	(0.018)	(0.032)	(0.035)	(0.031)	(0.028)
PS		-0.012	0.040	-0.005	-0.045
		(0.061)	(0.050)	(0.052)	(0.044)
IT*(PS-PS_avg)		-0.111			
		(0.085)			
IT*Time			-0.004		
			(0.004)		
Fixed exchange rate regime				-0.018	
				(0.024)	
IT*Fixed exchange rate regime				0.184***	
				(0.048)	
Fiscal balance					0.004*
					(0.002)
IT*Fiscal balance					-0.003
					(0.005)
No of obs.	1336	1336	1336	1336	1336

Notes: *, ** and *** indicate the significant level of 10 %, 5% and 1% respectively.

Table 2.6. Descriptive statistics, developing countries

		Pre-adoption	Post-adoption	Difference
Loose IT				
IT	Inflation	18.99	7.23	-11.76
	Income velocity volatility	0.53	0.30	-0.23
	Inflation volatility	8.84	3.90	-4.94
	Real output growth volatility	3.28	2.77	-0.51
	Money growth volatility	9.66	6.00	-3.66
	Real money balance growth volatility	9.81	6.98	-2.83
Non-IT	Inflation	9.81	6.04	-3.77
	Income velocity volatility	0.51	0.43	-0.08
	Inflation volatility	6.97	3.71	-3.26
	Real output growth volatility	4.03	3.38	-0.65
	Money growth volatility	9.30	7.69	-1.61
	Real money balance growth volatility	9.60	8.46	-1.14
Strict IT				
IT	Inflation	15.85	5.56	-10.29
	Income velocity volatility	0.47	0.24	-0.23
	Inflation volatility	9.02	2.13	-6.89
	Real output growth volatility	3.15	2.66	-0.49
	Money growth volatility	9.45	6.36	-3.09
	Real money balance growth volatility	8.95	6.80	-2.15
Non-IT	Inflation	9.31	6.06	-3.25
	Income velocity volatility	0.51	0.41	-0.10
	Inflation volatility	6.77	3.50	-3.27
	Real output growth volatility	3.99	3.25	-0.74
	Money growth volatility	9.76	7.01	-2.75
	Real money balance growth volatility	10.15	7.78	-2.38

Note: Average values of the outcome variables over 10 years during the pre- and post-IT periods.

Table 2.7. Estimates of the difference-in-difference method

	Inflation	Income velocity volatility	Inflation volatility	Real output growth volatility	Money growth volatility	Real money balance growth volatility
Loose IT						
IT	-1.615	-0.140**	-0.065	-0.488	-1.815**	-1.547*
	(0.981)	(0.062)	(0.894)	(0.501)	(0.869)	(0.866)
Initial value	-0.695***	-0.535***	-0.860***	-0.836***	-0.666***	-0.694***
	(0.052)	(0.067)	(0.056)	(0.111)	(0.097)	(0.102)
Constant	3.044***	0.189***	2.730***	2.722***	4.586***	5.521***
	(0.457)	(0.035)	(0.425)	(0.439)	(0.833)	(0.988)
No of obs.	84	84	84	84	84	84
R-squared	0.88	0.48	0.77	0.62	0.50	0.49
Strict IT						
IT	-2.573***	-0.148**	-1.596***	-0.484	-0.608	-0.813
	(0.899)	(0.059)	(0.406)	(0.498)	(1.132)	(1.099)
Initial value	-0.684***	-0.550***	-0.901***	-0.880***	-0.856***	-0.869***
	(0.064)	(0.069)	(0.041)	(0.062)	(0.064)	(0.076)
Constant	3.111***	0.180***	2.831***	2.772***	5.608***	6.444***
	(0.501)	(0.033)	(0.348)	(0.333)	(0.666)	(0.828)
No of obs.	84	84	84	84	84	84
R-squared	0.85	0.48	0.86	0.69	0.66	0.62

Notes: *, ** and *** indicate the significant level of 10 %, 5% and 1% respectively. The robust standard errors are shown in the parentheses.

Table 2.8: Estimates of the treatment effects (excluding some non-IT countries in terms of real GDP per capita in 2013)

	Loose IT							Strict IT						
	Nearest-neighbor	3-nearest-neighbor	Radius		Kernel		Local linear	Nearest-neighbor	3-nearest-neighbor	Radius		Kernel		Local linear
			r=0.05	r=0.10	Gaussian	Epanechn				r=0.05	r=0.10	Gaussian	Epanechn	
Inflation	-1.985	-1.581	-1.187	-1.533	-1.477	-1.272	-1.496	-0.861	-1.713	-1.698	-1.621	-1.700	-1.718	-1.610
	(1.002)**	(1.607)	(1.418)	(1.336)	(1.318)	(1.413)	(1.649)	(0.660)	(1.149)	(1.446)	(1.408)	(1.400)**	(1.446)	(0.948)*
	[1.137]*	[1.118]	[0.822]	[0.789]*	[0.803]*	[0.805]	[0.796]*	[0.721]	[0.772]**	[0.575]***	[0.554]***	[0.567]***	[0.597]***	[0.567]***
Income velocity volatility	-0.092	-0.135	-0.115	-0.116	-0.114	-0.121	-0.118	-0.061	-0.043	-0.056	-0.057	-0.056	-0.055	-0.047
	(0.029)***	(0.046)***	(0.041)***	(0.038)***	(0.037)***	(0.040)***	(0.055)**	(0.031)**	(0.048)	(0.044)	(0.043)	(0.043)	(0.044)	(0.049)
	[0.030]***	[0.039]***	[0.036]***	[0.031]***	[0.033]***	[0.034]***	[0.036]***	[0.033]*	[0.029]	[0.028]**	[0.026]**	[0.025]**	[0.025]**	[0.025]*
Inflation volatility	-1.634	-2.932	-2.936	-2.907	-2.908	-2.988	-2.921	-1.187	-2.226	-2.417	-2.313	-2.304	-2.406	-2.149
	(0.421)***	(0.687)***	(0.548)***	(0.514)***	(0.506)***	(0.546)***	(0.818)***	(0.401)***	(0.689)***	(0.594)***	(0.577)***	(0.574)***	(0.596)***	(0.847)**
	[0.472]***	[0.674]***	[0.582]***	[0.577]***	[0.570]***	[0.559]***	[0.587]***	[0.486]**	[0.687]***	[0.648]***	[0.593]***	[0.603]***	[0.614]***	[0.627]***
Real output growth volatility	-1.248	-1.835	-1.913	-1.956	-1.930	-1.915	-1.872	-1.419	-1.854	-1.855	-1.814	-1.813	-1.856	-1.731
	(0.213)***	(0.326)***	(0.297)***	(0.280)***	(0.276)***	(0.296)***	(0.381)***	(0.219)***	(0.322)***	(0.327)***	(0.318)***	(0.317)***	(0.328)***	(0.406)***
	[0.233]***	[0.268]***	[0.268]***	[0.249]***	[0.253]***	[0.253]***	[0.252]***	[0.226]***	[0.364]***	[0.289]***	[0.230]***	[0.309]***	[0.307]***	[0.313]***
Money growth volatility	-1.058	-2.021	-1.985	-2.040	-1.985	-2.047	-2.156	-0.464	-1.328	-1.608	-1.412	-1.431	-1.599	-1.588
	(0.477)**	(0.718)***	(0.727)***	(0.688)***	(0.679)***	(0.724)***	(0.709)***	(0.487)	(0.686)*	(0.853)*	(0.831)*	(0.828)*	(0.855)*	(0.749)**
	[0.497]**	[0.731]***	[0.710]***	[0.644]***	[0.629]***	[0.642]***	[0.596]***	[0.539]	[0.784]*	[0.718]**	[0.718]**	[0.654]**	[0.698]**	[0.705]**
Real money balance growth volatility	-1.334	-1.879	-1.806	-1.824	-1.801	-1.854	-1.891	-0.430	-1.105	-1.432	-1.273	-1.280	-1.431	-1.404
	(0.515)***	(0.762)**	(0.746)**	(0.706)***	(0.697)***	(0.743)**	(0.735)***	(0.507)	(0.694)	(0.868)*	(0.846)	(0.843)	(0.870)	(0.746)*
	[0.558]**	[0.613]***	[0.542]***	[0.549]***	[0.548]***	[0.564]**	[0.506]***	[0.521]	[0.721]	[0.663]**	[0.594]**	[0.620]**	[0.606]**	[0.661]**

Notes: 0.06 fixed bandwidth is used for kernel and local linear regression matching. The analytical standard errors are shown in parentheses and the bootstrapped standard errors are shown in brackets (they are based on 500 replications of the data). *, ** and *** indicate the significant level of 10 %, 5% and 1%, respectively.

Table 2.9. Balancing property (Loose IT)

	Nearest-neighbor matching				Radius matching (r=0.10)				Kernel matching (Gaussian)			
	Mean		Bias	P-value	Mean		Bias	P-value	Mean		Bias	P-value
	Treated	Control	Reduction		Treated	Control	Reduction		Treated	Control	Reduction	
Before matching												
Lagged inflation	6.64	7.25		0.393	6.64	7.25		0.393	6.64	7.25		0.393
GDP per capita growth	0.03	0.02		0.005	0.03	0.02		0.005	0.03	0.02		0.005
Broad money growth	13.47	13.02		0.644	13.47	13.02		0.644	13.47	13.02		0.644
Fixed exchange rate regime	0.25	0.81		0.000	0.25	0.81		0.000	0.25	0.81		0.000
Trade openness	69.17	81.73		0.000	69.17	81.73		0.000	69.17	81.73		0.000
Financial openness	0.42	-0.12		0.000	0.42	-0.12		0.000	0.42	-0.12		0.000
Fiscal balance	-2.11	-1.94		0.714	-2.11	-1.94		0.714	-2.11	-1.94		0.714
After matching												
Lagged inflation	6.72	8.15	-135.6	0.112	6.72	8.22	-145.9	0.063	6.72	8.21	-145.0	0.065
GDP per capita growth	0.03	0.03	63.8	0.454	0.03	0.04	-11.8	0.043	0.03	0.04	-8.4	0.049
Broad money growth	13.38	13.56	60.4	0.885	13.38	14.18	-79.6	0.502	13.38	14.16	-73.7	0.515
Fixed exchange rate regime	0.26	0.26	98.7	0.891	0.26	0.26	98.7	0.889	0.26	0.26	99.5	0.959
Trade openness	69.87	73.44	71.6	0.399	69.87	70.49	95.1	0.877	69.87	70.43	95.6	0.888
Financial openness	0.38	0.09	46.5	0.090	0.38	0.18	63.0	0.236	0.38	0.17	61.5	0.218
Fiscal balance	-2.09	-2.40	-84.9	0.490	-2.09	-2.01	55.8	0.863	-2.09	-2.01	55.7	0.864

Table 2.10. Balancing property (Strict IT)

	Nearest-neighbor matching				Radius matching (r=0.10)				Kernel matching (Gaussian)			
	Mean		Bias	P-value	Mean		Bias	P-value	Mean		Bias	P-value
	Treated	Control	Reduction		Treated	Control	Reduction		Treated	Control	Reduction	
Before matching												
Lagged inflation	5.35	7.36		0.008	5.35	7.36		0.008	5.35	7.36		0.008
GDP per capita growth	0.03	0.02		0.027	0.03	0.02		0.027	0.03	0.02		0.027
Broad money growth	12.59	13.05		0.653	12.59	13.05		0.653	12.59	13.05		0.653
Fixed exchange rate regime	0.24	0.80		0.000	0.24	0.80		0.000	0.24	0.80		0.000
Trade openness	70.05	81.68		0.002	70.05	81.68		0.002	70.05	81.68		0.002
Financial openness	0.58	-0.13		0.000	0.58	-0.13		0.000	0.58	-0.13		0.000
Fiscal balance	-2.25	-1.94		0.530	-2.25	-1.94		0.530	-2.25	-1.94		0.530
After matching												
Lagged inflation	5.36	5.51	92.8	0.808	5.36	6.06	65.4	0.234	5.36	6.04	66.3	0.247
GDP per capita growth	0.03	0.02	54.4	0.380	0.03	0.04	16.2	0.126	0.03	0.04	19.3	0.141
Broad money growth	12.59	12.74	69.0	0.895	12.59	13.02	8.8	0.705	12.59	13.04	4.1	0.692
Fixed exchange rate regime	0.24	0.31	87.0	0.198	0.24	0.23	99.1	0.928	0.24	0.24	99.9	0.988
Trade openness	70.08	72.31	80.8	0.585	70.08	71.53	87.5	0.726	70.08	71.55	87.3	0.723
Financial openness	0.56	0.39	75.4	0.340	0.56	0.49	89.2	0.672	0.56	0.47	86.4	0.596
Fiscal balance	-2.23	-2.52	4.7	0.553	-2.23	-2.22	97.0	0.983	-2.23	-2.16	78.1	0.878

Table 2.11. Estimates of propensity scores (probit model)

	Adding Government debt to GDP		Adding Turnover rate of central bank governors		Alternative sample period 1990-2007	
	Loose IT	Strict IT	Loose IT	Strict IT	Loose IT	Strict IT
Inflation (lag)	-0.011*	-0.052***	-0.003	-0.071***	-0.001	-0.050***
	(0.007)	(0.010)	(0.008)	(0.020)	(0.007)	(0.013)
GDP per capita growth	4.178***	3.446***	5.045***	3.593**	3.768***	2.368*
	(1.179)	(1.194)	(1.729)	(1.776)	(1.251)	(1.302)
Broad money growth	0.001	-0.001	-0.007	-0.014	-0.001	-0.006
	(0.005)	(0.007)	(0.007)	(0.011)	(0.005)	(0.008)
Fiscal balance	-0.023**	-0.037***	0.018	-0.001	-0.013	-0.037***
	(0.010)	(0.011)	(0.017)	(0.022)	(0.010)	(0.011)
Fixed exchange rate regime	-1.799***	-1.952***	-1.415***	-1.831***	-1.658***	-1.939***
	(0.139)	(0.149)	(0.221)	(0.251)	(0.164)	(0.178)
Trade openness	-0.005***	-0.008***	-0.004*	-0.005	-0.005***	-0.007***
	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)
Financial openness	0.150***	0.214***	0.060	0.176**	0.125***	0.212***
	(0.042)	(0.045)	(0.071)	(0.072)	(0.048)	(0.052)
Government debt to GDP	-0.022**	-0.005	-	-	-	-
	(0.010)	(0.012)				
Turnover rate of central bank governors	-	-	-0.851	-0.672	-	-
			(0.568)	(0.814)		
No. of obs.	1362	1362	570	570	1155	1155
Pseudo-R^2	0.38	0.46	0.29	0.44	0.35	0.46

Notes: Constant terms and year trend are included but not reported. Robust standard errors are presented in parenthesis. *, **, and *** indicate the significant level of 10 %, 5 %, and 1 %, respectively.

Table 2.12. Estimates of the treatment effects

	Loose IT							Strict IT						
	Nearest-neighbor	3-nearest-neighbor	Radius r=0.05	Radius r=0.10	Kernel Gaussian	Kernel Epanechn	Local linear	Nearest-neighbor	3-nearest-neighbor	Radius r=0.05	Radius r=0.10	Kernel Gaussian	Kernel Epanechn	Local linear
Adding Government debt to GDP														
Inflation	-1.150	-2.026	-1.544	-1.557	-1.518	-1.522	-1.464	-1.835	-1.820	-1.835	-1.699	-1.781	-1.853	-1.689
	(0.820)	(1.079)*	(0.926)*	(0.897)*	(0.895)*	(0.928)	(1.168)	(0.712)***	(0.988)*	(1.035)*	(0.992)*	(0.984)*	(1.036)*	(1.361)
	[0.902]	[1.205]*	[1.013]	[1.054]	[0.915]*	[1.023]	[1.972]	[0.657]***	[0.729]**	[0.578]***	[0.550]***	[0.554]***	[0.598]***	[0.563]***
Income velocity volatility	-0.183	-0.162	-0.163	-0.160	-0.159	-0.164	-0.161	-0.131	-0.069	-0.070	-0.075	-0.076	-0.070	-0.069
	(0.033)***	(0.037)***	(0.037)***	(0.035)***	(0.035)***	(0.037)***	(0.047)***	(0.032)***	(0.043)	(0.047)	(0.045)*	(0.045)*	(0.047)	(0.057)
	[0.035]***	[0.043]***	[0.034]***	[0.030]***	[0.033]***	[0.036]***	[0.033]***	[0.031]***	[0.034]**	[0.028]**	[0.028]***	[0.029]***	[0.028]**	[0.027]***
Inflation volatility	-3.443	-3.722	-3.476	-3.471	-3.432	-3.480	-3.475	-2.923	-2.281	-2.527	-2.406	-2.400	-2.482	-2.364
	(0.477)***	(0.553)***	(0.394)***	(0.377)***	(0.377)***	(0.395)***	(0.710)***	(0.481)***	(0.636)***	(0.478)***	(0.459)***	(0.456)***	(0.478)***	(0.739)***
	[0.507]***	[0.593]***	[0.507]***	[0.500]***	[0.473]***	[0.491]***	[0.481]***	[0.532]***	[0.597]***	[0.544]***	[0.480]***	[0.460]***	[0.497]***	[0.495]***
Real output growth volatility	-2.349	-2.770	-2.596	-2.468	-2.475	-2.590	-2.464	-2.106	-1.801	-1.875	-1.899	-1.890	-1.859	-1.831
	(0.371)***	(0.425)***	(0.255)***	(0.244)***	(0.243)***	(0.255)***	(0.493)***	(0.361)***	(0.470)***	(0.314)***	(0.302)***	(0.300)***	(0.315)***	(0.598)***
	[0.361]***	[0.556]***	[0.441]***	[0.416]***	[0.390]***	[0.459]***	[0.400]***	[0.386]***	[0.419]***	[0.335]***	[0.342]***	[0.342]***	[0.331]***	[0.340]***
Money growth volatility	-1.407	-1.284	-1.083	-1.175	-1.162	-1.084	-1.124	-0.928	-0.295	-0.275	-0.175	-0.241	-0.300	-0.290
	(0.483)***	(0.578)**	(0.556)*	(0.538)**	(0.538)**	(0.557)*	(0.627)*	(0.534)*	(0.680)	(0.673)	(0.652)	(0.648)	(0.673)	(0.834)
	[0.511]***	[0.613]**	[0.518]**	[0.497]**	[0.515]**	[0.510]**	[0.513]**	[0.537]*	[0.663]	[0.561]	[0.535]	[0.550]	[0.588]	[0.553]
Real money balance growth volatility	-1.856	-1.639	-1.412	-1.443	-1.419	-1.434	-1.476	-1.421	-0.657	-0.590	-0.572	-0.611	-0.612	-0.662
	(0.506)***	(0.596)***	(0.552)**	(0.534)***	(0.534)***	(0.553)***	(0.660)**	(0.544)***	(0.703)	(0.669)	(0.649)	(0.645)	(0.669)	(0.815)
	[0.498]***	[0.591]***	[0.508]***	[0.468]***	[0.510]***	[0.534]***	[0.501]***	[0.555]***	[0.655]	[0.587]	[0.559]	[0.585]	[0.600]	[0.497]
Adding Turnover rate of central bank governors														
Inflation	-0.166	0.415	-0.769	-0.824	-0.793	-0.655	-0.549	-2.227	-1.948	-1.900	-2.764	-2.631	-1.879	-2.067
	(1.367)	(1.344)	(1.556)	(1.509)	(1.499)	(1.554)	(1.536)	(1.123)**	(1.029)*	(1.542)	(1.394)**	(1.387)*	(1.558)	(1.389)
	[1.467]	[1.445]*	[1.289]	[1.251]	[1.226]	[1.312]	[1.313]	[1.196]*	[1.311]	[1.133]*	[0.939]***	[0.945]***	[1.072]*	[1.007]**
Income velocity volatility	-0.231	-0.243	-0.256	-0.260	-0.257	-0.261	-0.265	-0.216	-0.258	-0.253	-0.229	-0.231	-0.259	-0.245
	(0.061)***	(0.055)***	(0.036)***	(0.035)***	(0.034)***	(0.036)***	(0.080)***	(0.056)***	(0.067)***	(0.051)***	(0.046)***	(0.046)***	(0.051)***	(0.071)***
	[0.061]***	[0.063]***	[0.052]***	[0.048]***	[0.050]***	[0.051]***	[0.052]***	[0.062]**	[0.072]**	[0.065]***	[0.057]***	[0.060]***	[0.063]***	[0.062]***
Inflation volatility	-4.140	-4.029	-4.303	-4.120	-4.094	-4.284	-4.420	-4.910	-4.938	-4.746	-4.893	-4.776	-4.765	-4.813
	(0.872)***	(0.798)***	(0.581)***	(0.560)***	(0.557)***	(0.580)***	(1.092)***	(1.013)***	(0.975)***	(0.720)***	(0.657)***	(0.657)***	(0.724)***	(1.183)***
	[0.888]***	[0.957]***	[0.777]***	[0.738]***	[0.722]***	[0.790]***	[0.738]***	[1.028]***	[1.118]***	[1.025]***	[0.880]***	[0.936]***	[0.887]***	[0.972]***
Real output growth volatility	-1.498	-1.425	-1.542	-1.601	-1.557	-1.543	-1.564	-2.360	-2.631	-2.899	-2.634	-2.611	-2.942	-2.723
	(0.458)***	(0.406)***	(0.282)***	(0.272)***	(0.270)***	(0.281)***	(0.646)**	(0.639)***	(0.627)***	(0.389)***	(0.359)***	(0.359)***	(0.391)***	(0.852)***
	[0.491]***	[0.549]***	[0.464]***	[0.459]***	[0.446]***	[0.474]***	[0.457]***	[0.682]***	[0.885]***	[0.861]***	[0.725]***	[0.723]***	[0.852]***	[0.826]***
Money growth volatility	-2.734	-2.339	-2.670	-2.560	-2.561	-2.642	-2.694	-2.866	-2.871	-2.511	-2.511	-2.529	-2.570	-2.546
	(0.869)***	(0.836)***	(0.838)***	(0.817)***	(0.813)***	(0.837)***	(0.988)***	(0.962)***	(0.940)***	(1.047)**	(0.983)**	(0.983)***	(1.052)**	(1.083)**
	[0.813]***	[0.824]***	[0.744]***	[0.722]***	[0.682]***	[0.698]***	[0.753]***	[0.999]***	[0.981]***	[0.870]***	[0.834]***	[0.816]***	[0.818]***	[0.807]***
Real money balance growth volatility	-3.294	-2.981	-3.298	-3.198	-3.182	-3.318	-3.364	-3.595	-3.703	-3.548	-3.242	-3.328	-3.614	-3.491
	(0.930)***	(0.912)***	(0.853)***	(0.830)***	(0.826)***	(0.852)***	(1.126)***	(1.075)***	(1.052)***	(1.105)***	(1.039)***	(1.039)***	(1.110)***	(1.241)***
	[0.863]***	[0.969]***	[0.773]***	[0.758]***	[0.759]***	[0.771]***	[0.750]***	[1.079]***	[1.086]***	[1.031]***	[0.926]***	[1.003]***	[1.010]***	[1.047]***
Alternative sample period 1990-2007														
Inflation	-1.787	-1.002	-0.996	-1.061	-1.055	-0.924	-1.132	-1.654	-1.835	-1.749	-1.991	-1.992	-1.732	-1.822
	(1.275)	(1.379)	(1.097)	(1.067)	(1.061)	(1.100)	(1.794)	(0.779)**	(0.963)*	(1.234)	(1.118)*	(1.115)*	(1.239)	(1.176)
	[1.188]	[1.305]	[1.080]	[1.072]	[1.141]	[1.060]	[1.101]	[0.755]**	[0.818]**	[0.699]**	[0.611]***	[0.619]***	[0.671]***	[0.615]***
Income velocity volatility	-0.190	-0.186	-0.195	-0.187	-0.189	-0.194	-0.194	-0.176	-0.133	-0.095	-0.107	-0.104	-0.096	-0.108
	(0.040)***	(0.050)***	(0.039)***	(0.037)***	(0.037)***	(0.039)***	(0.050)***	(0.040)***	(0.062)**	(0.055)*	(0.049)**	(0.049)**	(0.055)*	(0.057)*
	[0.046]***	[0.053]***	[0.037]***	[0.035]***	[0.035]***	[0.037]***	[0.032]***	[0.043]***	[0.048]***	[0.038]**	[0.033]***	[0.033]***	[0.037]***	[0.033]***
Inflation volatility	-3.718	-4.008	-3.960	-3.862	-3.867	-3.988	-3.960	-3.683	-3.570	-3.458	-3.465	-3.420	-3.451	-3.494
	(0.608)***	(0.590)***	(0.446)***	(0.431)***	(0.428)***	(0.446)***	(0.782)***	(0.633)***	(0.765)***	(0.586)***	(0.530)***	(0.530)***	(0.588)***	(0.955)***
	[0.630]***	[0.719]***	[0.609]***	[0.543]***	[0.538]***	[0.550]***	[0.569]***	[0.674]***	[0.842]***	[0.689]***	[0.627]***	[0.557]***	[0.650]***	[0.604]***
Real output growth volatility	-2.696	-2.685	-2.935	-2.862	-2.882	-2.909	-2.920	-2.717	-2.448	-2.268	-2.452	-2.404	-2.268	-2.448
	(0.457)***	(0.391)***	(0.270)***	(0.261)***	(0.258)***	(0.270)***	(0.638)***	(0.460)***	(0.554)***	(0.377)***	(0.341)***	(0.340)***	(0.378)***	(0.702)***
	[0.444]***	[0.557]***	[0.447]***	[0.394]***	[0.429]***	[0.433]***	[0.414]***	[0.523]***	[0.581]***	[0.439]***	[0.433]***	[0.408]***	[0.455]***	[0.436]***
Money growth volatility	-1.635	-1.586	-1.457	-1.475	-1.473	-1.497	-1.457	-0.881	-0.459	-0.334	-0.455	-0.465	-0.318	-0.379
	(0.654)**	(0.677)**	(0.663)**	(0.648)**	(0.645)**	(0.663)**	(0.849)*	(0.694)	(0.784)	(0.874)	(0.816)	(0.815)	(0.876)	(0.865)
	[0.668]**	[0.704]**	[0.623]**	[0.607]**	[0.632]**	[0.617]**	[0.586]**	[0.729]	[0.798]	[0.807]	[0.753]	[0.682]	[0.771]	[0.732]
Real money balance growth volatility	-1.520	-1.753	-1.618	-1.584	-1.566	-1.642	-1.596	-1.425	-0.767	-0.543	-0.674	-0.661	-0.534	-0.637
	(0.670)**	(0.700)**	(0.658)**	(0.644)**	(0.641)**	(0.659)**	(0.880)*	(0.729)*	(0.832)	(0.869)	(0.814)	(0.813)	(0.871)	(0.914)
	[0.670]**	[0.736]**	[0.598]***	[0.570]***	[0.589]***	[0.584]***	[0.646]**	[0.736]*	[0.835]	[0.900]	[0.777]	[0.787]	[0.869]	[0.792]

