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The Asymmetric Impact of Exchange Rate Changes on Bilateral Trade between Vietnam and the US: Does the COVID-19 Pandemic Matter?

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ABSTRACT

This study examines the relationship between the exchange rate and the Vietnam-US trade balance by employing a combination of Autoregressive Distributed Lag (ARDL) and non-linear Autoregressive Distributed Lag (NARDL) approaches with disaggregated data from 21 industries from 2008 to 2022. The findings reveal that, in both ARDL and NARDL models, a real Vietnamese Dong (VND) depreciation does not significantly impact on the aggregated trade balance in the long-run. The results provide evidence of an asymmetric impact of the real exchange rate on the trade balance. These findings also suggest that the COVID-19 pandemic may have induced structural breaks in the relationship between exchange rates and trade balances, leading to increased sensitivity of trade balances to exchange rate movements.

Keywords: ARDL, NARDL, Exchange Rate, Trade Balance, COVID-19, Vietnam, US
JEL Classifications: F13, F14, F31

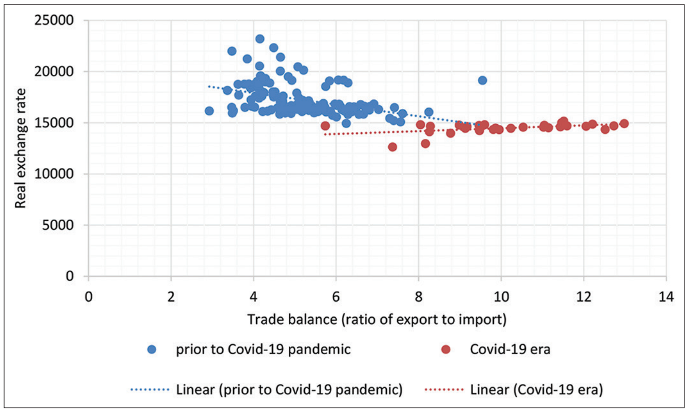
1. INTRODUCTION

The US has emerged as Vietnam's largest export partner and has consistently ranked among Vietnam's top three most prominent trading partners since 2003, following China and Korea. In 2017, exports from Vietnam to the US reached 41.6 billion USD, representing 26% of Vietnam's total exports globally. Concurrently, imports from the United States amounted to 9.2 billion USD, resulting in a substantial trade surplus of 32.4 billion USD for Vietnam. Subsequent data from the US Census Bureau indicates that Vietnam maintained trade surpluses with the United States, recording 39.5 billion USD and 55.8 billion USD in 2018 and 2019, respectively. These growing trade imbalances with Vietnam have prompted concerns and observations from the US Treasury Department. Therefore, examining the intricate relationship between the exchange rate and the trade balance becomes a vital aspect of addressing whether Vietnam engages in exchange rate manipulation.

Furthermore, the scatter plots depicting the trade balance between the two countries in relation to the real exchange rate reveal a distinct pattern (Figure 1). Prior to the onset of the COVID-19 pandemic, a notable inverse relationship existed: an increase in the real exchange rate corresponded with a decrease in the trade balance—a phenomenon contradicting established economic theory. However, during the COVID-19 period, this relationship reversed course, with the correlation between the trade balance and exchange rate turning positive. These intriguing findings suggest the presence of a linear relationship between the trade balance and exchange rate, with discernible structural breaks occurring around the time of the initial confirmation of the spread of the coronavirus disease (COVID-19) in Vietnam.

In this paper, we employ a combination of linear and non-linear Autoregressive Distributed Lag approaches to assess the impact of the real exchange rate on trade balance between Vietnam and the United States from 2005 to 2022. If our analysis reveals that

Figure 1: Real exchange rate and trade balance of Vietnam with US, 2008-2022



Source: General Statistics Office and author's calculation

the depreciation of VND would not change or improve the trade balance of Vietnam with the US, it would be unreasonable to conclude that Vietnam uses exchange rate manipulation to gain advantages in bilateral trade. Furthermore, this study incorporates an interaction term, the product of a dummy variable and the real exchange rate, to capture the COVID-19 pandemic effect.

The rest of the paper is arranged as follows: The following section is for a brief literature review on the common approaches to estimate the impacts of the exchange rate on trade flows in conventional economics. Section 3 explains the data sources and methodology. Then, section 4 presents empirical results and makes some discussions. A brief summary and concluding remarks on the findings are provided in final section.

2. LITERATURE REVIEW

The impact of exchange rates on trade is a topic that has attracted a very large volume of studies in economic literature. Based on the characteristics of employed data, Bahmani-Oskooee and Baek (2016) classified the literature into three categories:

The first type of study employed aggregate export or import data between a country and the rest of the world. Some typical studies among which are Noland (1989); Demirden and Pastine (1995) Felrningham (1988); Mahdavi and Sohrabian (1993). Most studies used Marshall-Lerner condition, which is satisfied if the sum of a country's export and import demand price elasticities is greater than one. Bahmani-Oskooee and Ardalani (2006) indicated that "mixed conclusions have been derived from these studies as far as the effectiveness of devaluation or depreciation is concerned." The inconsistent conclusions could be resulted from the bias problem in using aggregated data, since "a positive impact of devaluation against one country might be offset by its negative impact against another one" (Halicioglu, 2007).

To avoid the aggregation bias problem, Rose and Yellen (1989) introduced a study that used cointegration and error-correction models to estimate the impacts of real bilateral exchange rate on the trade flows between the US and its six largest trading partners. This study laid the foundation for developing the second category, which used disaggregate trade data at the bilateral level to estimate the impacts. Some typical studies include Wilson (2001); Arora et al. (2003).

