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THRESHOLD EFFECT OF FINANCIAL INTEGRATION ON LINKAGES BETWEEN MONETARY INDEPENDENCE AND FOREIGN EXCHANGE RESERVES

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ABSTRACT

This paper investigates the relationship between monetary independence and its potential determinants — foreign exchange reserves, exchange rate stability, financial integration and inflation. This paper contributes to the literature by testing the threshold effect of the degree of financial integration on the relation between monetary independence and foreign exchange reserves. In particular, a linear model and a threshold model are compared using average cross-sectional data from 55 countries. The linear model shows that foreign exchange reserves increase monetary independence. Nonetheless, the threshold estimation indicates that foreign exchange reserves can maintain monetary independence when the degree of financial integration of a country is above a certain threshold value. Such a finding suggests that the relationship between monetary independence and foreign exchange reserves is subject to the degree of financial integration. Moreover, the evidence supports a weakening effect from financial integration to the phenomenon of 'fear of floating'.

Keywords: monetary independence, foreign exchange reserves, financial integration, threshold effect, cross-sectional data

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INTRODUCTION

There are three main objectives the policymakers prefer in the context of the open economy: exchange rate stability, financial integration and monetary independence. However, the Mundell–Fleming model shows that it is impossible for any country to have all three of the objectives at the same time. This phenomenon is also coined as the "trilemma" or the "impossible trinity". For example, if a country wants to maintain their monetary independence and exchange rate stability, the economy must be closed to foreign capital, as such an arrangement would avoid disturbances from external markets. On the other hand, monetary independence and financial integration are achievable concurrently if a flexible exchange rate regime is adopted, where the exchange rate fluctuations absorb external impacts. This phenomenon has been studied frequently and among them are Obstfeld, Shambaugh and Taylor (2005), Rose (1996), Yu (2012), and Akcelik, Cortuk and Turhan (2014).

In recent years, several researchers have highlighted that foreign exchange reserves can weaken the trilemma effect (Aizenman, Chinn, & Ito, 2010; Aizenman & Ito, 2012; Hutchison, Sengupta, & Singh, 2012). Aizenman et al. (2010) show that higher foreign exchange reserves in developing countries not only reduce exchange rate volatility but also enable monetary independence and financial stability. In emerging Asian economies, some countries have implemented several policies, including hoarding large foreign exchange reserves, to enable them to implement an independent monetary policy (Aizenman & Ito, 2012). Moreover, Hutchinson et al. (2012) find that in India, foreign exchange reserves accumulation and financial integration occur concurrently; thus, both minimise the trade-off between exchange rate stability and monetary policy.

Interestingly, the dynamic between the reserves and monetary independent could vary in size, direction and statistical significance under a different level of financial integration. Theoretically, financial integration will reduce the monetary independence by exposing a country to the monetary decision made by foreign counterparts. More discussion of this argument is available in the literature review of this paper. However, there is another possibility that financial integration could play a role in affecting monetary independence. In detail, the financial integration could bring benefit to the economy by smoothing the domestic consumption, promote economic growth, enhance discipline in handling macroeconomic policy and increase the financial stability by reducing the government intervention in the financial market (Agenor, 2003). The last two benefits ensure the stability of foreign exchange reserves. This is crucial because fluctuating foreign exchange reserves will increase the market uncertainties and if the authorities react to

calm the market, the monetary independence could be undermined during the process. For instance, if a government has macroeconomic discipline and the financial market is stable due to financial integration, the probability of excessive withdrawal or movement of foreign funds will be smaller, guaranteeing the stable performance of foreign exchange reserves. Following this, the positive impact from foreign exchange reserves will be stronger.

On the other hand, Agenor (2003) also lists the potential weaknesses of financial integration that could lead to greater economic fluctuation and therefore reducing the effectiveness of foreign exchange reserves. In particular, greater integration with the world market could reduce the macroeconomic stability caused by the capital inflows. Besides, volatility of capital flows will be higher due to pro-cyclical and short-term capital. These effects will lead to weaker positive effects from foreign exchange reserves on monetary independence.