Notes: 0.06 fixed bandwidth is used for kernel and local linear regression matching. The analytical standard errors are shown in parentheses and the bootstrapped standard errors are shown in brackets (they are based on 500 replications of the data). *, ** and *** indicate the significant level of 10 %, 5% and 1%, respectively.

Chapter 3

Inflation targeting and exchange market pressure in developing economies: Some international evidence

3.1 Introduction

Developing countries have frequently experienced foreign exchange market turmoil so that the policy choice is of particular important for their macroeconomic stability. Fundamental domestic policies, including monetary policy, may affect a country's external sector. Since foreign exchange markets often induce unstable external conditions, sound monetary arrangement is required for developing economies to absorb pressures from foreign exchange markets under a globalized world (Weymark, 1997, 1998).[16] To capture such market pressures, Girton and Roper (1977) define exchange market pressure (EMP) as the sum of the nominal exchange rate depreciation and the percentage change of international reserves holdings scaled by the base money (see Eichengreen et al., 1994; Bussiere & Fratzscher, 2006; Klaassen & Jager, 2011).[17] Currency depreciation only captures turmoil or crisis initiated mainly by 'successful' speculative attacks that lead to deviation from the fixed exchange rate with consequent currency depreciation. The concept of EMP incorporates instances of 'unsuccessful' speculative attacks that reflect declines in international reserves associated with monetary authority's intervention in the foreign exchange market.

[16] Weymark (1997, 1998) examine the effectiveness of exchange rate management to mitigate the EMP through changes in exchange rate or in international reserves, or both.

[17] The monetary approach to the balance of payment is based on fixed exchange rate, while that to exchange rate determination is based on perfectly flexible exchange rate. However, most countries have neither a fixed nor a perfectly flexible regime. To overcome limitations of the traditional approaches, Girton and Roper (1977) develop the EMP measure, which can be used in fixed, flexible, and managed floating exchange rate regimes. In a fixed regime, the depreciation rate is zero. In a flexible regime, the change of international reserves is zero. In a managed floating regime, the exchange market pressure is absorbed by either currency depreciation, or reserve losses, or a combination of the two.

Inflation targeting (IT) has been adopted across advanced countries since the early 1990s. Some emerging and developing countries have also introduced an IT regime since the late 1990s, although this regime has not been prevailed yet.[18] As an IT regime is not only a domestically focused policy framework but also related to the exchange rate regime (Taylor, 2001; Rose, 2007), examining whether an IT adoption has any beneficial effect on the external economy is a crucial issue for financial regulators. Although several studies investigate the domestic effects of an IT regime, its international effects are largely unexplored.[19] Exception may include the works of Rose (2007) and Lin (2010), which present that the IT regime helps stabilize exchange rate and accumulate international reserves. However, past studies investigate the link of an IT regime with exchange rate and international reserves independently and do not focus on the relationship between an IT regime and EMP which reflects both of the two elements. Thus, this study extends the present IT-related literature by evaluating the role of an IT regime as a monetary framework in determining EMP in developing countries. In addition, we attempt to verify the IT effects on the volatilities of exchange rate depreciation and international reserves changes, which enables us to discuss how the IT adoption relates to policy stances in the foreign exchange market.

This study applies the propensity score matching (PSM) method to mitigate self-selection problems, following several works on the IT effects (Lin & Ye, 2007, 2009; Lin, 2010; Vega & Winkelried, 2005; de Mendonca & de Guimaraes e Souza, 2012; Samarina et al., 2014). The main result shows clear evidence supportive of the IT role in stabilizing EMP

[18] The main feature of an IT regime is an explicit quantitative inflation target and strong central bank legal commitments (e.g., Mishkin, 2000; Mishkin & Savastano, 2001). The main argument is that an official announcement of an inflation target improves a central bank's credibility and helps to lower inflation and the volatilities of inflation and real output (see, e.g., Bernanke et al., 1999; Svensson, 1997; Mishkin, 1999). As of 2013, fifteen non-OECD countries have adopted an IT regime.

[19] Recent studies on the IT effects on the domestic economic variables include Ball and Sheridan (2005), Vega and Winkelried (2005), Batini and Laxton (2007), Goncalves and Salles (2008), Lin and Ye (2009), de Mendonca and de Guimaraes e Souza (2012), Samarina et al. (2014), Thornton (2016), Kadria and Aissa (2016), and Balima et al. (2017).

in developing countries. In addition, our analysis of the decomposition of EMP reveals that an IT regime helps stabilize international reserves holdings, while it does not affect exchange rate volatility significantly. Some studies highlight that an IT regime is often related to a floating exchange rate regime (Rose, 2007; Lin & Ye, 2009; Taylor, 2001). Hu (2006) and Brenner and Sokoler (2010) argue that the flexibility of exchange rate motivates monetary authority to adopt an IT regime, and its rigidity is not suitable for IT policies in the long run. However, our results show no clear evidence that IT adoption induces exchange rate stability. At the same time, the policy commitment to an IT regime improves the credibility of monetary policy conduct, along with less speculative behaviors of market participants. In this case, a central bank tends not to, or is not required to, intervene in the foreign exchange market, so that changes in international reserves would become more stable under an IT regime. The rest of this paper is organized as follows. Section 2 explains methodology and the empirical results with some policy implications. Section 3 concludes.

3.2 Empirical analysis

3.2.1 Methodology

This study evaluates the IT effects on EMP over 101 developing countries from 1990 to 2014 by applying the PSM method that involves a two-step procedure. Among various definitions of an IT adoption year, this study uses the 'loose' and 'strict' types of adoption years, following Rose (2007), Lin (2010), and Samarina et al. (2014). A loose adoption year represents the earliest adoption year in which inflation targets are announced without strong commitments, and a strict adoption year represents the latest year in which credible commitments are made to achieve inflation targets with a single inflation target via monetary policies. This study identifies developing countries based on the IMF's country classification, and our treatment group includes 16 IT countries and control group contains 85 non-IT

countries.[20] Table 3.1 shows a list of IT countries with loose and strict adoption years, and Table 3.2 presents non-IT countries in our sample.

We apply four PSM methods. The first matching method is the nearest-neighbor matching without replacement, which matches each treated observation to the n control observations that have the closest propensity scores, but each control observation is used no more than one time as a match for a treated observation. We use two nearest-neighbor matching estimators: $n = 1$ and $n = 3$. The second method involves radius matching, where each treated observation is matched with control observations with estimated propensity scores that fall within a specified radius. We use two radius matching estimators: $r = 0.05$ and $r = 0.1$. The next involves kernel matching method, which matches each treated observation to control observations with weights inversely proportional to the distance between the treated and control observations. We use two kernel matching methods: Gaussian and Epanechnikov. The last matching method involves applying the regression-adjusted local linear matching approach developed by Heckman et al. (1998).

The PSM method includes a two-step procedure. This study first applies a probit model to estimate the propensity score, which is the conditional probability that a country adopts an IT regime based on the country's characteristics:

$$P(X) = \text{Prob}(D = 1|X) = E(D|X),$$

where D is a treatment or IT dummy that takes one when a country adopts an IT regime and zero otherwise, and X is the matrix of the country's characteristics that are expected to drive IT regime selection, following de Mendonca and de Guimaraes e Souza (2012), Lin and Ye

[20] To ensure that the treatment and control groups are comparable, Lin and Ye (2009) and Lin (2010) exclude some non-IT countries with substantially different features (e.g., real GDP per capita) from IT countries. Following their method, we exclude some non-IT countries whose real GDP per capita levels are lower than those of the smallest IT country.

(2007), and Samaria et al. (2014).[21] The model includes the one-year lagged inflation rate, real per capita GDP growth rate, broad money growth, and fiscal balance. To control for external economic conditions, we also incorporate the measures of exchange rate flexibility, trade openness, and financial openness.[22] Trade openness is calculated from the ratio of the sum of exports and imports to GDP. The data are taken from World Development Indicators (WDI), World Economic Outlook (WEO), Reinhart and Rogoff's (2004) de facto exchange rate arrangement classification, and Chinn and Ito's (2008) capital account openness index.

As a second step, we estimate the ATT by using estimated propensity scores:

$$\mathrm{ATT} = \mathrm{E}[\mathrm{Y_{i1}}|\mathrm{D_i} = 1] - \mathrm{E}[\mathrm{Y_{i0}}|\mathrm{D_i} = 1],$$

where $\mathrm{D_i}$ is the IT dummy for country i; $\mathrm{Y_{i1}}$ and $\mathrm{Y_{i0}}$ are potential outcomes of IT and non-IT regimes (two counterfactual situations), respectively; $\mathrm{Y_{i0}}|\mathrm{D_i} = 1$ is the value of the outcome that would have been observed if the IT country had not adopted an IT regime; and $\mathrm{Y_{i1}}|\mathrm{D_i} = 1$ is the value of the outcome that is actually observed in the same country. A crucial problem concerns the difficulty of estimating the ATT because of the unobservable value of $\mathrm{E}[\mathrm{Y_{i0}}|\mathrm{D_i} = 1]$. When a country's choice of IT regime is random, the ATT can be estimated from differences in the sample means of the outcome variable between the groups of the IT and non-IT countries.

[21] As noted by Lin and Ye (2007), finding an appropriate statistical model that explains the probability of IT adoption is not the main goal of estimating propensity scores. Under conditional independence assumptions, the exclusion of variables that systematically affect the likelihood of IT adoption but do not affect outcome variables, such as inflation and its volatility, is not problematic in the case of probit regressions (see Persson, 2001).

[22] According to Reinhart and Rogoff's (2004) classification, the fine grid classification includes fourteen categories, and the coarse grid version aggregates these into five categories. By using the coarse grid classification, we construct the classification of the exchange rate flexibility with three categories (fixed, intermediate, and flexible).

However, IT regime selection is not random in the sense that such a choice is systematically correlated with a set of observable covariates that also affect the outcome variable, thereby creating problems in the selection of observables (e.g., Dehejia & Wahba, 2002; Heckman et al., 1998). To mitigate such a problem, we apply the PSM method, which uses a control group of non-IT countries to mimic a randomized experiment. As suggested by Rosenbaum and Rubin (1983), treatment and control observations can be matched based on propensity scores $p(X)$ to solve high-dimensional set of observed covariates. Once $p(X)$ is given, the ATT is estimated under two main assumptions, i.e., conditional independence and common support assumptions, as follows:

$$\mathrm{ATT} = \mathrm{E}[\mathrm{Y_{i1}}|\mathrm{D_i} = 1, \mathrm{p}(\mathrm{X_i})] - \mathrm{E}[\mathrm{Y_{i0}}|\mathrm{D_i} = 0, \mathrm{p}(\mathrm{X_i})].$$

3.2.2 Results

Our main interest is to determine how IT adoption affects variability of EMP in developing countries. Since EMP is composed of exchange rate depreciation and changes in international reserves, we attempt to evaluate IT effects by estimating the treatment effect of an IT regime on the volatilities of each EMP component. Similar to the works of Lin (2010), we measure the volatilities of EMP, exchange rate depreciation, and changes in international reserves scaled by base money as the standard deviation of the twelve monthly observations for each year. The data is obtained from International Financial Statistics (IFS). We first estimate the propensity scores by using a probit model. Table 3.3 presents the estimation results for the loose IT and strict IT regimes. Countries with higher inflation rates for the previous period, sound fiscal conditions, and higher levels of trade openness are less likely to adopt an IT regime. In addition, countries with the higher degrees of financial openness and exchange rate flexibility are more likely to adopt an IT regime. These results generally

coincide with the findings of previous studies (e.g., de Mendonca & de Guimaraes e Souza, 2012; Lin & Ye, 2007; Lin, 2010).

Once the propensity scores are estimated, we estimate the ATT by applying matching methods. We first ensure the sharing of the same support or confirm the highly and reasonably comparability between the treatment and control groups. As in the works of Lin and Ye (2007, 2009) and Thornton and Vasilakis (2017), we reconstruct the dataset that satisfies the common support assumption by sorting all observations based on estimated propensity scores and discarding control units with propensity scores that fall below the lowest treatment unit value and exceed the highest treatment unit value.

Table 3.4 reports the ATT on the volatilities of EMP and its components for the loose and strict IT regimes.[23] The first seven columns report the results of the loose IT regime, and the last seven show the results of the strict IT regime. Our results show that EMP volatility is negatively significant irrespective of the choice of the IT regime, which indicates that IT adoption helps stabilize EMP in developing countries. In addition, the results clearly show that IT adoption reduces volatility of changes in international reserves in loose and strict IT regimes. The average estimated ATTs on the volatilities of EMP and changes in international reserves are about $-4 \sim -2$ % and $-3 \sim -2$ %, respectively. On the other hand, our analysis presents no clear evidence that IT adoption would affect volatility of exchange rate changes, although some studies suggest that an IT regime is often related to a floating exchange rate regime (Hu, 2006; Rose, 2007; Lin & Ye, 2009; Brenner & Sokoler, 2010; Taylor, 2001). Our analysis of the decomposition of EMP generally shows that a reduction in EMP volatility originates from the international reserves component under an IT regime. The policy commitment to an IT regime improves the credibility of monetary policy conduct,

[23] For robustness checks, we also estimate the ATT by using an alternative sample including some non-IT countries that were excluded from our baseline analysis to ensure the comparability of treatment and control groups. The results are generally consistent with the baseline findings (see Tables 3.7 and 3.8).

which can mitigate speculative behaviors of market participants. Thus, once an IT regime is adopted, central banks may not necessitate the intervention in the foreign exchange market so that international reserves holdings become more stable.

For the better understanding, we also evaluate the IT effect for sub-samples of developing countries by dividing our full sample of developing countries into the groups of low- and middle-income developing countries.[24] Tables 3.5 and 3.6 report the probit estimates and the ATTs on the volatilities of EMP and its components for each of the two groups of low- and middle-income developing countries, respectively. Our results show clear evidence that the IT adoption has a beneficial impact on the volatilities of EMP and changes in international reserves in middle-income developing countries. However, our analysis fails to present clear evidence of the IT effectiveness in low-income developing countries. These results imply that the IT adoption would enhance the policy credibility mainly in middle-income developing countries.

3.3 Conclusion

This study has applied the PSM method to examine whether an IT regime helps stabilize EMP and its two components. The empirical results have indicated that an IT regime would help stabilize EMP. In addition, our analysis has provided evidences that an IT regime lessens volatility of changes in international reserves, while our results show no clear evidence that an IT regime affects exchange rate variability. These findings suggest that the policy commitment to an IT regime improves the credibility of monetary policy conduct. Under an IT regime, central banks would not be required to intervene in the foreign exchange market. More interestingly, our findings have also shown that an IT regime is more beneficial for middle-income developing countries rather than for low-income developing countries.

[24] The developing countries whose real GDP per capita in 2013 is below and above 6, 000 USD are classified into the low- and middle- income developing countries, respectively. For the robustness check, we also estimate our models by using the critical real GDP per capita of 8,000 USD. The results are qualitatively similar.

Table 3.1. Inflation targeting developing countries and starting years

Country	Starting Year	
	Inflation targeting (loose)	Inflation targeting (strict)
Armenia	2006	2006
Brazil	1999	1999
Chile	1991	2000
Colombia	2000	2000
Ghana	2003	2007
Guatemala	2005	2006
Hungary	2001	2001
Indonesia	2005	2006
Mexico	1995	2001
Peru	2002	2002
Philippines	2002	2002
Poland	1999	1999
Romania	2005	2006
Thailand	2000	2000
Turkey	2002	2006
South Africa	2000	2000

Note: Targeting dates are taken from De Mendonca and De Guimaraes e Souza (2012), Thornton (2016), Rose (2007), and Lin and Ye (2009).