Recently, Bahmani-Oskooee and Fariditavana (2016) indicated another bias of period studies since their common assumption is that "the effects of exchange rate changes on the trade balance are symmetric." Using nonlinear ARDL model developed by Shin et al. (2014) which was established to examine asymmetric relations, Bahmani-Oskooee and Fariditavana (2016) showed that "the effects of exchange rate changes are asymmetric in most bilateral trade balance models between the US and each of her six largest partners." This study pioneered the third category which consists of more recent studies that used disaggregate trade data at the industry level to examine the asymmetry effects of exchange rate changes based on nonlinear models. According to Bahmani-Oskooee and Baek (2018), distinguishing the impacts of currency depreciations and appreciations separately helps provide more precise evidence for better managing exchange rate policy. Bahmani-Oskooee and Gelan (2020) found evidence of both significant short-run and long-run asymmetric effects since they examined the impacts of exchange rate changes on the trade balance of 13 African countries.

So far, the number of studies on the impacts of exchange rate on trade between Vietnam and US is quite limited and most of them still employed old-fashioned approaches. For example, Vu et al. (2013) employed the Vector Correction Model (VECM) approach to examine the impacts of the exchange rate on exports from Vietnam to major trading partners, which are the US, EU, Japan, Korea. The study found that a devaluation of VND would exert a positively significant impact on exports from Vietnam to US. However, as this study did not evaluate the effects on imports, the final impact on the balance of trade was not accounted for.

Phan and Jeong (2015) employed panel co-integration techniques to investigate the impacts of real exchange rates on the trade balance between Vietnam and 16 trading partners (including US) on a bilateral basis over the period 1999-2012. The authors found that the devaluation of VND would improve the trade balance between Vietnam and US in both Fully-Modified OLS (FMOLS) and Dynamic OLS (DOLS) estimations. However, the study does not separate between short-run and long-run impacts, so it could not argue for the existence of J-curve effect.

Most recently, Anh et al. (2019) used ARDL model to consider the link between exchange rate and Vietnam-China bilateral trade. This study indicated that "the exchange rate is unlikely to be an effective tool to improve the trade balance between Vietnam and China." Using nonlinear ARDL model, Nguyen et al. (2022) concluded that "the exchange rate positively affects the Vietnam-Japan trade balance in the case of currency depreciation, whereas currency appreciation has no impact on the trade balance."

Recent international events have prompted numerous studies to explore whether exogenous shocks can impact currency exchange rates and their relationship with international trade. Specifically, they have focused on the global financial crisis, EU referendum, and the COVID-19 pandemic (Kang and Dagli, 2018; Lewis and

De Schryder, 2015). While the exact implications of COVID-19 on trade are still being studied, it is evident that the pandemic has already a significant adverse impact on global trade, comparable to the consequences of the global financial crisis (Hayakawa and Mukunoki, 2021; Li et al., 2022). COVID-19 is linked to demand and supply shocks that bear resemblance to those witnessed during the financial crisis. The significant demand and supply shocks brought about by the COVID-19 pandemic, along with the concurrent uncertainty they introduced, have a much greater impact on international trade than exchange rate changes. The COVID-19 pandemic has resulted in supply chain disruptions and structural change of the global value chain (Demirkıran, 2023; Raj et al., 2022). This may impact how international trade responds to exchange rate changes. For example, because of supply chain disruptions, companies importing intermediate materials shift towards domestic supplier. Therefore, currency depreciation does not increase the costs of intermediate imported inputs used in the production of export goods, thus not affecting the competitive advantage. In other words, the currency depreciation in the context of the COVID-19 pandemic could have a stronger impact on exports and then the trade balance. Several studies have pointed out the role of deepening GVC (Global Value Chains) in the relationship between exchange rates and trade, as demonstrated by như Ahmed et al. (2016), Patel et al. (2019), Cheng et al. (2016), Gangnes et al. (2014). On the other hand, impact of exchange rate on trade during COVID-19 pandemic may depend on structure of trade or a larger scale of economy's structure. In general, an overview of the literature suggests that the relationship between exchange rates and trade may be influenced by the COVID-19 pandemic.

This study examines the nexus between exchange rates and the trade balance by focusing on Vietnam's bilateral trade with the US across 21 HS industries. While several studies have explored this relationship in the context of Vietnam's trade with other nations, this study aims to contribute to the topic in the following ways:

Firstly, this research replicates prior studies conducted in the Vietnamese context. It aims to establish whether changes in exchange rates have a symmetric or asymmetric impact on the trade balance between Vietnam and the United States, utilizing an updated dataset.

Secondly, this study contributes to understanding whether the relationship between these key variables may change due to the COVID-19 pandemic.

Thirdly, it is worth noting that previous studies predominantly rely on quarterly or annual data, which can introduce aggregation bias because of lower frequency (Taylor, 2001). Therefore, this research employs monthly data from 2008 to 2022.

3. METHODOLOGY

3.1. The models

Following Bahmani-Oskooee and Baek (2016), we adopt the following model specification to evaluate the impact of exchange rate on trade balance between Vietnam and US:

$$Ln\left(\frac{X_i}{M_i}\right)_t = \varphi_1 + \varphi_2 LnY_t^{VN} + \varphi_3 LnY_t^{US} + \varphi_4 LnREX_t + \varepsilon_t \tag{1}$$

In which, X_i is the export to and M_i is the import from US for industry i of Vietnam, therefore $\frac{X_i}{M_i}$ is also reflected trade balance of industry i; Y^{VN} (Y^{US}) is the real income of Vietnam (US); *REX* is the real bilateral exchange rate USD/VND, defined in a manner that a decline reflects a real appreciation of VND. All variables are presented in logarithmic form. For the coefficients, φ_2 is expected to be negative (-), φ_3 is positive (+) and φ_4 is positive (+). As previously mentioned, this study also places particular emphasis on assessing the impact of the exchange rate on the trade balance during the pandemic. To address this, an interaction variable has been incorporated into Equation (1).

$$\begin{aligned} Ln\left(\frac{X_i}{M_i}\right)_t &= \omega_1 + \omega_2 LnY_t^{VN} + \omega_3 LnY_t^{US} \\ &+ \omega_4 LnREX_t + \omega_5 LnREX_t * D + \omega_6 D + \varepsilon_t \end{aligned}$$

Where D is a dummy variable that equals 1 over the period 2020:02 up to end of the sample period and 0 otherwise. So, we denote the product of $LnREX_t$ and D by *inter*.