Given these insights, our paper presents a novel attempt to examine whether there is a threshold level of financial integration that could trigger the indirect effect from the financial integration on the effects of foreign exchange reserves on the monetary independence.[1] If the financial integration is below the threshold level, the indirect effect might not occur. For the opposite case, the impact is inconclusive based on the arguments mentioned above. Cross-sectional linear and threshold analyses based on 55 developed and developing countries from 2002 to 2014 are conducted to achieve these objectives. Based on a review of the literature, only a few published papers offer empirical evidence of the impact of foreign exchange reserves on monetary independence, not to mention the non-linear impacts of foreign reserves. This idea of this paper is similar to that of Taguchi (2011), which focuses on seven Asian and ten South American countries. Using domestic interest rates as the dependent variable, he finds a negative interaction term of foreign reserves and the United States (US) interest rate (the proxy for foreign interest rate). Such a result indicates that foreign exchange reserves mitigate the linkage between foreign and domestic interest rates. Nonetheless, the method used in that study is questionable because he applied the generalised method of moments on a macro panel data (long T and short N). Instead of looking at the significance of foreign exchange reserves, this study investigates whether the impact from foreign exchange reserves on the monetary independence is contingent on the financial integration of the country which is absent in Taguchi's (2011) paper. The findings will provide an insight to policy-makers to consider formulating a policy regarding foreign exchange reserves management. This is due to the potential impacts of financial integration on the economy as argued by Agenor (2003), which subsequently affect the nexus between foreign exchange reserves and monetary independence. The review of

literature shows that there are conflict views about the role of financial integration: it promotes and reduces the effectiveness of influence of foreign exchange reserve on monetary independence.

Furthermore, this research considers the de facto measurement for a currency regime in the baseline model and that is different from Taguchi (2011). The main advantage of the de facto measurement of this indicator is that it is easier to estimate and more important because it shows the actual choice of exchange rate regime and it is more convincing because the authorities might not follow their announced regime (Obstfeld et al., 2005). Besides, this paper applies the monetary independence indicator provided by Aizenman, Chinn and Ito (2013) as the dependent variable instead of using the domestic interest rate. The monetary policy independence indicator measures the correlation between the domestic and foreign interest rates, which allows an easier interpretation compared with the methods used by Taguchi (2011).

LITERATURE REVIEW

The factors in determining monetary independence have been examined extensively in the literature. For instance, it is linked with inflation since monetary policy is a major tool in controlling inflation. The intention to control rising inflation has link the domestic monetary policy with a foreign monetary policy that supports low inflation in order to obtain the reputation of preferring low domestic inflation (You, Kim, & Ren, 2014). Higher inflation prompts greater political pressure on a central bank to intervene in the price level via monetary policy and erodes and the freedom of a central banker to formulate monetary policy (Cukierman, 1992). Nonetheless, excessive inflation in the past can cause a central bank to become more averse to high inflation, causing that central bank to implement anti-inflationary policies to help protect the central bank's independence (Hayo, 1998) while facilitating public acceptance towards inflation (D'Amato, Pistoresi, & Salsano, 2009). This lead to less pressure on the central bank to reduce inflation and increase its independence.

Another two components in the "impossible trinity", namely financial integration and exchange rate stability, are considered crucial in influencing the monetary independence. The former factor is linked with the central banks' respond to the volatility in the exchange rate. The globalisation has reduced the barriers in capital movement and more countries have adopted a flexible exchange rate system (Mohanty & Scatigna, 2005) Central banks are therefore required to change their interest rate policy more frequently which reduces monetary independence (Hutchison et al., 2012). Furthermore, the global financial cycle is

causing capital flows and asset prices in different regions to move together and the cycle starts in a central nation (such as the US) which in turn influences the monetary policies in other countries (Rey, 2015).

The latter factor, exchange rate stability, is hypothesised that a flexible exchange rate can maintain domestic interest rate independence. A greater flexibility in the exchange rate is expected to increase the monetary independence as it allows the domestic and foreign interest rates to vary (Edwards, 2015). The negative relationship between exchange rate stability and monetary independence is supported by Shambaugh (2004) and Di Giovanni and Shambaugh (2008) when they conclude that during the fixed currency regime, linkages between the domestic and base country's interest rate are established through the domestic output's reactions to the base country's interest rate. Additionally, Boresztein, Zettelmeyer and Philippon (2001) show that the interest rates of Singapore, a country that adopts the flexible exchange rate regime, have smaller responses to the changes of interest rate in the US as compared to Hong Kong where the fixed exchange regime is implemented. A similar finding found for the impact of Japan's flexible exchange rates on its interest rate independency in the long run (An, Kim, & You, 2016).