Table 3.2. Control group countries

Afghanistan	Gabon	Niger
Albania	Gambia, The	Nigeria
Algeria	Georgia	Oman
Angola	Grenada	Pakistan
Anguila	Guinea	Panama
Antigua and Barbuda	Guinea-Bissau	Papua New Guinea
Argentia	Guyana	Paraguay
Aruba	Haiti	Qatar
Azerbaijan	Honduras	Russian Federation
Bahamas, The	Hong Kong, China	Rwanda
Bahrain	India	Samoa
Bangladesh	Iran, Islamic Rep.	Sao Tome and Principe
Barbados	Iraq	Senegal
Belarus	Jamaica	Serbia, Republic of
Belize	Jordan	Seychelles
Benin	Kazakhstan	Sierra Leone
Bhutan	Kenya	Solomon Islands
Bolivia	Kuwait	Sri Lanka
Bosnia and Herzegovina	Kyrgyz Republic	St. Kitts and Nevis
Botswana	Lao PDR	St. Lucia
Brunei	Lebanon	St. Vincent and the Grenadines
Bulgaria	Lesotho	Sudan
Burundi	Liberia	Suriname
Cambodia	Libya	Swaziland
Cameroon	Macao	Syrian Arab Republic
Cape Verde	Macedonia, FYR	Tajikistan
Central African Republic	Madagascar	Tanzania
Chad	Malawi	Togo
China	Malaysia	Tonga
Comoros	Maldives	Trinidad and Tobago
Congo, Rep.	Mali	Tunisia
Costa Rica	Manaco	Uganda
Croatia	Mauritania	Ukraine
Djibouti	Mauritius	United Arab Emirates
Dominica	Mongolia	Uruguay
Dominican Republic	Montserrat	Vanuatu
Ecuador	Morocco	Venezuela
Egypt, Arab Rep.	Mozambique	Vietnam
El Salvador	Myanmar	Yemen, Rep.
Equatorial Guinea	Namibia	Zambia
Eritrea	Nepal	Zimbabwe
Ethiopia	Netherlands Antilles	
Fiji	Nicaragua	

Table 3.3. Estimates of propensity scores

	Loose IT	Strict IT
Inflation (lag)	-0.024***	-0.060***
	(0.007)	(0.011)
GDP per capita growth	2.944**	1.592
	(1.156)	(1.288)
Broad money growth	-0.006	-0.007
	(0.004)	(0.005)
Fiscal balance	-0.003**	-0.005***
	(0.001)	(0.001)
Exchange rate regime	1.264***	1.395***
	(0.109)	(0.119)
Trade openness	-0.011***	-0.012***
	(0.002)	(0.002)
Financial openness	0.137***	0.199***
	(0.042)	(0.045)
No. of obs.	1329	1329
Pseudo-R^2	0.36	0.44

Notes: Constant terms and year trend are included but not reported. Robust standard errors are presented in parenthesis. *, **, and *** indicate the significant level of 10 %, 5 %, and 1 %, respectively.

Table 3.4. Estimates of the treatment effects

	Loose IT							Strict IT						
	Nearest-neighbor	3-nearest-neighbor	Radius		Kernel		Local linear	Nearest-neighbor	3-nearest-neighbor	Radius		Kernel		Local linear
			r=0.05	r=0.10	Gaussian	Epanechn				r=0.05	r=0.10	Gaussian	Epanechn	
Exchange market pressure	-2.171	-2.553	-2.171	-2.500	-2.444	-2.179	-2.244	-1.806	-3.667	-3.770	-3.268	-3.399	-3.856	-3.481
	(1.033)**	(2.049)	(1.929)	(1.803)	(1.776)	(1.942)	(1.710)	(0.869)**	(1.078)***	(1.985)*	(1.893)*	(1.876)*	(2.002)*	(1.216)***
	[1.208]*	[1.357]*	[1.003]**	[0.915]***	[0.867]***	[0.934]**	[0.860]***	[0.980]*	[1.331]***	[1.267]***	[1.085]***	[1.180]***	[1.165]***	[1.074]***
Exchange rate depreciation	-0.120	-0.268	-0.356	-0.208	-0.251	-0.384	-0.315	-0.178	-0.024	-0.160	-0.045	-0.056	-0.183	-0.151
	(0.365)	(0.404)	(0.595)	(0.557)	(0.549)	(0.599)	(0.494)	(0.412)	(0.329)	(0.465)	(0.445)	(0.442)	(0.469)	(0.430)
	[0.381]	[0.491]	[0.450]	[0.375]	[0.357]	[0.461]	[0.397]	[0.409]	[0.459]	[0.404]	[0.370]	[0.378]	[0.417]	[0.431]
Change in international reserve	-2.082	-2.082	-1.699	-2.016	-1.922	-1.693	-1.797	-1.530	-2.999	-3.286	-2.710	-2.821	-3.334	-2.961
	(1.054)**	(2.047)	(1.888)	(1.767)	(1.741)	(1.900)	(1.643)	(0.954)	(1.085)***	(1.957)*	(1.869)	(1.853)	(1.974)*	(1.169)**
	[1.170]*	[1.351]	[0.922]*	[0.934]**	[0.917]**	[0.903]*	[0.926]*	[1.026]	[1.421]**	[1.257]***	[1.126]**	[1.094]***	[1.167]***	[1.109]***

Notes: 0.06 fixed bandwidth is used for kernel and local linear regression matching. The analytical standard errors are shown in parentheses and the bootstrapped standard errors are shown in brackets (they are based on 500 replications of the data). *, ** and *** indicate the significant level of 10 %, 5% and 1%, respectively.

Table 3.5. Estimates of propensity scores

	Loose IT	Strict IT
Sub-sample: low-income developing countries		
Inflation (lag)	-0.018	-0.043***
	(0.012)	(0.015)
GDP per capita growth	2.487	2.712
	(1.608)	(1.895)
Broad money growth	-0.006	-0.010
	(0.006)	(0.007)
Fiscal balance	0.001	0.005
	(0.017)	(0.022)
Exchange rate regime	0.656***	0.807***
	(0.153)	(0.167)
Trade openness	-0.004	-0.004
	(0.002)	(0.003)
Financial openness	0.180***	0.233***
	(0.054)	(0.061)
No. of obs.	666	666
Pseudo- R^2	0.23	0.29
Sub-sample: middle-income developing countries		
Inflation (lag)	-0.041***	-0.086***
	(0.012)	(0.018)
GDP per capita growth	5.132***	2.593
	(1.526)	(2.408)
Broad money growth	-0.013**	-0.010
	(0.007)	(0.009)
Fiscal balance	-0.002	-0.004**
	(0.001)	(0.002)
Exchange rate regime	1.984***	2.005***
	(0.204)	(0.204)
Trade openness	-0.013***	-0.012***
	(0.002)	(0.003)
Financial openness	0.157**	0.204***
	(0.065)	(0.068)
No. of obs.	663	663
Pseudo- R^2	0.57	0.61

Notes: Constant terms and year trend are included but not reported. Robust standard errors are presented in parenthesis. *, **, and *** indicate the significant level of 10 %, 5 %, and 1 %, respectively.

Table 3.6. Estimates of the treatment effects

	Loose IT							Strict IT						
	Nearest-neighbor	3-nearest-neighbor	Radius		Kernel		Local linear	Nearest-neighbor	3-nearest-neighbor	Radius		Kernel		Local linear
			r=0.05	r=0.10	Gaussian	Epanechn				r=0.05	r=0.10	Gaussian	Epanechn	
Sub-sample: low-income developing countries														
Exchange market pressure	-1.057	-0.745	-0.916	-1.069	-1.203	-0.896	-0.693	0.650	0.159	-0.337	-0.312	-0.520	-0.371	-0.442
	(1.388)	(1.467)	(1.205)	(1.103)	(1.087)	(1.214)	(1.762)	(0.946)	(1.332)	(1.316)	(1.194)	(1.179)	(1.329)	(1.006)
	[1.447]	[1.356]	[0.753]	[0.709]	[0.799]	[0.722]	[0.719]	[1.376]	[1.282]	[0.773]	[0.688]	[0.748]	[0.796]	[0.718]
Exchange rate depreciation	-0.303	-0.183	-0.336	-0.336	-0.340	-0.321	-0.343	0.212	-0.026	-0.010	-0.024	-0.039	-0.005	-0.083
	(0.262)	(0.248)	(0.435)	(0.394)	(0.387)	(0.438)	(0.309)	(0.251)	(0.536)	(0.286)	(0.265)	(0.262)	(0.288)	(0.264)
	[0.371]	[0.617]	[0.227]	[0.220]	[0.237]	[0.219]	[0.227]	[0.447]	[0.467]	[0.213]	[0.209]	[0.196]	[0.221]	[0.222]
Change in international reserve	-1.096	-0.697	-0.931	-1.182	-1.241	-0.940	-0.783	0.635	-0.571	-0.505	-0.460	-0.674	-0.505	-0.647
	(1.416)	(1.463)	(1.148)	(1.053)	(1.040)	(1.156)	(1.802)	(1.080)	(1.586)	(1.324)	(1.195)	(1.179)	(1.338)	(1.252)
	[1.470]	[1.391]	[0.795]	[0.761]	[0.778]	[0.749]	[0.736]	[1.550]	[1.692]	[0.805]	[0.778]	[0.781]	[0.782]	[0.797]
Sub-sample: middle-income developing countries														
Exchange market pressure	-2.776	-5.951	-4.707	-5.000	-4.948	-4.769	-5.231	-4.293	-10.067	-8.670	-8.790	-8.783	-8.572	-8.050
	(1.194)**	(9.094)	(5.130)	(4.700)	(4.607)	(5.154)	(2.587)**	(1.260)***	(4.079)**	(6.215)	(5.607)	(5.590)	(6.125)	(3.041)***
	[2.431]	[3.101]*	[2.582]*	[2.526]**	[2.372]**	[2.546]*	[2.831]*	[1.413]***	[2.581]***	[2.487]***	[2.329]***	[2.416]***	[2.606]***	[2.534]***
Exchange rate depreciation	0.613	-0.623	-0.809	-0.198	-0.308	-0.816	-0.469	1.210	0.018	-0.246	-0.385	-0.271	-0.182	-0.693
	(0.462)	(0.856)	(0.560)	(0.518)	(0.509)	(0.563)	(1.148)	(0.451)	(1.027)	(0.491)	(0.456)	(0.455)	(0.489)	(0.912)
	[0.475]	[1.261]	[1.374]	[0.838]	[0.871]	[1.368]	[0.959]	[0.498]**	[0.865]	[0.990]	[0.916]	[0.915]	[0.943]	[1.006]
Change in international reserve	-2.422	-4.954	-3.481	-4.253	-4.144	-3.530	-4.192	-3.297	-8.504	-6.999	-7.049	-7.144	-6.936	-6.067
	(1.156)**	(9.084)	(5.117)	(4.687)	(4.594)	(5.141)	(2.384)*	(1.234)***	(4.037)**	(6.213)	(5.606)	(5.588)	(6.123)	(2.957)**
	[2.539]	[3.288]	[2.378]	[2.353]*	[2.206]*	[2.425]	[2.415]*	[1.347]**	[2.688]***	[2.238]***	[2.254]***	[2.226]***	[2.581]***	[2.321]**

Notes: 0.06 fixed bandwidth is used for kernel and local linear regression matching. The analytical standard errors are shown in parentheses and the bootstrapped standard errors are shown in brackets (they are based on 500 replications of the data). *, ** and *** indicate the significant level of 10 %, 5% and 1%, respectively.

Table 3.7. Estimates of propensity scores (alternative sample)

	Loose IT	Strict IT
Inflation (lag)	-0.022***	-0.058***
	(0.007)	(0.011)
GDP per capita growth	3.753***	2.688**
	(0.894)	(1.059)
Broad money growth	-0.008**	-0.011**
	(0.004)	(0.005)
Fiscal balance	-0.002	-0.004***
	(0.001)	(0.001)
Exchange rate regime	1.122***	1.241***
	(0.091)	(0.103)
Trade openness	-0.008***	-0.009***
	(0.001)	(0.002)
Financial openness	0.142***	0.200***
	(0.036)	(0.039)
No. of obs.	1825	1825
Pseudo-R^2	0.30	0.37

Notes: Constant terms and year trend are included but not reported. Robust standard errors are presented in parenthesis. *, **, and *** indicate the significant level of 10 %, 5 %, and 1 %, respectively.

Table 3.8. Estimates of the treatment effects (alternative sample)

	Loose IT							Strict IT						
	Nearest-neighbor	3-nearest-neighbor	Radius		Kernel		Local linear	Nearest-neighbor	3-nearest-neighbor	Radius		Kernel		Local linear
			r=0.05	r=0.10	Gaussian	Epanechn				r=0.05	r=0.10	Gaussian	Epanechn	
Exchange market pressure	-5.171	-4.986	-4.190	-3.967	-4.058	-4.372	-4.121	-2.879	-4.809	-5.869	-5.807	-5.627	-5.810	-6.179
	(2.184)**	(1.907)***	(1.435)***	(1.307)***	(1.286)***	(1.445)***	(3.514)	(1.292)**	(1.269)***	(1.642)***	(1.558)***	(1.538)***	(1.647)***	(2.080)***
	[1.729]***	[2.767]*	[1.447]***	[1.290]***	[1.284]***	[1.591]***	[1.397]***	[2.475]	[2.145]**	[2.287]**	[2.235]***	[1.954]***	[2.290]**	[2.293]***
Exchange rate depreciation	-0.166	-0.104	-0.125	-0.036	-0.013	-0.120	-0.152	0.296	0.190	0.154	0.175	0.187	0.144	0.102
	(0.267)	(0.318)	(0.431)	(0.394)	(0.388)	(0.434)	(0.346)	(0.238)	(0.249)	(0.493)	(0.468)	(0.462)	(0.494)	(0.303)
	[0.284]	[0.322]	[0.242]	[0.206]	[0.219]	[0.238]	[0.247]	[0.239]	[0.279]	[0.245]	[0.239]	[0.235]	[0.243]	[0.244]
Change in international reserve	-4.492	-4.330	-3.664	-3.411	-3.504	-3.841	-3.548	-2.397	-4.126	-5.272	-5.164	-4.976	-5.205	-5.541
	(2.133)**	(1.863)**	(1.396)***	(1.272)***	(1.251)***	(1.405)***	(3.435)	(1.293)*	(1.263)***	(1.603)***	(1.522)***	(1.503)***	(1.608)***	(2.085)***
	[1.821]***	[2.484]*	[1.415]***	[1.266]***	[1.260]***	[1.549]***	[1.395]**	[2.229]	[2.199]*	[2.195]**	[2.192]**	[2.000]**	[2.192]**	[2.318]**

Notes: 0.06 fixed bandwidth is used for kernel and local linear regression matching. The analytical standard errors are shown in parentheses and the bootstrapped standard errors are shown in brackets (they are based on 500 replications of the data). *, ** and *** indicate the significant level of 10 %, 5% and 1%, respectively.

Chapter 4

Inflation targeting and central bank credibility: Any difference between advanced and developing economies?

4.1 Introduction

Since monetary policy is a useful tool to quickly, but temporarily, achieve macroeconomic objectives, central banks influenced by political or governmental authorities tend to emphasize short-term economic expansions, leading to the inflationary policy bias (Cukierman, 1994; Walsh, 2005). One possible solution to mitigate such a policy bias is to allow central banks to be sufficiently independent from political influences in stabilizing inflation, thereby enhancing their credibility in financial markets. Indeed, many countries, particularly advanced countries, have granted autonomy to their monetary authorities in the past few decades. The monetary autonomy issue is more substantial in developing countries than it is in advanced countries. Fry (1998) suggests that macroeconomic policy including monetary policy in developing countries is often dominated by government fiscal positions. According to his fiscal dominance hypothesis of central bank independence, the size of the government`s deficit and the methods by which it is financed determine the central banks' independence in developing countries. In line with these arguments, the notion of central bank independence (CBI) has emerged as an effective means of insulating monetary policy from political interference to achieve long-term economic stability without the monetization of public debt and the loss of inflation-fighting credibility (Bernhard, 2002; Garriga, 2016; Eijffinger & De Haan, 1996).[25]

[25]CBI generally refers to the freedom of monetary policymakers from direct political or governmental influence in the conduct of policy. Bernhard (2002) and Garriga (2016) argue that CBI is the central bank's ability to control the instrument of monetary policy or, in contrast, is the set of restrictions to the influence of the government on the central bank's arrangement of monetary policy. Eijffinger and De Haan(1996) highlight

The conventional theory on central bank independence relates to the inflationary bias inherent in monetary policy due to the time inconsistency problem (Kydland & Prescott, 1977; Barro & Gordon, 1983). The 'rules versus discretion' literature initiated by Barro and Gordon (1983) and Rogoff (1985) suggests that the credible delegation of monetary control to an independent central bank can mitigate the time-inconsistency problem and the inflationary bias.[26] From empirical perspectives, most political scientists and economists generally agree with the theoretical argument that central bank independence lowers inflation. There have been many empirical studies performed on the role of central bank independence relating to various aspects, such as monetary policy, financial liberalization, political institutions, democratization, or responses to crises (Adam et al., 2011; Klomp & de Haan, 2009; Reenock et al., 2013; Rosas, 2006). Among them, some works, including Klomp and de Haan (2009) and Lohmann (2006), argue that central bank independence contributes to achieving price stability as well as financial stability.

In the past, central banks tended to maintain confidentiality with less transparency. Some were engaged in commercial banking operations and did not release much information about public finances. However, the recent trend of central bank independence has demanded accountability, legitimacy considerations and guidance, which call for central bank transparency (CBT) (Crowe & Meade, 2008; Dincer & Eichengreen, 2014).[27] Transparency

three types of independence of the central banks, such as personnel, financial, and policy independence. Personnel independence is the limitation to the influence of the government on the membership or tenure of the central bank board. Financial independence reflects restrictions to the capability of the government to use the central bank's loans to finance government budget deficits. Policy independence implies the central bank's ability to formulate and implement the monetary policy, such as setting the goals and/or choosing the monetary policy instrument to achieve its primary objective.

[26]For the economics literature, see, e.g., Barro and Gordon (1983a, 1983b), Rogoff (1985), Lohmann (1992), Cukierman (1992), and Eijffinger and De Haan (1996). For the political science literature, see, e.g., Hirsch and Goldthorpe (1978), Beck (1984), Woolley (1984), Lindberg and Maier (1985), Mayer (1990), and Goodman (1992).

[27]Dincer and Eichengreen (2014) highlight that the rise of central bank transparency can be seen as (1) improving the government's response to the public; (2) a crucial element of accountability or a mechanism allowing the public to assess the consistency of the central bank's actions with a mandate; (3) a way of making market participants more smoothly responsive to monetary policy decisions; and (4) a method of enhancing the credibility of the central bank's commitment.

is an inverse concept of confidentiality. Transparency can be regarded as a necessary mechanism, which enables the public to assess the consistency of a central bank's actions with its mandate and allows the private sector and financial operators to improve their expectations and business decisions (Blinder, 1998; Van der Cruijsen & Demertzis, 2007; Crowe & Meade, 2008). In addition, central bank transparency improves policy credibility as well as policy flexibility. A credible commitment makes a central bank flexible to deviate from a policy target when exceptional conditions occur since the public clearly understands that the deviation is temporary without an inconsistency with long-term targets.

Since the early 1990s, inflation targeting (IT) has been widely adopted as an alternative monetary policy framework in advanced countries. Since the late 1990s, some emerging and developing countries have also introduced an IT regime, although this regime is not yet prevalent in all developing and emerging countries.[28] The main feature of an IT regime is an explicit quantitative inflation target and strong central bank legal commitment to the transparency, accountability, and credibility of price stability when implementing monetary policies (Mishkin, 2000; Mishkin & Savastano, 2001). The argument underlying this feature is that an official announcement of an inflation target improves a central bank's credibility and helps to lower inflation and the volatilities of inflation and real output (Bernanke et al., 1999; Svensson, 1997; Mishkin, 1999).

The conventional view is that the adoption of an IT regime as a reform in the monetary policy context increases the transparency of monetary policy conduct (Bernanke et al., 1999; Faust & Henderson, 2004; Mishkin & Schmidt-Hebbel, 2007; Mishkin & Schmidt-Hebbel, 2002; Svensson, 1999). Crowe (2010) suggests that IT adoption contributes to the convergence in forecast errors, implying that it improves transparency. In addition, some studies, including Mishkin (1999) and Freedman and Otker-Robe (2010),

[28]Indeed, as of 2012, there were 12 advanced economies and 17 emerging and developing countries, according to the IMF classification (De Mendonca & De Guimaraes e Souza, 2012).

discuss the relationship between the introduction of IT and the independence of central banks. Mishkin (1999) argues that an IT regime can eliminate the political pressure on central banks to implement expansionary policies since it enables central banks to focus on price stability in the long run. Freedman and Otker-Robe (2010) highlight that IT countries have passed legislation providing the central bank with the authority to control monetary policy. In spite of growing debates on institutional reforms of central banks, few empirical studies have examined how IT adoption affects central banks' transparency and independence as the institutional reforms, which are closely related to their credibility. Although several studies show the favorable macroeconomic effects of an IT regime, its direct impact on central bank independence and transparency in advanced and developing countries is still unexplored.[29] In addition, the central banks' institutional reform has become more important for developing countries that often face economic and financial instability as well as political pressures. Thus, this study attempts to extend the present IT-related literature by addressing such issues in both advanced and developing countries and to discuss the differences between them.

This study investigates how IT adoption relates to the transparency and independence of central banks by applying the entropy balancing method to mitigate self-selection problems, following several works on the treatment effects (Neuenkirch & Neumeier, 2016; Huang & Yeh, 2014). Policy debates have been conducted to determine the countries that have actually adopted the IT regime in an effective manner (Caballero & Krishnamurthy,

[29]Recent studies on the IT effects on the domestic economic variables include Ball and Sheridan (2005),Vega and Winkelried (2005), Batini and Laxton (2007), Goncalves and Salles (2008), Lin and Ye (2009), de Mendonca and de Guimaraes e Souza (2012), Samarina et al. (2014),and Thornton (2016). Several works have studied the effects of IT regimes on some macroeconomic conditions other than inflation, inflation volatility, and output volatility via the PSM method. For example, Lin (2010) shows that the IT regime reduces levels of real and nominal exchange rate volatility, while increasing international reserves in developing countries, although it intensifies the exchange rate instability and reduces international reserves in advanced economies. Lucotte (2012) indicates that IT regimes have a positive significant effect on tax revenue collection in developing countries. Kadria and Aissa (2016) conclude that an IT regime can help reduce budget deficits in developing economies. Balima et al. (2017) show that IT adoption reduces levels of sovereign debt risk.

2005; Mishkin, 2004; Sims, 2005; Svensson, 1997). Among various definitions of an adoption year, this study uses the 'loose' and 'strict' types of adoption years, following Rose (2007), Lin (2010), and Samarina et al. (2014). A loose adoption year represents the earliest adoption year in which inflation targets are announced without strong commitments, and a strict adoption year represents the latest year in which credible commitments are made to achieve inflation targets with a single inflation target via monetary policies. Moreover, this study attempts to examine heterogeneous features of the performance of an IT regime, as in the work of Carare and Stone (2006), Mishkin (2004), and Fraga et al. (2003). To check the validity of the results derived from the entropy balancing method, this study further applies the standard panel approaches, including the dynamic panel estimation method developed by Arellano and Bover (1995) and Blundell and Bond (1998), as alternative methods, as in the works of Neuenkirch and Neumeier (2016).

