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Symmetric and asymmetric effects of exchange rates on money demand: Empirical evidence from Vietnam[⋆]

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Abstract

This empirical investigation aims at exploring the determinants of money demand in Vietnam by using both linear and nonlinear autoregressive distributed lags models over the period spanning from the third quarter of 2000 to the first quarter of 2018. Our findings can be summarized as follows: firstly, when the shock is symmetric (i.e. a permanent nominal appreciation of one percent), the money demand increases by 3.7 percent in the long term. Secondly, when the shock is asymmetric, for a permanent nominal appreciation of one percent, we observe an increase of 15.6 percent in the money demand. Whereas, for a permanent nominal depreciation of one percent, we observe a decrease of 7.4 percent in the money demand. These results are consistent with symmetry tests and lead us to think that asymmetries occur mainly in the short run and are transmitted to the long run.

Keywords: Money Demand, Exchange Rate, ARDL models, NARDL models, Dollarization
JEL: C22, E41, F31, F33, F41

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1. Introduction

Vietnam has been one of the most buoyant economies in the world with an average economic growth of 6.45% over the period spanning from 2000 to 2018. In this context of high

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economic growth, the rate of inflation has known several swings during this period. Indeed, it surged to 2-digit inflation in the crisis period between 2008 and 2011. Facing these upward inflation pressures, the government has taken a series of measures[1] in 2011 and 2014, to rein in inflation pressures and ensure macroeconomic stability. In this perspective, the State Bank of Vietnam (SBV, hereafter) used several monetary instruments.

On the one hand, the SBV regulates the monetary aggregates to contain price inflation. The money supply growth is regulated by setting the money growth target at the beginning of each year. As a result, the inflation rate has been well controlled, and was stable with an average rate of 3.5% over the period spanning from 2014 to 2018.

On the another hand, the SBV has regulated the exchange rate regime with more flexibility to reflect market developments. The exchange rate regime of the U.S. dollar/Vietnamese dong exchange rate corresponds to a crawling peg. The SBV sets the reference rate to follow foreign exchange market developments, and the exchange rate will move in a band setting by central bank to pursue its policy objectives. Before 2015, the reference rate was an average of the latest traded market price. At the end of 2015, the reference rate was calculated based on a basket of eight currencies in order to be more market oriented. The band was small during the inflation pressure period (-/+1%, then -/+2%), and in the recent period, the band is -/+3%.

In this general context, our study aims to improving the understanding of monetary developments in Vietnam. Indeed, as briefly seen above, monetary aggregates play a crucial role in the conduct of the monetary policy in this country. Thus, our empirical investigation tries to improve the literature on the determinants of money demand for the Vietnamese economy. As noted by Mundell (1963), the money demand could depend upon the exchange rate in addition to the level of income and the rate of interest[2].

[1] These measures are described in two directives issued by the SBV: the directive 11/NQ-CP of February 24, 2011, and the directive 01/CT-NHNN of January 15, 2014.

[2] We suppose that, at equilibrium, the money demand is equal to money supply, since the demand in excess will not be satisfied.

We try to assess the impact of nominal exchange rate on the money demand thanks to linear and nonlinear dynamic models (i.e. ARDL and NARDL models), as there are no a priori reasons to believe that exchange rate depreciation and appreciation will have the same effect on money demand. After a nominal depreciation against the U.S. dollar, domestic residents can hold more foreign currency to protect themselves from this adverse exchange rate variation. This currency substitution effect may explain the phenomenon of dollarization in Vietnam. As there is no reason indicating that waves of dollarization (after a nominal depreciation) or waves of de-dollarization (after a nominal appreciation) are symmetric, we use two specifications, a symmetric specification and an asymmetric specification that opens the possibility to explore of nonlinear effects. Since the pioneering contribution of Mundell (1960), it is well known that this phenomenon of dollarization may hinder the conduct of an autonomous monetary policy in absence of capital controls[3]. As underlined by Aizenman and Ito (2014), the trilemma constraint can raise a number of issues for developing countries. Thus, these empirical results could be especially interesting to improve the interaction between the monetary policy and the exchange rate policy in Vietnam.

In the empirical literature, nonlinear models are explored and used more frequently as rigidity in linear models is prone to biased or distorted interpretation. The literature reviewing such asymmetric and non-linear models begins with Balke and Fomby (1997) who introduce the threshold co-integration with a regime-switching type model. Then, Granger and Yoon (2002) highlight the "hidden co-integration" explaining that if the positive and negative components are co-integrated, the series bear the "hidden co-integration". Schorderet (2003) develops the paper of Granger and Yoon (2002) to estimate the asymmetric effect of hidden co-integration. Based on the work of Pesaran et al. (2001), some studies test the co-integration for small samples Narayan (2005). Finally, Shin et al. (2014) introduce a nonlinear version of the

[3]The well know Impossible Trinity problem (i.e. an impossible combination of an autonomous monetary policy, a perfect capital mobility and a floating exchange rate) is also referred to as the Trilemma, a more neutral term.

framework of Pesaran et al. (2001) to explore the asymmetries in the short term and / or in the long term.

The remainder of this paper is organized as follows: we resume the literature review in the second section, then we present the econometric methodology used in this study. We show the results in the fourth section, and we conclude in the last section.

2. Literature

2.1. Industrialized countries

Bahmani-Oskooee and Chomsisengphet (2002) investigate the determinants of money demand and check the stability for industrial countries including Australia, Austria, Canada, France, Italy, Japan, The Netherlands, Norway, Sweden, Switzerland, UK and the USA by using an ECM model over various periods for each country. They found that real income, interest rate on three-month T-Bills and nominal effective exchange rate that are the determinants of money demand. In addition, they demonstrate the stability for all countries except Switzerland and the UK.

Dreger and Wolters (2010) also point out the strong stability in the long term of money demand in the EMU with quarterly data over the period spanning from the first quarter of 1983 to the last quarter of 2004 by including the inflation rate and allowing short-run homogeneity in the co-integration model. Moreover, they use a threshold auto-regressive model to demonstrate the existence of a monetary target (as a threshold for the inflation rate) that impacts money demand.

2.2. Emerging countries

Bahmani-Oskooee et al. (2013) study the same research question, but focus on emerging markets such as six Central and Eastern European emerging economies (Armenia, Bulgaria, the Czech Republic, Hungary, Poland and Russia) and four other emerging economies (Bolivia, South Africa, Colombia and Malaysia). By replacing the interest rate variable by the inflation rate, and including two variables such as economic uncertainty and monetary uncertainty, they point out that money demand is stable in all countries over the studied period. In addition, Bahmani-Oskooee and Rehman (2005) focus on Asian developing countries such as India, Indonesia, Malaysia, Pakistan, the Philippines, Singapore and Thailand in the quarterly periods of 1973-2000. Their results demonstrate that the M1 monetary aggregate is stable over time for India, Indonesia and Singapore, whereas the M2 aggregate is stable for the remaining countries. Moreover, in a recent article Bahmani-Oskooee et al. (2019) examine the determinants of money demand for India, Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore and Thailand by using both ARDL and NARDL models. They find that exchange rate appreciation and depreciation significantly influence the money demand in all countries. In more detail, the appreciation of the currency has an adverse effect on the money demand for India, Indonesia, but a positive effect for the Philippines and Singapore, and no effect for Korea.

