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Do central banks respond to exchange rates and restrictions to capital flows? Evidence from panel data

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Abstract

This paper examines whether central banks consider exchange rates and restrictions to capital flows when setting the policy rate. Specifically, this paper studies if there is a difference in the reaction between inflation targeting central bank and non-inflation targeting central banks in advanced and emerging economies. The recent financial crisis is also covered, that is, did the crisis change whether central banks are considering movements in the exchange rate as well as restrictions to capital flows as determinants of their policy rate. Using a linear monetary policy reaction function where the short-term interest rate reacts to expected future inflation deviation, output-gap and real exchange rate fluctuations. Then in order to investigate the effect of restrictions to capital flows (as measured by the Schindler index) on central bank's exchange rate policy, these variables are included in the policy function. A panel data set of 48 inflation targeting and non-targeting is employed, and the empirical results suggest that short-term interest rates in both advanced and emerging inflation targeting countries react to real exchange rate deviations and foreign interest rates. When the whole sample period is considered no significant response to the restriction variables is found, however when the sample period is divided in to a pre- and post-crisis period a reaction to the restriction variables is found.

Keywords: Inflation targeting, Taylor rule, real exchange rate, Schindler index

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I. Introduction

Inflation targeting as a monetary policy framework has been debated since it was first adopted by New Zeeland in 1990. As inflation targeting is a relatively recent addition to the monetary policy toolbox it is not always defined in the same way, but one definition offered by Mishkin (2000) is that inflation targeting can be said to consist of five elements, namely: (i) a public announcement of medium-term targets for the level of inflation; (ii) price stability as the primary goal of monetary policy enforced by an institutional commitment; (iii) an information inclusive strategy in which many variables, and not just monetary aggregates or the exchange rate, are used for deciding the setting of policy instruments; (iv) increased transparency of the monetary policy strategy through communication with the public and the markets about the plans, objectives, and decisions of the monetary authorities; and lastly (v) increased accountability of the central bank for attaining its inflation objectives.

In practice inflation targeting is considered to be flexible which means that central banks aims at stabilizing inflation around its target and the real economy, commonly represented by the output-gap (deviation of actual output from trend output level) (Svensson 2010). The literature on inflation targeting in advanced economies proposes that targeters let their exchange rate float freely (Taylor 2001, Svensson 2002) often without interventions and capital controls (Rose 2007). Nonetheless, recent empirical studies focusing on both advanced and emerging economies (Lubik and Schorfheide 2007, Mishkin and Schmidt-Hebbel 2007, Aizenman et al. 2011) suggest that short-term interest rates do react to both inflation and exchange rates, thus implying that all inflation targeting countries do not after all follow a freely floating exchange rate regim.

From a theoretical standpoint a well-functioning flexible inflation targeting framework requires a flexible exchange rate. The rationale for this statement is based on the policy dilemma of the impossible trinity (Berganza and Broto 2012). The impossible trinity says that the monetary authority can only choose two out of three desirable policy goals: independent monetary policy, a fixed exchange rate and perfect capital mobility. As the main goal of central banks in inflation targeting countries is to stabilize domestic inflation and the domestic output-gap hence domestic short-term interest rates has to be adjusted independently of foreign rates whenever inflation deviates from its target (Mukherjee 2011). Consequently, the central bank has to choose between a fixed exchange rate and perfect capital mobility. Under the assumption of perfect capital mobility, the optimal strategy for the central banks is to follow a flexible exchange rate regime. Hence, in this paper I examine whether central banks

in inflation targeting countries are considering movements in the exchange rate as well as restrictions to capital flows as determinants of their policy rate.

Therefore the purpose of this paper is to answer the following questions:

- Do central banks consider exchange rates and restrictions to capital flows when setting the policy rate? Is there a difference in the reaction between inflation targeting central bank and non-inflation targeting central banks, in advanced and emerging economies?
- Did the reaction by central banks differ before and after the recent financial crisis?

In order to answer the above-mentioned questions, I employ a panel data set of 48 countries in order to empirically examine a linear monetary policy reaction function where the short-term interest rate reacts to expected future inflation deviation (deviation of expected future inflation from its target level), output-gap and real exchange rate fluctuations. Then in order to investigate the effect of restrictions to capital flows (as measured by the Schindler index) on central bank's exchange rate policy, I incorporate an interaction term between exchange rate and the restriction variables and further control for the restriction variables themselves to avoid omitted variables problem. The Schindler (2009) index measures de jure restrictions on the direction of capital flows, i.e. in- and outflows. When analyzing the policy response de jure measures of restrictions are more relevant, since it is these restrictions that policymakers control. Thus, making the Schindler index is preferable in the context of policy analysis.

The empirical results suggest that short-term interest rates in both advanced and emerging inflation targeting countries react to real exchange rate deviations and foreign interest rates. When the whole sample period is considered no significant response to the restriction variables is found, however when the sample period is divided in to a pre- and post-crisis period a reaction to the restriction variables is found.

The paper proceeds as follows. Section 2 discusses the relevant literature on inflation targeting. Section 3 presents the data and empirical methodology. Section 4 discusses the results, and section 5 concludes.

II. Literature Review

John Taylor showed in his seminal paper (Taylor, 1993) that a simple monetary policy rule appropriately describes the conduct of policy by the US Federal Reserve. The Fed raises its policy rate when inflation exceeds a 2% implicit inflation target or when real GDP exceeds trend GDP. This result has led to a large line of research on Taylor rules and in the literature there are two approaches when examining the inflation targeting framework.

The first approach focuses on the effects of inflation targeting on macro-economic variables such as inflation and inflation volatility. The second approach focuses on the characteristics of central bank operating procedures, attempting to separate the differences in policy functions of inflation-targeting countries and non-targeting countries. Studies belonging to the first approach of the empirical literature employ both individual country time-series and multi-country panel methods, while studies of the second approach mostly focused on individual country time-series, however a few studies take an panel approach (see for example Caputo and Herrera (2013), Aizenman et al. (2011) and Mishkin and Schmidt-Hebbel (2007)). This paper follows the second approach to examining the inflation targeting framework, and thereby contributes to the literature taking a panel approach.