The empirical analysis shows several important findings. First, the entropy balancing approach presents clear evidence supportive of the role of IT in improving central bank transparency in both advanced and developing countries. Second, more importantly, the results suggest a clear difference between advanced and developing countries in the IT effects on central bank independence. Advanced countries that have adopted an IT regime experience higher central bank independence, while developing countries with an IT adoption experience lower central bank independence. The standard panel approaches as alternative methods confirm the empirical validity of the results of the entropy balancing analysis. The negative effect of an IT regime on central bank independence in developing countries may reflect the argument in the political economy context that central banks are granted stringent monetary authority in pursuit of price stability at the expense of losing independence from political authorities that often tend to keep central banks under their authority.

Third, our analysis also presents heterogeneous effects on transparency and the independence of central banks. Concerning the IT effects on transparency, a more flexible exchange rate causes an IT regime to be less effective at improving transparency in advanced countries, while it causes an IT regime to be more effective at improving transparency in developing countries. Regarding the role of fiscal discipline in the effectiveness of an IT regime, developing countries with a high fiscal discipline have less motivation to improve transparency. On the other hand, the heterogeneous effects on independence reveal that the higher flexibility of the exchange rate causes an IT regime to be less effective at improving independence in advanced countries. In addition, the negative effect of an IT regime on independence decreases over time in developing countries.

The rest of this paper is organized as follows. Section 2 presents a literature review on the adoption of IT, central bank independence and transparency. In section 3, we estimate the average treatment effects on the treated (ATT) by applying entropy balancing methods. Then, we present our empirical results of the IT effects on central bank transparency and independence and discuss their intuitions by identifying their differences between advanced and developing countries. Section 4 presents our conclusions.

4.2 Literature review

4.2.1 Measures of central bank independence and transparency

Since the 1990s, many central banks in advanced countries have started adopting an IT regime and the credibility of a central bank has become more important for monetary authorities because a lower level of central bank credibility leads to less effectiveness of monetary policy. Central bank independence (CBI) and central bank transparency (CBT) might play a crucial role in improving the credibility of central banks since they may reduce time inconsistency problems of monetary policy and enable market participants to assess the consistency of a central bank's actions with its mandate. With the increasing importance of

credibility in the conduct of monetary policy, we need appropriate measurements of CBI and CBT to capture the credibility of a central bank's monetary policy.

Cukierman (1994) highlights that there are four main types of CBI indices, such as legal indices derived from the charters of central banks, questionnaire-based indices, the actual turnover of central bank governors, and the political vulnerability of central banks. Some studies use measures of de facto CBI, which are based on questionnaires (Blinder, 2000; Cukierman et al., 1992; Fry et al., 1996) or in terms of the turnover rate of central bank governors (Cukierman & Webb, 1995; Cukierman et al., 1992; De Haan & Siermann, 1996). The measures based on questionnaires may be less reliable partly because of their narrow coverage, problematic cross-sectional comparability, and little within-country variation (Garriga, 2016). Cukierman et al. (1992) suggests that the central bank governors' turnover rate is an appropriate measure in predicting the impact of CBI in developing countries.

Many empirical studies also apply de jure measures of CBI based on central banks statutes instead of applying de facto measures (Alesina et al., 1989; Cukierman, 1992; Cukierman, et al., 1992; Grilli et al., 1991). Alesina et al. (1989) and Grilli et al. (1991) build de jure measures of CBI based on various factors, such as political, financial, and economic independence.[30] Cukierman et al. (1992) construct the CBI index (the CWN index) based on

[30]Alesina et al. (1989) construct the CBI index partly based on studies by Masciandaro and Tabellini (1988) that consider two dimensions of independence, such as political independence (the central bank's ability to formulate and implement the monetary policy, such as setting the goals and/or choosing the monetary policy instrument) and financial independence (the degree of restrictions to the government's ability to use central bank's loans to finance government budget deficits).Alesina et al. (1989) emphasizes the criterion related to political aspects and suggest that the degree of CBI is affected by four main criteria: (i) institutional and formal relationships between central banks and the executives (for instance, the identification of the responsibility for (and frequency of) the appointment of a central bank's governor, the presence of government officials on the board of directors of central banks, and the requirements of the government's approval of specific policies); (ii) informal relationships and contacts between a central bank and executive members; (iii) budgetary and financial relationships between a central bank and the executive; and (iv) macroeconomic relationships, such as the existence of rules forcing a central bank to accommodate fiscal policy.

Grilli et al. (1991) distinguish two types of CBI: political independence (the ability of a central bank to choose the objectives of monetary policy) and economic independence (the ability of a central bank to choose its instruments). They measure political independence based on three aspects of a monetary regime: (i) the procedure for appointing the members of the central bank government bodies; (ii) the relationship between these bodies and the government; and (iii) the formal responsibilities of the central bank. In addition, they measure economic independence based on (i) the influence of the government in determining how much to

the legal independence reflecting the independence of the chief executive officer (CEO) of the central bank, the central banks' independence in policy formation, its objective or mandate, and the stringency of limits on its lending to the public sector. Recently, Dincer and Eichengreen (2014) elaborate de jure measures of CBI by incorporating some legal aspects, such as limits on the reappointment of the CEO and board members, restrictions on government representation on the board, and the intervention of the government in exchange rate policy formulation, into the criteria of the CWN index. In addition, Garriga (2016) constructs the comprehensive dataset on the de jure CBI measures that identify statutory reforms affecting the CBI, their direction, and the attributes necessary to build the CWN index. Garriga (2016) highlights that de jure measures are suitable to explore the determinants of the independence of monetary institutions, although the indices of legal CBI have been criticized.[31] Bodea and Hicks (2014) also attempt to code CBI information annually and directly identify reform years in their coding of the reforms of the past twenty-five years. They code the texts of approximately 80 countries for the year 1973 to 2008 to update the CWN index of CBI. CWN's original data covers 72 countries for four decades (1950–59, 1960–72, 1973–79, and 1980–89). Recently, Bodea and Hicks (2015) updated their CBI data for 144 countries, covering the period from 1972 to 2015.

Regarding the measurement of central bank transparency (CBT), Fry et al. (2000) is the first study to construct comprehensive measures of CBT. The strength of the measures of Fry et al.(2000) is its wide country coverage based on a survey of 94 central banks, and its limitation is the relatively restrictive definition of transparency. Fry et al. (2000) measure

borrow from the central bank; and (ii) the nature of the monetary instruments under the control of the central bank. Debelle and Fischer (1994) define political and economic independence as a goal and instrument independence, respectively. Arnone et al. (2009) also construct the CBI indicator based on the methodology proposed by Grilli et al. (1991).

[31] De jure measures are often criticized since laws do not consider all possible conditions that might affect the relationships between a central bank and the government. Moreover, the facts described in the laws often deviate from the actual practices, especially in developing countries, and even independent central banks can be influenced by the government's appointments and threats to the bank (Lohmann, 1998).

transparency based on an equally weighted average of three indicators: (i) whether a central bank provides prompt public-explanations of its policy decisions; (ii) the frequency and form of forward-looking analysis provided to the public; and (iii) the frequency of bulletins, speeches, and research papers.[32] Eijffinger and Geraats (2006) distinguish more aspects of transparency and consider more than one point in time. Their indices distinguish political transparency (openness about policy objectives), economic transparency (openness about data, models, and forecasts), procedural transparency (openness about the way decisions are made, achieved mainly through the release of minutes and votes), policy transparency (openness about the policy implications, achieved through prompt announcement and explanation of decisions), and operational transparency (openness about the implementation of those decisions—in other words, about control errors and macroeconomic disturbances affecting their magnitude). The advantage of this approach is its comprehensiveness, including multi-dimensional definitions of transparency, but its limitation is that the transparency index is constructed for only nine central banks.

In general, most studies measure CBT using either a very limited number of central banks or a single point in time. Following the five elements of Eijffinger and Gerrats (2006), Crowe and Meade (2008) construct the measures of CBT covering 37 central banks over 2 periods. Dincer and Eichengreen (2007) replicate and extend the indices of Eijffinger and Geraats (2006), and Dincer and Eichengreen (2014) update their CBT index covering over 100 central banks during 13 periods (1998 to 2010). This study uses the indices of CBI and CBT constructed by Dincer and Eichengreen (2014) in our baseline analysis. For the robustness check, we also consider the CBI index of Garriga (2016) and Bodea and Hicks (2015) as alternative measures of CBI.

[32] Chortareas et al. (2002, 2003) adopt a slightly different approach, focusing on two aspects of CBT: (i) the publication of forecasts and (ii) the release of information on the monetary policy decisions; these two aspects correspond broadly to the categories of economic transparency and policy transparency, respectively.

4.2.2 Consequences and determinants of central bank independence and transparency

Achieving macroeconomic and financial stability requires monetary policy credibility, which is closely related to CBI and CBT.[33] Concerning the consequences of CBI, an independent central bank can control inflation through the reduction of the risk of time inconsistency in monetary policy (Kydland & Prescott, 1977; Barro & Gordon, 1983; Haga, 2015). Many studies show a negative effect of CBI on inflation, mainly focusing on advanced countries (Grilli et al., 1991; Cukierman, 1992; Cukierman et al., 1992; Alesina & Summers, 1993; Eijffinger et al., 1998; Crowe & Meade, 2008; Dincer & Eichengreen, 2014).[34] However, some studies have doubted the negative relationship between CBI and inflation (Campillo & Miron, 1997; Forder, 1998; King & Ma, 2001; Daunfeldt & de Luna, 2008; Jacome & Vasquez, 2008). Ismihan and Ozkan (2004) provide a theoretical explanation for the less significant relationship between CBI and inflation, arguing that although CBI contributes to lower inflation in the short term, the effects on growth make CBI less likely to achieve lower inflation in the long-term. Thus, the relationship between CBI and inflation is still controversial particularly in developing countries. Some studies suggest that CBI is significantly and negatively related to inflation in developing countries (Cukierman, 1992; Cukierman et al., 1992; De Haan & Kooi, 2000; Brumm, 2006; Garriga, 2016), while others fail to present clear linkages between CBI and inflation in developing

[33]Both transparency and independence tend to enhance credibility (Eijffinger & Hoeberichts, 2002). Eijffinger et al. (2006) indicate that transparency increases central bank credibility, flexibility and reputation.

[34]Dreher et al. (2008) suggest the possibility of a reverse relationship between inflation and CBI, often based on turnover rates, since central bankers who have failed to control inflation have often been replaced. In addition, some studies examine how CBI not only relates to inflation but also to other macroeconomic conditions, such as inflation volatility and output, and the credibility of monetary policy (Bodea & Hicks, 2015; Cukierman, 1992; Cukierman et al., 2002; Cukierman et al., 1992; Persson & Tabellini, 1990; Rogoff, 1985; Dincer & Eichengreen, 2014; Garriga, 2016). Moreover, some empirical studies focus on the association between CBI and financial market performance (Klomp & de Haan, 2009; Kuttner & Posen, 2010; Moser & Dreher, 2010; Forch & Sunde, 2012).

countries (Cukierman, 1992; Cukierman et al., 1992; Campillo & Miron, 1997; Ismihan & Ozkan, 2004; Arnone et al., 2009; Sturm & de Haan, 2001).

Regarding the consequences of CBT, many studies explore its effects on macroeconomic variables, including inflation and variabilities of inflation and output, using various forms of transparency.[35] By employing the CBT index of Fry et al. (2000), Chortareas et al. (2002) find that information disclosure reduces inflation, and Cecchetti and Krause (2002) show that a better macroeconomic performance consisting of inflation and output variabilities is associated with the transparency of central banks rather than with their independence. In addition, by using the index of CBT constructed by Demertzis and Hallett (2007) indicate that CBT helps reduce inflation variability but its impacts on the level of inflation and output and the variability of output in nine OECD countries are less clear. Moreover, Dincer and Eichengreen (2007, 2014) construct the index of CBT and find that transparency lowers inflation and the variabilities of inflation and output.

Although many studies exist on the consequences of CBI and CBT, a relatively small number of empirical studies explore their determinants. D'Amato et al. (2009) evaluate the determinants of CBI and present that OECD countries experiencing higher inflation with lower political instability have more incentive to increase CBI, while non-OECD countries with more trade openness, higher GDP per capita, higher inflation, and less developed fiscal systems tend to have greater CBI. Dincer and Eichengreen (2014) also evaluate the determinants of CBI and suggest that independence is likely to increase in countries with trade openness under IMF programs, while it tends to decrease in countries with a British

[35]Studies on the effect of transparency on financial markets also provide favorable results. Fratzscher (2006) suggests that transparency lowers the exchange rate volatility and uncertainty. De Goeij and Marquering (2006) and Ranaldo and Rossi (2010) find that the bond market reacts significantly to central bank communication. Neuenkirch (2012) provides the evidence that transparency lowers the bias in money market expectations and dampens their variation. Reeves and Sawicki (2007) suggest that the publication of the inflation report lowers stock market volatility. Papadamou et al. (2014) provide the empirical evidence that transparency helps stabilize stock market volatility, implying that it is beneficial for maintaining financial stability.

legal practice. Dincer and Eichengreen (2007, 2014) generally highlight the determinants of CBT and confirm that transparency is greater in countries with high-income levels, flexible exchange rate regimes, developed financial markets, and stable political systems.

4.2.3 Inflation targeting

During the past decades, the IT regime has been widely adopted by several central banks as a policy measure. On the theoretical front, clear predictions have not been made regarding the effectiveness of IT adoption. Several studies, including Bernanke and Woodford (2005), Caballero and Krishnamurthy (2005), Mishkin (2000, 2004), and Sims (2005), suggest that the current lack of institutional development and inconsistencies among macroeconomic conditions in developing countries could undermine the success of IT and result in worse outcomes. However, a number of other studies, such as Svensson (1997), Mishkin (1999), and Bernanke et al. (1999), argue that as the credibility of central banks is initially low in emerging economies, the adoption of IT renders monetary policies more credible, thereby contributing to better macroeconomic outcomes in these economies.

Some empirical studies investigate the driving factors for central banks to adopt the IT regime as a monetary policy conduct. Hu (2006) suggests that a country's decision to adopt an IT regime may be influenced by several economic and institutional factors, such as fiscal position, financial depth, exchange rate flexibility, and the monetary autonomy of the central bank. Goncalves and Carvalho (2008, 2009) indicate that countries with lower debts, higher inflation, and flexible exchange rates are more likely to adopt an IT regime. Ismailov et al. (2016) find that the desires to keep or enhance anti-inflation credibility and a more flexible exchange rate without a nominal exchange rate anchor are the main driving forces to adopt an IT regime in high-income countries, while a high level of debts may hinder the countries' desirability of IT adoption in low-income countries. On the other hand, there have been many empirical studies on how an IT regime affects macroeconomic variables. Among

them, Vega and Winkelried (2005), Lin and Ye (2007, 2009), De Mendonca and de Guimaraes e Souza (2012), and Samarina et al. (2014) indicate that IT adoption lowers inflation, inflation volatility, and output volatility.[36] The possible reason of the IT effectiveness is that central banks may improve the credibility of their monetary policy by the adoption of the IT regime.

In contract to many works on the macroeconomic effects of an IT regime, a relatively small number of empirical studies have been conducted on its impacts on the central bank's institutional structure reforms, particularly on CBI and CBT. Mishkin (1999) and Batini and Laxton (2007) discuss that an IT adoption would promote greater de facto or de jure independence of the central bank since its adoption focuses on price stability and is associated with less political pressure to implement expansionary policies. Mishkin and Schmidt-Hebbel (2002) suggest that an IT regime is associated with a greater increase in transparency and accountability. To the best of our knowledge, few comprehensive empirical studies have been conducted regarding the impacts of an IT regime on transparency and the independence of central banks (CBT and CBI). In addition, the central banks' institutional reform has become more important for developing countries that often face economic and financial instability as well as political pressures. Thus, this study attempts to extend the present IT-related literature by addressing such issues in both advanced and developing countries and to discuss the difference between them.

[36]Several works have studied the effects of IT regimes on some macroeconomic conditions other than inflation, inflation volatility, and output volatility. For example, Lin (2010) shows that the IT regime reduces levels of real and nominal exchange rate volatility, while increasing international reserves in developing countries, although it intensifies exchange rate instability and reduces international reserves in advanced economies. Lucotte (2012) indicates that IT regimes have a positive significant effect on tax revenue collection in developing countries. Kadria and Aissa (2016) conclude that an IT regime can help reduce budget deficits in developing economies. Balima et al. (2017) show that IT adoption reduces levels of sovereign debt risk.

4.3 Empirical analysis

4.3.1 Methodology

Following Ball and Sheridan (2005), previous studies on the effects of IT regimes have applied the difference-in-differences (DID) method (Goncalves & Salles, 2008; Batini & Laxon, 2007; Thornton, 2016). However, the DID method can suffer from identification problems related to the timing of the adoption of IT among non-IT countries as well as from self-selectivity problems related to policy adoption (Bertrand et al., 2004; Lin & Ye, 2007). Recently, several studies have employed the propensity score matching (PSM) framework to mitigate such problems (Vega & Winkelried, 2005; Lin & Ye, 2007, 2009; Lin, 2010; de Mendonca & de Guimaraes e Souza, 2012; Samarina et al., 2014). The PSM method is a statistical matching technique that estimates the effect of a treatment by taking into account observed covariates that predict receiving the treatment, and it attempts to mitigate biases resulting from the presence of confounding variables in estimates of treatment effects obtained from simple comparisons of the outcomes between units with treatment versus those without treatment. A country's decision to adopt an IT regime can be endogenous since the policy approach is often influenced by various macroeconomic, financial, and institutional conditions.

This study evaluates the IT effects on CBI and CBT over 83 advanced and developing countries during the period from 1998 to 2010, by applying the entropy balancing method. Entropy balancing is employed to select the best matches for the treated groups and to estimate the ATT, a method defined by Hainmueller (2012). Entropy balancing can be applied to observational studies with a binary treatment and works as a reweighting scheme that incorporates covariate balance at a level specified by a researcher. Since entropy balancing is a method of combining matching and regression analysis, it has some advantages compared to other treatment effect estimators (Neuenkirch & Neumeier,

2016).[37]Among them, one crucial advantage is that entropy balancing is non-parametric in the sense that no empirical model for either the outcome variable or the selection into treatment needs to be specified to decrease potential types of misspecification. The advantage of entropy balancing over regression-based analysis is that entropy balancing can avoid multicollinearity since the reweighting scheme orthogonalizes the covariates subject to a treatment indicator. Another advantage compared to other matching methods is that entropy balancing ensures a high balance of covariates between treatment and control groups even in small samples. Entropy balancing assigns the vector of weights to the control units and allows the involvement of any non-negative values to create an artificial control group that represents the perfect image of the treatment group. Thus, the entropy balancing approach can be seen as a generalization of conventional matching approaches.[38]

Entropy balancing is a two-step procedure. The first step is to compute the weights, which are assigned to units not subject to treatment, and the weights are selected to satisfy prespecified balanced constraints, including the sample moments of pretreatment characteristics, by remaining at the same time as close as possible to uniform base weights. In this study, the balanced constraints necessitate equal means (first sample moment) of covariates across the treatment and control group to ensure that the control units are as similar as possible to the units of treatment. As the second step, we regress the outcome of our interest (CBI or CBT) on treatment (IT dummy) to estimate the treatment effect on the

[37] Entropy balancing also has several limitations over other matching methods, such as propensity score matching. Among them, one limitation is that there exists no weighting solution if the balancing constraints are not consistent. The second limitation can occur when the balanced constraints are consistent but there are no set of positive weights that satisfy the balanced constraints. The last limitation is that the solution includes an extreme adjustment to the weights of some control units due to a limited overlapping area. Particularly, if only few control units are similar to the treatment units, these control units may obtain more large weights. Moreover, a small number of highly weighted control units increases the value of variance for the subsequent analysis and may be uncomfortable for the user (Hainmueller, 2012). It should be noted that more fundamental problems include the argument that matching approaches are an appropriate method to overcome the selection bias caused by observables and to estimate the average treatment effect in observational studies. However, these matching approaches can control only for observable selection biases and may generate unreliable results if unobservable biases exist, i.e., systematical differences between members and non-members.