2.3. Evidence for the Vietnamese economy

Very few empirical studies have explored money determinants for Vietnam. Nguyen and Pfau (2010) employ quarterly data from the first quarter of 1999 to the second quarter of 2009 and error-correction models. They find that the long-run determinants of money demand are national income, foreign interest rate (FED rate) and real stock price. Inflation and nominal exchange rate are included, but are excluded in the final estimation. They also confirm the stability of money demand during the sample period.

The same research question is explored in Lai (2012) who extends the sample period by two years thanks to an ARDL model. She uses a variable list including domestic income, expected inflation[4], nominal exchange rate and gold price to explain the money demand dynamics. Her findings can be summarized as follows: the exchange rate is the most important variable that

[4]For expected inflation, her calculations were based on Gerlach and Svensson (2003).

determines the money demand dynamics. A depreciation of one percent for the Vietnamese dong should induce a decrease between 3.1 and 6 percent for the money demand.

Pham and Bui (2018) also study this research question by using a vector error correction model in the monthly period from 2003 to 2014. They indicate that gold price and real effective exchange rate are important variables to determine real money demand, whereas the deposit interest rate is not significant.

Even though the relationship between exchange rate and money demand has been investigated in previous research, there are still shortcomings in this area of the literature. Firstly, gold stock exchange was not fully fledged in Vietnam until recently. Hence, the gold price is collected from the unofficial market thus, the empirical result could be impacted by this uncertainty. Secondly, the State Bank of Vietnam does not officially set an inflation target as used by Lai (2012). Therefore, we do not include these variables in our model. Thirdly, previous studies impose the same value for the elasticity in case of appreciation and depreciation, in both the short and long term.

3. Methodology

3.1. Symmetric specification

We follow the recent contribution of Bahmani-Oskooee et al. (2017) to explore the determinants of money demand in Vietnam that can be explained by the nominal exchange rate, the gross domestic product, and the interest rate.

$$M2D_t = \beta_0 + \beta_1 NER_t + \beta_2 GDP_t + \beta_3 IR3_t + \epsilon_t \tag{1}$$

Where $M2D$ denotes the money demand for the local currency; NER stands for the nominal exchange rate (VND per USD)[5], GDP stands for the Gross Domestic Product and, $IR3$ is the

[5]An increase in NER indicates a depreciation of the Vietnamese dong.

3-month deposit interest rate. The data used in this investigation and their sources are fully described in Table A.1 and A.2 in Appendix.

To capture the short-run dynamics, we can write the linear ARDL(p,q) model associated with equation (1) as explained in Pesaran et al. (2001):

$$M2D_t = \beta_0 + \sum_{j=1}^{p} \phi_j M2D_{t-j} + \sum_{j=0}^{q} (\beta_{2j} NER_{t-j} + \beta_{3j} GDP_{t-j} + \beta_{4j} IR3_{t-j}) + \upsilon_t \tag{2}$$

Following Shin et al. (2014), it is straightforward to write the error correction form for the linear ARDL model[6]:

$$\begin{aligned}
\Delta M2D_t &= \beta_0 + \beta_1 M2D_{t-1} + \beta_2 NER_{t-1} + \beta_3 GDP_{t-1} + \beta_4 IR3_{t-1} + \sum_{i=1}^{p-1} \varphi_j \Delta M2D_{t-j} \\
&\quad + \sum_{j=0}^{q-1} \left(\gamma_{1j} \Delta NER_{t-j} + \gamma_{2j} \Delta GDP_{t-j} + \gamma_{3j} \Delta IR3_{t-j}\right) + \upsilon_t \\
&= \beta_1 \xi_{t-1} + \sum_{i=1}^{p-1} \varphi_j \Delta M2D_{t-j} + \sum_{j=0}^{q-1} \left(\gamma_{1j} \Delta NER_{t-j} + \gamma_{2j} \Delta GDP_{t-j} + \gamma_{3j} \Delta IR3_{t-j}\right) + \upsilon_t
\end{aligned} \tag{3}$$

Where $\beta_1 = \sum_{j=1}^{p} \phi_j - 1$, $\varphi_j = -\sum_{i=j+1}^{p} \phi_i$ for $j = 1, ..., p-1$, $\beta_2 = \sum_{j=0}^{q} \beta_{2i}$, $\beta_3 = \sum_{j=0}^{q} \beta_{3i}$, $\beta_4 = \sum_{j=0}^{q} \beta_{4i}$, $\gamma_{2i} = \beta_{2i}$ for $i = 0$, $\gamma_{3i} = \beta_{3i}$ for $i = 0$, $\gamma_{4i} = \beta_{4i}$ for $i = 0$, $\gamma_{1j} = -\sum_{i=j+1}^{q} \beta_{2j}$ for $j = 1, ..., q-1$, $\gamma_{2j} = -\sum_{i=j+1}^{q} \beta_{3j}$ for $j = 1, ..., q-1$, $\gamma_{3j} = -\sum_{i=j+1}^{q} \beta_{4j}$ for $j = 1, ..., q-1$, and $\xi_t = M2D_{t-1} - L_2 NER_{t-1} - L_3 GDP_{t-1} - L_4 IR3_{t-1}$ is the error-correction term where $L_{ner} = \frac{-\beta_2}{\beta_1}$, $L_{gdp} = \frac{-\beta_3}{\beta_1}$ and $L_{ir3} = \frac{-\beta_4}{\beta_1}$ are the associated long run parameters.

3.2. Asymmetric specification

Bahmani-Oskooee et al. (2017) have demonstrated that the effect of exchange rate on money demand may be asymmetric. By employing the approach of Shin et al. (2014), we decompose the exchange rate into asymmetric effects: the partial sums of positive and negative

[6]The error correction form for the nonlinear model can be found in equation (2.7) of Shin et al. (2014). The explanatory variables are split into positive partial sums and negative partial sums in order to capture asymmetric effects.

changes of the exchange rate indicating a depreciation for the Vietnamese dong (with a positive superscript) and appreciation for the Vietnamese dong (with a negative superscript).