Being a long-run model, the coefficients of equation (1) reflect the impacts of independent variables on trade balance of industry i in the long-run. To estimate the short-run impacts, equation (1) is rewritten in error-correction format as following:

$$\begin{aligned} \Delta Ln\left(\frac{X_i}{M_i}\right)_t &= \alpha + \sum_{k=1}^{n}\beta_{t-k}\Delta Ln\left(\frac{X_i}{M_i}\right)_{t-k} + \sum_{k=0}^{n}\delta_{t-k}\Delta LnY_{t-k}^{VN} \\ &+ \sum_{k=0}^{n}\gamma_{t-k}\Delta LnY_{t-k}^{US} + \sum_{k=0}^{n}\delta_{t-k}\Delta LnREX_{t-k} \\ &+ \sum_{k=0}^{n}\vartheta_{t-k}\Delta inter_{t-k} + \varphi_1 Ln\left(\frac{X_i}{M_i}\right)_{t-1} + \varphi_2 LnY_{t-1}^{VN} \\ &+ \varphi_3 LnY_{t-1}^{US} + \varphi_4 LnREX_{t-1} + \varphi_5 inter_{t-1} + \mu_{t-1} \end{aligned} \tag{2}$$

For equation (2), Pesaran et al. (2001) propsed to use the standard F-statistic to test the joint significance of lagged level variables as evidence of cointegration among the variables. The hypothesis for this test is H_0: $\varphi_1 = \varphi_2 = \varphi_3 = \varphi_4 = \varphi_5 = 0$, if F-statistic turns out to be significant then H_0 could be rejected, in other words there exists the long-run relationship among variables.

The key assumption in both equation (1) and (2) is that all independent variables have symmetric effects on the trade balance $\frac{X_i}{M_i}$; it means that, for example, if 1% depreciation of *REX* improves $\frac{X_i}{M_i}$ by θ% then 1% appreciation should worsen it by θ% in the opposite direction. However, as argued in the Literature Review section, this assumption is quite unrealistic as changes in exchange rates could have asymmetric effects on trade balance. To address this issue, it is crucial to develop new variables of exchange rate to better reflect the situation (Delatte and López-Villavicencio, 2012; Bahmani-Oskooee and Fariditavana, 2015; Bahmani-Oskooee and Gelan, 2020). This is done by decomposing changes in the exchange rate into two new variables, where one variable reflects only appreciation, and the other variable reflects only depreciation (Bahmani-Oskooee and Baek, 2018). In this study, *POS* and *NEG* would reflect the depreciation and appreciation of VND respectively in the following forms:

$$POS_t = \sum_{j=1}^{t} \Delta lnREX_j^+ = \sum_{j=1}^{t} max(\Delta lnREX_j, 0) \quad (3)$$

$$NEG_t = \sum_{j=1}^{t} \Delta lnREX_j^- = \sum_{j=1}^{t} min(\Delta lnREX_j, 0) \quad (4)$$

We follow Shin et al. (2014) in replacing *LnREX* in (2) with *POS* and *NEG* from (3) and (4) to produce the new following specification:

$$\begin{aligned}\Delta Ln(\frac{X_i}{M_i})_t &= \alpha' + \sum_{k=1}^{n} \beta'_{t-k} \Delta Ln(\frac{X_i}{M_i})_{t-k} + \sum_{k=0}^{n} \delta'_{t-k} \Delta LnY_{t-k}^{VN} \\ &+ \sum_{k=0}^{n} \gamma'_{t-k} \Delta LnY_{t-k}^{US} + \sum_{k=0}^{n} \pi_{t-k} \Delta POS_{t-k} \\ &+ \sum_{k=0}^{n} \vartheta_{t-k} \Delta NEG_{t-k} + \varphi'_1 Ln(\frac{X_i}{M_i})_{t-1} + \varphi'_2 LnY_{t-1}^{VN} \\ &+ \varphi'_3 LnY_{t-1}^{US} + \varphi'_4 POS_{t-1} + \varphi'_5 NEG_{t-1} + \mu'_{t-1} \quad (5)\end{aligned}$$

As the two new variables generate a nonlinearity feature, error-correction model in equation (5) could be called nonlinear ARDL model (hereafter NARDL) while equation (2) is called the linear ARDL model (hereafter ARDL). According to Bahmani-Oskooee and Baek (2018), bound testing approaches and critical values applied in ARDL could be used equally for NARDL.

3.2. Main Tests and Data Sources

In equation (5), if estimated φ'_4 and φ'_5 have the same signs and magnitude, it implies that exchange rate exerts symmetric effects on trade balance in long-run. In opposition, if those two have different signs and magnitudes, it means that exchange rate exerts asymmetric effects on trade balance. This assessment can be conducted using the Wald test, which examines the statistical significance of the normalized coefficients on POS and NEG with the null hypothesis $H_0 : \varphi'_4 / \varphi'_1 = \varphi'_5 / \varphi'_1$. Similarly, the short-run asymmetric effects would be tested with hypothesis $H_0 : \sum_{k=0}^{n} \pi_{t-k} = \sum_{k=0}^{n} \vartheta_{t-k}$

This study employs monthly data from January 2008 to August 2022 for all ARDL and NARDL estimations. Bilateral export and import figures between Vietnam and US are taken from the database of International Trade Centre, covering 21 industries based on a Harmonized System (HS) (Appendix Table 1). However, due to the absence of data for HS03 (Animal or Vegetable Fats and Oils) and HS19 (Arms and Ammunition) industries, the model results presented below pertain only to the 19 sectors.

In the study, real income variables are proxied by the industrial production because of limitations on the monthly data for real income. Real exchange rate (*REX*) is calculated from nominal exchange rate and difference in consumer price index on monthly basis. Those data are taken from database of State Bank of Vietnam and US Federal Reserve.