[38] Hainmueller (2012), using Monte Carlo simulations and empirical applications, argues that entropy balancing outperforms other matching methods in terms of estimation bias and mean square error.

treated (ATT) by using a weighted OLS regression after obtaining entropy balancing weights in the first step. Our interest is to evaluate the ATT as follows:

$$\mathrm{ATT} = \mathrm{E}[\mathrm{Y}(1)|\mathrm{T} = 1] - \mathrm{E}[\mathrm{Y}(0)|\mathrm{T} = 1],$$

where $\mathrm{Y}(\cdot)$ is the outcome variable (CBI or CBT),T indicates whether a country adopted an IT regime ($\mathrm{T} = 1$) or not ($\mathrm{T} = 0$), $\mathrm{E}[\mathrm{Y}(1)|\mathrm{T} = 1]$ is the expected value of the outcome after treatment that is actually observed, and $\mathrm{E}[\mathrm{Y}(0)|\mathrm{T} = 1]$ is the counterfactual outcome, i.e., the expected value of the outcome that would have been observed if the IT country had not adopted an IT regime in the same country. A crucial problem concerns the difficulty of estimating the ATT because of the unobservable value of $\mathrm{E}[\mathrm{Y}(0)|\mathrm{T} = 1]$. As the counterfactual outcome is not observable, we need a proper substitute to estimate the ATT. When a country's choice of an IT regime is random, the ATT can be estimated from differences between the groups of the IT countries (treatment) and non-IT countries (control) in the sample means of the outcome variable. However, IT regime selection is not random in the sense that such a choice is systematically correlated with a set of observable covariates that also affect the outcome variable, thereby creating problems in the selection of observables (Dehejia & Wahba, 2002; Heckman et al., 1998). To mitigate such a problem, we apply the entropy balancing to mimic a randomized experiment by balancing the treatment and control observations based on observed similar characteristics (covariates) as follows:

$$\mathrm{ATT} = \mathrm{E}[\mathrm{Y}(1)|\mathrm{T} = 1, \mathrm{X} = \mathrm{x}] - \mathrm{E}[\mathrm{Y}(0)|\mathrm{T} = 0, \mathrm{X} = \mathrm{x}],$$

where $\mathrm{E}[\mathrm{Y}(1)|\mathrm{T} = 1, \mathrm{X} = \mathrm{x}]$ and $\mathrm{E}[\mathrm{Y}(0)|\mathrm{T} = 0, \mathrm{X} = \mathrm{x}]$ are the potential outcomes of the IT and non-IT countries given some covariates, and X is the matrix of the country's

characteristics (covariates) that are expected to drive IT regime selection. The covariates include the one-year lagged inflation rate. Some studies, including Truman (2003), Lin and Ye (2009), Masson et al. (1997), and Minella et al. (2003), suggest that a country tends to adopt an IT regime when its inflation rate is at a reasonably low level because announcing a target rate that is significantly different than the actual inflation rate can cause its central bank to lose credibility. We also consider real GDP per capita growth to capture a country's level of macroeconomic conditions, which is expected to be a precondition for the adoption of IT (Truman, 2003; Lin & Ye, 2007).

The pretreatment characteristics also incorporate broad money growth. The high levels of broad money growth are expected to decrease the likelihood of IT adoption because of the presence of strong inflationary pressures. In addition, fiscal balance is also included in the model. As noted in Mishkin (2004) and de Mendonca and de Guimaraes e Souza (2012), under a government's balanced budget, debt monetization or government budget financing by a central bank is not needed, particularly for developing countries. Thus, sound fiscal conditions can be a precondition for the adoption of an IT regime. However, studies on fiscal theory of price levels initiated by Woodford (2001) suggest that as the determination of price levels is a fiscal phenomenon, the control of money is not sufficient for determining paths of inflation. In this case, the presence of sound fiscal conditions implies less inflationary pressure, which can reduce the motivations for IT adoption.

To control for economic conditions related to external conditions, we incorporate the flexibility of exchange rates, trade openness, and financial openness as pretreatment covariates. Some studies, including Hu (2006), find that the flexibility of exchange rates enhances a country's motivations for adopting IT regimes. The exchange rate nominal anchor should be subordinate to IT because the rigidity of exchange rates is not suitable for IT policies in the long run (Brenner & Sokoler, 2010). In addition, trade openness or

integration with international markets reduces the inflation biases of central banks (Romer, 1993; Rogoff, 2003), which might not necessitate the adoption of an IT regime. Moreover, financial integration can affect the nature of central bank monetary conduct, including motivations to adopt IT policies in the midst of globalization processes (de Mendonca & de Guimaraes e Souza, 2012; Mishkin, 2004; Samarina et al., 2014; Truman, 2003). Data on inflation, real GDP per capita, broad money, imports and exports were obtained from the World Bank's World Development Indicators (WDI), while data on fiscal balances are obtained from the World Economic Outlook (WEO). Trade openness is calculated from the ratio of the sum of exports and imports to GDP. We use the de facto exchange rate arrangement classification developed by Reinhart and Rogoff (2004) to define the exchange rate flexibility.[39] To measure the degrees of financial openness, we use the Chinn-Ito capital account openness index developed by Chinn and Ito (2008).

Concerning the IT dummy used as a dependent variable in the model, a clear consensus has not been reached on the exact date by which each country has implemented an IT regime, although the correct identification of adoption years is crucial to evaluate the effects of an IT regime. Vega and Winkelried (2005) propose two types of IT adoption dates, namely, soft and full-fledged adoption dates, and they define soft IT as a simple announcement of numerical inflation targets; they define a transition to a complete IT regime (i.e., the partial adoption of an IT regime) and full-fledged IT as a complete IT regime (i.e., the explicit adoption of an IT regime in the absence of nominal anchors other than inflation

[39] In general, two different classifications are used as measures of exchange rate regimes. As a de jure classification, the International Monetary Fund publishes the self-reported exchange rate regime statuses of member countries. However, a country's actual choice of exchange rate regimes often differs from its self-reported status. Thus, many studies use the de facto classification developed by Reinhart and Rogoff (2004). Although countries, particularly developing countries, facing 'fear to floating' conditions (Calvo & Reinhart, 2002) may officially announce the adoption of a floating regime, they often involve foreign market intervention; therefore, in practice, their actual regimes can be viewed as managed exchange rate regimes. Hence, we also use a de facto exchange rate regime classification. According to Reinhart and Rogoff's (2004) classification, the fine grid classification includes fourteen categories, and the coarse grid version aggregates these into five categories. By using the coarse grid classification, we construct the classification of the exchange rate flexibility with three categories (fixed, intermediate, and flexible).

targets). Similarly, Rose (2007) proposes two types of adoption dates (default and conservative dates) that are nearly consistent with the adoption dates of Vega and Winkelried (2005). In this study, we use two types of adoption years ('loose' and 'strict' adoption years) that correspond to the soft and full-fledged adoption dates, respectively, proposed by Vega and Winkelried (2005), as in the studies of de Mendonca and de Guimaraes e Souza (2012) and Samaria et al. (2014).

4.3.2 Central bank independence and transparency

There are many types of methods used to determine the indices of CBI and CBT, as mentioned in the previous section. Most studies measure CBI based on central bank laws in place (legal) or the turnover rate of governors. Studies by Bade and Parkin (1978) may be the first attempt to construct measures of CBI. Cukierman et al. (1992) construct the most extensive set of measures of CBI (CWN index), covering four decades for 72 developed and developing countries. Dincer and Eichengreen (2014) update measures of CBI over the period from 1998 to 2010 by adding some measures of legal aspects, such as limits on the reappointment of the CEO, provisions affecting the (re)appointment of other board members similar to those provisions affecting the CEO, restrictions on government representation on the board, and the intervention of the government in exchange rate policy formulation, into the original CWN's criteria.[40] By employing CWN's criteria, Garriga (2016) also constructs de jure CBI measures, focusing on statutory measures and particularly on reforms affecting independence and their direction, in over 182 countries between 1970 and 2012.[41] Garriga (2016) mentions that CWN's criteria have some advantages over other criteria in Alesina et

[40] The CWN criteria is based on legal independence, reflecting the independence of the chief executive officer (CEO) of the central bank, its independence in policy formation, its objective or mandate, and the stringency of limits on its lending to the public sector.

[41] Garriga (2016) also points out that reliance on a legal-based measure is useful for several reasons. First, a measure of statutory CBI allows collecting comparable cross-sectional data across observations. Second, and more importantly, the use of the measure depends on the research question for which it is used. Statutory measures of CBI are useful to assess governments' institutional choices, that is, when and to what extent governments give independence to their central banks or limit them.

al. (1989) and Grilli et al. (1991). First, CWN's criteria for coding are clear and easily replicable. Second, CWN's component variables are exhaustive, which allows for further recodifications for other purposes and studies on particular components of the index (Banaian et al., 1998). Moreover, CWN's criteria have been widely used for the construction of de jure CBI, and the larger cross-sectional and historical coverage allows for checking the reliability of the coding (Acemoglu et al., 2008). Bodea and Hick (2015) also update the CWN index for 78 countries from 1973 to 2008. They code the CBI based on the CWN original index, and the CBI scores are based on a weighted aggregated calculation of 16 indicators in 4 categories: the CEO, policy formation, objectives, and limitations on lending to the government. Thus, this study uses the CBI constructed by Dincer and Eichengreen (2014) in the baseline models. For the robustness checks, we also use the two CBI indexes of Garriga (2016) and Bodea and Hicks (2015) as alternative measures of independence.

For the measurement of CBT, Eijffinger and Gerrats (2006) use the classification based on five aspects of transparency: political, economic, procedural, policy, and operational transparency. Dincer and Eichengreen (2008, 2010) extend the CBT index of Eijffinger and Gerrats (2006), and Dincer and Eichengreen (2014) update their CBT index covering over 100 central banks and 13 periods that extend from 1998 to 2010. This study uses the CBT index of Dincer and Eichengreen (2014). Our sample includes 23 developed and 60 developing countries (83 countries in total), of which 22 countries are IT countries, and covers the period from 1998 to 2010. For the advanced countries, there are 12 IT countries in the treatment group and 11 non-IT countries in the control group. For the developing countries, there are 10 IT countries and 50 non-IT countries. We identify developed and developing countries based on the World Bank's income classification. Table 1 shows a list of IT countries with loose and strict adoption years, and Table 2 presents non-IT countries in our sample.

4.3.3 Results

Our main interest is to identify how IT adoption affects CBI and CBT over 83 developed and developing countries during the period from 1998 to 2010. We use the indices of CBI and CBT defined by Dincer and Eichengreen (2014). For the robustness checks of the IT effects on CBI, we also use the CBI index of Garriga (2016) and Bodea and Hicks (2015). The higher values of the indices indicate the greater independence and transparency of a central bank. Concerning the timing of IT adoption, we use two different IT adoption years: 'loose' and 'strict' adoption years.

4.3.3.1 Descriptive statistics

Table 4.3 shows the descriptive statistics. Columns (1) and (2) present the sample means of all covariates across the treatment and potential control groups, respectively, and column (3) shows the difference in means between two groups with t-test statistics and p-values. As the descriptive statistics reveal that the pretreatment characteristics between treatment group (IT group) and control group (non-IT group) are different, it is important to choose an appropriate control group using a matching method before calculating the treatment effects; otherwise, the treatment effect estimation might be inaccurate. Tables 4.4 and 4.5 present the sample means of all matching covariates, which are obtained through entropy balancing, across the treatment group and the synthetic control group, based on the loose and strict IT treatment indicators, respectively. As the similar average realizations of the pretreatment characteristics between the two groups confirm the efficacy of entropy balancing, all matching covariates may be well balanced. It implies that the control group in the subsequent empirical analysis consists of appropriate counterfactuals for the sample of observations subject to the IT adoption.

4.3.3.2 Average treatment effects

We estimate the ATTs by applying weighted OLS after obtaining entropy balancing weights. Table 4.6 shows the estimated results for the indices of CBT and CBI. The first six columns report the results for the loose IT regime, and the last six columns show the results for the strict IT regime. We present the estimated ATTs for the models without and with control variables in the second-step regression for the full sample and each of the two sub-samples of developed and developing countries.[42] First, concerning the IT effects on CBT, the estimated results highlight an important role of an IT regime in improving transparency for both advanced and developing countries, irrespective of the choice of the loose or strict IT regimes. Our findings suggest that the adoption of an IT regime enhances the transparency of central banks in both advanced and developing countries.

The consensus view of policymakers and academicians is that an IT adoption helps improve the transparency of monetary policymaking, which would increase a central bank's credibility and help lower inflation and the volatilities of inflation and real output (Bernanke et al., 1999; Mishkin, 1999; Mishkin and Schmidt-Hebbel, 2007; Svensson, 1999). By assessing the direct effect of an IT adoption on the CBT index constructed by Dincer and Eijeena (2014), our study confirms the arguments of previous literatures relating to the IT effect on the transparency of monetary policymaking. Crowe (2010) conducts an empirical test of the IT impact on transparency by defining transparency as 'the removal of information asymmetries' and suggests that the introduction of an IT regime helps improve the private sector's ability to forecast inflation and promote convergence in forecast errors. Given the argument that transparency helps reduce various forms of uncertainties private agents face,

[42] In the weighted OLS regression, we additionally control for the covariates applied in the first step (covariate balancing regression) and country-effects, as in the works of Neuenkirch and Neumeier (2016). This is equivalent to incorporating control variables in a randomized experiment and improves the efficiency of estimation. The results are shown in Tables 6-8.

our finding is also consistent with the finding of Crowe (2010) on the conventional view of the beneficial IT impact on transparency.

Second, more interestingly, concerning the IT effects on CBI, the estimated results in Table 4.6 show a sharp contrast between advanced and developing countries in the IT effects on the index of CBI. Irrespective of the choice of the loose and strict IT regimes, IT adoption improves independence in advanced countries, while it reduces independence in developing countries. Table 4.7 and 4.8 present the ATTs by using the different CBI indices of Garriga (2016) and Bodea and Hicks (2015), and the results are generally consistent with the findings based on the baseline estimation with the use of the CBI index of Dincer and Eichengreen (2014). Our findings of the different effects between developed and developing countries of an IT regime on CBI are related to different political and administrative relations between a central bank and government, including perhaps finance, planning ministries and political institutions, depending on the country's development stage. Central banks in developing countries are generally influenced by political or governmental pressures in the conduct of monetary policy and might set inflation targets either by prior contract or in close coordination with the government. The negative IT effect on CBI in developing countries may reflect the argument in the political economy context that a central bank is granted stringent monetary authority in pursuit of price stability at the expense of losing independence from central authorities, including the government, the ministry of finance, and political institutions, which often tend to keep a central bank under the control of their authorities. Central authorities in developing countries give parts of the power to a central bank by allowing the central bank to control monetary policy (an IT regime) and to make it more transparent, but they at the same time attempt to keep the power by reducing the autonomy or independence of the central bank.

Moreover, Eijffinger and De Haan (1996) emphasize that delegating the autonomy to a central bank leads to greater credibility of monetary policy, but it reduces flexibility in monetary policymaking from the political perspective; therefore, the optimal level of CBI is determined by the balance between flexibility and credibility. Our results showing different IT effects on CBI between advanced and developing countries imply a crucial difference in the consequences on the credibility and flexibility of monetary policy conduct through changing the degree of independence of monetary authority. In advanced countries, the IT adoption increases the degree of monetary autonomy, thus enhancing the credibility of monetary policy at the expense of the loss of flexibility. In contrast, in developing countries, the IT adoption decreases the degree of monetary autonomy, thus enhancing flexibility in monetary policymaking at the expense of the loss of credibility. Politicians are less willing to subordinate other goals, such as growth and employment, to the fight against inflation (Goodman, 1991). This issue can be more apparent particularly in developing countries, in which less independent central banks generally conform to their government agendas. Political authorities in developing countries tend to emphasize short-term macroeconomic goals that may require greater flexibility of monetary policy.

4.3.3.3 Heterogeneity in treatment effects

Substantial heterogeneity in social and economic development is known to occur, especially in developing countries. Many studies have shown that the causes and consequences of IT adoption are associated with the various economic and institutional characteristics of developing countries (Carare & Stone, 2006; Fraga et al., 2003; Fry et al., 2000; Masson et al., 1997; Minella et al., 2003; Mishkin, 2004; Mishkin & Savastano, 2001; Svensson, 2002; Lin & Ye, 2009; Soe & Kakinaka, 2018). For example, Lin and Ye (2009) analyze the heterogeneities of the average treatment effects of the IT adoption on inflation and its variability. Examining the heterogeneous effects of the IT adoption on CBT and CBI is

critical for understanding policy evaluations in advanced and developing countries. This study also evaluates four possible sources of heterogeneities, partly following the work of Lin and Ye (2009). The first source concerns the time lagged effects of the IT adoption that is based on the argument that it often takes some time for monetary policy to be effective. The second and third sources concern the role of fiscal conditions and exchange rate arrangements, respectively, in determining the effects of the IT adoption.[43] Mishkin (2004) and Mishkin and Savastano (2001) suggest that the performance of an IT regime would be influenced by government fiscal positions and levels of exchange rate flexibility.

Tables 4.9 and 4.10 present the estimated results of the three sources of the heterogeneous effects of the loose and strict IT regimes on our outcome variables of CBT and CBI, respectively. We include country- and time-specific effects in the models. The first four columns show the results for the full sample, and the second and last four columns present the estimated results for developed and developing countries, respectively. The first and second panels correspond to the results for the loose IT regime and the strict IT regime, respectively. First, to examine the role of the time length on IT effects, we include the interaction term of the IT dummy and the time length (year) from the IT adoption year.[44]

[43] Lin and Ye (2009) evaluate the heterogeneous features of IT effects by taking into account four sources of heterogeneities: (1) the pre-conditions of an IT adoption (captured by the estimated propensity score from a probit regression), (2) time lagged effects, (3) fiscal conditions, and (4) exchange rate arrangements. Our baseline analysis of heterogeneous features considers three possible sources without the pre-conditions of an IT adoption. For the robustness checks, following the work of Lin and Ye (2009), we estimate propensity scores from a probit regression and include the estimated propensity score and interaction term of the IT regime and the difference between the estimated propensity score and its sample mean to evaluate how IT effects are dependent on the preconditions of the IT adoption. The results are consistent with the findings related to the three sources of heterogeneity in the baseline analysis (see Table A1 for the probit regression results and Tables A2 and A3 for heterogeneity in the treatment effects). The results related to the pre-conditions of an IT adoption are as follows. Concerning the IT effect on CBT, the estimated coefficient on the interaction between the IT dummy and the difference between the estimated propensity score and its sample mean is significantly negative in advanced countries, while it is significantly positive in developing countries. Concerning the IT effect on CBI, the coefficient on that interaction is significantly negative in both developed and developing countries. These results indicate that an IT regime performs less effectively at enhancing transparency and independence in advanced countries with the high preconditions of the IT adoption, while the positive IT effect on transparency and the negative IT effect on independence are more apparent for developing countries with the high estimated propensity scores that reflect more favorable preconditions for the IT adoption.

[44] As in Lin and Ye (2009), this study does not include the time length variable in the regression because the value of the time length variable is the same as the interaction term of the IT dummy and time length.

Second, we test the role of exchange rate arrangements in the heterogeneous IT effects by including the dummy for a flexibility of exchange rate and an interaction term of the IT dummy and the exchange rate flexibility in the models. Third, we incorporate fiscal balance and its interaction term with the IT dummy into the models to examine the role of a fiscal disciple on the IT effects.

Concerning the IT effects on CBT, the results in Table 4.9 first show that the coefficients on the interaction terms of the IT dummy and the time length in developing countries are significantly negative, while those in advanced countries are insignificant, irrespective of the choice of the IT regime. In developing countries, the effectiveness of the IT regime on CBT is dependent on the time length since the IT adoption. An IT regime is likely to become less effective at enhancing transparency over time in developing countries. Second, the estimation results show that the coefficients on the interaction terms of the IT dummy and the exchange rate flexibility are negative in advanced countries but are positive in developing countries, although the results for the loose IT regime are less significant. Under higher flexibility of the exchange rate, the IT effect on CBT is less effective in advanced countries, but it is more pronounced in developing countries. Third, the estimated coefficients on the interaction terms of fiscal balance and the IT dummy are insignificant in advanced countries, implying that no clear evidence is observed for the heterogeneous IT effects on CBT in advanced countries in terms of fiscal positions. However, the results provide clear evidence that the coefficients on the interaction terms are significantly negative in developing countries. This implies that the IT effect on CBT is less effective in developing countries with a sound fiscal discipline, while it is more pronounced in developing countries facing issues related to weak fiscal discipline, such as large fiscal deficits.

Regarding the IT effects on CBI, the results in Table 4.10 first present that the coefficients on the interaction terms of the IT dummy and the time length in developing

countries are significantly positive, while those in advanced countries are insignificant. The negative IT effects on CBI tend to diminish over time in developing countries. Second, the coefficients on the interaction terms of the IT dummy and the exchange rate flexibility are negative in advanced countries but are generally insignificant in developing countries. The higher flexibility of the exchange rate could cause the IT effect on CBI to be less effective in advanced countries than in developing countries. Third, the coefficients on the interaction terms of fiscal balance and the IT dummy are generally insignificant in advanced and developing countries, implying less clear evidence supporting the heterogeneous IT effects on CBI in terms of fiscal positions. In summary, our analysis presents some clear evidence of the heterogeneous features of the IT effects: (i) the positive IT effects on CBT and the negative IT effects on CBI tend to diminish over time in developing countries; (ii) the IT effects tend to become less effective at improving CBT and CBI in advanced countries due to the high flexibility of the exchange rate; (iii) the IT effects tend to become more effective at improving CBT in developing countries due to the high flexibility of the exchange rate; and (iv) the IT effects on CBT tend to become more substantial in developing countries with weak fiscal positions.

4.3.4 Alternative methods

For the robustness check of the empirical validity of the results from the entropy balancing method, we also conduct the standard panel data analysis as an alternative approach.[45] Following previous works, such as studies by Neuenkirch and Neumeier (2016), we estimate the following empirical model:

$$Y_{it} = \beta_0 + \beta_1 IT_{it} + \beta_j \sum_j X_{ijt} + \alpha_i + \varepsilon_{it},$$

[45] We also apply the propensity score matching (PSM) method to confirm the findings of the baseline method. The PSM results are generally consistent with the baseline results (see Table A4). In addition, the balancing conditions between treatment and control groups are also satisfied (see figures A1, A2, and A3).

where i denotes country and t denotes time (year); Y denotes the outcome of interest (CBT or CBI); IT_{it} is the IT adoption dummy; X stands for the set of seven control variables; α_i is a country-specific effect; and ε_{it} is the error term. In addition, this study estimates the dynamic panel data model with one lag of the dependent variable as an independent variable to allow for a partial adjustment mechanism:

$$Y_{it} = \beta_0 + \beta_1 Y_{it-1} + \beta_2 IT_{it} + \beta_j \sum_j X_{ijt} + \alpha_i + \varepsilon_{it}.$$

One crucial limitation is that our dynamic panel models with some lags of the dependent variable as covariates and with unobserved panel level fixed or random effects may suffer from possible endogeneity problems. By construction, the lagged dependent variables are correlated with the unobserved panel level effects. In addition, as the explanatory variables are not strictly exogenous, they are correlated with past and possibly current realizations of the errors. For example, inflation targeting is assumed to be endogenous since causality may run in both directions between inflation targeting and CBT (CBI); therefore, these regressors may be correlated with the error term. Thus, the levels of CBT and CBI might influence the decision to adopt an IT regime. Moreover, the model may contain heteroskedasticity and autocorrelation within individual units' errors but not across them. In such cases, standard estimators could become inconsistent. Arellano and Bond (1991) develop a consistent GMM estimator for such a model. However, the Arellano-Bond estimator performs poorly if the autoregressive parameters or the ratio of the variance of the panel level effect to the variance of idiosyncratic error are relatively large. Poor instruments in the difference GMM estimator cause the inefficient and biased coefficient estimates (Arellano & Bond, 1991; Bound et al., 1995; Baltagi, 2008).