Nevertheless, there are inconsistent findings when examining the hypothesis (Fratzscher, 2002). Some have argued that the exchange rate regime is irrelevant in monetary independence (Kim & Lee, 2008) where only developed countries enjoy monetary independence (Frankel, Schmukler, & Serven, 2004). It is suggested that the ability of a country to maintain its monetary independence does not depend on the currency regime since central banks can control domestic inflation rates (Mohanty & Scatigna, 2005). Some have even suggested a contradict conclusion. The classical gold standard before the 1910s was found to grant countries freedom in conducting monetary policy (Bordo & MacDonald, 1997) and the impacts from the US interest rate changes on the domestic interest rates is larger during the loose dollar peg regime in Latin America (Frankel, 1999). This could attributable to the "fear of floating" and prompt a country to move the domestic interest rate in tandem with foreign monetary policy and therefore a general trend of pegged exchange rate regimes result in more stable interest rate changes is observed (Hosny, Kishor, & Bahmani-Oskooee, 2015).

A possible explanation for the contradict findings proposed by Edwards (2015) where the final impacts of flexibility in exchange rates depend on whether the local domestic monetary authority follows foreign policy or otherwise. Through examining the federal fund rates into the policy function of Chile, Colombia and Mexico, Edwards (2015) found that although these countries implement a flexible

exchange rate regime, a unidirectional spillover and partial pass-through occurs from a change in the federal fund rate to the domestic interest rate. Thus, a high credibility and low economic integration are requirements for a positive impact from a floating exchange rate to be presented.

The foreign reserve available in the domestic economy, however, has been suggested to change the relationship within the "impossible trinity" in recent studies. Typically, the reserves act as precautionary reserves for balance-of-payment and currency crises, intervene the foreign exchange market to avoid excessive volatility in exchange rates, and predicting fluctuations in the currency and in industrial production and the request of financing facilities from IMF during the 2008–2009 crisis (Frankel & Saravelos, 2012). Thus, a forward-looking central bank will accumulate additional foreign reserves, at minimal costs, to smooth the volatility in output and prices due to a crisis (Bar-Ilan & Lederman, 2007). This has contributed to the small-output volatility among the emerging Asian countries, which have relatively high financial and trade openness (Aizenman & Ito, 2012).

Its role in affecting monetary independence is revealed in recent studies. For instance, Taguchi (2011) finds that the foreign exchange reserves serve as an anchor for macroeconomic policy and increase market confidence in a country's economic strength. A greater level of foreign reserve alleviates the 'fear of floating' due to smaller impacts from external monetary shocks that transmit via the exchange rate pass-through effect (Akcelik et al., 2014). A higher foreign reserve is therefore reducing the dependence of domestic interest rate to foreign interest rate while the upward pressure from higher foreign reserve to the domestic monetary base decreases with the increasing bank reserves requirement. These factors contribute to a positive impact of foreign reserves in achieving a balance between the trilemma issue (stable exchange rate, high financial integration and high monetary independence) in emerging countries which in turn promote the domestic monetary independence (Akcelik et al., 2014). Nevertheless, some studies also proposed an opposite view. The hoarding of the foreign reserve could increase the impact of foreign influences on local monetary policy even with increasing foreign reserves during a foreign capital influx through greater domestic broad money (Glick & Hutchison, 2009).

The ambiguous findings regarding the relationship between monetary independence, foreign exchange reserves, financial integration and flexible exchange rate have motivated this study to construct a deeper analysis in this area. Furthermore, to the authors' best knowledge, there is limited empirical evidence in the literature presented for the threshold effect caused by financial integration

in the relation between foreign exchange reserves and monetary independence. Hence, this research aims to fill the knowledge gap by investigating the impact of the determinants of monetary independence, particularly the foreign exchange reserves, in both linear and non-linear frameworks using the cross-sectional dataset.