We defined these partial sums for nominal exchange rate changes as follows:

$$NER_t^+ = \sum_{j=1}^{t} \Delta NER_j^+ = \sum_{j=1}^{t} max(\Delta NER_j, 0)$$
$$NER_t^- = \sum_{j=1}^{t} \Delta NER_j^- = \sum_{j=1}^{t} min(\Delta NER_j, 0) \quad (4)$$

To explore the asymmetric linkages between the exchange rate and money demand[7], we employ the approaches of Schorderet (2003) and of Shin et al. (2014) to formulate 4 different cases: (i) the long-run and short-run asymmetry; (ii) only long-run asymmetry; (iii) only short-run asymmetry; and (iv) the symmetry that corresponds to the linear ARDL as specified in equation 3.

3.2.1. Case (i): long-run and short-run asymmetry

The long-run and short-run asymmetry of exchange rate on money demand can be expressed as follows:

$$\begin{aligned}\Delta M2D_t = \beta_0 + \beta_1 M2D_{t-1} + \beta_2^+ NER_{t-1}^+ + \beta_2^- NER_{t-1}^- + \beta_3 GDP_{t-1} + \beta_4 IR3_{t-1} \\ + \sum_{i=1}^{p} \varphi_i \Delta M2D_{t-i} + \sum_{i=0}^{q} \left(\gamma_{1i}^+ \Delta NER_{t-i}^+ + \gamma_{2i}^- \Delta NER_{t-i}^- + \gamma_{3i} \Delta GDP_{t-i} + \gamma_{4i} \Delta IR3_{t-i}\right) + \upsilon_t \end{aligned} \quad (5)$$

Where $L_{ner^+} = \frac{-\beta_2^+}{\beta_1}$ and $L_{ner^-} = \frac{-\beta_2^-}{\beta_1}$ are the long run coefficients of positive and negative changes of the exchange rate to the money demand. The positive and negative superscripts stand for the partial sums of positive and negative changes of the nominal exchange rate. Besides, $L_{gdp} = \frac{-\beta_3}{\beta_1}$, $L_{ir3} = \frac{-\beta_4}{\beta_1}$ are the long-run coefficients of the GDP and of the interest rate.

[7]This approach has been employed in Delatte and López-Villavicencio (2012) to investigate the asymmetric effects of exchange rate on prices in four major industrial countries. In addition, Konopczak (2019) argues that the incompleteness of exchange rate pass-through is a statistical artifact thanks to a threshold NARDL model.

To test the existence of co-integration, Pesaran et al. (2001) propose the *bounds test* that is a joint test on all the lagged values of explanatory variables in levels. There are two tests: t-statistic of Banerjee et al. (1998) and F-statistic of Pesaran et al. (2001). Firstly, the t-statistic tests the null hypothesis of $\beta_1 = 0$ against the alternative hypothesis $\beta_1 < 0$. Secondly, the F-statistic tests the null hypothesis of $\beta_1 = \beta_2^+ = \beta_2^- = \beta_3 = \beta_4 = 0$ for the case of long-run asymmetry, $\beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$ in case of linear ARDL. The lower bound critical values are computed under the hypothesis that all the variables are stationary, whereas the upper critical value are calculated under the hypothesis that all the variables are non-stationary. If F-statistic is higher than the upper bound critical value, we reject the null hypothesis of no co-integration, thus, we accept the existence of a long-run relationship.

The long-run symmetry hypothesis can be tested by the *Wald test* of the null hypothesis of $L_{ner^+} = L_{ner^-}$; to test the existence of short-run symmetry, we use the *Wald test* to test the null hypothesis of $\sum_{i=0}^{q} \gamma_{1i}^+ = \sum_{i=0}^{q} \gamma_{1i}^-$. The rejection of the null hypothesis of symmetry indicates that we should use a specification allowing asymmetric effect of the nominal exchange rate (NER) on the money demand ($M2D$) in the short and / or the long run.[8]

3.2.2. Case (ii): long-run asymmetry and short-run symmetry

When the long-run symmetry test is rejected, but not the short-run symmetry, then the long-run asymmetry of exchange rate on money demand is expressed as:

$$\begin{aligned}\Delta M2D_t = \beta_0 + \beta_1 M2D_{t-1} + \beta_2^+ NER_{t-1}^+ + \beta_2^- NER_{t-1}^- + \beta_3 GDP_{t-1} + \beta_4 IR3_{t-1} \\ + \sum_{i=1}^{p} \varphi_i \Delta M2D_{t-i} + \sum_{i=0}^{q} \left(\gamma_{1i} \Delta NER_{t-i} + \gamma_{2i} \Delta GDP_{t-i} + \gamma_{3i} \Delta IR3_{t-i}\right) + v_t \end{aligned} \quad (6)$$

[8] Pal and Mitra (2016) implement an augmented version of the NARDL model with both symmetric and asymmetric regressors in an empirical investigation about the transmission from crude to oil product prices in India. Besides, they found that the use of a multiple threshold NARDL model (MTNARDL) improves precision in estimating asymmetric effects.

3.2.3. Case (iii): long-run symmetry and short-run asymmetry

When the short-run symmetry test is rejected, but not the long-run symmetry, then the short-run asymmetry of exchange rate on money demand is expressed as:

$$\begin{aligned}\Delta M2D_t &= \beta_0 + \beta_1 M2D_{t-1} + \beta_2 NER_{t-1} + \beta_3 GDP_{t-1} + \beta_4 IR3_{t-1} \\ &+ \sum_{i=1}^{p} \varphi_i \Delta M2D_{t-i} + \sum_{i=0}^{q} \left(\gamma_{1i}^{+} \Delta NER_{t-i}^{+} + \gamma_{2i}^{-} \Delta NER_{t-i}^{-} + \gamma_{3i} \Delta GDP_{t-i} + \gamma_{4i} \Delta IR3_{t-i}\right) + \upsilon_t \end{aligned} \quad (7)$$

3.2.4. Dynamic multipliers

When the null hypothesis of symmetry is rejected, we can obtain the asymmetric dynamic multipliers of the change of positive and negative variations of the explanatory variables. Here, these asymmetric dynamic multipliers capture the impact of nominal appreciations and nominal depreciations on the money demand. As explained before, there is no reason to expect that nominal appreciation and nominal depreciation will have the same effect on money demand. We can use the following formulas to compute the asymmetric dynamic multipliers:

$$\begin{aligned} m_h^{+} &= \sum_{j=0}^{h} \frac{\partial M2D_{t+j}}{\partial NER_t^{+}} \\ m_h^{-} &= \sum_{j=0}^{h} \frac{\partial M2D_{t+j}}{\partial NER_t^{-}} \end{aligned} \quad (8)$$

By construction, when $h \to \infty$, $m_h^{+} \to L_{ner^{+}}$ and $m_h^{-} \to L_{ner^{-}}$. These dynamic multipliers could capture the cumulative effects of nominal depreciation and nominal appreciation on the money demand from an initial equilibrium to the new equilibrium[9] as shown by Shin et al. (2014).