Following the work of Arellano and Bover (1995), Blundell and Bond (1998) develop a system GMM estimator that includes additional moment conditions, which is designed for panel data with many panels and short periods, under the assumption that there is no autocorrelation in the idiosyncratic errors and the panel level effects are uncorrelated with the first-difference of the first observation of the dependent variable. The system GMM estimator combines the use of lagged levels of the series as instruments for the pre-determined and endogenous variables in equations in first differences and the use of lagged differences of the dependent variable as instruments for equations in levels. The system GMM estimator derives more efficient results. Thus, this study employs the two-step system GMM estimator to estimate the empirical model. Lacking valid instruments for an IT regime, we cannot claim to have fully resolved all endogeneity issues, but the system GMM estimator mitigates some of them since this methodology is suitable for the adjustment process of the dependent variable with independent variables that are not strictly exogenous.

Tables 4.11 and 4.12 present the estimated results of the standard panel estimators and the two-step system GMM estimators. Five types of estimation results based on the same control variables applied in the entropy balancing method are shown for each of different samples (full sample and two subsamples of advanced and developing countries). Columns (1), (6), and (11) show the OLS results, and columns (2), (7), and (12) report the OLS results of the models with one-year lagged control variables. Columns (3), (8), and (13) show the results of the fixed effects models, and columns (4), (9), and (14) present the results of the fixed effects models with one-year lagged control variables. Finally, columns (5), (10), and (15) show the results of the two-step system GMM estimation. When applying the system GMM estimators, we need to confirm the first- but not the second-order serial correlation. As the specification tests, the AR(1) and AR(2) statistics show that in every model, the null hypothesis of no second-order serial correlation cannot be rejected, but the null hypothesis

of no first-order serial correlation can be rejected, as required by the specification. In addition, as the Hansen tests for the exogeneity show that the J-statistic has a p-value greater than 0.10 in all models, we cannot reject the null hypothesis that instruments as a group are exogenous in the system GMM estimation, as required by the specification.

Our empirical results of the standard panel and system GMM estimation present that the coefficients on the IT dummy are significantly positive in all models of CBT for the subsamples of advanced and developing countries, which confirms the empirical results from the entropy balancing approach that the adoption of IT helps increase the transparency of central banks in both advanced and developing countries. In addition, our results indicate that the coefficients on the IT dummy are significantly positive in all models of CBI for advanced countries, while they are significantly negative in all models of CBI for developing countries. The IT effects on the independence of central banks are different between advanced and developing countries: there is a positive IT effect in advanced countries and a negative IT effect in developing countries. These findings from the standard panel and system GMM estimation are also consistent with the results of the entropy balancing analysis in the previous subsection. Thus, our robustness checks confirm the empirical validity of the estimated results of the entropy balancing method.

4 Conclusion

This study has examined how an IT adoption relates to the credibility of the central bank, which is captured by its transparency and independence, over 83advanced and developing countries during the period from 1998 to 2010. This study has applied the entropy balancing method, which has recently been used to mitigate the self-selection bias although it may suffer from hidden biases derived from unobserved covariates or factors. Thus, to confirm the empirical validity of the results of our entropy balancing approach, this study has also applied the standard panel and dynamic panel methods as alternative methods. Our empirical

results have indicated that an IT adoption helps improve central bank transparency in both advanced and developing countries. Transition of monetary policy frameworks toward the adoption of an IT regime encourages financial regulators to implement administrative and institutional reforms such that the central bank provides the general public and financial markets with relevant information on its policy strategy, decisions, assessments, and their procedures in an open, clear, and timely manner.

More importantly, our finding has also demonstrated that the IT effects on central bank independence differ between advanced countries and developing countries, although central bank independence is generally expected to be granted to central banks to shield them from short-term political pressures when they fulfill their mandate of ensuring price stability. In advanced countries, the IT adoption improves central bank independence while it reduces independence in developing countries. The different IT effects on central bank independence between advanced and developing countries would be related to different political and administrative relations between a central bank and government, perhaps including finance and planning ministries and political institutions, depending on the country's development stage. In addition, the negative IT effect on independence in developing countries reflects the argument in the political economy context that central authorities in developing countries give parts of the power to a central bank by allowing the central bank to fully control monetary policy (an IT regime) and to make it more transparent. However, at the same time central authorities attempt to keep their power by reducing the autonomy or independence of the central bank.

Table 4.1. Inflation targeting countries and starting years

Country	Starting Year	
	Inflation targeting(loose)	Inflation targeting(strict)
Advanced countries		
Australia	1993	1994
Canada	1991	1994
Czech Republic	1998	1998
Hungary	2001	2001
Iceland	2001	2001
Isreal	1992	1997
Korea	1998	2001
New Zealand	1990	1990
Norway	2001	2001
Poland	1999	1999
Sweden	1993	1995
United Kingdom	1993	1993
Developing countries		
Armenia	2006	2006
Colombia	2000	2000
Indonesia	2005	2006
Mexico	1995	2001
Peru	2002	2002
Philippines	2002	2002
Romania	2005	2006
South Africa	2000	2000
Thailand	2000	2000
Turkey	2002	2006

Note: Targeting dates are taken from De Mendonca and De Guimaraes e Souza(2012), Thornton (2016), Rose (2007), and Lin and Ye(2009).

Table 4.2. Control group countries

Advanced countries		
Bahama	Oman	Trinidad and Tobago
Barbados	Saudi Arbia	United Arab Emirates
Chile	Seychelles	United States of America
Japan	Singapore	
Developing countries		
Albania	Guyana	Nigeria
Angola	India	Papua New Guinca
Argentina	Iraq	Moldova
Azerbaijan	Jamaica	Russia
Belarus	Jordan	Samoa
Belize	Kenya	Sierra Leone
Bhutan	Kyrgyzstan	Solomon Islands
Bosnia and Herzegovina	Lao PDR	Sri Lanka
Botswana	Lesotho	Syria
Bulgaria	Macedonia	Tanzania
Cambodia	Malawi	Tunisia
China	Malaysia	Uganda
Croatia	Maldives	Vanuatu
Cuba	Mauritius	Venezuela
El Salvador	Mongolia	Yamen
Fiji	Mozambique	Zambia
Georgia	Namibia	

Table 4.3. Descriptive statistics

	Loose IT					Strict IT				
	(1)	(2)	(3) = (2) – (1)			(1)	(2)	(3) = (2) – (1)		
	Treatment	Control	Difference	t-test	p-value	Treatment	Control	Difference	t-test	p-value
Inflation (lag)	4.584	7.305	2.721	5.217	0.000	3.896	7.506	3.610	8.639	0.000
GDP per capita growth	0.026	0.035	0.009	3.037	0.001	0.025	0.035	0.010	3.569	0.000
Broad money growth	12.501	18.241	5.740	5.173	0.000	12.150	18.276	6.126	5.460	0.000
Fiscal balance	-1.421	-1.674	-0.253	-0.710	0.239	-1.324	-1.704	-0.380	-1.072	0.142
Exchange rate regime	1.990	1.282	-0.708	-16.299	0.000	1.971	1.301	-0.670	-15.249	0.000
Trade openness	72.089	94.838	22.749	7.257	0.000	72.842	94.218	21.376	6.785	0.000
Financial openness	1.045	0.295	-0.750	-6.775	0.000	1.105	0.285	-0.820	-7.395	0.000
Observations	214	570				205	579			

Table 4.4. Covariate balancing (Loose IT)

	Full sample		Advanced countries		Developing countries	
	Treatment	Control	Treatment	Control	Treatment	Control
Before						
Inflation (lag)	4.584	7.305	3.171	3.211	6.816	8.230
GDP per capita growth	0.026	0.035	0.023	0.018	0.030	0.038
Broad money growth	12.500	18.24	11.520	8.802	14.050	20.370
Fiscal balance	-1.421	-1.674	-1.132	0.609	-1.877	-2.189
Exchange rate regime	1.991	1.282	1.977	1.571	2.012	1.217
Trade openness	72.090	94.84	76.990	118	64.350	89.600
Financial openness	1.045	0.295	1.548	1.171	0.252	0.097
After						
Inflation (lag)	4.584	4.584	3.171	3.170	6.816	6.816
GDP per capita growth	0.026	0.026	0.023	0.023	0.030	0.031
Broad money growth	12.500	12.500	11.520	11.520	14.050	14.050
Fiscal balance	-1.421	-1.421	-1.132	-1.132	-1.877	-1.877
Exchange rate regime	1.991	1.991	1.977	1.977	2.012	2.012
Trade openness	72.090	72.090	76.990	76.990	64.350	64.360
Financial openness	1.045	1.045	1.548	1.548	0.252	0.252
Weighted obs.	214	214	131	131	83	83

Notes: Year dummy are included but not reported.

Table 4.5. Covariate balancing (Strict IT)

	Full sample		Advanced countries		Developing countries	
	Treatment	Control	Treatment	Control	Treatment	Control
Before						
Inflation (lag)	3.896	7.507	3.155	3.229	5.154	8.477
GDP per capita growth	0.025	0.035	0.022	0.019	0.029	0.039
Broad money growth	12.150	18.280	11.290	9.131	13.610	20.350
Fiscal balance	-1.324	-1.704	-1.191	0.648	-1.550	-2.237
Exchange rate regime	1.971	1.301	1.977	1.579	1.961	1.237
Trade openness	72.840	94.220	77.150	117.100	65.530	89.040
Financial openness	1.105	0.285	1.583	1.137	0.294	0.092
After						
Inflation (lag)	3.896	3.897	3.155	3.155	5.154	5.153
GDP per capita growth	0.025	0.025	0.022	0.022	0.029	0.029
Broad money growth	12.150	12.150	11.290	11.290	13.610	13.610
Fiscal balance	-1.324	-1.325	-1.191	-1.190	-1.550	-1.551
Exchange rate regime	1.971	1.971	1.977	1.977	1.961	1.960
Trade openness	72.840	72.840	77.150	77.190	65.530	65.520
Financial openness	1.105	1.105	1.583	1.582	0.294	0.295
Weighted obs.	205	205	129	129	76	76

Notes: Year dummy are included but not reported.

Table 4.6. Treatment effects of IT on central bank transparency and independence index

	Loose IT						Strict IT					
	Full sample		Advanced countries		Developing countries		Full sample		Advanced countries		Developing countries	
	Baseline	Controls	Baseline	Controls	Baseline	Controls	Baseline	Controls	Baseline	Controls	Baseline	Controls
Transparency												
IT dummy	3.378***	1.545***	3.654***	2.391***	2.732***	1.160***	3.414***	1.027***	3.761***	0.605	2.726***	0.782***
	(0.344)	(0.281)	(0.525)	(0.653)	(0.315)	(0.451)	(0.350)	(0.243)	(0.478)	(0.513)	(0.356)	(0.291)
Covariates	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Time-effect	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Country-effect	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
No. of obs.	784	784	236	236	548	548	784	784	236	236	548	548
Independence												
IT dummy	0.408**	1.050***	1.894***	3.426***	-1.494***	-0.141**	0.375*	0.769***	1.844***	1.533***	-1.700***	-0.105*
	(0.206)	(0.364)	(0.231)	(0.334)	(0.320)	(0.066)	(0.207)	(0.298)	(0.224)	(0.486)	(0.337)	(0.060)
Covariates	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Time-effect	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Country-effect	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
No. of obs.	781	781	235	235	546	546	781	781	235	235	546	546

Notes: Table shows the ATTs obtained by weighted least squares regressions. Constant terms are included but not reported. Standard errors are shown in parentheses. *, ** and *** indicate the significant level of 10 %, 5% and 1%, respectively. Following Neuenkirch and Neumeier (2016), we include all covariates in the weighted regression. In addition, country-fixed and time-fixed effects are controlled in the weighted regression to address the panel structure since entropy balancing model combines a reweighting scheme with a regression analysis. The inclusion of country-fixed effects can control for potential unobserved heterogeneity across countries as well as time-invariant country-specific characteristics.

Table 4.7. Treatment effects of IT on Garriga's (2016) central bank independence index

	Loose IT						Strict IT					
	Full Sample		Advanced countries		Developing countries		Full sample		Advanced countries		Developing countries	
	Baseline	Controls	Baseline	Controls	Baseline	Controls	Baseline	Controls	Baseline	Controls	Baseline	Controls
Independence												
IT dummy	0.563***	0.750**	1.019***	2.774***	-0.401	-0.560***	0.481**	0.498*	1.070***	1.181***	-0.725**	-0.304**
	(0.188)	(0.345)	(0.210)	(0.331)	(0.339)	(0.158)	(0.190)	(0.281)	(0.211)	(0.422)	(0.345)	(0.127)
Covariates	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Time-effect	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Country-effect	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
No. of obs.	773	773	236	236	537	537	773	773	236	236	537	537

Notes: Table shows the ATTs obtained by weighted least squares regressions. Constant terms are included but not reported. Standard errors are shown in parentheses. *, ** and *** indicate the significant level of 10 %, 5% and 1%, respectively. Following Neuenkirch and Neumeier (2016), we include all covariates in the weighted regression. In addition, country-fixed and time-fixed effects are controlled in the weighted regression to address the panel structure since entropy balancing model combines a reweighting scheme with a regression analysis. The inclusion of country-fixed effects can control for potential unobserved heterogeneity across countries as well as time-invariant country-specific characteristics.

Table 4.8. Treatment effects of IT on Bodea and Hicks's (2015) central bank independence index

	Loose IT						Strict IT					
	Full Sample		Advanced countries		Developing countries		Full sample		Advanced countries		Developing countries	
	Baseline	Controls	Baseline	Controls	Baseline	Controls	Baseline	Controls	Baseline	Controls	Baseline	Controls
Independence												
IT dummy	0.938***	0.232	1.394***	1.651***	0.171	-0.384**	0.895***	0.116	1.425***	0.609**	-0.133	-0.280*
	(0.182)	(0.149)	(0.226)	(0.375)	(0.356)	(0.182)	(0.185)	(0.119)	(0.223)	(0.263)	(0.368)	(0.165)
Covariates	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Time-effect	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Country-effect	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
No. of obs.	737	737	210	210	527	527	737	737	210	210	527	527

Notes: Table shows the ATTs obtained by weighted least squares regressions. Constant terms are included but not reported. Standard errors are shown in parentheses. *, ** and *** indicate the significant level of 10 %, 5% and 1%, respectively. Following Neuenkirch and Neumeier (2016), we include all covariates in the weighted regression. In addition, country-fixed and time-fixed effects are controlled in the weighted regression to address the panel structure since entropy balancing model combines a reweighting scheme with a regression analysis. The inclusion of country-fixed effects can control for potential unobserved heterogeneity across countries as well as time-invariant country-specific characteristics.

Table 4.9. Heterogeneity in the treatment effects (Transparency)

	Full sample			Advanced countries			Developing countries		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Loose IT									
IT dummy	1.556***	0.511	1.581***	2.403***	3.405**	2.354***	1.156***	0.376	0.978**
	(0.282)	(0.502)	(0.291)	(0.655)	(1.393)	(0.603)	(0.438)	(0.786)	(0.428)
IT*Time	0.011			0.003			-0.064**		
	(0.014)			(0.020)			(0.031)		
Exchange rate regime		-0.173			1.355*			-0.735***	
		(0.131)			(0.754)			(0.232)	
IT*Exchange rate regime		0.587**			-0.839			0.426	
		(0.237)			(0.734)			(0.360)	
Fiscal balance			0.011			0.040**			0.009
			(0.009)			(0.017)			(0.022)
IT*Fiscal balance			-0.012			-0.037			-0.122***
			(0.020)			(0.029)			(0.040)
Time-effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of obs.	784	784	784	236	236	236	548	548	548
Strict IT									
IT dummy	0.997***	-0.171	1.022***	0.609	3.659**	0.643	0.782***	-0.705	0.653**
	(0.250)	(0.520)	(0.253)	(0.515)	(1.773)	(0.523)	(0.276)	(0.647)	(0.282)
IT*Time	0.023			-0.006			-0.099**		
	(0.023)			(0.036)			(0.049)		
Exchange rate regime		-0.177			2.527***			-0.810***	
		(0.133)			(0.858)			(0.202)	
IT*Exchange rate regime		0.647***			-1.817**			0.769***	
		(0.244)			(0.734)			(0.282)	
Fiscal balance			0.008			0.031**			0.003
			(0.009)			(0.016)			(0.024)
IT*Fiscal balance			0.003			-0.023			-0.123***
			(0.021)			(0.037)			(0.043)
Time-effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of obs.	784	784	784	236	236	236	548	548	548

Notes: Table shows the ATTs obtained by weighted least squares regressions. The covariates applied in the covariate balancing regression and constant terms are included but not reported. Standard errors are shown in parentheses. *, ** and *** indicate the significant level of 10 %, 5% and 1%, respectively.

Table 4.10. Heterogeneity in the treatment effects (Independence)

	Full sample			Advanced countries			Developing countries		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Loose IT									
IT dummy	1.039***	1.391***	0.938***	3.402***	5.171**	3.429***	-0.138**	0.203	-0.157**
	(0.363)	(0.371)	(0.309)	(0.331)	(0.768)	(0.339)	(0.065)	(0.159)	(0.077)
IT*Time	-0.011**			-0.006			0.031**		
	(0.005)			(0.004)			(0.014)		
Exchange rate regime		0.153**			1.592***			0.034	
		(0.066)			(0.229)			(0.054)	
IT*Exchange rate regime		-0.194**			-1.442**			-0.187*	
		(0.097)			(0.565)			(0.103)	
Fiscal balance			-0.005			0.003			0.003
			(0.005)			(0.005)			(0.004)
IT*Fiscal balance			0.038**			0.004			-0.010
			(0.017)			(0.017)			(0.014)
Time-effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of obs.	781	781	781	235	235	235	546	546	546
Strict IT									
IT dummy	0.770***	1.229***	0.678***	1.532***	6.751***	1.562***	-0.105*	0.204	-0.116*
	(0.299)	(0.343)	(0.244)	(0.487)	(0.802)	(0.479)	(0.059)	(0.164)	(0.070)
IT*Time	-0.0003			0.002			0.058***		
	(0.010)			(0.014)			(0.022)		
Exchange rate regime		0.183***			3.195***			0.017	
		(0.069)			(0.435)			(0.050)	
IT*Exchange rate regime		-0.248***			-3.106***			-0.160*	
		(0.095)			(0.420)			(0.097)	
Fiscal balance			-0.005			0.001			0.002
			(0.005)			(0.005)			(0.005)
IT*Fiscal balance			0.041**			-0.017			-0.011
			(0.019)			(0.019)			(0.019)
Time-effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of obs.	781	781	781	235	235	235	546	546	546

Notes: Table shows the ATTs obtained by weighted least squares regressions. The covariates applied in the covariate balancing regression and constant terms are included but not reported. Standard errors are shown in parentheses. *, ** and *** indicate the significant level of 10 %, 5% and 1%, respectively.