A. Macroeconomic effects of inflation targeting

The results from studies focusing on the macroeconomic outcome of implementing inflation targeting are mixed. For example, Lin and Ye (2007) evaluate the average treatment effect of inflation targeting in seven advanced economies (Australia, Canada, Finland, New Zealand, Spain, Sweden and the UK) and find that inflation targeting has no significant impact on inflation or inflation variablility. On the other hand, when using the same model for 13 inflation targeting developing countries (Brazil, Chile, Columbia, Czech Republic, Hungary, Israel, South Korea, Mexico, Peru, the Philippines, Poland, South Africa and Thailand) Lin and Ye (2009) find that that inflation targeting has significant impact on inflation and inflation variablility. Their results show that on average the adoption of inflation targeting led to a fall in the level of inflation by nearly 3 percentage points.

In an influential cross-section study for 20 OECD countries Ball and Sheridan (2005) find no evidence that inflation targeting improves economic performance as measured by the behavior of inflation, output, or interest rates. However, it should be noted that the results in Ball and Sheridan (2005) has been heavily debated since many of the non-inflation targeters in OECD sample have implemented monetary policies that are very similar in practice to formal inflation targeting. This generates a lack of sharpness in the classification scheme make the

results for the OECD countries hard to interpret. Which as Svensson (2010) notes may in fact suggest the opposite conclusion, that is that inflation targeting has instead been relatively effective for the OECD countries. For example, when extending Ball and Sheridan's (2005) analysis to a subset of 36 emerging market economies Gonçalves and Salles (2008) find that inflation targeting countries compared to non-targeting countries have lower inflation volatility and greater inflation reduction. The results by Gonçalves and Salles (2008) are consistent with the results in Fraga et al. (2003). On the other hand, in a more recent paper by Brito and Bystedt (2010), they argue that once common time trends are controlled for, the positive benefit of inflation-targeting regimes disappears and even argue that the disinflation period is potentially more recessionary under inflation-targeting.

B. Policy functions in inflation-targeting regimes

Most studies that focus on policy functions in inflation-targeting regimes usually consider differences in policy regimes by explicitly estimating Taylor rule equations for individual countries. A large number of studies in this genre, focusing on advanced economies, find some evidence that countries in inflation targeting regimes are following significantly different policy rules than countries in non-targeting regimes (see for instance, Corbo et al. (2001), Mohanty and Klau (2004), Edwards (2006)).

Corbo et al. (2001) estimate Tylor rule reaction functions for 17 OECD countries and find that inflation targeters exhibit a larger inflation gap coefficient relative to the output gap coefficient, although in most cases the coefficients are not significant. Whilst Lubik and Schorfheide (2007) use a dynamic structural general equlibrium model for a small open economy, where central banks react not only to inflation and output but to exchange rates as well. Their estimates show that the central banks of New Zeeland and Australia do not react to exchange rates, whereas the central banks of England and Canada do. Meanwhile, Dennis (2003) uses a Taylor rule to investigate the role of exchange rates in the Australian monetary policy and finds that both inflation and exchange rates are taken into acount when setting interest rates.

Aizenman et al. (2011) find, using panel data for 17 emerging market economies, that among the inflation-targeting countries commodity exporters are more exposed to terms-of-trade shocks and real exchange rate disturbances. Thus, these countries react more to exchange rates compared to non-commodity exporters. Mohanty and Klau (2004) use a modified Taylor rule which considers both the inflation and output gap as well as lagged interest rates and current and lagged exchange rate changes. They find that the policy resopones of emerging

markets central banks to exchange rate changes were larger compared to the response to the inflation gap and the output gap, which supports the "fear of floating" hypothesis.

The larger response to exchange rate changes could also reflect the fact that central banks in emerging markets may have dual targets, of stabilizing both the exchange rate and the inflation. This argument has been put forward by Amato and Gerlach (2002). They argue that in emerging markets financial markets are not well developed and because of the lack of depth in the domestic capital market, firms, households and governments in these economies borrow in foreign currency. Consequently, movements in the exchange rate has a severe impact on the borrower's balance sheet. Hence, the central bank may be required to increase the short-term interest rate severely in response to a depreciation, which violates the precondition of exchange rate subordination under inflation targeting. Amato and Gerlach (2002) also argue that with a poor track record of monetary stability, the exchange rate also serves as a focal point for inflationary expectations.

Berganza and Broto (2012) uses a panel model to study the intervention of emerging markets central banks on exchange rate markets within an inflation targeting framework, and they state that these interventions might have implications for monetary policy and the use of policy rules. Interventions that may imply a departure from the corner solutions derived from the "impossibility Trinity". Berganza and Broto (2012) also find that exchange rates are more volatile in an inflation targeting regime than under other regimes, results which are in line with De Gregorio et al. (2005) and Edwards (2006). Berganza and Broto (2012) conclude that there is some scope for emerging markets which have adopted inflation targeting to interpret the implementation of their inflation targeting regime with certain degree of flexibility.

C. Shocks, crises and capital controls in inflation-targeting regimes

The literature regarding how the inflation targeting regime can cope with economic shock is less extensive, however Mishkin and Schmidt-Hebbel (2007) using a VAR-panel model compare targeters and non-targeters facing oil price shocks. The hypothesis they set out to test is the following: if inflation targeting increases credibility of the central bank in anchoring price expectations, one could expect targeters to perform better in terms of inflation, and the consequences of shocks through exchange rate will be less pronounced. The conclusions of Mishkin and Schmidt-Hebbel (2007) are in favor of targeters.

Rose (2007) studies the implications of inflation targeting adoption in terms of exchange rate volatility, external reserves accumulation, sudden stops of capital flows and current account

balance. Using a sample of 68 countries, including 23 targeters, from 1990 to 2005, the conclusions of Rose (2007) are that inflation targeters have lower exchange rate volatility and face less frequent sudden stops of capital flows than similar non-targeters. The current accounts or international reserves of inflation targeting countries do not look different from non-targeters. Lin (2010) conducts a study similar to that of Rose (2007). Using propensity score matching, he finds that for developing countries, inflation targeting reduces the exchange rate volatility and increases external reserves accumulations. On the other hand, for industrial countries, inflation targeting increases in exchange rate volatility and lowers external reserves accumulation.