MODEL SPECIFICATION

This study employs a baseline linear equation as follows to estimate the impacts of selected regressors on monetary independence:

$$MI_i = \alpha + \beta_1 RES_i + \beta_2 EXH_i + \beta_3 FIN_i + \beta_4 CPI_i + e_i \quad (1)$$

where *MI* is monetary independence, *RES* is the ratio of foreign exchange reserves to GDP, *EXH* is the exchange rate stability indicator, *FIN* is the financial integration indicator, *CPI* is the consumer price index which is the proxy for inflation or price level and is the error term. This test which is conducted on cross-sectional data reduce the implication due to unknown and, possibly varying dynamics. It also allows the estimation of the average behavioural relationship over the time (Cheung & Ito, 2009).

Monetary independence in this paper refers to a situation where the relationship between the domestic and foreign interest rates is weak or disconnected. This study expects the β_1 to be positive because higher reserves will give the monetary authority more space to conduct monetary policy with less influence from external economies. The assumption for this case is that the increasing foreign exchange reserves do not inflate the quantity of money supply in the domestic market. On the one hand, β_2 is expected to be ambiguous. A positive sign means a flexible exchange rate allows the domestic interest rate to vary from the foreign interest rate. On the other hand, exchange rate flexibility also increases the possibility of "fear of floating", causing lower monetary independence. Another reason is that risk premia that come with a flexible exchange rate regime contribute to the negative relation between monetary the independence and flexible exchange rate (Frankel et al., 2004). The expected sign of β_3 is negative. In particular, an integrated financial market could induce the domestic economy to be more responsive to alterations in foreign monetary policy. Finally, β_4 should be negative because efforts to control high inflation could cause the co-movement of the exchange rate in the domestic and base countries with the low inflation rate and contribute to the connection between foreign and domestic interest rates (You et al., 2014).

As presented in the introduction, the financial integration is included in the model as the contingent factor (threshold factor) to examine if it differentiates the elasticity or the direction of effect of explanatory variables, especially the foreign exchange reserves, on the monetary independence. To this end, this study employs a threshold regression proposed by Hansen (1996; 2000). This estimator is utilised in this study as it enables the analysis of whether the elasticity or the impact of explanatory variables is contingent on the contingent factor. It provides a practical and straightforward method in estimating the differential effects of the independent variable (i.e. foreign exchange reserves), depending on whether the contingent factor is above or below a certain threshold level (Funke & Niebuhr, 2005). The threshold regression analyses the significance of the identified threshold based on regime selected by data instead of using asymptotic distribution theory (Papageorgiou, 2002).

Now, the estimation model is expressed as follows:

$$MI_i = \begin{cases} \alpha + \beta_1^1 RES_i + \beta_2^1 EXH_i + \beta_3^1 FIN_I + \beta_4^1 CPI_I + e_i, FIN_i \leq \gamma \\ \alpha + \beta_1^2 RES_i + \beta_2^2 EXH_i + \beta_3^2 FIN_I + \beta_4^2 CPI_I + e_i, FIN_i > \gamma \end{cases} \quad (2)$$

where *FIN* serves as a threshold variable that splits the model into two regimes. The impact of independent variables will take two different values depending on the threshold variable. For example, if the financial integration ratio is lower or equal to the estimated threshold level , then the impact of RES on MI is measured by β_1^1. When *FIN* increases above the estimated threshold level, the RES coefficient will change to β_1^2.

The threshold level in this paper is estimated using the procedure suggested in Hansen (2000). The first step is to estimate the value of γ. In particular, the model will be estimated with all possible values of γ and the minimiser $\hat{\gamma}$ is obtained through the minimum of the residual sum of squared computed across all possible values of γ. The estimation of slope parameters follows trivially. Lastly, the significance of the reshold parameter is examined by conducting the inferences via a model-based inference bootstrap because γ cannot be identified under the null hypothesis of non-linearity (Hansen, 2000).

DATA DESCRIPTION

This analysis focuses on 55 countries, including both developed and developing countries. The average data from 2002 to 2014 are calculated and tested here. The countries, which were selected based on the availability of data, are listed in the Appendix. The monetary policy independence indicator is the monetary

independence index from Aizenman et al. (2013).[2] More specifically, monetary independence is measured as below:

$$MI = 1 - \frac{corr\,(ir_i, ir_j) - (-1)}{1 - (-1)}$$

where $corr(ir_i,ir_j)$ is the correlation between the interest rate chi(ir) of home countries (i) and several base countries (j). Full monetary independence is represented by one, otherwise the value is zero. Please refer to Aizenman et al. (2013) for the list of base countries used in the index calculation.