[9] Even though asymmetric error correction is not explicitly modeled by allowing regime dependency for β_1, we may still observe asymmetric adjustment trajectories thanks to the asymmetric dynamic multipliers. Alternatively, we could use a time-varying regression model based on the Kalman filter as in Jelassi et al. (2017) and Sidiropoulos et al. (2005).

Table 1: Unit root test

			Levels			
	$ln(M2D)$	$ln(NER)$	$ln(GDP)$	$IR3$	$ln(NER^{+})$	$ln(NER^{-})$
PP	-1.785	-0.363	-2.410	-2.232	-0.105	0.492
DF-GLS	-1.552	-1.347	-1.751	-1.690	-1.643	-1.459
			First differences			
	$\Delta ln(M2D)$	$\Delta ln(NER)$	$\Delta ln(GDP)$	$\Delta IR3$	$\Delta ln(NER^{+})$	$\Delta ln(NER^{-})$
PP	-11.887^{*}	-8.292^{*}	-6.846^{*}	-5.964^{*}	-7.681^{*}	-8.105^{*}
DF-GLS	-3.579^{*}	-4.470^{*}	-1.831	-6.515^{*}	-4.022^{*}	-5.934^{*}

Note: * $p < 0.05$. All the variables are augmented with three lags in the PP test. In these tests, statistical significance amounts to stationarity.
Source: author's calculations.

4. Results

4.1. Unit root tests

Even though the methodology used in this paper allows for a mixture of stationary I(0) series and non-stationary I(1) series in the estimation of the error correction model, according to Shin et al. (2014), we must verify all variables are really a mixture of I(0) series and I(1) series. Indeed, we need at least two non-stationary I(1) series in the model, and we have to exclude the non-stationary I(2) series (i.e. a series that needs to be differenced twice to be stationary). To this end, we test the levels and the first differences with the Dickey-Fuller GLS and the Phillips-Perron tests as recommended by Philips (2018) and Jordan and Philips (2018). The results are shown in Table 1. As the unit root tests indicate that the variables are non-stationary I(1) series, we can move to the next step and estimate an ARDL model as specified in equation (3) and an NARDL model as described in equation (5).

4.2. Short run dynamics

As we can observe in Figure B.1 and B.2 in Appendix B, during the period spanning from the last quarter of 2000 to the first quarter of 2018, the Vietnamese dong underwent large episodes of continuous depreciation against the U.S. dollar (up to 13 quarters). This opens the possibility for testing whether past exchange rates variations (above 4 quarters) have had an effect on the dynamics of money demand. We implement a general-to-specific approach to choose the optimal lag order for the ARDL model and the NARDL model. First, we choose the largest model with the best combination of the following statistics: the lowest AIC, the lowest RMSE, and the highest error-correction term. This gives an ARDL(7,7) for the symmetric specification and an ARDL(2,12) for the asymmetric model[10]. Second, we use a backward stepwise selection procedure based on the AIC to obtain our final models presented in Table 2 and 3.

On the one hand, in the ARDL model, the short-run coefficients of the nominal exchange rate are positive and statistically significant at the one percent level except for the first dynamic lag as we can see in Panel A of Table 2. These positive signs could indicate that the wealth effect dominates the substitution effect in the short run. We will come back to these two effects in the next section. Besides, three out of five short-run coefficients for the gross domestic product are positive and statistically significant. These positive signs are expected and reflect that domestic residents need more money to achieve a higher level of transaction (i.e. the transaction motive). Finally, the dynamic lags for the interest rate are not significant.

On the other hand, in the NARDL model, nine out of twelve short-term coefficients for positive partial sums of the nominal exchange rate are positive and significant at the five percent level[11] as we can note in Panel A of Table 3. Again, this could imply that wealth effects dominate substitution effects in case of nominal depreciation (see the Panel A of Figure B.2 in Appendix), but only in the short run. Thus, a nominal depreciation leads to an increase in money demand. Since the domestic residents observe an increase of the value of foreign currency, the consumption increases. As we will see in the following section, the transition to the new equilibrium will

[10]We do not include dynamic lags for the other variables for two reasons: first, our variables of interest are the positive and negative partial sums of the nominal exchange rate and, second, to preserve degrees of freedom. Nevertheless, when we introduce dynamic lags for the gross domestic product and the interest rate, these last variables are not statistically significant and do not improve the AIC or the RMSE.

[11]Except for the first dynamic lag that has a negative sign.

change the relative importance of these two effects. For the negative partial sums of the nominal exchange rate, five out of twelve are positive and significant at the five percent level. This could indicate, again, that wealth effects dominate substitutions effects in the short run. Indeed, a nominal appreciation will lead to a reduction in the value of foreign currency. Finally, this reduction will lead to a lower level of consumption.

4.3. Long run dynamics

In Table 2 and 3, we estimate the symmetric and asymmetric effects of the exchange rate on the money demand for the Vietnamese economy. At first glance, we can see that the long-run coefficients are correctly signed and are statistically significant at the one percent level. In the Panel B of Table 2, the nominal exchange rate elasticity to money demand is equal to 3.74 percent. Consequently, a nominal appreciation of one percent increases the money demand by 3.74 percent in the long run. This empirical result indicates that the substitution effect dominates the wealth. Indeed, when we observe a nominal appreciation, the value of foreign currency expressed in local currency drops. Facing this negative wealth effect, domestic residents will reduce their consumption, consequently, they need less money for their transactions. However, this negative wealth effect can be more than offset by a substitution effect as the domestic residents will be less prone to acquire assets in dollars to protect themselves from adverse exchange rate variation. In addition, we can note that these results fall within the range found in Lai (2012), as she found an elasticity between 3.1 and 6 percent for various monetary aggregates.

As the long-run coefficients are negative, we can conclude that after an appreciation of the Vietnamese dong (i.e. a depreciation of the U.S. dollar), the domestic money demand will grow, as the substitution effect is stronger than the wealth effect. This is confirmed by the results of the NARDL model (Panel B of Table 3) where episodes of negative changes in the nominal exchange rate (i.e. a nominal appreciation) have a positive effect on the money demand in the long term. Here, the long run elasticity is equal to -15.69. At the same time, episodes of positive changes in the nominal exchange rate (i.e. a nominal depreciation) have a negative effect on the money demand in the long term with an elasticity of -7.39. These results suggest that the substitution effect dominates the wealth effect in the long term. Interestingly, a nominal appreciation has a higher elasticity than a nominal depreciation. We will come back to this point in the next section.