One of few who have analyzed the recent financial crisis effect on inflation targeters and non-targeters using a panel method is de Carvalho Filho (2010, 2011). With panel estimates and a difference in difference approach, covering 51 countries, including 23 inflation targeters, de Carvalho Filho (2011) finds that countries which adopted inflation targeting faced lower decrease in GDP growth. This result is challenged by Fouejieu (2013) who finds that when controlling for the exchange rate regime there is no significant difference between targeters and non targeters when it comes to GDP growth during the crisis. However, when it comes to magaging the increase in the real interest rate and increased inflation volatility Fouejieu (2013) finds that inflation targeting central banks perform better compared to non-targeting central banks.

Xafa (2008) notes that inflation targeting countries have imposed capital controls to discourage capital flows and reduce appreciation pressure, e.g. Chile in 1991, Thailand in 2006, and Colombia in 2007. However, the empirical evidence on whether capital controls are effective in slowing capital flows are mixed, and over the longer term, one can argue that markets will find ways around the controls. Nevertheless, using high frequency data for Chile from 1991 to 1998, Edwards and Rigobon (2009) found that a tightening of capital controls resulted in a depreciation of the domestic currency in Chile. While Coelho and Gallagher (2010) find that capital controls on inflows were modestly successful in Colombia and Thailand in reducing the overall of capital inflows, reducing exchange rate appreciation and volatility, however the experience in Thailand was less successful than Colombia. Ostry et al. (2010) conclude that there may be circumstances in which capital controls are a legitimate part of the policy response to surges in capital inflows. Mukherjee (2011) empirically examine whether the responsiveness of the interest rate to exchange rate fluctuations can be explained in terms of limited capital openness does find that short-term interest rates do

respond to real exchange rate fluctuations. However, the responsiveness of the interest rate to the exchange rate declines significantly as capital market openness increases.

Thus several empirical studies (e.g. Mohanty and Klau 2004, Lubik and Schorfheide (2007), Aizenman et al. (2011)) suggest that that in some inflation targeting countries central banks respond sytematically to both inflation and exchange rates and there is some recent literature (Edwards and Rigibon (2009), Ostry et al. (2010), Coelho and Gallaher (2010)) suggesting that controls on capital inflows versus capital outflows may have very different impact on real exchange rate volatility. Further, although the literature to date offers explanations why the inflation targeting countries, especially the emerging markets react to exchange rate changes, the impact of controls on capital inflows versus capital outflows on the responsiveness of the interest rate to exchange rate movements is still relatively unexplored and lack a panel approach including both emerging and advanced economies. Therefore, in this paper, I examine whether the inflation targeting countries are imposing restrictions on capital flows to manage exchange rate movements while maintaining an independent monetary policy.

III. Data and Empirical Methodology

A. Estimation equation

The short-term interest rate is chosen as the monetary policy instrument in inflation targeting countries. Following the extensive literature that has emerged since Taylor (1993), the following monetary policy reaction function is assumed to be a forward-looking and a linear one (Aizenman et al. 2011, Caputo and Herrera 2013), where the target interest rate responds to expected future inflation deviation, output-gap and exchange rate deviations:

$$i_{it} = \rho i_{it-1} + \gamma_\pi(E_t[\pi_{it+1}] - \pi^*) + \gamma_y(y_{it} - \bar{y}_{it}) + \gamma_{i^F} i_t^F + \gamma_e X_{it} + \nu_{it} \qquad (1)$$

where π is the expected CPI inflation rate in *t+1*, π^* is the target inflation rate, y_{it} is the output of country *i* at time *t*, $\bar{y}_{it}$ is the trend output of country *i* at time *t* and ν_{it} is an exogenous random shock to the interest rate and is assumed to be independently and identically distributed. As seen in equation (1) the current interest rate (i_t) is assumed to depend on its own lagged value, in accordance with the strong empirical evidence (English et al. 2003, Clarida et al. 1998), where the parameter ρ represents the degree of interest rate smoothing.

Following Caputo and Herrera (2013) I will also consider the foreign interest rate, i_t^F, as one of the determinants of the policy rate. The variables in X_{it} are possible additional determinants of the policy rate, namely the deviation of the real effective exchange rate from trend and the variables reflecting controls on capital in- and outflows (kai_{it} and kao_{it} respectively, see Appendix B for more details about their composition). More precisely, as in Mukherjee (2011) an interaction term in between the variables on controls on capital in- and outflows and the exchange rate deviations, and to avoid omitted variable bias the variables on controls on capital in- and outflows themselves will also be controlled for.

The rationale for estimating a forward-looking Taylor rule is, firstly, that by explicitly including expected inflation in the reaction function makes it easier to unravel the link between the estimated coefficients and central bank objectives. In fact, as note by Clarida et al. (1998) it is not clear from the simple contemporaneous Taylor specification whether the central bank responds to the output gap independently of concern about future inflation, or if the output gap is in fact a target. Secondly, by having the central bank respond to forecasts of inflation, output and other contemporaneous variables, one incorporates a more realistic feature of policy-making, specifically that central banks consider a broad array of information (Caputo and Herrera 2013).

In the spirit of Aizenman et al. (2011) the inflation target variable, π^*, is assumed to be time invariant for each country and is therefore subsumed in the country fixed effect parameter, α_i.

$$i_{it} = \alpha_i + \rho i_{it-1} + \gamma_\pi(E_t[\pi_{it+1}]) + \gamma_y(y_{it} - \bar{y}_{it}) + \gamma_{i^F} i_t^F + \gamma_e X_{it} + \nu_{it} \qquad (2)$$

The specification in (2) includes an inertial element in the Taylor rule. This is useful to introduce in order to reflect the fact that monetary policy changes only gradually as new information becomes available. Therefor in this context, the coefficients in (2), and subsequent equations, can be interpreted as short-run policy responses[1].

B. Data

In order to investigate if there is a difference in the reaction to exchange rates between inflation targeting central bank and non-inflation targeting central banks in advanced and emerging economies data for 22 inflation targeting countries and 26 non-targeting countries is used. Of the 48 countries 29 are classified as advanced economies and 19 are classified as emerging market economies according to IMF's World Economic Outlook (WEO). The data sample was restricted by the country coverage of the Schindler index.

The 48 countries in my dataset are: Argentina, Australia, Austria, Belgium, Brazil, Bulgaria, Canada, Chile, China, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Greece, Hong Kong, Hungary, Iceland, India, Indonesia, Ireland, Israel, Italy, Japan, Korea, Latvia, Malaysia, Malta, Mexico, Netherlands, New Zealand, Norway, Pakistan, Peru, Philippines, Portugal, Romania, Russia, Singapore, Slovenia, South Africa, Spain, Sweden, Switzerland, Thailand, Turkey and United Kingdom. See Appendix A for more details on the countries included in the sample.