According to Pesaran et al. (2001), ARDL methodology does not require all variables to be $I(0)$, that it can be used with a mixture of $I(1)$ and $I(0)$, but definitely not valid with $I(2)$. This condition is checked by conducting unit root test employing the Augmented Dickey-Fuller (ADF) and Phillip Perron (PP) procedures on all variables in the models. The results show that no variable is $I(2)$, most of them are $I(0)$ or $I(1)$ according to ADF at 1% and PP at 5% levels, which sastify the crucial condition of ARDL methodology. The optimal lags for equation (2) and (4) are obtained based on Akaike Information Criterion (AIC) criteria. A maximum lag of 6 is used in finding the optimal lags.[1]

Bound testing results for each model is presented in Appendix Tables 2 and 3. For ARDL models, there are 13/19 industries having cointegration relationship whereas 6/19 industries show no evidence of cointegration. For NARDL, cointegration relationship is found in 11/19 industries; there are 8 industries that display no evidence of cointegration.

According to Bahmani-Oskooee and Ardalani (2006), bound testing F-test would be sensitive to the number of lags imposed on variables. Banerjee et al. (1998) proposed to use the criterion of error-correction term (ECT_{t-1}) to address this issue. If error-correction term is found statistically significant and negative, which supports the long-run relationship among the variables. The results of this test, presented in Appendix Tables 2 and Table 3, indicate that all error-correction terms are negative and statistically significant, therefore satisfy the requirement of further estimations.

In addition, a number of tests are conducted to check for model specification including: Autocorrelation test (LM test), Heteroskedasticity (HK test), model specification (RESET test), Stability test (CUSUM and CUSUMSQ tests). Results of those tests, presented in Appendix Table 2 (for ARDL model) and Appendix Table 3 (for NARDL model), indicate that all models are not affected by problems of autocorrelation, heteroskedasticity and model specification. The CUSUM and CUSUMSQ tests reveal that the majority of the models exhibit stable coefficients (stable coefficients are denoted as "Y," while coefficients that display instability are referred to as "N").

4. EMPIRICAL RESULTS

4.1. Results of ARDL Models

4.1.1. Estimation of long-run coefficients

Estimation of long-run coefficients of ARDL models are presented in Table 1, which indicate that 5 industries (accounting for 23% of import and 8.75% of export between Vietnam and US in 2017) would be significantly affected by exchange rate. In detail, for 1% depreciation of VND, the trade balance of the following industries would be worsened: HS08 (Raw Hides, Skins, Leather, and Furs) by 4.53%, HS17 (Transportation) by 6.45%. The industries would have positive impact in trade balance: HS02 (Vegetable Products) improve by 6.12%, HS06 (Chemicals and Allied Industries) by 2.94%, HS13 (Stone/Glass) by 5.39%. It is noted that in ARDL

1. The detail results of the tests will be provided upon request

Table 1: Estimation of long-run coefficients of ARDL models

Industries	LRER		Interaction term		INCOMEVN		INCOMEUS	
HS01	−1.14	(1.55)	0.00	(0.02)	0.18	(0.49)	1.22	(1.69)
HS02	6.12***	(1.58)	−0.01	(0.02)	−0.35	(0.57)	1.17	(1.86)
HS04	−0.35	(1.75)	0.043**	(0.02)	−0.98*	(0.56)	0.94	(1.67)
HS05	4.80	(11.98)	0.01	(0.13)	−2.44	(3.96)	−24.29*	(13.63)
HS06	2.94***	(0.53)	0.03***	(0.01)	−0.30*	(0.17)	0.65	(0.56)
HS07	0.47	(1.59)	0.13***	(0.02)	−0.06	(0.58)	3.70*	(1.89)
HS08	−4.53***	(1.71)	0.01	(0.02)	−0.51	(0.54)	2.13	(2.07)
HS09	−2.18	(3.11)	0.20***	(0.04)	−0.77	(1.12)	6.17*	(3.53)
HS10	0.67	(0.94)	0.02	(0.01)	0.25	(0.35)	0.06	(1.10)
HS11	−0.39	(2.16)	0.01	(0.03)	0.02	(0.72)	−5.34**	(2.58)
HS12	−2.97	(2.96)	0.05	(0.03)	2.24*	(1.19)	−2.65	(3.24)
HS13	5.39**	(2.14)	0.13***	(0.02)	−0.41	(0.69)	3.40	(2.55)
HS14	0.75	(2.40)	−0.07**	(0.03)	0.68	(0.80)	−2.13	(2.76)
HS15	−1.41	(2.19)	0.06***	(0.02)	−0.57	(0.69)	6.62***	(2.36)
HS16	−3.18	(4.28)	0.22***	(0.06)	−3.90**	(1.95)	5.50	(4.59)
HS17	−6.45**	(2.79)	0.24***	(0.03)	-2.60***	(0.92)	4.22	(3.01)
HS18	−1.81	(1.34)	0.09***	(0.02)	0.42	(0.46)	4.86***	(1.49)
HS20	−0.64	(2.01)	0.14***	(0.02)	0.04	(0.68)	2.67	(2.37)
HS21	−0.65	(1.32)	0.08***	(0.02)	−0.75*	(0.45)	3.39**	(1.54)
HStotal	0.56	(0.54)	0.08***	(0.01)	−0.59***	(0.17)	2.51***	(0.62)

The standard errors for the regression coefficients are in parentheses; ***, **, and * indicate the 1%, 5%, and 10% significance levels, respectively

model, trade balance is assumed to receive symmetric impact from exchange rate so the above figures would be reversed in signs if VND appreciated by 1%.

As the estimated coefficient of aggregate model (HSTotal) is insignificant, it means that exchange rate does not have impact on total sum of export/import between two countries. In other words, exchange rate has no statistical impact on aggregate trade balance. While several industries proved to react with exchange rate movement, this finding seem support the argument by Baek (2013) that using aggregate data in ARDL estimation may provide biased outcome.

The long-run coefficients of the interaction term between LRER and a dummy variable are statistically significant in 12 industries, with most of these coefficients exhibiting a positive sign, except for HS14. These industries accounted for 64.58% of import and 52.70% of export between Vietnam and US in 2017. Additionally, the results also indicate that COVID-19 Pandemic leads to increased sensitivity of the trade balance to the real exchange rate movement. The trade balance elasticity may be bigger in period of depreciation during Covid-19 Era. To illustrate, the interaction variable has a significant positive coefficient of 0.08% in *HStotal* model, implying that the impact of exchange rate on trade balance increase 0.08%. This finding can be explained by structural factor. As mentioned earlier, The COVID-19 pandemic has caused a disruption in the global supply chain. Reducing participation in the global value chain during the pandemic period has led to a strengthened link between exchange rates and trade balance in developing countries like Vietnam.