For the gross domestic product variable, in Panel B of Table 2, the long-run elasticities are positive and significant at the one percent level in the ARDL specification and in the NARDL specification. These results suggest that higher income increases the money demand for transaction purposes. Besides, the value of the long- run elasticities are 2.21 and 3.22 for the ARDL model and for the NARDL model, respectively. These results are close to those of previous studies about the symmetric specification. For the income elasticity, Lai (2012) found values around 1.5 and Nguyen and Pfau (2010) found values slightly above 2.5.

For the interest rate variable, in Panel B of Table 2, the long run coefficients are negative and significant at the one percent level in the ARDL specifications. We found a long-run coefficient of -0.03 for the ARDL and NARDL model. These results suggest the existence of an inter-temporal substitution effect. Indeed, an increase in the 3-month deposit rate decreases the money demand because domestic residents will substitute present consumption by future consumption. Furthermore, our results are close to those of Nguyen and Pfau (2010) who found a long-run coefficient of -0.02 for the interest rate variable.

4.4. Coefficient diagnostics

To validate our error-correction model, we need to test whether a long-term relationship exists or not. To this end, we implement the t-test of Banerjee et al. (1998) and F-statistic of Pesaran et al. (2001). In Table 4, we can clearly see that the t-statistic is below the critical value at the one percent level and that the F-statistic is above the critical value at the one percent level for the ARDL and the NARDL models. Based on these results, we have relatively strong evidence of co-integration.

Table 2: Symmetric specification for the money demand equation (ARDL)

Panel A: Short-run coefficient estimates							
	Lag Order						
	0	1	2	3	4	5	6
$\Delta ln(M2D)$			-0.24**	-0.37***	-0.16		
			(0.12)	(0.13)	(0.12)		
$\Delta ln(NER)$		1.47	4.79***	5.56***	3.84***	3.35***	6.11***
		(0.99)	(0.97)	(1.20)	(1.17)	(1.19)	(1.15)
$\Delta ln(GDP)$	10.75***		4.42	8.01***		4.22	8.44***
	(2.52)		(2.71)	(2.45)		(2.68)	(3.09)
$\Delta IR3$	-0.02	0.02					
	(0.01)	(0.01)					
Panel B: Co-integration vector (ECM form)							
Constant	$ln(NER_{t-1})$	$ln(GDP_{t-1})$	$IR3_{t-1}$				
11.93***	-3.52***	2.08***	-0.03***				
(2.03)	(0.51)	(0.28)	(0.01)				
Panel C: Long-run coefficient estimates							
L_{ner}	L_{gdp}	L_{ir3}					
-3.74***	2.21***	-0.03***					
Panel D: Diagnostic statistics							
ECM	*Adj. R2*	*RMSE*	*AIC*	*Obs.*			
-0.94***	0.62	0.0843	-116.38	63			
(0.11)							

Notes: standard errors in parentheses. The symbols ***, ** and * correspond to statistical significance at 1, 5 and 10 percent, respectively. The value of the dynamic multipliers is obtained thanks to bootstrapping techniques described in Philips (2018).
Source: author's calculations.

Table 3: Asymmetric specification for the money demand equation (NARDL)

Panel A: Short-run coefficient estimates						
	Lag Order					
	0	1	2	3	4	5
$\Delta ln(NER^{+})$	-3.14**	4.53**	7.52***	7.85***	7.66***	5.55***
	(1.43)	(1.83)	(1.61)	(1.57)	(1.84)	(1.84)
$\Delta ln(NER^{-})$	0.97	13.85*	15.23	12.46	17.46**	21.02***
	(5.45)	(7.91)	(9.12)	(8.37)	(7.16)	(7.43)
	6	7	8	9	10	11
$\Delta ln(NER^{+})$	4.41**	1.79	6.66***	3.64**	4.99***	3.65*
	(1.60)	(1.54)	(1.60)	(1.64)	(1.69)	(1.89)
$\Delta ln(NER^{-})$	35.39***	22.27***	10.16	8.17	13.59*	6.03
	(6.48)	(7.14)	(6.69)	(6.20)	(7.48)	(5.67)
Panel B: Co-integration vector (ECM form)						
Constant	$ln(NER^{+}_{t-1})$	$ln(NER^{-}_{t-1})$	$ln(GDP_{t-1})$	$IR3_{t-1}$		
-40.95***	-8.60***	-18.26**	3.74***	-0.04***		
(7.52)	(1.68)	(6.96)	(0.67)	(0.01)		
Panel C: Long-run coefficient estimates						
$L_{ner^{+}}$	$L_{ner^{-}}$	L_{gdp}	L_{ir3}			
-7.39***	-15.69***	3.22***	-0.03***			
Panel D: Diagnostic statistics						
ECM	*Adj. R2*	*RMSE*	*AIC*	*Obs.*		
-1.16***	0.65	0.0827	-106.91	58		
(0.20)						

Notes: standard errors in parentheses. The symbols ***, ** and * correspond to statistical significance at 1, 5 and 10 percent, respectively.
Source: author's calculations.

Table 4: Co-integration tests, Symmetry tests and Diagnostic tests

Tests	ARDL	NARDL
t_{BMD}	-8.69***	-5.72***
F_{PSS}	21.02***	11.27***
LR symmetry test		3.11*
SR symmetry test		7.90***
C-H test for autocorrelation (L-B) (1 to 6 / 1 to 12)	0.07 [0.79]	4.46 [0.61]
LM test for ARCH (6 / 12)	2.41 [0.87]	14.20 [0.28]
Shapiro-Wilk W test	0.95 [0.03]	0.99 [0.98]

Notes: t_{BMD} denotes the t-statistic of Banerjee et al. (1998) and F_{PSS} is the F-statistic of Pesaran et al. (2001). The p-values are in brackets. The upper bound critical values for the F-test in case of unrestricted intercept, no trend for k=4, n=67 is 5.57 (5.285 when k=5) at the one percent level (Narayan, 2005). Moreover, the upper bound critical values for the t-test in case of unrestricted intercept, no trend for k=4, n=67 is -4.60 (-4.790 when k=5) at the one percent level, but, here, asymptotic critical values are used.
Source: author's calculations.