The main data source used in this paper is IMF's International Financial Statistics database. For inflation targeting countries the data set ranges from a time when a particular country started targeting inflation through 2012 at annual frequency[2]. The start year for the data on non-targeting countries is 1995[3] and ranges through 2012 at annual frequency. Thus, the panel data set used will be an unblanced one. Data on the money market rate has been used as a proxy for short-term nominal interest rate. The money market rate in United States has been used as a proxy for the foreign interest rate, which is the reason why the United States is not included in the sample. Inflation is calculated as the time difference of the log CPI. The

[1] Long-run coefficients are thus obtained by dividing the estimates by $\frac{1}{1-\rho}$.

[2] The Schindler index is only available at annual frequency.

[3] The start year selected was start year of the Schindler (2009) index, i.e. 1995.

output-gap is constructed by subtracting the trend level of real-GDP from actual real GDP where the trend real GDP is calculated using Hodrick-Prescott filter (smoothing parameter 100). Correspondingly, the data for real exchange rate deviation is constructed by subtracting the trend real exchange rate (calculated using Hodrick-Prescott filter with smoothing parameter 100), from the actual real effective exchange rate. Thus, an increase in the exchange rate is considered as a real depreciation of the domestic exchange rate. The Schindler (2009) index is used to measure de jure restrictions on the direction of capital flows, i.e. in- and outflows. When analyzing the policy response de jure measures of restrictions are more relevant, since these restrictions are the ones that policymakers control. Thus, making the Schindler index is preferable in the context of policy analysis. The index lies between 0 and 1, and a lower value means a more financially open economy, see Appendix B for a further discussion on the construction of the Schindler index.

Summary statistics for all the variables are reported in Table 1. Columns (1)-(3) report the mean and standard deviation for the inflation-targeting countries in the sample, columns (4)-(6) reports the mean and standard deviation for the non-targeting countries in the sample.

Table 1: *Summary Statistics*

	Inflation-targeters			Non-targeters		
Variable	Full Sample	Advanced economies	Emerging economies	Full Sample	Advanced economies	Emerging economies
	(1)	(2)	(3)	(4)	(5)	(6)
Capital inflow restriction	0.291	0.196	0.435	0.279	0.150	0.573
	(0.256)	(0.174)	(0.299)	(0.334)	(0.224)	(0.357)
Capital outflow restriction	0.345	0.188	0.582	0.363	0.2173	0.692
	(0.368)	(0.260)	(0.371)	(0.390)	(0.287)	(0.392)
Inflation	0.073	0.006	0.176	-0.056	0.002	-0.193
	(1.052)	(0.005)	(1.666)	(1.244)	(0.034)	(2.247)
Interest rate	3.762	0.990	7.952	5.166	3.183	9.657
	(5.043)	(2.063)	(5.322)	(11.755)	(2.485)	(20.252)
Output gap	2.692	4.467	0.008	0.005	0.005	0.004
	(3.979)	(4.290)	(0.024)	(0.034)	(0.027)	(0.046)
Real effective exchange rate change	1.468	2.190	0.377	0.001	0.002	0.000
	(2.146)	(2.312)	(1.238)	(0.049)	(0.034)	(0.072)
US money market rate	2.627	2.964	2.117	3.167	3.160	3.181
	(2.122)	(2.153)	(1.959)	(2.2283)	(2.228)	(2.221)
Number of observations	321	193	128	468	325	143

Mean and in parenthesis standard deviation

Before estimating the Taylor rule, unit root tests are performed to control that the series are stationary. As shown in Table 2, the null hypothesis of common unit root can be rejected in all cases, based on the results from the Levin et al. (2002) and the Breitung (2000) tests.

Table 2: *Panel Unit Root Tests*

	Inflation-targeters		Non-targeters	
Variable	LLC	Breitung	LLC	Breitung
Capital inflow restriction	-12.2370***	-8.2313***	-8.3954***	-6.0736***
Capital outflow restriction	-10.6083***	-5.0077***	-6.4708***	-4.7052***
Inflation	-13.8901***	-4.6123***	-244.585***	-3.3986**
Interest rate	-5.9238***	-4.1169***	-11.6210***	-3.1522**
Output gap	-5.5053***	-2.0639**	-3.6073***	-2.5900**
Real effective exchange rate change	-10.5416***	-2.0117**	-3.6373***	-4.4754***
US money market rate	-9.7796***	-8.9152***	-7.3084**	-14.2613***

Null hypothesis: Unit root (assumes common unit root process)
** Indicate the significance level at 5%.
*** Indicate the significance level at 1%.

C. Empirical estimation

The method used to estimate the forward-looking Taylor rule in equation (2) is the same as in Caputo and Herrera (2013) and Aizenman et al. (2011) in order to insure comparability of the results. However, when estimating an equation as the one in (2) one faces two problems. The first one is that when the time dimension (T) of a panel with a lagged dependent variable is small, estimations are biased (Aizenman et al. 2011). The second problem, noted by Caputo and Herrera (2013), is that the correlation between the error term in equation (2) and expected inflation used as regressor in the Taylor rule regression could produce biased and inconsistent estimates and this independently of the size of the time dimension (T).

In order to correct the first problem, a country fixed-effects least-squares estimation procedure (LSDV) is used to correct the bias generated by the presence of a lagged dependent variable. As shown by Judson and Owen (1999) the LSDV estimator performs well in a panel with a large T.