Furthermore, the foreign exchange reserves are the variable of interest in this paper and are proxied by the ratio of the foreign exchange component of the foreign exchange reserves to current GDP. Foreign exchange is also the largest component of total foreign exchange reserves. Data on foreign exchange reserves and current GDP are available from Datastream and World Bank Open Data, respectively. Moreover, the exchange rate stability index from Aizenman et al. (2013) is used as a proxy for exchange rate stability. This de facto exchange rate stability measurement is calculated using the following formula:

$$EXH = \frac{0.01}{0..01 + stddev(\Delta(\log(exh\_rate))}$$

where *stddev* is the standard deviation of the monthly bilateral exchange rate between the home and host countries. The greater the figure, the more stable is the exchange rate. Aizenman et al. (2013) treat an exchange rate as fixed (valued as one) if the monthly changes range around 0.33%. This step is taken to avoid incorrect measurement due to exchange rate movement within a narrow band that will inflate the indicator of exchange rate flexibility.

As for financial integration, this paper not only considers foreign direct investment (FDI) but also the openness to short-term capital, i.e. portfolio investment (PI). More specifically, this factor is represented by the ratio of the sum of FDI and PI to current GDP. A similar measurement is applied in several papers, such as those by Muradoglu, Onay and Phylaktis (2014), Chen and Quang (2014), and Motella and Biekpe (2015). Data on FDI and PI are taken from Datastream. Finally, inflation is represented by the consumer price index, collected from World Bank Open Data. All data is tested without being seasonally adjusted. All variables are transformed into the logarithm form in order to capture the variables' elasticities (Hoque & Yusop, 2010). The only exception is the foreign reserve and financial integration since both are expressed in ratio and its elasticity can be captured directly.

Table 1
Descriptive statistics

	Mean	SD	Max	Min
MI	1.0146	0.0081	1.0259	1.0000
RES	0.1659	0.1790	0.9265	0.0063
EXH	1.0235	0.0121	1.0413	1.0078
FIN	0.2423	0.4914	2.1836	-1.5268
CPI	1.9746	0.0235	2.0316	1.8913

Note: MI = monetary independence; *RES* = the ratio of foreign exchange reserves to GDP; *EXH* = exchange rate stability indicator; *FIN* = financial integration indicator; *CPI* = consumer price index; SD = standard deviation; Max = maximum value; Min = the minimum value.

Table 1 summarises the mean, standard deviation and the maximum and minimum values of all examined variables. Substantial variation can be observed in the data. As indicated by the standard deviations, the largest variation is found in *FIN* and the lowest is in *MI*. In particular, the highest *MI* is found in South Africa (1.0259), whereas another ten countries registered at 1. These countries are Austria, Belgium, France, Italy, Netherlands, Finland, Greece, Ireland, Portugal and Spain. Significant differences are also found in other variables. For instance, *RES* ranged from 0.9265 in Hong Kong to 0.0063 in Greece. However, the lowest *EXH* is found in South Africa (1.0078) and the most stable exchange rates are found in Austria, Belgium, France, Italy, Netherlands, Finland, Greece, Ireland, Portugal, Spain and Ecuador. For the *FIN*, the range is from 2.1836 in Hong Kong to –1.5268 in Iceland. Lastly, the largest *CPI* (2.0316) is found in China and the lowest (1.8913) is recorded for Ukraine. Finally, Table 2 indicates that correlation among the independent variables is relatively low (below 0.50).

Table 2
Correlation among the variables

MI	1.0000				
RES	0.4065	1.0000			
EXH	-0.6962	0.0672	1.0000		
FIN	-0.1527	0.4763	0.3183	1.0000	
CPI	-0.3821	0.0650	0.2002	0.2950	1.0000

Note: MI = monetary independence; *RES* = the ratio of foreign exchange reserves to GDP; *EXH* = exchange rate stability indicator; *FIN* = financial integration indicator; *CPI* = consumer price index.

EMPIRICAL RESULTS

This paper presents the outputs from a linear model (see Table 3) before discussing those from a linear model with a threshold effect. First, the *RES* is found to be statistically significant in promoting monetary independence. Such a finding supports the positive impact of *RES* on *MI*, as argued by Aizenman et al. (2010) and Taguchi (2011). Meanwhile, the *EXH* reduces the *MI* indicator, indicating that "fear of floating" plays a role in this case. It also implies that a greater fluctuation in the exchange rate increases risk premia and, therefore, lowers monetary independence (Frankel et al., 2004).