Table 4.11. Panel estimates (Transparency)

	Full sample					Advanced countries					Developing countries				
	OLS	Lag	FE	Lag/FE	GMM	OLS	Lag	FE	Lag/FE	GMM	OLS	Lag	FE	Lag/FE	GMM
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Loose IT															
IT dummy	3.490***	4.020***	2.181***	2.116***	1.227**	4.281***	4.374***	1.824*	1.934**	2.641**	3.269***	3.262***	2.309***	2.212***	0.914**
	(0.205)	(0.203)	(0.430)	(0.455)	(0.469)	(0.242)	(0.247)	(0.876)	(0.724)	(1.219)	(0.230)	(0.221)	(0.428)	(0.421)	(0.423)
Inflation (lag)	-0.014*	-0.020**	-0.009	-0.011*	0.007	-0.085***	-0.056**	-0.074**	-0.071**	-0.002	0.012	0.008	-0.002	-0.002	0.007
	(0.008)	(0.009)	(0.006)	(0.006)	(0.004)	(0.024)	(0.023)	(0.028)	(0.027)	(0.025)	(0.008)	(0.010)	(0.006)	(0.005)	(0.004)
GDP per capita growth	1.291	0.331	0.427	-0.310	0.901*	-5.611	-4.417	-2.270	-1.087	-0.489	1.787	0.091	0.574	-0.573	1.106*
	(1.644)	(1.551)	(1.221)	(1.065)	(0.491)	(4.189)	(4.341)	(3.318)	(3.095)	(1.809)	(1.673)	(1.643)	(1.140)	(0.942)	(0.617)
Broad money growth	-0.008	-0.005	0.001	0.004**	-0.002	-0.010	-0.008	0.003	0.009*	-0.004	-0.011*	-0.008	0.001	0.003	-0.002
	(0.006)	(0.005)	(0.003)	(0.002)	(0.002)	(0.011)	(0.009)	(0.005)	(0.004)	(0.004)	(0.006)	(0.006)	(0.003)	(0.003)	(0.003)
Fiscal balance	-0.032**	-0.020	0.009	0.013	-0.003	-0.129***	-0.128***	0.007	0.001	-0.001	0.001	0.018	0.013	0.028**	-0.001
	(0.015)	(0.016)	(0.011)	(0.014)	(0.005)	(0.021)	(0.021)	(0.019)	(0.025)	(0.018)	(0.019)	(0.019)	(0.011)	(0.013)	(0.006)
Exchange rate regime	1.160***	1.150***	0.083	0.075	0.116	1.185***	1.118***	0.810	0.578*	0.359	0.468***	0.525***	-0.061	-0.084	-0.003
	(0.121)	(0.118)	(0.173)	(0.183)	(0.128)	(0.202)	(0.211)	(0.478)	(0.328)	(0.784)	(0.140)	(0.129)	(0.135)	(0.144)	(0.095)
Trade openness	-0.0004	-0.0001	0.007*	0.007*	0.0004	-0.004***	-0.004***	0.012	0.013	0.001	0.005**	0.005***	0.004	0.004	0.001
	(0.001)	(0.001)	(0.004)	(0.004)	(0.001)	(0.001)	(0.001)	(0.009)	(0.010)	(0.003)	(0.002)	(0.002)	(0.004)	(0.004)	(0.001)
Financial openness	0.346***	0.337***	-0.031	-0.026	0.039	0.803***	0.816***	0.057	0.216	0.082	-0.022	-0.037	-0.123	-0.159**	-0.017
	(0.050)	(0.051)	(0.106)	(0.128)	(0.041)	(0.096)	(0.098)	(0.208)	(0.294)	(0.208)	(0.055)	(0.056)	(0.082)	(0.079)	(0.036)
Transparency (lag)	-	-	-	-	0.802***	-	-	-	-	0.729***	-	-	-	-	0.836***
					(0.060)					(0.163)					(0.081)
Constant	1.610***	1.608***	5.098***	5.135***	0.688***	3.330***	4.277***	5.514***	5.452***	0.157	1.611***	1.560***	4.632***	4.771***	0.680**
	(0.349)	(0.348)	(0.526)	(0.550)	(0.192)	(0.652)	(0.624)	(1.505)	(1.457)	(0.575)	(0.348)	(0.331)	(0.388)	(0.379)	(0.290)
No. of Obs.	784	768	784	768	784	236	235	236	235	236	548	533	548	533	548
R-squared	0.63	0.63	0.61	0.59	-	0.78	0.77	0.61	0.62	-	0.65	0.46	0.65	0.64	-
AR(2) test	-	-	-	-	0.90	-	-	-	-	0.12	-	-	-	-	0.15
Sargan test	-	-	-	-	0.55	-	-	-	-	0.41	-	-	-	-	0.32
Hansen test	-	-	-	-	0.51	-	-	-	-	0.13	-	-	-	-	0.24
Strict IT															
IT dummy	3.942***	4.031***	1.567***	1.494***	1.107	4.176***	4.312***	1.283	1.527**	1.010**	3.155***	3.152***	1.704***	1.538***	0.689***
	(0.208)	(0.206)	(0.414)	(0.435)	(0.770)	(0.249)	(0.252)	(0.812)	(0.665)	(0.477)	(0.247)	(0.244)	(0.451)	(0.486)	(0.311)
Inflation (lag)	-0.004	-0.010	-0.009	-0.010	0.008	-0.084***	-0.053**	-0.076**	-0.074**	0.004	0.021**	0.016	-0.003	-0.001	0.011**
	(0.009)	(0.010)	(0.006)	(0.006)	(0.005)	(0.024)	(0.024)	(0.030)	(0.029)	(0.015)	(0.010)	(0.012)	(0.006)	(0.006)	(0.005)
GDP per capita growth	2.111	0.412	1.030	-0.059	1.064*	-3.044	-4.642	-1.634	-1.669	0.446	2.418	0.343	1.213	-0.127	1.734***
	(1.658)	(1.601)	(1.231)	(1.116)	(0.576)	(4.435)	(4.698)	(3.215)	(3.042)	(1.228)	(1.697)	(1.697)	(1.197)	(1.058)	(0.526)
Broad money growth	-0.009	-0.003	0.001	0.005**	-0.003	-0.006	-0.003	0.004	0.010**	-0.0001	-0.012**	-0.008	0.0001	0.003	-0.004
	(0.006)	(0.006)	(0.003)	(0.002)	(0.002)	(0.011)	(0.009)	(0.006)	(0.005)	(0.003)	(0.006)	(0.007)	(0.003)	(0.003)	(0.002)
Fiscal balance	-0.035**	-0.027*	0.009	0.010	-0.002	-0.126***	-0.122***	0.006	0.004	-0.005	-0.006	0.006	0.012	0.022	-0.005
	(0.015)	(0.016)	(0.011)	(0.015)	(0.006)	(0.021)	(0.021)	(0.019)	(0.026)	(0.013)	(0.019)	(0.020)	(0.011)	(0.013)	(0.007)
Exchange rate regime	1.271***	1.266***	0.150	0.124	0.237*	1.285***	1.262***	0.982*	0.810**	0.231	0.634***	0.669***	-0.003	-0.073	0.112
	(0.122)	(0.118)	(0.188)	(0.194)	(0.131)	(0.212)	(0.221)	(0.534)	(0.386)	(0.227)	(0.148)	(0.139)	(0.150)	(0.153)	(0.082)
Trade openness	-0.001	-0.0002	0.007	0.007*	0.0001	-0.004***	-0.004***	0.012	0.014	-0.0003	0.004**	0.004**	0.004	0.004	0.001
	(0.001)	(0.001)	(0.004)	(0.004)	(0.001)	(0.001)	(0.001)	(0.009)	(0.010)	(0.001)	(0.002)	(0.002)	(0.004)	(0.004)	(0.001)
Financial openness	0.339***	0.329***	-0.041	-0.035	0.053	0.756***	0.754***	0.018	0.133	0.057	-0.008	-0.024	-0.133	-0.155*	-0.011
	(0.050)	(0.052)	(0.114)	(0.135)	(0.041)	(0.101)	(0.102)	(0.235)	(0.289)	(0.095)	(0.055)	(0.056)	(0.083)	(0.081)	(0.033)
Transparency (lag)	-	-	-	-	0.766***	-	-	-	-	0.836***	-	-	-	-	0.807***
					(0.110)					(0.080)					(0.042)
Constant	1.517***	1.491***	5.204***	5.253***	0.767**	3.358***	4.043***	5.575***	5.230***	0.455	1.405***	1.363***	4.683***	4.883***	0.642***
	(0.352)	(0.351)	(0.548)	(0.581)	(0.308)	(0.666)	(0.634)	(1.529)	(1.548)	(0.438)	(0.367)	(0.357)	(0.401)	(0.402)	(0.191)
No. of Obs.	784	768	784	768	784	236	235	236	235	236	548	533	548	533	548
R-squared	0.62	0.56	0.58	0.57	-	0.77	0.77	0.60	0.61	-	0.43	0.44	0.62	0.61	-
AR(2) test	-	-	-	-	0.81	-	-	-	-	0.11	-	-	-	-	0.13
Sargan test	-	-	-	-	0.30	-	-	-	-	0.102	-	-	-	-	0.22
Hansen test	-	-	-	-	0.17	-	-	-	-	0.21	-	-	-	-	0.39

Notes: Year dummy are included but not reported. Robust standard errors are shown in parentheses. *, ** and *** indicate the significant level of 10 %, 5% and 1%, respectively.

Table 4.12. Panel estimates (Independence)

	Full sample					Advanced countries					Developing countries				
	OLS	Lag	FE	Lag/FE	GMM	OLS	Lag	FE	Lag/FE	GMM	OLS	Lag	FE	Lag/FE	GMM
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Loose IT															
IT dummy	0.297	0.295	0.896*	0.997	0.501***	2.042***	2.109***	3.347***	3.478***	1.007**	-0.859***	-0.803***	-0.156	-0.282*	-1.012*
	(0.189)	(0.187)	(0.527)	(0.614)	(0.189)	(0.238)	(0.238)	(0.565)	(0.587)	(0.358)	(0.255)	(0.256)	(0.165)	(0.162)	(0.545)
Inflation (lag)	0.040***	0.049***	0.003	0.002	0.006**	0.095***	0.102***	0.031***	0.340***	0.016	0.014	0.017	-0.003	-0.003	0.003
	(0.011)	(0.012)	(0.004)	(0.006)	(0.003)	(0.025)	(0.029)	(0.009)	(0.011)	(0.023)	(0.011)	(0.013)	(0.003)	(0.005)	(0.005)
GDP per capita growth	3.315*	4.096**	0.345	0.382	0.010	-4.317	-3.504	-0.427	0.095	-0.449	1.210	2.185	0.703	1.038**	0.290
	(1.997)	(1.906)	(0.659)	(0.633)	(0.378)	(3.472)	(3.418)	(0.736)	(0.535)	(1.130)	(2.132)	(2.084)	(0.546)	(0.447)	(0.774)
Broad money growth	0.017***	0.015***	-0.001	0.002	0.002	0.001	-0.003	0.002	0.002	-0.001	0.012**	0.012**	-0.002	0.002	0.003
	(0.005)	(0.005)	(0.002)	(0.002)	(0.001)	(0.008)	(0.007)	(0.001)	(0.001)	(0.002)	(0.006)	(0.006)	(0.002)	(0.002)	(0.003)
Fiscal balance	-0.033*	-0.035**	-0.003	-0.002	-0.007*	-0.065***	-0.070***	-0.001	-0.010	0.002	0.062***	0.058***	-0.001	0.002	0.021
	(0.017)	(0.017)	(0.006)	(0.005)	(0.004)	(0.020)	(0.020)	(0.003)	(0.007)	(0.008)	(0.022)	(0.022)	(0.009)	(0.006)	(0.017)
Exchange rate regime	-0.537***	-0.523***	0.220**	0.179*	-0.159*	-0.697***	-0.714***	0.295	0.112	-0.104	0.168	0.172	0.173	0.168*	0.189
	(0.127)	(0.127)	(0.107)	(0.099)	(0.088)	(0.174)	(0.169)	(0.200)	(0.119)	(0.192)	(0.170)	(0.168)	(0.112)	(0.010)	(0.188)
Trade openness	-0.004***	-0.004***	0.002	0.0004	0.0002	0.001	0.0002	0.001	-0.001	0.001	-0.005***	-0.005**	0.002	0.0004	-0.003
	(0.001)	(0.001)	(0.002)	(0.002)	(0.0004)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.004)
Financial openness	0.146***	0.160***	-0.114	-0.037	0.004	0.319***	0.306***	-0.122	-0.060	-0.002	0.314***	0.331***	-0.148	-0.045	0.180*
	(0.049)	(0.050)	(0.128)	(0.127)	(0.022)	(0.074)	(0.070)	(0.079)	(0.061)	(0.069)	(0.066)	(0.066)	(0.153)	(0.161)	(0.104)
Independence (lag)	-	-	-	-	0.890***	-	-	-	-	0.876**	-	-	-	-	0.385
					(0.034)					(0.024)					(0.266)
Constant	4.401***	4.446***	3.770***	3.930***	0.518***	2.106***	2.864***	1.119*	1.378***	0.009	4.647***	4.708***	4.593***	4.758***	3.117*
	(0.358)	(0.395)	(0.312)	(0.275)	(0.180)	(0.577)	(0.514)	(0.590)	(0.467)	(0.284)	(0.449)	(0.497)	(0.235)	(0.160)	(1.572)
No. of Obs.	781	765	781	765	776	235	234	235	234	233	546	531	546	531	543
R-squared	0.10	0.10	0.18	0.17	-	0.34	0.35	0.71	0.71	-	0.10	0.11	0.13	0.11	-
AR (2) test	-	-	-	-	0.18	-	-	-	-	0.40	-	-	-	-	0.38
Sargan test	-	-	-	-	0.81	-	-	-	-	0.77	-	-	-	-	0.85
Hansen test	-	-	-	-	0.30	-	-	-	-	0.28	-	-	-	-	0.84
Strict IT															
IT dummy	0.215	0.226	0.650	0.706	0.476***	1.981***	2.049***	2.504***	2.684***	1.116**	-1.124***	-1.058***	-0.204	-0.278*	-0.999*
	(0.193)	(0.191)	(0.431)	(0.485)	(0.176)	(0.237)	(0.237)	(0.804)	(0.728)	(0.517)	(0.258)	(0.263)	(0.126)	(0.157)	(0.552)
Inflation (lag)	0.040***	0.049***	0.002	0.003	0.007**	0.095***	0.103***	0.028***	0.033**	0.011	0.010	0.013	-0.004	-0.004	0.002
	(0.011)	(0.012)	(0.005)	(0.006)	(0.003)	(0.025)	(0.030)	(0.009)	(0.014)	(0.026)	(0.011)	(0.012)	(0.004)	(0.005)	(0.005)
GDP per capita growth	3.358*	4.092**	0.595	0.499	0.154	-3.031	-3.515	0.796	-0.941*	-0.570	0.954	2.022	0.653	0.987**	0.075
	(1.993)	(1.902)	(0.588)	(0.610)	(0.402)	(3.570)	(3.674)	(1.287)	(0.481)	(1.074)	(2.142)	(2.094)	(0.519)	(0.424)	(0.735)
Broad money growth	0.017***	0.015***	-0.001	0.003*	0.002	0.001	-0.001	0.005*	0.004**	-0.003	0.012**	0.011*	-0.002	0.002	0.004
	(0.005)	(0.005)	(0.002)	(0.002)	(0.001)	(0.008)	(0.007)	(0.002)	(0.002)	(0.003)	(0.006)	(0.006)	(0.002)	(0.002)	(0.003)
Fiscal balance	-0.032*	-0.035**	-0.003	0.001	-0.007*	-0.063***	-0.067***	-0.003	-0.005	-0.003	0.067***	0.064***	-0.001	0.003	0.024
	(0.017)	(0.017)	(0.006)	(0.006)	(0.004)	(0.020)	(0.020)	(0.003)	(0.005)	(0.013)	(0.022)	(0.022)	(0.009)	(0.006)	(0.018)
Exchange rate regime	-0.506***	-0.496***	0.248**	0.201*	-0.139*	-0.648***	-0.641***	0.597	0.531	-0.214	0.208	0.212	0.171	0.169*	0.147
	(0.124)	(0.123)	(0.117)	(0.105)	(0.082)	(0.175)	(0.174)	(0.395)	(0.322)	(0.322)	(0.162)	(0.161)	(0.109)	(0.100)	(0.201)
Trade openness	-0.004***	-0.004***	0.002	0.0004	0.0001	0.0003	0.0001	0.0001	0.001	0.001	-0.006***	-0.005**	0.002	0.0004	-0.004
	(0.001)	(0.001)	(0.002)	(0.002)	(0.0004)	(0.001)	(0.001)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.004)
Financial openness	0.150***	0.163***	-0.118	-0.041	0.005	0.296***	0.277***	-0.196	-0.207	0.032	0.322***	0.338***	-0.147	-0.046	0.184*
	(0.050)	(0.050)	(0.128)	(0.128)	(0.022)	(0.076)	(0.073)	(0.127)	(0.112)	(0.116)	(0.066)	(0.066)	(0.153)	(0.162)	(0.106)
Independence (lag)	-	-	-	-	0.890***	-	-	-	-	0.786***	-	-	-	-	0.352
					(0.034)					(0.093)					(0.261)
Constant	4.392***	4.437***	3.812***	3.985***	0.503***	2.658***	2.902***	1.176	1.015*	0.386	4.668***	4.710***	4.613***	4.764***	3.326**
	(0.359)	(0.396)	(0.321)	(0.277)	(0.173)	(0.505)	(0.523)	(0.731)	(0.557)	(0.552)	(0.441)	(0.485)	(0.235)	(0.161)	(1.583)
No. of Obs.	781	765	781	765	776	235	234	235	234	233	546	531	546	531	543
R-squared	0.10	0.10	0.16	0.15	-	0.33	0.34	0.57	0.58	-	0.10	0.1	0.13	0.11	-
AR (2) test	-	-	-	-	0.19	-	-	-	-	0.37	-	-	-	-	0.36
Sargan test	-	-	-	-	0.81	-	-	-	-	0.19	-	-	-	-	0.87
Hansen test	-	-	-	-	0.27	-	-	-	-	0.17	-	-	-	-	0.87

Notes: Year dummy are included but not reported. Robust standard errors are shown in parentheses. *, ** and *** indicate the significant level of 10 %, 5% and 1%, respectively.

Appendix

Table A1. Estimates of propensity scores (probit model)

	Full sample		Advanced countries		Developing countries	
	Loose IT	Strict IT	Loose IT	Strict IT	Loose IT	Strict IT
Inflation (lag)	-0.022***	-0.042***	0.015	0.016	-0.017	-0.064***
	(0.008)	(0.009)	(0.025)	(0.025)	(0.013)	(0.016)
GDP per capita growth	-0.060	-0.996	7.678**	5.964*	-0.811	-2.140
	(1.454)	(1.491)	(3.260)	(3.227)	(2.709)	(3.094)
Broad money growth	-0.006	-0.006	0.025**	0.019**	-0.031***	-0.030**
	(0.005)	(0.005)	(0.011)	(0.009)	(0.012)	(0.013)
Fiscal balance	0.024**	0.026**	-0.026*	-0.028*	0.058***	0.083***
	(0.011)	(0.011)	(0.015)	(0.015)	(0.021)	(0.023)
Exchange rate regime	0.981***	0.897***	0.447***	0.377**	1.648***	1.554***
	(0.096)	(0.095)	(0.156)	(0.155)	(0.180)	(0.193)
Trade openness	-0.004***	-0.004***	-0.005***	-0.005***	-0.009***	-0.009***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)	(0.003)
Financial openness	0.183***	0.188***	0.093	0.131**	0.347***	0.350***
	(0.039)	(0.039)	(0.063)	(0.064)	(0.069)	(0.075)
No. of obs.	784	784	236	236	548	517
Pseudo-R^2	0.28	0.28	0.15	0.14	0.42	0.42

Notes: Constant terms and year trend are included but not reported. Robust standard errors are presented in parenthesis. *, **, and *** indicate the significant level of 10 %, 5 %, and 1 %, respectively.

Table A2. Heterogeneity in the treatment effects (Transparency)

	Full sample				Advanced countries				Developing countries			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Loose IT												
IT dummy	1.273***	1.557***	0.477	1.581***	2.143***	2.435***	3.478**	2.378***	0.593	1.058**	0.144	0.894**
	(0.335)	(0.283)	(0.522)	(0.291)	(0.616)	(0.639)	(1.354)	(0.588)	(0.476)	(0.436)	(0.750)	(0.429)
PS	-1.975	-0.392	-0.825	0.060	-1.766	-3.540**	-3.556**	-3.490**	3.049*	4.405***	3.927**	3.747**
	(1.699)	(1.362)	(1.417)	(1.310)	(1.653)	(1.754)	(1.722)	(1.719)	(1.635)	(1.647)	(1.645)	(1.610)
IT*(PS-PS_avg)	1.521**				-3.005***				1.160*			
	(0.717)				(1.123)				(0.640)			
IT*Time		0.011				0.006				-0.079**		
		(0.015)				(0.020)				(0.031)		
Exchange rate regime			0.073				1.998**				-2.817***	
			(0.383)				(0.805)				(0.871)	
IT*Exchange rate regime			0.607**				-0.880				0.506	
			(0.253)				(0.708)				(0.338)	
Fiscal balance				0.011				0.010				-0.053
				(0.012)				(0.022)				(0.034)
IT*Fiscal balance				-0.012				-0.037				-0.123***
				(0.020)				(0.028)				(0.041)
Time-effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of obs.	784	784	784	784	236	236	236	236	548	548	548	548
Strict IT												
IT dummy	0.670**	1.001***	-0.239	1.024***	0.514	0.575	3.823**	0.608	-0.026	0.578**	-1.020*	0.477*
	(0.289)	(0.251)	(0.545)	(0.254)	(0.458)	(0.527)	(1.752)	(0.533)	(0.345)	(0.275)	(0.560)	(0.285)
PS	-2.900**	-0.709	-1.217	-0.472	-0.444	-1.657	-3.448	-1.779	4.554***	6.309***	6.187***	5.784***
	(1.461)	(1.235)	(1.342)	(1.207)	(2.527)	(2.567)	(2.529)	(2.517)	(1.423)	(1.395)	(1.287)	(1.369)
IT*(PS-PS_avg)	2.315***				-3.796**				1.962***			
	(0.697)				(1.387)				(0.606)			
IT*Time		0.025				-0.006				-0.113**		
		(0.024)				(0.035)				(0.048)		
Exchange rate regime			0.145				3.158**				-3.874***	
			(0.325)				(0.997)				(0.612)	
IT*Exchange rate regime			0.690***				-1.958**				0.828***	
			(0.266)				(0.899)				(0.229)	
Fiscal balance				0.011				0.014				-0.139***
				(0.012)				(0.030)				(0.041)
IT*Fiscal balance				0.004				-0.024				-0.113***
				(0.021)				(0.037)				(0.042)
Time-effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of obs.	784	784	784	784	236	236	236	236	517	517	517	517

Notes: Table shows the ATTs obtained by weighted least squares regressions. The covariates applied in the covariate balancing regression and constant terms are included but not reported. Standard errors are shown in parentheses. *, ** and *** indicate the significant level of 10 %, 5% and 1%, respectively.