Now, in order to correct the bias generated by the correlation between the error term and the explanatory variable, the LSDV estimator is estimated using an instrumental variable approach, as in Caputo and Herrera (2013). More precisely, the unobserved expected inflation is removed by rewriting the policy rule in equation (2) in terms of realized variables, as follows:

$$i_{it} = \alpha_i + \rho i_{it-1} + \gamma_\pi \pi_{it+1} + \gamma_y (y_{it} - \bar{y}_{it}) + \gamma_{i^F} i_t^F + \gamma_e X_{it} + \epsilon_{it} \qquad (3)$$

where the error term, ϵ_{it} ,is a linear combination of the forecast errors of inflation and the exogenous errors, ν_{it} . In order to proceed with the instrumental variable estimation one needs to define a vector of variables within each central bank's information set, called $\mathbf{u}_{it}$. This vector is, at the time each central bank chooses its interest rate, orthogonal to ν_{it} (Verbeek 2012, Clarida et al. 1998). In other words meaning that $E(\epsilon_{it} | \mathbf{u}_{it}) = 0$. This condition, along with equation (3), implies the following set of orthogonality conditions used for estimation:

$$E\left(i_{it} - \alpha_i - \rho i_{it-1} - \gamma_\pi \pi_{it+1} - \gamma_y (y_{it} - \bar{y}_{it}) - \gamma_{i^F} i_t^F - \gamma_e X_{it} \middle| \mathbf{u}_{it}\right) = 0 \qquad (4)$$

Now, when estimating the parameters of interest, the set of instruments, $\mathbf{u}_{it}$, used includes lagged values of the output gap, inflation , the policy rate, and the variables included in X_{it}; the deviation of the real effective exchange rate from trend and the variables reflecting restrictions to capital in- and outflows and the interaction terms between these variables.

IV. Estimation results

A. Main results

This section discusses the results from the whole sample, i.e. the difference between inflation and non-inflation targeting central banks. The results from the estimation using the full sample are presented in Table 3. For the inflation targeting sample (column 1), all the variables in the benchmark Taylor rule are significant and an interesting result is that central banks in an inflation targeting regime seem to react to foreign rates (US money market rate) which are consistent with results in Caputo and Herrera (2013). Another result shown in Table 3 is that the lagged interest rate is highly significant and that the value of ρ is quite high reflecting a high degree of persistence, results which are consistent with Clarida et al. (1998). The high degree of persistence shows that central banks react slowly as new information becomes available.

The estimation results from the benchmark model also holds for the extended model, i.e. significant reaction to foreign rates and high degree of persistence (see column 2). For the extended Taylor rule the exchange rate deviation is significant, thus suggesting that central banks in inflation targeting countries are considering the exchange rate when setting the policy rate. However, neither of the variables reflecting restrictions to capital in- and outflows nor their interaction with the exchange rate deviation is found to be significant.

The results for the non-targeting sample are quite similar to the ones for the inflation targeting sample. All the variables in the benchmark Taylor rule are significant (column 3) and once again the foreign rate is highly significant and there is a high degree of persistence. The results for the extended Taylor rule show that central banks in non-targeting countries do not consider the exchange rate deviation nor do they consider variables reflecting restrictions to capital in- and outflows.

Table 3: *Forward-Looking Taylor Rules Estimates*

		Inflation-targeters		Non-targeters	
Variable	Coefficient	Benchmark Taylor rule (1)	Extended Taylor rule (2)	Benchmark Taylor rule (3)	Extended Taylor rule (4)
kai_{it}	γ_{kai}		0.366		-0.477
			(0.737)		(0.422)
kao_{it}	γ_{kao}		-0.145		-0.457
			(0.599)		(0.318)
π_{it+1}	γ_{π}	-0.312***	-0.318***	-0.242**	0.042
		(0.047)	(0.047)	(0.104)	(0.152)
i_{it-1}	ρ	0.378**	0.402***	0.408***	0.379***
		(0.143)	(0.144)	(0.060)	(0.053)
$y_{it} - \bar{y}_{it}$	γ_{y}	-0.014***	-0.016***	6.917***	8.413***
		(0.005)	(0.004)	(1.880)	(2.446
$e_{it} - \bar{e}_{it}$	γ_{e}		0.010**		1.809
			(0.005)		(2.411)
$(e_{it} - \bar{e}_{it}) * kai_{it}$	γ_{ekai}		-0.164		-18.045
			(0.339)		(13.140)
$(e_{it} - \bar{e}_{it}) * kao_{it}$	γ_{ekao}		0.075		2.745
			(0.246)		(11.648)
i_t^F	γ_{i^F}	0.036***	0.032***	0.340***	0.355***
		(0.008)	(0.008)	(0.052)	(0.050)
Long Run Coefficients					
π		-0.501	-0.532	-0.408	0.067
$y - \bar{y}$		-0.022	-0.027	11.689	13.540
$e - \bar{e}$			0.016		2.911
Observations		275	275	415	415
R^2 adjusted		0.9149	0.9154	0.8223	0.8224

Robust standard errors in parenthesis
* Indicate the significance level at 10%.
** Indicate the significance level at 5%.
*** Indicate the significance level at 1%.

B. Advanced and emerging sub-sample analyses

This section discusses if the central bank policy rule differs among advanced and emerging economies, Table 4 reports the results from the sample of advanced economies whilst Table 5 reports the results from the emerging sample.

As shown in Table 4 the results from the advanced sample are similar to the main results discussed in the previous section. That is, for both the benchmark and the extended Taylor the foreign rate is significant and there is a quite a high degree of persistence. Again the difference between the non-targeting and targeting countries seem to be that inflation targeting central banks in advanced economies also consider the exchange rate deviations when setting the policy rate. For the advanced sample there is one result that is different to the main results, which is that the interaction term between the exchange rate deviations and the variable reflecting restrictions to capital outflows. Thus, suggesting that apart from exchange rate deviations the central banks in advanced economies also consider its interaction with controls on capital outflows.

Table 4: *Forward-Looking Taylor Rules Estimates – Advanced Economies*

		Inflation-targeters		Non-targeters	
Variable	Coefficient	Benchmark Taylor rule (1)	Extended Taylor rule (2)	Benchmark Taylor rule (3)	Extended Taylor rule (4)
kai_{it}	γ_{kai}		-0.510		-0.253
			(0.334)		(0.454)
kao_{it}	γ_{kao}		0.334		-0.6589**
			(0.230)		(0.289)
π_{it+1}	γ_{π}	0.638	-1.016	8.953	2.043
		(1.245)	(1.658)	(19.724)	(16.716)
i_{it-1}	ρ	0.438***	0.452***	0.474***	0.460***
		(0.155)	(0.151)	(0.073)	(0.070)
$y_{it} - \bar{y}_{it}$	γ_{y}	-0.005	-0.006*	10.560***	11.332***
		(0.004)	(0.004)	(2.556)	(2.330)
$e_{it} - \bar{e}_{it}$	γ_{e}		0.009**		-0.711
			(0.004)		(2.423)
$(e_{it} - \bar{e}_{it}) * kai_{it}$	γ_{ekai}		0.216		-21.227
			(0.1314)		(20.789)
$(e_{it} - \bar{e}_{it}) * kao_{it}$	γ_{ekao}		-0.156*		0.733
			(0.091)		(12.049)
i_t^F	γ_{i^F}	0.010*	0.010**	0.319***	0.332***
		(0.006)	(0.005)	(0.054)	(0.050)
Long Run Coefficients					
Π		1.135	-1.855	17.005	3.779
$y - \bar{y}$		-0.009	-0.011	20.058	20.965
$e - \bar{e}$			0.017		-1.316
Observations		170	170	288	288
R^2 adjusted		0.9275	0.9200	0.8530	0.8585

Robust standard errors in parenthesis
* Indicate the significance level at 10%.
** Indicate the significance level at 5%.
*** Indicate the significance level at 1%.