Table 3
Linear model

	Coefficient	Standard Error	*t*-statistic
RES	0.0195***	0.0042	4.6429
EXH	-0.3905***	0.0671	-5.8197
FIN	-0.0015	0.0017	-0.8824
CPI	-0.0917***	0.0329	-2.7872
Constant	1.5956***	0.0864	18.4676
R^2	0.69		
Observation	55		

Notes: Dependent variable is MI, monetary independence; RES, the ratio of foreign exchange reserves to GDP; EXH, exchange rate stability indicator; FIN, financial integration indicator; CPI, consumer price index. R^2 is the R-squared. Standard errors are corrected for heteroscedasticity. *** indicates statistical significance at the 1% level.

Additionally, the *FIN* has been found to produce a negative coefficient, although the coefficient is statistically insignificant. The negative sign is in line with the argument that the process of financial integration enables a shock, especially an external shock, which affects the domestic economy, leading to weaker control in the domestic monetary policy. Inflation also mitigates the *MI* by inducing the domestic currency to move with foreign currencies, leading to the existence of a connection between the domestic and foreign monetary policy. Finally, the model's goodness of fit is reasonably acceptable, where the *R*-squared value indicates that the model explains 69% of the variation in monetary independence.

Although *RES* has a statistically significant impact on monetary independence in the linear model, this paper argues that a more dynamic impact could be discovered by examining whether the relation might be different based on the contingent factor, i.e. *FIN*. Hence, a threshold estimation is used to capture this possible non-linear relationship based on different levels of *FIN*. The

threshold is estimated using the bootstrap method with 5,000 replications and 15% trimming percentage. The results are presented in Table 4. According to that table, a threshold exists at 2.1364 with the LM test *p*-value = 0.0118. Therefore, the overall sample can be split into two regimes: countries with lower financial integration (i.e. with *FIN* below or equal to 2.1364) and countries with higher financial integration (i.e. with *FIN* ratio above 2.1364).

Table 4
Model with threshold effect

Threshold estimate	0.1364	
LM test for no threshold	14.1914	
p-value	0.0128	
	Regime 1 Ratio ≤ 0.1364	Regime 2 Ratio > 0.1364
RES	0.0104 (1.8909)	0.0263*** (5.3469)
EXH	-0.4344*** (-4.1850)	-0.3798*** (-5.0843)
FIN	0.0020 (1.2500)	-0.0070*** (-2.8750)
CPI	-0.0948** (-2.2582)	-0.1015*** (-3.9302)
Constant	1.6433*** (18.5432)	1.6034*** (18.2411)
R^2	0.71	0.81
Observation	27	28

Notes: Dependent variable is MI. Standard errors are corrected for heteroscedasticity. FIN is used as threshold variable. RES, the ratio of foreign exchange reserves to GDP; EXH, exchange rate stability indicator; FIN, financial integration indicator; CPI, consumer price index. R^2 is the R-squared. *** and ** indicate statistical significance at the 1% and 5%, respectively. The *t*-statistic values are reported in parentheses.

Four main points can be concluded from the results. First, the positive impact from *RES* on *MI* remains positive only for Regime 2 or when *FIN* is above 2.1364. In contrast, *RES* would exert smaller and statistically insignificant impact on the *MI* of the country when the country is having *FIN* below 2.1364. This result supports the significance of the contingent factor, i.e. *FIN* and the positive indirect effect from financial integration on the stability of foreign exchange reserves appear when a certain level of financial integration is achieved. Furthermore, *FIN* above the threshold level also enhance the positive linkages between *RES* and *MI*

when comparing the coefficient size of *RES* in both regimes: the coefficient of *RES* is larger in Regime 2.

Second, the *FIN* only has negative implication to the *MI* in Regime 2. Moreover, the sign of the coefficient of *FIN* reveals that financial integration has a small (the coefficient is close to zero). The coefficient sign is also in line with the findings of Hutchison et al. (2012) and Rey (2015). In other words, greater financial integration will bring in more positive effect via the positive effect on the foreign exchange reserves compared to its direct effect on the *MI*.