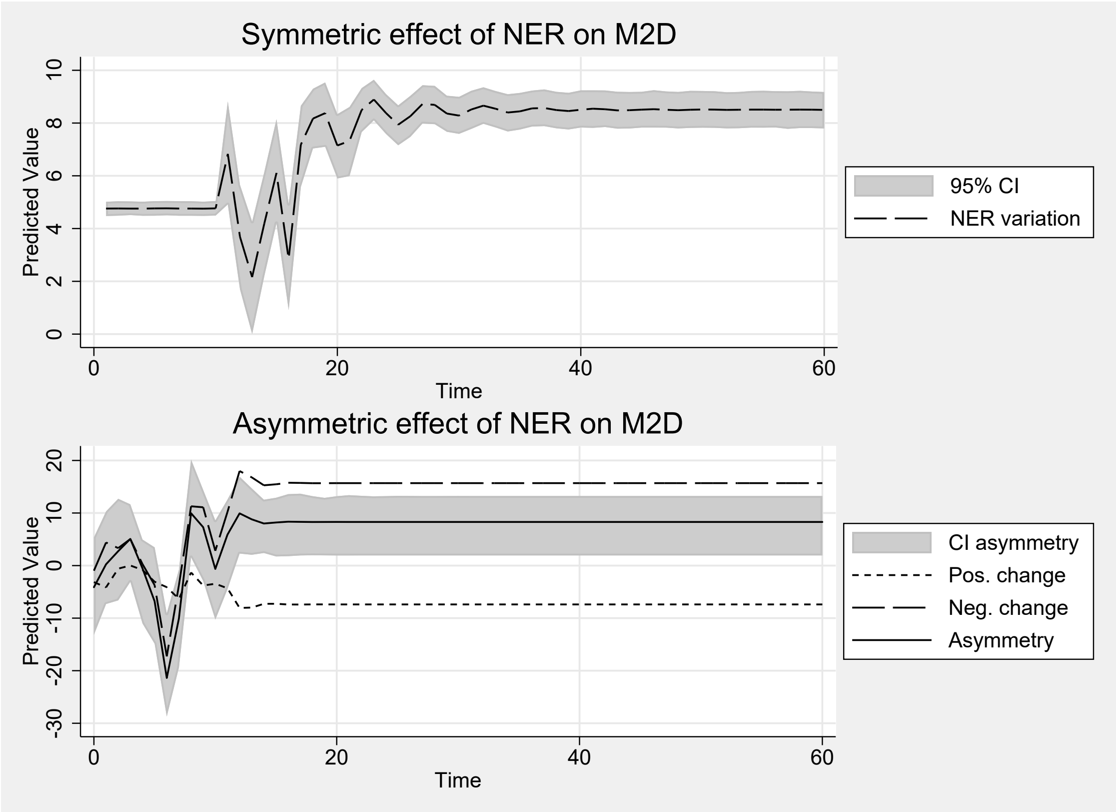
Then, we test the possible existence of asymmetry in the short term and in the long term in Table 4 as specified in 5. We find that the null hypothesis of short run symmetry is rejected at the one percent level, but the null hypothesis of long run symmetry is rejected only at the ten percent level. In addition, auto-correlation[12], heteroscedasticity and normality tests indicate that the residuals of the ARDL and of the NARDL specification are not affected by severe problems of auto-correlation, heteroscedasticity or non-normality. Except for the residuals of the ARDL model that do not seem to be normally distributed as shown by the p-value of the Shapiro-Wilk W test, but this may be due to a unique outlier as we can see in Panel C of Figure C.1 in Appendix.

In the two specifications, the error correction terms are close to unity. For the ARDL model, in Table 2, the confidence interval spans from -0.72 to -1.16 at 95 percent level. Besides, in the NARDL model (see Table 3), the error correction term is above unity indicating oscillatory convergence as explained by Loayza and Ranciere (2006) in a panel setting. In Figure 1, we can see that the model tends to oscillate after a nominal appreciation of one percent. Ultimately,

[12]To test auto-correlation, we use the more versatile framework for the tests of Cumby and Huizinga (1992) implemented by Baum et al. (2007).

the model reaches a new equilibrium when the oscillations become indistinguishable to the naked eye.

Figure 1: Dynamic multipliers



Note: In the symmetric model, the shock corresponds to a permanent appreciation of the Vietnamese currency. The mean value before the shock is equal to 4.76. The confidence intervals have been obtained through bootstrapping procedures using 100 replications. Source: author's calculations.

Indeed, the dynamic multipliers up to sixty quarters are presented in Figure 1. They are based on the ARDL and the NARDL specification described in equations (3) and (5). We can see that the new long-run equilibrium for the money demand after a symmetric or asymmetric shock is not reached monotonically. Instead of converging monotonically, the error-correction process oscillates around the new long-run equilibrium in a dampening manner as underlined by Narayan and Smyth (2006). Once the process is complete, the convergence to the equilibrium is fast[13]. When the shock is symmetric (i.e. a permanent nominal appreciation of one percent), the money demand increases by 3.7 percent in the long term. On the one hand, when the shock is asymmetric, for a permanent nominal appreciation of one percent, we observe an increase of 15.6 percent for the money demand. On the other hand, for a permanent nominal depreciation of one percent, we observe a decrease of 7.4 percent for the money demand. These results are consistent with symmetry tests and lead us to think that asymmetries occur mainly in the short run and are transmitted to the long run.

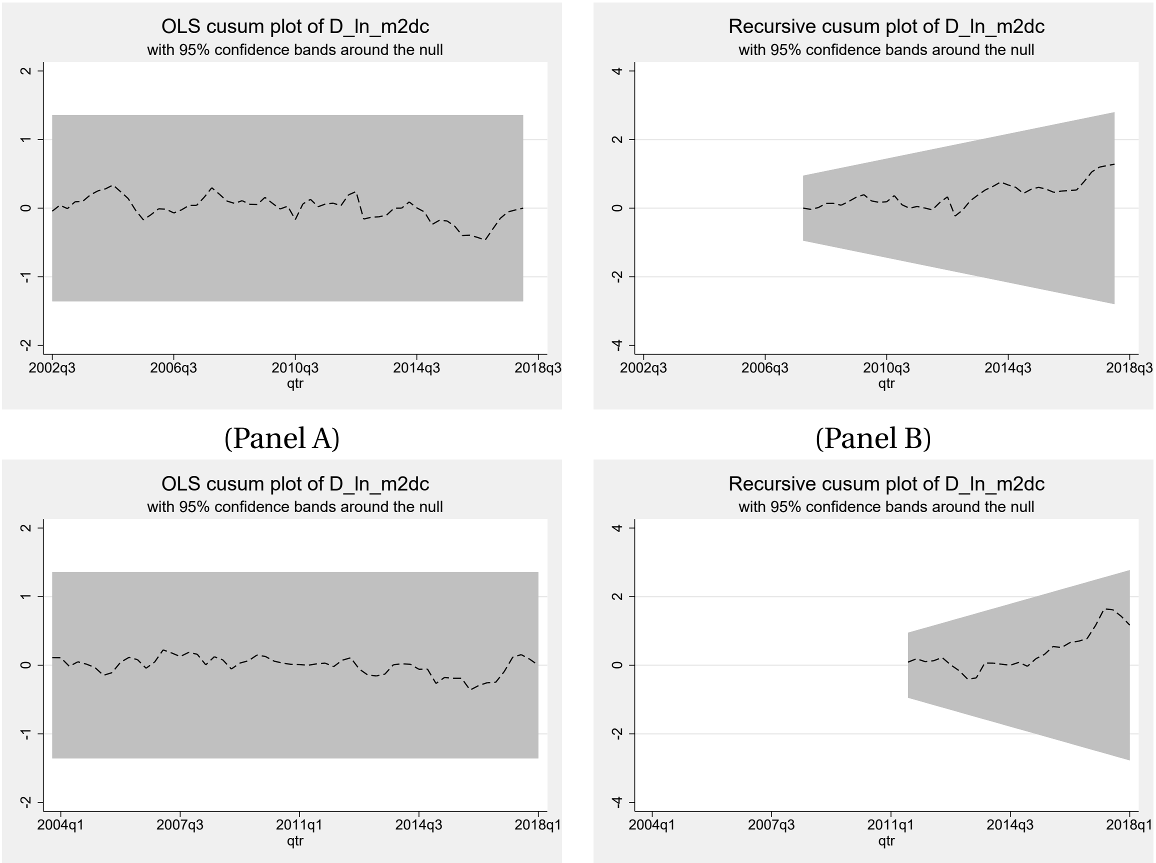
Lastly, we test the stability of the money demand in Figure 2. Indeed, we use two different tests for the ARDL and the NARDL specifications. The first one is based on the cumulative sum of OLS residuals and the second one is constructed with the cumulative sum of recursive residuals. As we can see, the coefficients for the two specifications describing the dynamics of money demand seem to be stable over the sample period.