In Table 5 the results from the emerging sample is shown. Again the results are similar to the main results, central banks in inflation targeting countries seem to consider the foreign rate as well as the exchange rate deviation as determinants of the policy rate. Another interesting result found in Table 5 is that for non-targeting emerging economies the exchange rate deviation is significant. All the results for the emerging sample are consistent with the ones in Aizenman et al. (2011).

For both inflation targeters and non-targeters in the emerging sample neither of the variables reflecting restrictions to capital in- and outflows nor their interaction with the exchange rate deviation is found to be significant.

Table 5: *Forward-Looking Taylor Rules Estimates – Emerging Economies*

		Inflation-targeters		Non-targeters	
Variable	Coefficient	Benchmark Taylor rule (1)	Extended Taylor rule (2)	Benchmark Taylor rule (3)	Extended Taylor rule (4)
kai_{it}	γ_{kai}		0.572		-0.957
			(1.749)		(1.952)
kao_{it}	γ_{kao}		-0.550		3.447
			(2.331)		(2.405)
π_{it+1}	γ_{π}	-0.245***	-0.260***	-0.206	-0.231
		(0.040)	(0.043)	(0.137)	(0.152)
i_{it-1}	ρ	0.339***	0.397***	0.387**	0.353***
		(0.111)	(0.124)	(0.063)	(0.078)
$y_{it} - \bar{y}_{it}$	γ_{y}	22.337**	24.286**		0.748
		(9.976)	(9.234)		(8.564)
$e_{it} - \bar{e}_{it}$	γ_{e}		0.919*		4.038*
			(0.531)		(2.309)
$(e_{it} - \bar{e}_{it}) * kai_{it}$	γ_{ekai}		-0.410		-72.765
			(0.3690)		(51.953)
$(e_{it} - \bar{e}_{it}) * kao_{it}$	γ_{ekao}		-20.530		-41.271
			(35.713)		(48.735)
i_t^F	γ_{i^F}	0.249**	0.212*	3.326	0.165
		(0.114)	(0.121)	(6.712)	(0.127)
Long Run Coefficients					
Π		-0.370	-0.430	-0.337	-0.365
$y - \bar{y}$		33.770	40.248	5.426	1.156
$e - \bar{e}$			1.522		6.235
Observations		105	105	127	127
R^2 adjusted		0.8032	0.8011	0.6614	0.6443

Robust standard errors in parenthesis
* Indicate the significance level at 10%.
** Indicate the significance level at 5%.
*** Indicate the significance level at 1%.

Thus, the results from both the emerging and advanced sample are similar to the main results in the previous section. Central banks in an inflation targeting regime in both samples seem to consider the foreign rate and the exchange rate deviations as determinants of the policy rate. Inflation targeting central banks thus attempt to "lean against the wind" and stabilize the exchange rates by increasing interest rates in response to real exchange rate depreciation. Non-targeting emerging-market central banks also respond to real exchange rates when setting interest rates. It is notable that the real exchange rate response is smaller for inflation targeters compared to the non-targeters. Thus, even if inflation targeting central banks attempt to "lean against the wind" their actions are seemingly more constrained by the commitment to target inflation than the non-targeters in how pro-actively this objective is followed.

The results from the estimation of forward-looking Taylor rules, namely a significant reaction exchange rate deviation, foreign rates and high degree of policy inertia, measured by the lagged interest rate coefficient, and confirms the results in Aizenman et al. (2011), Caputo and Herrera (2013) and Clarida et al. (1998).

C. Robustness check

As a robustness check of the results described in the two previous sections, the benchmark and extended Taylor rule are estimated for the inflation targeting sample using the start dates provided by Rose (2007). This means that instead of using the offical date of adoption of inflation targeting as the start of the sample period, the "start date" is when the effect of inflation targeting is noticed. Using a "start date" other than the offical means that one takes into account that there may be a lag between the announcement of inflation targeting and actual implementation of an inflation targeting regime (Mishkin and Schmidt-Hebbel 2007). The results are shown in Table 6.

The results using different start dates are consistent with the ones using the official start date, as shown in Table 6 the exchange rate deviation and the foreign rate seem to be part of the policy rule both advanced and emerging economies. Once again the variables reflecting restrictions to capital in- and outflows are not significant in any sample, and it is only for advanced economies that one of the interaction terms is significant, the between the exchange rate deviations and the variable reflecting restrictions to capital outflows (same result as when using official start dates).