Table A3. Heterogeneity in the treatment effects (Independence)

	Full sample				Advanced countries				Developing countries			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Loose IT												
IT dummy	1.016***	1.043***	1.343***	0.925***	3.397***	3.399***	5.168***	3.428***	0.038	-0.150**	0.160	-0.175**
	(0.321)	(0.362)	(0.371)	(0.305)	(0.345)	(0.330)	(0.770)	(0.338)	(0.059)	(0.070)	(0.135)	(0.084)
PS	-1.564**	-1.129**	-1.136**	-2.074***	0.429	0.294	0.150	0.246	1.056*	0.523	0.713	0.802
	(0.728)	(0.523)	(0.499)	(0.547)	(0.360)	(0.434)	(0.436)	(0.425)	(0.579)	(0.451)	(0.468)	(0.513)
IT*(PS-PS_avg)	0.201				-0.315				-0.472**			
	(0.517)				(0.361)				(0.199)			
IT*Time		-0.010*				-0.006				0.030**		
		(0.005)				(0.004)				(0.013)		
Exchange rate regime			0.492***				1.564***				-0.344	
			(0.163)				(0.597)				(0.248)	
IT*Exchange rate regime			-0.165*				-1.440**				-0.172*	
			(0.096)				(0.567)				(0.093)	
Fiscal balance				0.008				0.005				-0.011
				(0.006)				(0.005)				(0.010)
IT*Fiscal balance				0.044**				0.004				-0.011
				(0.018)				(0.017)				(0.014)
Time-effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of obs.	781	781	781	781	235	235	235	235	546	546	546	546
Strict IT												
IT dummy	0.732***	0.776***	1.191***	0.684***	1.572***	1.617***	6.691***	1.642***	0.002	-0.128*	0.162	-0.142*
	(0.251)	(0.298)	(0.343)	(0.242)	(0.406)	(0.469)	(0.796)	(0.462)	(0.066)	(0.067)	(0.142)	(0.079)
PS	-1.252*	-0.964**	-0.677*	-1.433***	5.022***	4.099**	1.247	3.995**	1.186**	0.711*	0.834*	0.853*
	(0.658)	(0.408)	(0.380)	(0.396)	(1.709)	(1.590)	(0.959)	(1.580)	(0.599)	(0.427)	(0.460)	(0.482)
IT*(PS-PS_avg)	0.299				-3.015***				-0.432*			
	(0.584)				(0.662)				(0.229)			
IT*Time		0.003				0.004				0.056***		
		(0.010)				(0.014)				(0.021)		
Exchange rate regime			0.362***				2.967***				-0.396*	
			(0.118)				(0.478)				(0.226)	
IT*Exchange rate regime			-0.224**				-3.055***				-0.152*	
			(0.096)				(0.423)				(0.091)	
Fiscal balance				0.005				0.040**				-0.019
				(0.005)				(0.016)				(0.012)
IT*Fiscal balance				0.045**				-0.014				-0.009
				(0.019)				(0.019)				(0.018)
Time-effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of obs.	781	781	781	781	235	235	235	235	517	517	517	517

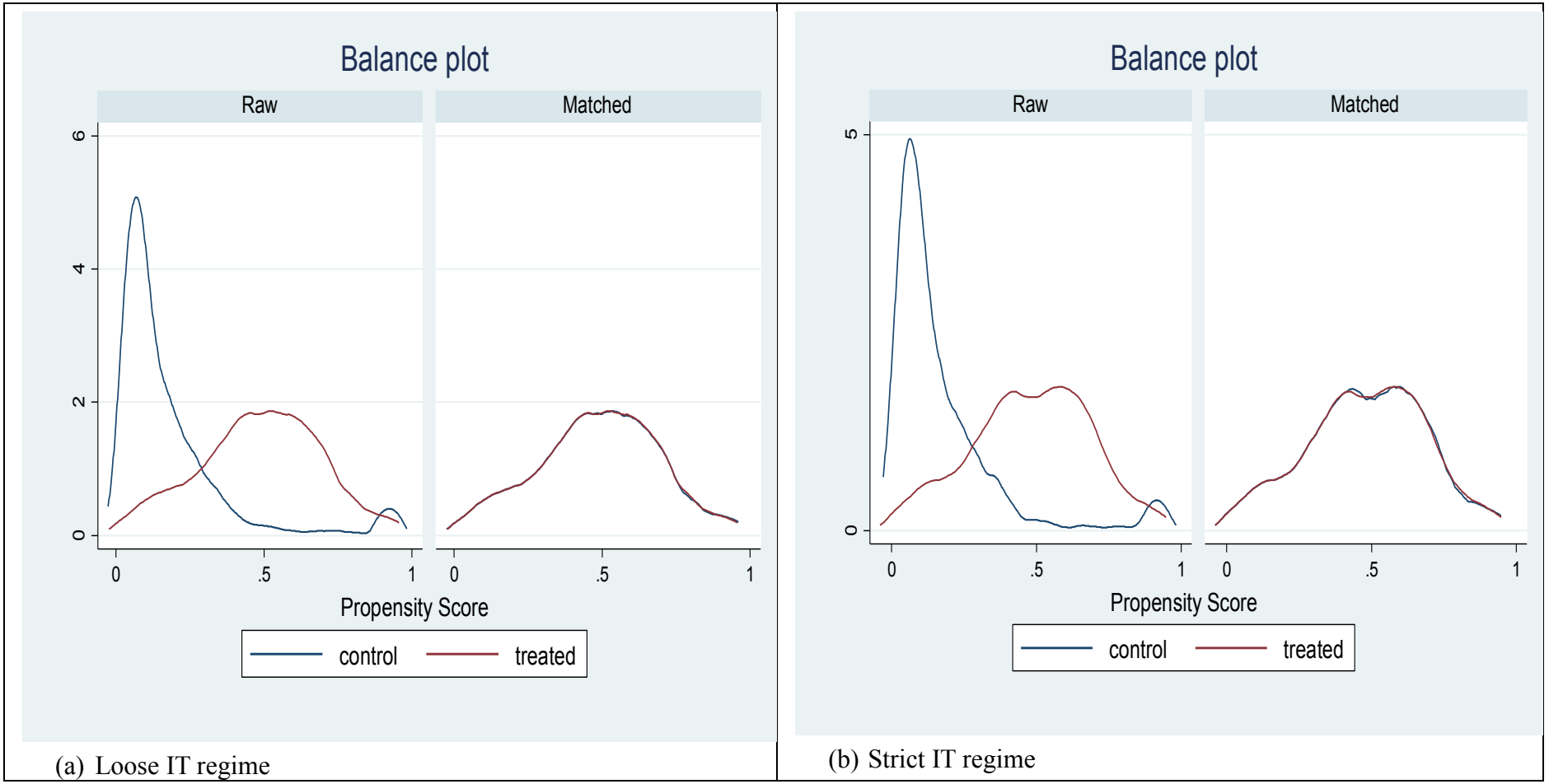
Notes: Table shows the ATTs obtained by weighted least squares regressions. The covariates applied in the covariate balancing regression and constant terms are included but not reported. Standard errors are shown in parentheses. *, ** and *** indicate the significant level of 10 %, 5% and 1%, respectively.

Table A4. Estimates of the treatment effects (PSM)

	Loose IT			Strict IT		
	Full sample	Advanced countries	Developing countries	Full sample	Advanced countries	Developing countries
Transparency	3.631***	4.415***	2.671***	3.581***	4.859***	2.910***
	(0.322)	(0.563)	(0.319)	(0.313)	(0.575)	(0.356)
No. of observation	784	236	548	784	236	517
Independence	-0.805***	1.815***	-0.955***	-0.704**	1.774***	-1.552***
(Dincer & Eichengreen)	(0.297)	(0.356)	(0.371)	(0.295)	(0.379)	(0.390)
No. of observation	781	235	546	781	235	517

Notes: The analytical standard errors are shown in parentheses. *, ** and *** indicate the significant level of 10 %, 5% and 1%, respectively.

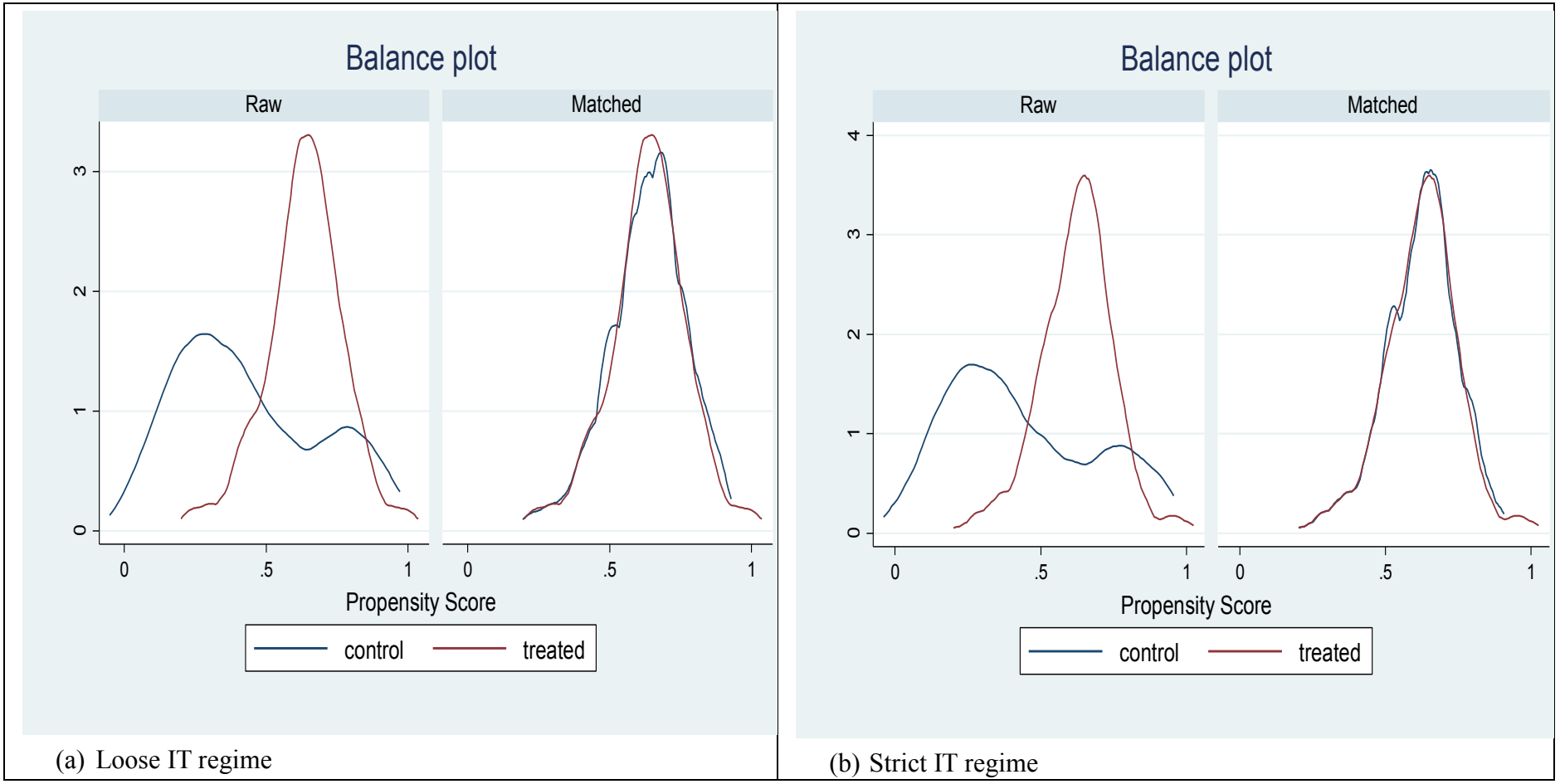
Figure A1: Balancing condition (Full Sample)



(a) Loose IT regime

(b) Strict IT regime

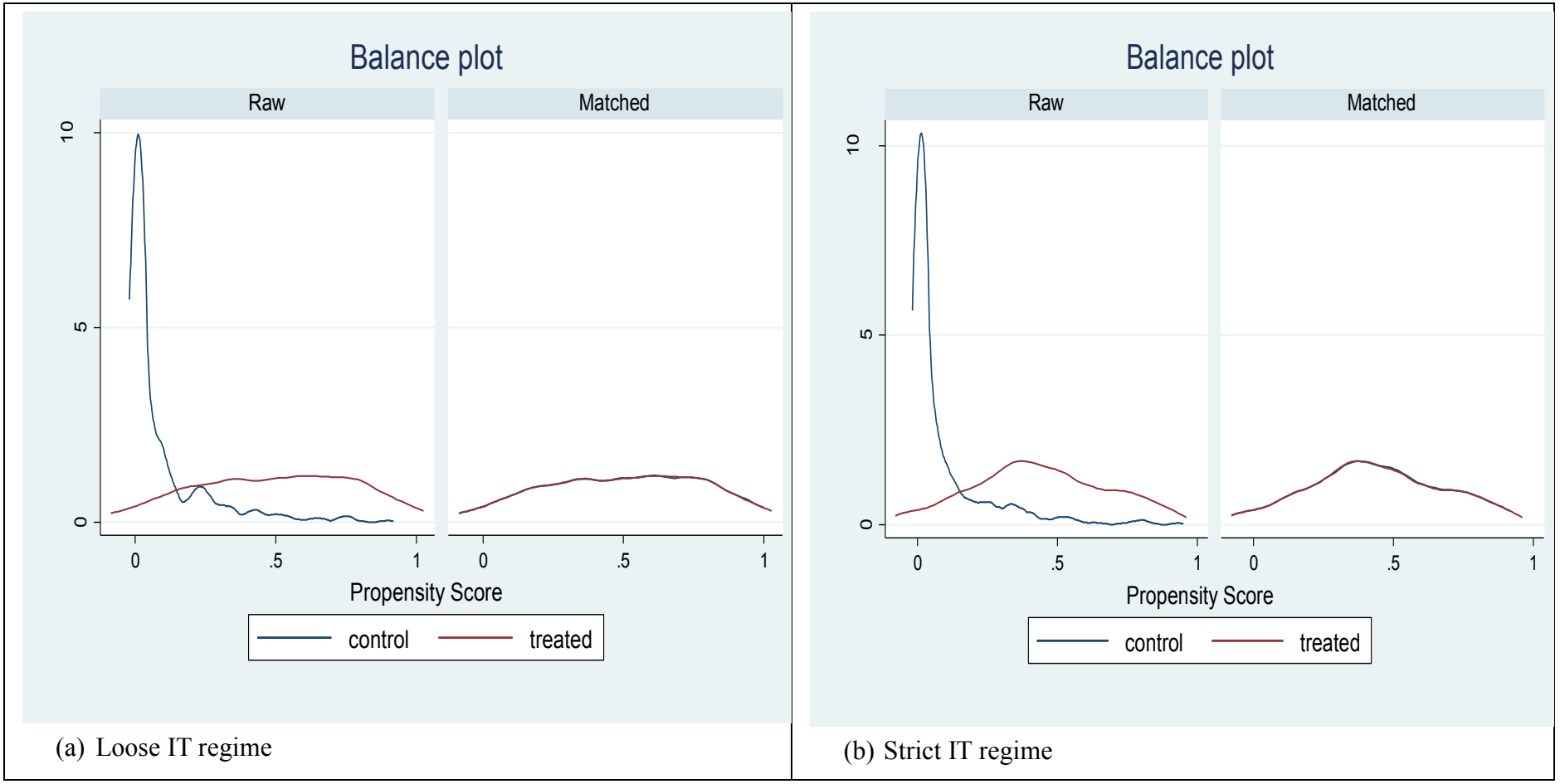
Figure A2: Balancing condition (Advanced countries)



(a) Loose IT regime

(b) Strict IT regime

Figure A3: Balancing condition (Developing countries)



(a) Loose IT regime

(b) Strict IT regime

Chapter 5

Conclusion

Since an IT regime has been widely adopted not only in advanced countries but also in developing countries as a monetary policy strategy, the policy makers and researches discusses the beneficial effects of the IT adoption on macroeconomic performance theoretically and empirically. Many empirical studies mainly examine the impacts of an IT regime on inflation, inflation volatility, and output volatility applying different methodologies including the DID and PSM methods. Generally, they suggest that an IT regime helps improve macroeconomic performance with low inflation, and the stability of inflation and output in developing countries while there is no clear evidence of a beneficial IT effect in advanced countries. However, the IT adoption might have several effects in various contexts. Thus, this dissertation has attempted to examine how an IT regime is related to domestic economy, external economy, and the institutional structure.

The first study has investigated the IT effects on income velocity which is related to domestic economy, over 84 developing countries from the period 1990 to 2013. Although an IT regime has become popular even in developing countries, many developing countries are still adopting monetary aggregates targeting due to unmatured money and financial markets. However, monetary aggregates targeting is often ineffective with the frequently failure of macroeconomic stability. Unstable income velocity is one of the main reasons for ineffective monetary aggregates targeting (Mishkin, 2006). According to Park (1970), income velocity is more volatile in developing countries than in advanced countries. Thus, stability of income velocity is crucial to achieve macroeconomic stability under monetary aggregates targeting. Taylor (2000) highlights that monetary targeting and inflation targeting can coexist and monetary aggregates would be an appropriate instrument to achieve inflation target in developing countries due to real interest rate uncertainty. If an IT regime helps

stabilize income velocity, monetary authorities can justify monetary aggregates targeting as an effective policy measure under an IT regime. Thus, the first study has attempted to examine the relationship between an IT regime and income velocity in developing countries.

The second study has examined the impacts of an IT regime on exchange market pressure which is related to external economy, over 101 developing countries from the period 1990 to 2014. Developing countries have often experienced foreign exchange market instability. Since foreign exchange markets are closely related to external conditions of an economy, foreign exchange market turmoil often induce the instability of external economy so that a sound monetary policy arrangement is important to absorb foreign exchange market pressures for their macroeconomic stability. If IT regime helps stabilize the exchange market pressures, policy makers will achieve the favorable external conditions and macroeconomic stability under an IT regime. Thus, the second study has attempted to investigate the relationship between an IT regime and exchange market pressure in developing countries.

The third study has analyzed the impacts of an IT regime on the credibility of the central bank which is captured by its transparency and independence, over 83 advanced and developing countries during the period from 1998 to 2010. Achieving macroeconomic and financial stability requires monetary policy credibility, which is closely related to institutional structure and their reforms so that many countries have been implementing the institutional reforms to achieve credibility. In addition, Eijffinger and Hoeberichts (2002) and Eijffinger et al. (2006) argue that central banks` monetary policy credibility is closely related to institutional reforms on (i) independence from the government and (ii) transparency to the public. At the same time, the IT adoption is one of the crucial monetary policy frameworks, which is expected to increase the monetary policy credibility. If an IT regime induces central bank credibility, policy makers will achieve favorable macroeconomic outcomes under an IT regime. Thus, the third study has attempted to

investigate the relationship between an IT regime and credibility of the central banks in advanced and developing countries.

This dissertation has applied the propensity score matching (PSM) and entropy balancing methods to discuss three contents: the first content is to examine the impact of an IT regime on income velocity volatility in developing countries, the second content is to examine the impact of an IT regime on exchange market pressure in developing countries, and the third content is to investigate the impact of an IT regime on the credibility of the central bank in advanced and developing countries. The first study has applied the PSM method to examine whether IT helps stabilize income velocity variability. The PSM method has commonly been used to eliminate self-selection bias, although it may suffer from issues related to small samples as well as hidden biases derived from unobserved covariates or factors (Pearl, 2000).

To confirm the empirical validity of our PSM results, this study has also applied another method widely used in IT-related studies, the DID method. The empirical results of both methods have indicated that IT would help stabilize income velocity in developing countries. Thus, our findings have shown clear support for Taylor's (2000) argument that monetary authorities in developing economies would prefer using monetary policy rule with monetary aggregates to achieve inflation targets under stable income velocity. In addition, our empirical results regarding IT effects on income velocity have highlighted that monetary authorities can pursue monetary aggregates as an effective policy measure under an IT regime. Moreover, our decomposition analysis of income velocity variability has provided evidences that IT lessens volatilities of inflation, real output growth, and money growth. Furthermore, our analysis of heterogeneous effects has revealed that an IT regime would be effective in reducing income velocity volatility under the favorable preconditions of IT adoption and floating exchange rate regime application. The time length also influences the

effectiveness of an IT regime, and IT is likely to become more effective in lowering income velocity volatility over time.

The second study has also applied the PSM method to examine whether an IT regime helps stabilize EMP and its two components. The empirical results have indicated that an IT regime would help stabilize EMP. In addition, our analysis has provided evidences that an IT regime lessens volatility of changes in international reserves, while our results show no clear evidence that an IT regime affects exchange rate variability. These findings suggest that the policy commitment to an IT regime improves the credibility of monetary policy conduct. Under an IT regime, central banks would not be required to intervene in the foreign exchange market. More interestingly, our findings have also shown that an IT regime is more beneficial for middle-income developing countries rather than for low-income developing countries.

The PSM method has been applied in the first study and the second study as the baseline approach. However, the ATT estimated from the PSM method can still suffer from biased results in the presence of misspecification in the propensity score model (Robins et al., 2007; Wooldridge, 2007, 2010). Thus, recent empirical studies apply entropy balancing method to build balanced samples in observational studies where the control group data can be reweighted to match the covariate moments in the treatment group (Neuenkirch & Neumeier, 2016). Compared to other matching methods, the entropy balancing has some advantages such as less misspecification problems, and higher balance of covariates between treatment and control groups (Neuenkirch & Neumeier, 2016). Therefore, the third study has used the entropy balancing method as the baseline method. To confirm the validity of the entropy balancing results, this study also has applied the standard panel and dynamic panel methods as well as the PSM method.

The empirical results have suggested that IT adoption helps improve transparency in both advanced and developing countries. More interestingly, the IT impacts on independence are different between advanced countries and developing countries, although central bank independence is generally expected to be granted to central banks to shield them from short-term political pressures when they fulfill their mandate of ensuring price stability. An IT regime increases independence in advanced countries, but lowers independence in developing countries. The possible reasons for different IT effects on independence between advanced and developing countries would be related to different political and administrative connections between a central bank and government, depending on the development stage. In addition, the negative effect of an IT regime on independence in developing countries may reflect the argument in the political economy context that central banks are granted stringent monetary authority in pursuit of price stability at the expense of losing independence from political authorities that often tend to keep central banks under their authority. The alternative methods (standard panel estimators, dynamic panel estimator and the PSM method) have also confirmed the empirical validity of the results of the entropy balancing results.

The third study have evaluated the heterogenous features of an IT adoption, our analysis shows (i) the positive IT effects on CBT and the negative IT effects on CBI tend to diminish over time in developing countries; (ii) the IT effects tend to become less effective at improving CBT and CBI in advanced countries due to the high flexibility of the exchange rate; (iii) the IT effects tend to become more effective at improving CBT in developing countries due to the high flexibility of the exchange rate; and (iv) the IT effects on CBT tend to become more substantial in developing countries with weak fiscal positions.

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