5. Conclusion

In the recent modified circular No. 42/2018/TT-NHNN of October 1, 2019, the SBV announces a series of new measures to prohibit foreign currency loans for credit institutions and foreign bank branches in both the short and the long term. These measures aim at limiting the dollarization of the Vietnamese economy. Indeed, the dollarization of this economy could increase the vulnerability to international shocks as shown by the Asian financial crisis of 1997. Consequently, the SBV pursues its de-dollarization policy to limit the role of the U.S. dollar and foreign currencies in the domestic economy. This may induce an increase of domestic prices relative to foreign prices (as borrowing costs for firms will be higher), but this negative effect could be more than offset by the benefits reaped from a higher economic stability and economic resilience to external shocks.

[13] As suggested by Johansen (1995), with a simple example of a bivariate co-integrated VAR(1), a stability condition for an error-correction model is that the error-correction term must be strictly inferior to zero and strictly superior to -2. Indeed, the error-correction model can be written as an AR(1) process for the disequilibrium error.

Figure 2: Stability tests for the ARDL and NARDL specifications



(Panel A) (Panel B)

(Panel C) (Panel D)

Note: the upper panels A and B display stability tests for the ARDL model and the lower panels C and D display stability tests for the NARDL model. Source: author's calculations.

In this context, the objective of this empirical investigation is to examine the effect of exchange rate variations on the demand for money in Vietnam. In our empirical approach, we use linear and nonlinear error-correction models (i.e. ARDL and NARDL models) that may capture symmetric and asymmetric effects of nominal exchange rate variations on the money demand. Indeed, there are no a priori reasons that nominal depreciation and nominal appreciation will have the same impact on the money demand.

In the linear and the nonlinear specifications, our results show that the substitution effect always dominates the wealth effect in both the short and the long term. Facing a nominal depreciation, domestic residents will acquire and hold more foreign currency to protect themselves from adverse exchange rate variations. Thus, the domestic money demand decreases. Consequently, this empirical result could help to understand the dollarization of the economy. Whereas, during a nominal appreciation, domestic residents will acquire and hold less foreign currency as the value expressed in foreign currency of the Vietnamese dong increases. Thus, the domestic money demand grows, leading to de-dollarization.

As stated before, our study opens the possibility to explore asymmetric effects. Indeed, when the shock is symmetric (i.e. a permanent nominal appreciation of one percent), the money demand increases by 3.7 percent in the long term. On the one hand, when the shock is asymmetric, for a permanent nominal appreciation of one percent, we observe an increase of 15.6 percent for the money demand. On the other hand, for a permanent nominal depreciation of one percent, we observe a decrease of 7.4 percent for the money demand.

These empirical results could help to improve the understanding of the linkages between monetary policy and exchange policy in a context of dollarization for the Vietnamese economy. Its seems to indicate that de-dollarization policies could be implemented as the long-run elasticity is two times higher in case of nominal appreciation than in case of nominal depreciation. Finally, these asymmetries could be explored with econometric models that allow regime switching for the error-correction term. We leave this for future research.

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Appendix A. Data description

Table A.1: Definition of the data

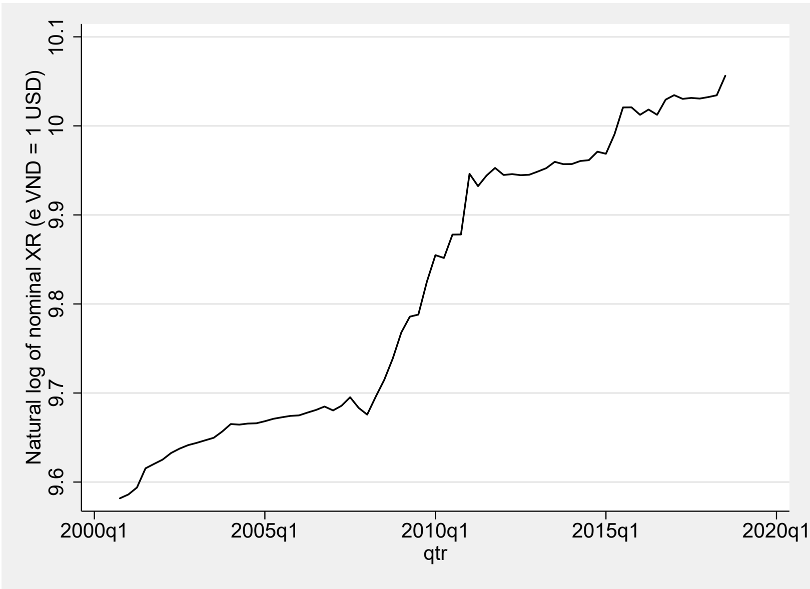
Variable	Definition
$M2D$	Money supply (M2) minus net foreign assets at constant prices in VND.
NER	Nominal exchange rate (e VND = 1 USD).
GDP	GDP at constant prices and seasonally adjusted (X12) in VND.
$IR3$	3-month deposit rate in percent as the average of 3 month deposit rates at the end of period from four large state-owned commercial banks.

Table A.2: Source of the data

Variable	Source
$M2D$	State Bank of Vietnam (SBV), Reuters, own calculations.
NER	Reuters.
GDP	General Statistics Office of Vietnam (GSO), own calculations.
$IR3$	Reuters.