Table 6: *Forward-Looking Taylor Rules – different start dates*

		All targeters		Advanced economies		Emerging economies	
Variable	Coefficient	Benchmark Taylor rule (1)	Extended Taylor rule (2)	Benchmark Taylor rule (3)	Extended Taylor rule (4)	Benchmark Taylor rule (5)	Extended Taylor rule (6)
kai_{it}	γ_{kai}		0.390		-0.367		-0.186
			(0.664)		(0.406)		(1.920)
kao_{it}	γ_{kao}				0.408		-0.039
					(0.276)		(2.354)
π_{it+1}	γ_{π}	0.325***	0.328***	0.166	0.466**	0.258***	0.266***
		(0.047)	(0.045)	(1.934)	(0.183)	(0.039)	(0.039)
i_{it-1}	ρ	0.444***	0.461***	0.437**	0.440**	0.406***	0.450***
		(0.159)	(0.159)	(0.199)	(0.197)	(0.119)	(0.116)
$y_{it} - \bar{y}_{it}$	γ_{y}	-0.013***	-0.011***	-0.007	-0.006	25.589***	27.337***
		(0.005)	(0.004)	(0.004)	(0.004)	(9.226)	(8.725)
$e_{it} - \bar{e}_{it}$	γ_{e}		0.021**		0.020***		1.011*
			(0.008)		(0.005)		(0.517)
$(e_{it} - \bar{e}_{it}) * kai_{it}$	γ_{ekai}		-0.169		0.164		-0.285
			(0.294)		(0.1599)		(0.376)
$(e_{it} - \bar{e}_{it}) * kao_{it}$	γ_{ekao}		-0.181		-0.192*		-26.204
			(0.244)		(0.114)		(34.953)
i_t^F	γ_{i^F}	0.023***	0.019***	0.507***	0.009*	3.668***	2.989***
		(0.007)	(0.006)	(0.187)	(0.005)	(0.876)	(0.971)
		Long Run Coefficients					
π		0.585	0.609	0.295	0.832	0.434	0.484
$y - \bar{y}$		-0.023	-0.020	-0.012	-0.011	43.079	49.704
$e - \bar{e}$			0.039		0.036		1.838
Observations		264	264	163	163	101	101
R^2 adjusted		0.9178	0.9177	0.9252	0.9260	0.8326	0.8444

Source: Rose (2007) Robust standard errors in parenthesis
* Indicate the significance level at 10%.
** Indicate the significance level at 5%.
*** Indicate the significance level at 1%.

D. Response after the financial crisis

In order to assess if the determinates of central bank policy rules have changed after the recent financial crisis, the sample is divided into a pre- and post-crisis period. The pre-crisis period consists of the years from adoption of the inflation targeting regime until 2007, the crisis period is 2008-2009 and the post-crisis period is 2009-2012, as in Fouejieu (2013). The estimation results from the sub-sample analysis is found in Table 7. Here only the extended Taylor rule is considered, and the results for all targeting countries suggest that after the crisis central banks are considering the restriction variables as well as exchange rate deviations in their policy rules. However, there is a difference between the central banks in advanced and emerging economies. Where emerging market central banks seem to react to the interaction of the restriction variables with the exchange rate deviations, whereas advanced economies central banks seem to react to capital inflows. Thus the results are somewhat inconclusive but suggest that after crisis inflation targeting central banks seem to consider restrictions to capital flows in some sense as well as foregin rates and exchange rate deivations. The results supports Ostry et al. (2010) conclusion that capital controls may be a legitimate part of policy response.

Table 7: *Policy Response Before and After the Financial Crisis*

		All targeters		Advanced economies		Emerging economies	
Variable	Coefficient	Pre	Post	Pre	Post	Pre	Post
kai_{it}	γ_{kai}	0.536	7.096***	-0.100	3.808*	-0.457	2.707
		(1.238)	(2.201)	(0.343)	(1.388)	(1.945)	(1.820)
kao_{it}	γ_{kao}	-0.658	-6.475**	0.052	-1.296	-1.939	-0.774
		(1.235)	(2.913)	(0.227)	(1.093)	(2.569)	(4.465)
π_{it+1}	γ_{π}	0.857**	1.338*	2.146***	4.845***	0.935**	0.070***
		(0.341)	(0.654)	(0.520)	(0.389)	(0.453)	(0.015)
i_{it-1}	ρ	0.277*	0.690***	0.402*	0.171	0.255**	0.187***
		(0.165)	(0.187)	(0.213)	(0.174)	(0.104)	(0.039)
$y_{it} - \bar{y}_{it}$	γ_{y}	0.002	0.004	0.006**	0.059**	7.681***	6.515***
		(0.069)	(0.201)	(0.003)	(0.014)	(2.738)	(0.242)
$e_{it} - \bar{e}_{it}$	γ_{e}	0.011	0.243***	0.004	0.032***	0.536	0.510**
		(0.091)	(0.019)	(0.005)	(0.001)	(1.528)	(0.177)
$(e_{it} - \bar{e}_{it}) * kai_{it}$	γ_{ekai}	-0.110	-2.602**	0.055	1.039*	-0.644	267.279***
		(0.637)	(1.114)	(0.138)	(0.024)	(0.757)	(45.246)
$(e_{it} - \bar{e}_{it}) * kao_{it}$	γ_{ekao}	0.241	3.162*	-0.043	0.838	-27.476	190.353***
		(0.514)	(1.653)	(0.094)	(0.497)	(51.199)	(59.530)
i_t^F	γ_{i^F}	0.095***	8.851*	0.005*	0.244*	0.127	11.562***
		(0.029)	(4.665)	(0.002)	(0.071)	(0.175)	(1.729)
Observations		187	44	126	22	61	22
R^2 adjusted		0.936	0.947	0.948	0.941	0.810	0.946

Robust standard errors in parenthesis
* Indicate the significance level at 10%.
** Indicate the significance level at 5%.
*** Indicate the significance level at 1%.

V. Conclusions

Using data for 48 countries, both inflation targeting and non-targeting countries, this paper aims to investigate whether central banks in consider exchange rates and restrictions to capital flows when setting the policy rate. One of the purposes of this paper was to examine if there was a difference between advanced and emerging economies, and the results show that the reaction to exchange rate deviations is large and significant for central banks in both advanced and emerging economies. Inflation targeting central banks attempts to "lean against the wind" and stabilize the exchange rates by increasing interest rates in response to real exchange rate depreciation. The results also show that central banks in an inflation targeting regime seem to react to foreign rates since it is found to be highly significant in both advanced and emerging inflation targeting economies. Here the results differ to the non-targeting sample, where foreign rates seem to play a bigger role to central banks in advanced economies than in emerging economies.

Another interesting result is the high degree of persistence, meaning that central banks react slowly as new information becomes available. This result also holds for the non-targeting sample.

However, the results for the variables reflecting restrictions to capital in- and outflows are found to be not significant, only the interaction of the exchange rate deviation and the variable reflecting restrictions to capital outflows is found to be significant for central banks in inflation targeting advanced economies. Thus when the entire time period is considered central banks seem not to react to the restriction variables themselves. The results found in this paper, namely a significant reaction exchange rate deviation, foreign rates and high degree of policy inertia, measured by the lagged interest rate coefficient, and confirms the results in Aizenman et al. (2011), Caputo and Herrera (2013) and Clarida et al. (1998).