The long-run coefficients of real income for Vietnam (*INCOMEVN*) are statistically significant in 6 industries (accounting for 48% of import and 32% of export between Vietnam and US in 2017). In detail, for 1% increase in real income of Vietnam, the trade balance of the following industries would be worsened: HS04 (Prepared Foodstuffs) by 0.98% HS06 (Chemicals and Allied Industries) by 0.3%, HS16 (Machinery/Electrical) by 3.9%, HS17 (Transportation) by 2.60% and HS21 (Works of Art) by 0.75%. Conversely, only one industry, HS12 (Footwear/Headgear), would experience an improvement in its trade balance, by 2.24%.

The long-run coefficients of real income for US (*INCOMEUS*) are statistically significant in 7 industries (accounting for 30.01% of import and 32.54% of export between Vietnam and US in 2017). There are 5 industries (accounting for 30% of import and 32.5% of export) with positive significant coefficient including HC07 (Plastics/Rubbers) improve by 3.7%, HS09 (Wood and Wood Products) improve by 6.17% and HS15 (Base Metals) improve by 6.62, HS18 (Precision Instruments) improve by 4.86%, HS21 (Works of Art) improve by 3.39%. In contrast, trade balance of HS05 and HS11 would be worsened 24.29% and 5.34% when real income of US increase 1%.

Generally, the statistically significant coefficients of Vietnam's income variable mostly have a negative sign, whereas those for the United States have a positive sign. Additionally, the signs of the income coefficients in the aggregated model align with the expected direction.

4.1.2. Estimation of short-run coefficients

Exchange rate is considered having impact on trade balance in short-run of an industry if there is at least one short-run estimated coefficient is statistical significant. The estimation of short-run coefficients in equation (2) are presented in Appendix Table 4, which indicates that 7 industries exhibit statistically significant coefficients HS02 (Vegetable Products), HS04 (Prepared Foodstuffs), HS07 (Plastics/Rubbers), HS06 (Chemicals and Allied Industries), HS08 (Raw Hides, Skins, Leather, and Furs), HS09 (Wood and Wood Products), HS17 (Transportation). These industries account for 30.3% of total import value and 10.3% of total export value of Vietnam with US in 2017. Among these industries, the short-run coefficients have at least one negative sign in HS04, HS06, HS07, HS09, HS17. Notably, the coefficients for

HS07 exhibit a positive sign at the first lag but turn negative at significant lags. Industries with consistently positive coefficients across all significant lags include HS02 and HS08. For the remaining industries (HS06, HS09, HS17), the signs of the short-run coefficients turn negative at different lag levels.

4.2. Results of NARDL Models

4.2.1. Estimation of long-run coefficients

Estimation of long-run coefficients of NARDL models (equations (3) and (4)) are presented in Table 2. As earlier dicussed, NARDL methodology estimates the impact on trade balance given the adjustments of exchange rate in two cases: appreciation and depreciation. Theory of asymmetric effects of exchange rate on trade balance stated that domestic producers would react quickly to increase the export when the exchange rate is depreciated. However, when the exchange rate is appreciated, their reactions would be slower due the factors such as market restrictions. Therefore, the expected impacts of depreciated exchange rate would be higher than appreciated exchange rate on trade balance.

In equations (3) and (4), as *POS* and *NEG* would reflect the depreciation and appreciation of VND in comparison with USD respectively; therefore, the asymmetric effects would not occur if estimated coefficients of *POS* and *NEG* got the same sign and manitude. The results in Table 2 reveal that 11 industries, accounting for 51.6% of imports and 50.9% of exports between Vietnam and the US, are affected by changes in the exchange rate. These industries include five that are similar to the ARDL estimation results: HS01 (Animal and Animal Products), HS02 (Vegetable Products), HS06 (Chemicals and Allied Industries), HS08 (Raw Hides, Skins, Leather, and Furs), HS17 (Transportation). In addition to the ARDL findings, NARDL estimations indentify 6 more industries that are impacted: HS05 (Mineral Products) HS09 (Wood and Wood Products), HS11 (Textiles), HS13 (Stone/Glass), HS14 (Natural or Cultured Pearls), HS18 (Precision Instruments) and HS20 (Miscellaneous Manufactured Articles).

Furthermore, NARLD also show the asymmetric effects of exchange rate on trade balance of each industry. For example, the industry HS01, HS02, HS05, HS06, H09, HS11, HS13, HS14, HS18, HS20 reflects the impact exchange rate on trade balance when there is depreciation. The estimated *POS* at −3.91, −16.47 or −5.63 indicate that when VND is depreciated by 1% (RER increase), the trade balance of HS01, HS05 or HS14 would worsen by 3.91%. 16.47% or 5.63% respectively. In contrast, the trade balance of industries HS02, HS06, HS09, HS13, HS18, HS20 would improve in the long-run when VND performed in the same manner. In the case of a 1% appreciation of the VND (resulting in a decrease in the real exchange rate), the trade balances of HS02, HS06, and HS13 worsen by 6.75%, 2.43%, and 8.42%, respectively. Meanwhile, the trade balances of HS08 and HS17 improve by 4.63% and 11.38%, respectively.

The signs of *POS* and *NEG* for HS02, HS06 and HS13 are all positive, indicating that a depreciation of the VND would have a positive impact, while an appreciation would have a negative impact on the trade balance. The results of Wald test indicate that there is no asymmetric effect in these industries, except in the case of HS13.

In the aggregate model, the estimated coefficients of HSTotal model exhibit that, in the long run, both the depreciation and appreciation of the VND do not exert a significant impact on the trade balance of Vietnam with the US (the estimated coefficients are statistically insignificant).