Third, the sign and statistical significance of *EXH* and *CPI* are unaffected when comparing the two regimes. Concerning the coefficient size, the impact from *EXH* is slightly lower in Regime 2 while the magnitude of *CPI* is largely unchanged. The reduction in the effect of *EXH* in Regime 2 suggests that the increased flexibility of exchange rate movement contributes to the lower monetary independence. Lastly, the model's goodness of fit is also greater than the linear model, where the *R*-squared in both regimes are 0.71 and 0.81.

Sensitivity Tests

This paper also performs two estimations to check and reconfirm the existence of threshold effect and the number of the threshold. The first test examines whether the *p*-value for the LM threshold test changes with different combinations of replication and trimming percentage. Trimming percentages range from 10% to 30% and the number of bootstrap replications is 1,000, 5,000 and 10,000. As presented in Table 5, the results show that the threshold effect remains intact as the null hypothesis of "no threshold" is rejected at the 5% confidence interval for all combinations. The second test, reported in Table 6, is the LM test to analyse whether the sample could be further split. For Regime 1, a threshold is found at 2.1023, but the *p*-value is 0.8372, which shows the threshold, is insignificant. Similarly, a statistically insignificant threshold is found in Regime 2 at 2.1789. This indicates that no further split is required for both regimes and the output reported in Table 4 is the optimal result.

Table 5
Bootstrapped p-values for different combination of replication and trimming percentage

Threshold estimated:	Trimming percentage				
LM test of no threshold:	10	15	20	25	30
Bootstrap replication					
1,000	0.0130	0.0100	0.0050	0.0130	0.0070
5,000	0.0106	0.0118	0.0120	0.0098	0.0126
10,000	0.0132	0.0136	0.0110	0.0120	0.0111

Table 6
Test for the second split of the sample

	Regime 1 Ratio ≤ 2.1364	Regime 2 Ratio > 2.1364
Threshold estimated	2.1023	2.1789
LM test for no threshold	5.6135	10.2472
p-value	0.8372	0.1364
Observation	27	28

Notes: The bootstrap *p*-values calculated with 5,000 replications and 15% trimming percentage.

Besides, this study also employed two alternative measurements of financial integration to verify if the changing of proxy will alter the conclusion. These two alternative measurements are the de jure capital account openness index (*LKAOPEN*) proposed by Chinn and Ito (2006) and the de facto financial integration (*NFA*) which is obtained from the updated and extended version of dataset constructed by Lane and Milesi-Ferretti (2007). Both results are available in Table 7 and Table 8, respectively. According to Table 7, the threshold value of the *LKAOPEN* is 0.5317. In other words, the impacts of independent variables on the monetary independence is different among the countries that their degree of capital account openness is above and below 0.5317. The statistical significance and sign of the estimators before and after a threshold level of financial integration in the original estimation are almost robustly supported in the model of *LKAOPEN* except for the statistical significance of exchange rate stability and the sign of financial integration change to negative during the Regime 1. The threshold effect is statistically significant as well. Equally important, the previous conclusion where the impacts from foreign exchange reserve contingent with the financial integration level of a country are supported.

For the case of *NFA*, the same inconsistency of the statistical significance and sign in Regime 1 as found in the *LKAOPEN* is also detected in Table 8.

Nonetheless, the estimated threshold is found insignificant. The differences in the estimations are not entirely surprising as the de facto and de jure measurement of financial integration measures different aspects of financial integration (Ito, Jongwanich, & Terada-Hagiwara, 2009). Moreover, each indicator subjects to its own weaknesses and strength (Ito et al., 2009; Quinn, Schindler, & Toyoda, 2011). It is therefore impossible to justify which outputs provide the most accurate findings. Nevertheless, the conclusion about the impacts of financial integration on the foreign exchange reserves-monetary independence nexus is roughly supported by most of the sensitivity tests and estimations presented in this section.