The second purpose of this paper was to assess if the determinates of central bank policy rules have changed after the recent financial crisis, therefore the sample was divided into a pre- and post-crisis period. Here the results suggest that emerging market central banks seem to react to the interaction of the variables reflecting restrictions to capital in- and outflows with the exchange rate deviations, whereas advanced economies central banks seem to react to capital inflows. However, the results are somewhat inconclusive but suggest that after crisis inflation targeting central banks seem to consider restrictions to capital flows in some sense as well as

foreign rates and exchange rate deviations. The results supports Ostry et al. (2010) conclusion that capital controls may be are a legitimate part of policy response.

For future research one interesting extension would be to look at the effects of controls on capital in- and outflows on a more disaggregate level, a possibility offered by the Schindler index. Thus, offering the possibility to see which type of capital control that is part of the policy response.

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Appendix A: Country overview

Table A1 and A2 describes the countries included in the sample. The classification of countries into advanced and emerging market economies is based on the classification in IMF's World Economic Outlook 2014. According to WEO 2014 Colombia, Lithuania, Poland, Ukraine and Venezuela are classified as emerging market economies and Taiwan and the following euro zone countries are classified as advanced economies; Estonia, Luxembourg and Slovakia. However, these are not included in the Schindler index (Venezuela are included in the Schindler index, but was excluded due to problems with data availability) and therefore restrict the sample to the countries presented in table A1 and A2.

Table A1: *Advanced economies sample*

Inflation-targeters	Year of adopting inflation targeting	Non-targeters
Australia	1993	Austria
Canada	1991	Belgium
Czech Republic	1998	Cyprus
Iceland	2001	Denmark
Israel	1992	Finland
Korea	1998	France
New Zealand	1990	Germany
Norway	2001	Greece
Sweden	1995	Hong Kong
Switzerland	2000	Ireland
United Kingdom	1992	Italy
		Japan
		Malta
		Netherlands
		Portugal
		Singapore
		Slovenia
		Spain

Source: Central banks' websites for inflation targeting start dates and IMF's WEO 2014

Table A2: *Emerging markets sample*

Inflation-targeters	Year of adopting inflation targeting	Non-targeters
Brazil	1999	Argentina
Chile	1999	Bulgaria
Hungary	2001	China
Indonesia	2001	India
Mexico	2001	Latvia
Peru	2002	Malaysia
Philippines	2002	Pakistan
Romania	2005	Russia
South Africa	2000	
Thailand	2000	
Turkey	2006	

Source: Central banks' websites for inflation targeting start dates and IMF's WEO 2014

Appendix B: Data details

Table B1 covers the definition and source of the main variables whereas Table B2 and accompanying text describes the Schindler index.

Table B1: *Data details*

Variable	Definition	Source
CPI inflation	Author's calculation of the time difference of log CPI.	IMF's International Financial Statistics database
Interest rate	Data on the money market rate has been used as a proxy for short-term nominal interest rate, where unavailable data on the discount rate has been used.	IMF's International Financial Statistics database
Output gap	Author's calculations using WDI data on real GDP (constant 2005 US$) and trend GDP (calculated using Hodrick-Prescott filter with smoothing parameter 100).	World Bank's World Development Indicators
Real effective exchange rate change	Authors' calculations using IFS real effective exchange rate data and trend real exchange rate (calculated using Hodrick-Prescott filter with smoothing parameter 100) and where unavailable nominal exchange rates and CPI from the IFS,. An increase in the real exchange rate is a real depreciation.	IMF's International Financial Statistics database
US money market rate		IMF's International Financial Statistics database

Schindler index

The Schindler index measures de jure restrictions on cross-border financial transactions and was originally constructed for 91 countries covering the period 1995 to 2005. The advantage of this index over other capital control indices is the possibility of using information at a more disaggregated level. This structure allows for the construction of several sub-indices, such as those for individual asset categories, for residents and nonresidents, and the sub-index used in this paper; restrictions on the direction of capital flows. The Schindler index is based on the on information in the Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER) published by the International Monetary Fund (IMF). The information in the AREAER is coded at the level of restrictions for resident and nonresident, in binary form taking a value of 0 if unrestricted and 1 if restricted.

Since the Schindler index publicly available only covers the period 1995-2005, and in order to cover the recent financial crisis I have extended the index forward until 2012 for my entire sample. The index is also extended backwards for five inflation targeters (Australia, Canada, Israel, New Zealand and United Kingdom) that adopted the regime before 1995, the index extends back until the start year of inflation targeting for each of the five countries. Following

the methodology presented in Schindler 2009 my restriction variables are calculated as described in table B2. Furthermore, for each country in each asset category, inflow restrictions are calculated as the average of the restriction dummies on ‘‘purchase locally by nonresidents’’ and ‘‘sale or issue abroad by residents,’’ whereas outflow restrictions are calculated as the average of the restriction dummies on ‘‘purchase abroad by residents’’ and ‘‘sale or issue locally by nonresidents”. For example if in a given year a country has a restriction on the sale of shares abroad by its residents but no restrictions for the purchase of sales by nonresidents, then eqi = 0.5.

Table B2: *Calculation of restrictions on directions of flows*

1997-2012			
$kai = \frac{eqi+boi+cii+mmi+fci+dii\_ldi}{6}$		$kao = \frac{eqo+boo+cio+mmo+fco+dio}{6}$	
eqi	equity inflow restriction	eqo	equity outflow restriction
boi	bond inflow restriction	boo	bond outflow restriction
cii	collective investment inflow restriction	cio	collective investment outflow restriction
mmi	money market inflow restriction	mmo	money market outflow restriction
fci	financial credit inflow restriction	fco	financial credit outflow restriction
dii_ldi	max(dii; ldi)	dio	direct investment outflow restriction
dii	direct investment inflow restriction		
ldi	direct investment liquidation restriction		
1990-1997			
$kai = \frac{eqi+cii+mmi+fci+dii\_ldi}{5}$		$kao = \frac{eqo+cio+mmo+fco+dio}{5}$	

Source: IMF’s AREAER 1991-1995, 2006-2013, Schindler 2009

Until 1995, the AREAER summarized a country’s openness to capital flows using a binary dummy variable, where 1 represents a restricted capital account and 0 represents an unrestricted capital account. However, since 1995, the AREAER has utilized a more structured approached, providing detailed information on restrictions on capital transactions in a number of subcategories, which is the reason why the calculations differ slightly before and after 1997.