The finding of NARDL models would address the limitation of ARDL models in assuming that impacts of exchange rate on trade balance are symmetric. By adding *POS* and *NEG* variables, NARDL models indicate that real exchange rate would have asymmetric impacts in many industries; whereas, in case of ARDL estimations, those industries showed no impact from exchange rate.

Table 2: Estimation of long-run coefficients of NARDL models

Industry	POS		NEG		INCOMEVN		INCOMEUS	
HS01	−3.91*	(2.13)	−2.48	(1.67)	0.45	(0.42)	2.77*	(1.54)
HS02	6.56***	(2.11)	6.75***	(1.66)	−0.39	(0.52)	2.05	(1.87)
HS04	1.87	(3.43)	0.86	(2.71)	−0.95	(0.82)	1.30	(2.64)
HS05	−19.10**	(8.33)	−0.13	(6.20)	−0.44	(1.82)	−1.45	(6.77)
HS06	2.86***	(1.01)	2.43***	(0.80)	−0.07	(0.24)	−0.33	(0.77)
HS07	3.14	(5.51)	−1.97	(4.65)	−0.22	(1.28)	−2.84	(4.60)
HS08	−1.67	(2.11)	−4.63***	(1.65)	−0.88*	(0.49)	−2.96*	(1.58)
HS09	11.21*	(6.24)	2.07	(4.84)	−1.47	(1.47)	−0.53	(4.59)
HS10	−0.18	(2.41)	−0.43	(1.89)	0.73	(0.57)	−0.54	(1.80)
HS11	−5.63*	(2.98)	−2.87	(2.42)	0.59	(0.68)	−2.07	(2.50)
HS12	−2.81	(3.79)	−2.31	(3.07)	2.93**	(1.45)	−0.38	(3.48)
HS13	14.06***	(3.42)	8.42***	(2.65)	−0.72	(0.82)	−0.47	(2.45)
HS14	−5.84*	(3.16)	−3.82	(2.43)	0.90	(0.78)	−4.01*	(2.36)
HS15	2.52	(2.75)	−0.23	(2.18)	−0.57	(0.68)	4.93**	(2.22)
HS16	5.40	(5.12)	−2.30	(4.22)	−3.31**	(1.57)	−2.18	(4.15)
HS17	−3.02	(8.03)	−11.38*	(6.78)	0.50	(2.22)	−11.85	(8.58)
HS18	4.31***	(1.30)	0.68	(0.98)	0.11	(0.33)	2.70***	(1.01)
HS20	14.48***	(5.34)	6.55	(4.21)	−0.94	(1.09)	−2.76	(3.64)
HS21	2.76	(2.82)	0.97	(2.17)	−0.96	(0.62)	3.65*	(2.00)
HSTotal	1.05	(1.05)	0.67	(0.75)	−0.68***	(0.24)	2.08***	(0.78)

The standard errors for the regression coefficients are in parentheses; ***, **, and * indicate the 1%, 5%, and 10% significance levels, respectively

In summary, trade balances are found to be more sensitive to exchange rates in NARDL models compared to ARDL models. Specifically, 11 industries (accounting for 50.9% of exports and 51.6% of imports) react significantly to changes in the exchange rate. The results also indicate that, in the long run, the depreciation of the VND has no impact on the aggregate trade balance of Vietnam with the US, and exchange rates are more sensitive to depreciation than to appreciation in disaggregated models.

4.2.2. Estimation of short-run coefficients

Appendix Tables 5 and 6 show the estimated result of short-run coefficients of NARDL (Appendix). The estimated coefficients of *POS* and *NEG* indicate the asymmetric impacts of exchange rate on trade balance. Similar to the long-run cases, the results of short-run NARDL models also show that there are more industries impacted by exchange rate than in the case of ARDL models. A depreciation of VND would exert impact on HS01, HS02, HS06, HS08, HS09, HS11, HS18, HS20 whereas an appreciation of VND would affect HS01, HS02, HS04, HS07, HS06, HS08, HS09, HS17, HS20. Results of Wald test indicate the occurrence of asymmetric impacts in HS11, HS17, HS18.

In general, results of short-run NARDL models also show more industries react to the change of exchange rate than in the case of short-run ARDL models. In addition, in short-run NARDL models, there are more indutries having asymmetric impacts from exchange rate than in long-run models.

5. CONCLUDING REMARKS

This study uses the linear ARDL and non-linear ARDL (NARDL) models to evaluate the impact of real exchange rate on the trade flows of 21 industries (HS code) trading between Vietnam and the US. The estimation results can be summarized as following:

First, in both the ARDL and NARDL models, it is observed that currency depreciation or appreciation of the Vietnamese Dong (VND) has no discernible impact on the aggregate trade balance with the United States, both in the short-run and the long-run. However, the influence of the real exchange rate on trade balance, as examined through disaggregated models, demonstrates variability among distinct industries. Specifically, among the 5 industries that response to exchange rate changes in the ARDL models, we observe that trade balances in three of these industries deteriorate in response to VND depreciation. Conversely, when employing the NARDL models, it becomes evident that a greater number of industries experience an improvement in their trade balances compared to those experiencing a deterioration. Specifically, six industries exhibit an improved trade balance in response to VND depreciation, whereas only three industries register a worsened trade balance. Therefore, the utilization of non-linear models proves valuable for exploring the asymmetric effects of exchange rate fluctuations on trade and identifying a greater number of industries that respond favorably to such changes.

Second, the sensitivity of the trade balance to exchange rate movement is notably higher in case of currency devaluation. Indeed, the NARDL model shows that there are 10 industries within this analysis, collectively accounting for 44% of exports and 47% of imports between the two countries, that exhibit a responsive behavior to VND devaluation. In contrast, only 5 industries, representing 23% of exports and 8.76% of imports between the two countries, respond to the appreciation of the VND. Among the 10 industries affected by VND devaluation, a noteworthy observation is that 6 of these industries experience an improvement in their trade balance. These 6 industries account for 23% of imports and 19.5% of exports between the two countries.

Third, ARDL model indicate that the impact of exchange rate movement on trade balance is much stronger in COVID-19 era. This strengthen can be explained by the disruption of supplier chain during the period.