Table 7
Threshold model with LKAOPEN as measurement of financial integration

Threshold estimate	0.5317	
LM test for no threshold	18.5342	
p-value	0.0006	
	Regime 1 Ratio ≤ 0.5317	Regime 2 Ratio > 0.5317
RES	0.0030 (0.9677)	0.0193*** (10.7222)
EXH	-0.0045 (-0.0647)	-0.4976*** (-18.0299)
LKAOPEN	-0.0001 (0.0196)	-0.0241** (-2.2523)
CPI	-0.0480*** (-4.0678)	-0.0961*** (-3.1927)
Constant	1.1181*** (14.3162)	1.7258*** (30.2242)
R^2	0.13	0.92
Observation	23	32

Notes: Dependent variable is MI. Standard errors are corrected for heteroscedasticity. LKAOPEN is used as threshold variable. RES, the ratio of foreign exchange reserves to GDP; EXH, exchange rate stability indicator; LKAOPEN, financial integration indicator; CPI, consumer price index. R^2 is the R-squared. *** and ** indicate statistical significance at the 1% and 5%, respectively. The *t*-statistic values are reported in parentheses.

Table 8
Threshold model with NFA as measurement of financial integration

Threshold estimate	1.4874	
LM test for no threshold	10.6021	
p-value	0.2042	
	Regime 1 Ratio ≤ 1.4874	Regime 2 Ratio > 1.4874
RES	0.0090 (0.5960)	0.0189*** (7.875)
EXH	-0.0789 (-1.4064)	-0.5026*** (-15.1386)
NFA	-0.0064 (0.9846)	-0.0003* (-1.7560)
CPI	-0.0679* (-1.9020)	-0.0591** (-2.2135)
Constant	1.0775*** (13.4017)	1.6428*** (28.6702)
R^2	0.21	0.91
Observation	18	37

Notes: Dependent variable is MI. Standard errors are corrected for heteroscedasticity. NFA is used as threshold variable. RES, the ratio of foreign exchange reserves to GDP; EXH, exchange rate stability indicator; NFA, financial integration indicator; CPI, consumer price index. R^2 is the R-squared. ***, ** and * indicate statistical significance at the 1%, 5% and 10%, respectively. The *t*-statistic values are reported in parentheses.

CONCLUDING REMARKS

This paper focuses on the function of foreign exchange reserves in maintaining the independence of monetary policy in the setting of linear and non-linear models. In particular, we test whether is a threshold level of financial integration that could affect the effectiveness of foreign exchange reserves in influencing the monetary independence. The estimation from a linear equation shows that foreign exchange reserves of a country promote monetary independence. Furthermore, other independent variables, apart from financial integration, are statistically significant, with the sign of the coefficient supported by the theories.

At the other end of the spectrum, the non-linear equation reveals that it is important to determine the threshold effects. More specifically, the positive effect of foreign exchange reserves only appears if the country has reached a certain level of financial integration. In addition, financial integration itself has a

negligent negative effect on monetary independence. Finally, the "fear of floating" effect seems to be lower during the higher financial integration regime. Equally important, the sensitivity tests show the results are robust to different replication and trimming percentage combinations and to the number of splits in the sample.

The first policy implication from this paper is the importance of maintaining sufficient foreign exchange reserves to ensure monetary independence. The second point is that although higher financial integration directly undermines monetary independence, its effect in alleviating the "fear of floating," instilling greater macroeconomic discipline and promoting financial stability should not be ignored. While this paper finds evidence to support the impact from foreign exchange reserves, the estimations do not segregate the countries to different categories such as developing and developed countries. Future research should cover this to discover more insights.

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NOTES

1. The authors would like to thank the anonymous reviewer for highlighting that it is crucial to investigate how the dynamics between financial integration and monetary independence is influenced by the foreign exchange reserves. The authors have started a research with similar objective in a panel data framework.
2. The United States is not included here because it is excluded from the trilemma index calculation by Aizenman et al. (2013).

APPENDIX

Table A1. Country List

Argentina	Hong Kong	Philippines
Australia	Hungary	Poland
Austria	Iceland	Portugal
Belgium	India	Romania
Bolivia	Indonesia	Singapore
Brazil	Ireland	Slovak Republic
Canada	Israel	Slovenia
Chile	Italy	South Africa
China	Japan	Spain
Colombia	Korea	Sweden
Croatia	Latvia	Switzerland
Czech Republic	Lithuania	Thailand
Denmark	Malaysia	Turkey
Ecuador	Mexico	Ukraine
Estonia	Netherlands	United Kingdom
Finland	New Zealand	Uruguay
France	Norway	Vietnam
Germany	Paraguay	
Greece	Peru	

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