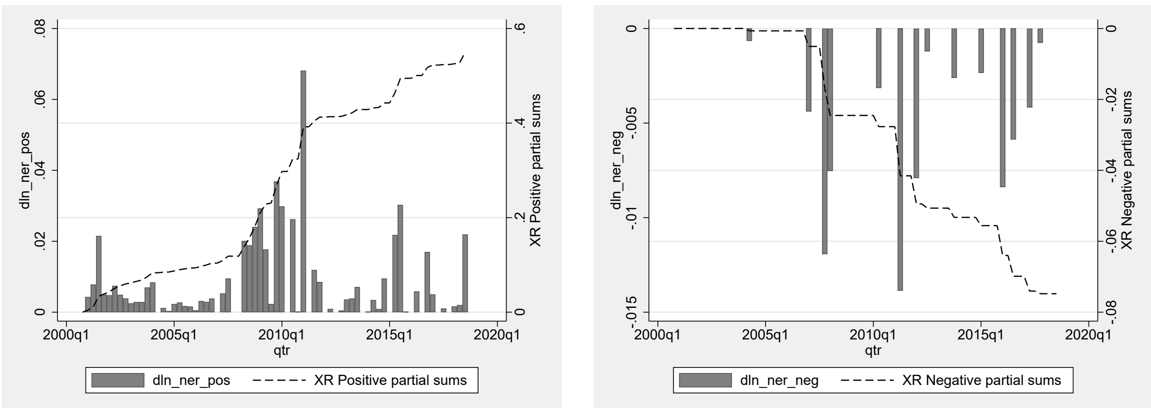
Appendix B. Partial sums

Figure B.1: Nominal exchange rate



Note: An increase of the NER represents a depreciation of the Vietnamese currency. Source: author's calculations.

Figure B.2: Positive and negative partial sums

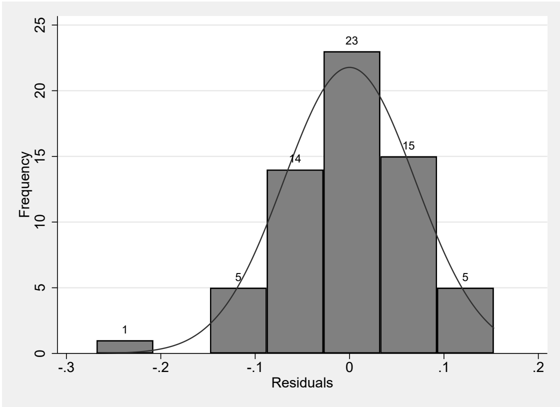


(Panel A) (Panel B)

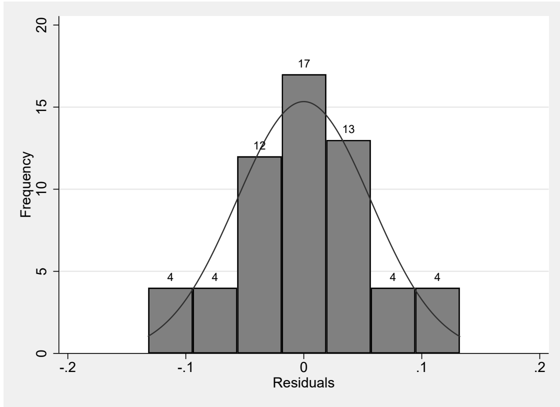
Source: author's calculations.

Appendix C. Residuals normality

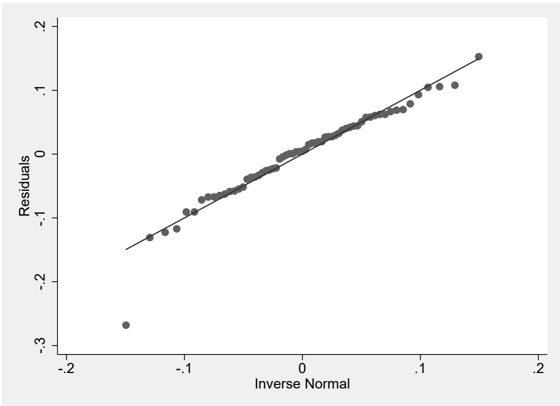
Figure C.1: Residuals plots for the ARDL and NARDL specifications



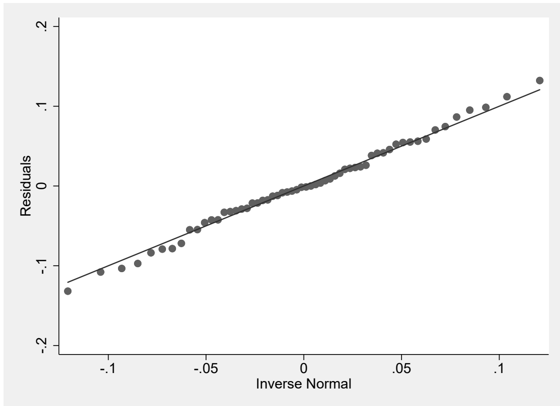
(Panel A)



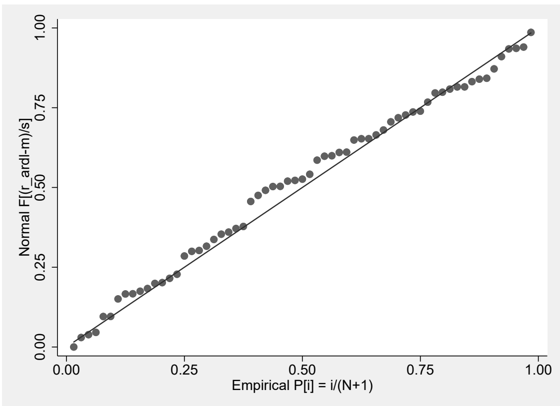
(Panel B)



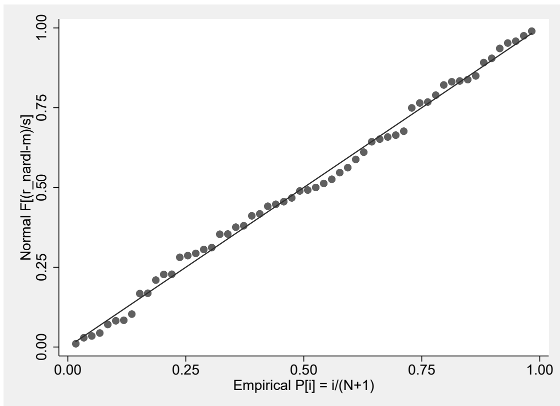
(Panel C)



(Panel D)



(Panel E)



(Panel F)

Note: the left hand side panels display residuals of the ARDL model and the right hand side panels display residuals of the NARDL model. Source: author's calculations.