In conclusion, empirical results of this study show that a depreciation of Vietnam currency hardly has any significant impact on the trade balance between Vietnam and US. In other words, exchange rate might not be an effective tool to improve bilateral trade balance for Vietnamese government. Additionally, as the income variables show the significant positive impacts on aggregated trade balance, it would be better for Vietnamese government to utilize other monetary (fiscal) policies rather than exchange rate policy to improve its external position.

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APPENDIX

Appendix Table 1: Harmonized system code

Industry	Content	Import share (%)	Export share (%)
HS01	Animal and Animal Products	4.86	2.05
HS02	Vegetable Products	10.09	4.33
HS03	Animal or Vegetable Fats and Oils	0.08	0.04
HS04	Prepared Foodstuffs	4.98	1.58
HS05	Mineral Products	0.49	0.33
HS06	Chemicals and Allied Industries	5.68	0.58
HS07	Plastics/Rubbers	3.98	2.05
HS08	Raw Hides, Skins, Leather, and Furs	1.62	2.47
HS09	Wood and Wood Products	3.25	0.48
HS10	Pulp of Wood or of Other Fibrous Material	1.80	0.31
HS11	Textiles	14.26	25.40
HS12	Footwear/Headgear	2.21	12.34
HS13	Stone/Glass	0.30	0.51
HS14	Natural or Cultured Pearls	0.91	0.34
HS15	Base Metals	3.43	2.81
HS16	Machinery/Electrical	31.70	29.53
HS17	Transportation	5.31	0.87
HS18	Precision Instruments	3.84	1.05
HS19	Arms and Ammunition	0.00	0.00
HS20	MiHSellaneous Manufactured Articles	0.45	12.53
HS21	Works of Art	0.75	0.42

Appendix Table 2: Results of bound testing and specification tests of ARDL models

Industry	F	ECM (t-1)	LM	RESET	HSK test	CUSUM	CUSUMSQ	R2
HS01	5.77***	−0.29***	1.48	0.58	0.85	Y	Y	0.17
HS02	6.89***	−0.47***	4.52	2.17	0.04	Y	Y	0.37
HS04	5.82***	−0.25***	4.48	1.89	0.36	Y	Y	0.18
HS05	2.34	−0.35***	1.45	1.94	10.888***	N	Y	0.55
HS06	29.64***	−0.94***	0.74	0.93	0.95	Y	Y	0.49
HS07	4.12**	−0.22***	5.17	0.53	0.00	N	Y	0.25
HS08	8.09***	−0.35***	1.40	0.26	0.05	Y	Y	0.46
HS09	2.46	−0.11**	2.72	1.61	2.54	Y	Y	0.36
HS10	10.84***	−0.48***	6.61	0.95	0.08	Y	Y	0.25
HS11	3.31	−0.20***	4.29	1.52	6.597***	Y	Y	0.23
HS12	3.33	−0.17**	3.22	1.08	1.04	Y	N	0.40
HS13	6.51***	−0.38***	33.02***	2.11	0.03	Y	Y	0.19
HS14	5.77***	−0.50***	3.18	0.90	0.06	Y	N	0.54
HS15	8.11***	−0.56***	5.01	1.91	0.42	Y	Y	0.35
HS16	2.24	−0.10**	1.08	0.39	0.11	Y	Y	0.33
HS17	7.10***	−0.53***	3.86	1.24	1.98	Y	N	0.53
HS18	2.73	−0.32***	7.08	0.22	15.518***	Y	Y	0.48
HS20	4.04**	−0.37***	2.51	2.532*	0.91	Y	Y	0.34
HS21	9.81***	−0.62***	7.06	0.85	7.48***	Y	N	0.48
HSTotal	10.58***	−0.56***	0.53	0.43	0.24	Y	Y	0.38

***, **, and * indicate the 1%, 5%, and 10% significance levels, respectively. The upper bound critical value of the F-test to reject H0 is 3.52 (10%), 4.01 (5%), 5.06 (1%)

Appendix Table 3: Results of bound testing and specification tests of NARDL models

Industry	F	ECM (t-1)	LM	RESET	HSK test	Wald_l	Wald_s	CUSUM	CUSUMSQ	R2
HS01	8.06***	−0.34***	3.06	0.19	0.30	3.614**	0.97	Y	Y	0.28
HS02	7.61***	−0.54***	2.03	1.77	0.00	0.06	0.06	Y	Y	0.36
HS04	3.11	−0.21***	4.04	1.00	2.61	0.65	0.01	Y	Y	0.18
HS05	33.08***	0.75***	1.270	2.260	14.64***	35.39***	0.05	Y	Y	0.53
HS06	21.34***	−0.77***	6.60	1.17	0.00	1.36	0.72	Y	Y	0.45
HS07	1.55	−0.10**	8.04	1.57	3.18*	6.03**	2.24	Y	Y	0.14
HS08	6.76****	−0.43***	7.02	1.07	0.22	15.38***	0.20	Y	Y	0.41
HS09	1.64	−0.09**	4.20	1.34	0.09	13.56***	0.01	Y	Y	0.33
HS10	3.20	−0.34***	5.79	1.74	0.64	0.09	0.04	Y	Y	0.31
HS11	3.74*	−0.28***	3.22	1.81	2.21	6.43**	6.453**	Y	N	0.22
HS12	2.75	−0.16**	2.09	0.64	2.21	0.11	0.10	Y	N	0.36
HS13	5.73***	−0.34***	39.79**	0.80	1.98	21.56***	0.00	N	Y	0.16
HS14	7.79***	−0.56***	7.70	0.53	0.34	3.15*	0.88	N	Y	0.50
HS15	6.76***	−0.66***	7.89	1.48	1.39	7.56***	0.00	Y	Y	0.37
HS16	2.18	−0.12**	3.90	0.05	1.17	18.1***	0.53	Y	Y	0.24
HS17	2.66	−0.26***	3.91	1.01	0.00	6.33**	5.37**	Y	N	0.42
HS18	6.24***	−0.46***	3.5*	0.25	3.36*	57.11***	19.34***	Y	Y	0.38
HS20	2.81	−0.24***	1.91	2.07	0.47	20.88***	0.05	Y	Y	0.44
HS21	6.28***	−0.48***	8.72*	1.45	14.75***	3.237*	1.02	Y	Y	0.41
HSTotal	7.15***	−0.42***	3.07	0.41	2.08	0.63	0.00	Y	Y	0.31

***, **, and * indicate the 1%, 5%, and 10% significance levels, respectively. The upper bound critical value of the F-test to reject H0 is 3.77 (10%), 4.35 (5%), 5.61 (1%)

Appendix Table 4: Estimation of short-run coefficient in the ARDL models

Industry	D.lrer		LD.lrer		L2D.lrer		L3D.lrer		L4D.lrer	L5D.lrer		Constant	Observations	R-squared
HS01	−0.33	(0.45)										1.57	170	0.17
HS02	8.46**	(3.67)										−29.48***	174	0.37
HS04	−1.45	(2.04)	2.11	(2.03)	−4.78**	(2.03)	3.35*	(1.89)				−2.00	172	0.18
HS05	−0.40	(18.61)										27.68	171	0.55
HS06	−2.02	(2.14)	−6.10***	(2.18)	−8.84***	(2.15)	−3.34	(2.15)	−5.18**			−28.80***	170	0.49
HS07	3.95**	(1.75)	−1.43	(1.76)	−4.88***	(1.68)						−4.63	173	0.25
HS08	0.59	(2.47)	2.15	(2.50)	4.47*	(2.48)	6.24***	(2.35)				13.49	172	0.46
HS09	−3.42**	(1.59)	−2.00	(1.58)	−1.99	(1.49)						−0.48	173	0.36
HS10	0.32	(0.45)										−3.69	175	0.25
HS11	3.09	(2.58)										14.74*	172	Z0.23
HS12	−0.50	(0.49)										5.84	170	0.40
HS13	2.03	(3.48)										−24.24**	172	0.19
HS14	6.83	(5.33)										0.34	173	0.54
HS15	−0.79	(1.24)										−7.58	170	0.35
HS16	−0.31	(0.41)										2.39	170	0.33
HS17	−14.03**	(6.47)	−5.67	(6.54)	−6.28	(6.35)	−15.92**	(6.14)	−20.28***	−16.75***	(5.93)	28.65	170	0.53
HS18	1.14	(1.90)	1.69	(1.88)	−1.67	(1.91)						−2.10	171	0.48
HS20	0.47	(3.32)	0.82	(3.28)								−0.45	173	0.34
HS21	−2.92	(3.69)	2.50	(3.71)	4.50	(3.46)						−3.10	173	0.48
HStotal	0.31	(0.30)										−7.14	170	0.38

The standard errors for the regression coefficients are in parentheses; ***, **, and * indicate the 1%, 5%, and 10% significance levels, respectively

Appendix Table 5: Estimation of short-run coefficient in the NARDL models (POS estimation)

Industry	D.lrer_p		LD.lrer_p		L2D.lrer_p		L3D.lrer_p		L4D.lrer_p		L5D.lrer_p	
HS01	−5.58	(3.87)	−1.23	(4.04)	5.23	(3.66)	5.71	(3.73)	3.16	(3.41)	10.87***	(3.45)
HS02	3.51***	(1.23)										
HS04	−2.75	(4.15)	0.97	(4.40)								
HS05	−10.47	(33.98)										
HS06	−4.58	(4.47)	−0.53	(4.69)	−9.55**	(4.20)						
HS07	0.31	(0.62)										
HS08	−2.26	(4.88)	0.69	(5.20)	9.48*	(5.42)						
HS09	1.57	(3.15)	−7.90**	(3.27)								
HS10	3.18	(4.65)	−1.02	(4.41)								
HS11	11.51**	(4.67)										
HS12	−0.45	(0.64)										
HS13	2.94	(6.82)	−3.25	(7.07)								
HS14	14.52	(10.41)										
HS15	1.89	(10.50)										
HS16	3.14	(3.68)										
HS17	−0.77	(2.04)										
HS18	1.97***	(0.67)										
HS20	2.94	(5.90)	−12.86**	(6.04)	5.32	(5.69)	−28.32***	(5.64)	8.82	(5.88)		
HS21	−2.76	(7.48)	8.60	(7.12)	7.48	(7.43)						
HSTotal	−0.23	(2.46)										

The standard errors for the regression coefficients are in parentheses; ***, **, and * indicate the 1%, 5%, and 10% significance levels, respectively

Appendix Table 6: Estimation of short-run coefficient in the NARDL models (NEG estimation)

Industry	D.lrer_n		LD.lrer_n		L2D.lrer_n		L3D.lrer_n		L4D.lrer_n	L5D.lrer_n
HS01	0.10	(3.75)	8.48**	(3.74)						
HS02	3.61***	(1.00)								
HS04	0.99	(3.97)	2.72	(3.87)	−9.86***	(3.43)	3.45	(3.41)		
HS05	6.43	(32.47)								
HS06	1.76	(4.26)	−9.13**	(3.94)						
HS07	3.56	(2.81)	−0.70	(2.79)	−8.95***	(2.74)				
HS08	4.18	(4.94)	0.05	(4.72)	−0.32	(4.59)	9.06**	(4.04)		
HS09	−6.46**	(2.95)	3.37	(2.89)	−3.76	(2.52)				
HS10	0.53	(4.37)								
HS11	−0.81	(0.66)								
HS12	−0.37	(0.50)								
HS13	4.21	(6.50)	−3.73	(6.21)						
HS14	−1.41	(9.79)								
HS15	1.56	(10.05)	1.20	(8.86)						
HS16	−1.15	(3.39)								
HS17	−2.91*	(1.72)								
HS18	0.31	(0.45)								
HS20	1.58*	(0.94)								
HS21	−0.73	(7.14)								
HSTotal	0.68	(2.31)	−1.20	(2.01)						

The standard errors for the regression coefficients are in parentheses; ***, **, and * indicate the 1%, 5%, and 10% significance levels, respectively