ISEAS YUSOF ISHAK INSTITUTE

No. 2022 - 7

ECONOMICS WORKING PAPER

Real Exchange Rate and Firm Productivity: The Case of Vietnamese Manufacturing

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December 2022

Abstract

This study investigates the relationship between the real exchange rate and firm productivity. Using the difference-in-differences methodology, a persistent real appreciation in VND has a positive effect on firm productivity in the Vietnamese manufacturing sector. One of the mechanisms that could explain this effect is that real appreciation boosts firm productivity through R&D. Small and medium-sized firms benefit more from real appreciation than large firms.

Keywords: Real Exchange Rate, Firm-Level, Productivity, R&D

JEL Codes: F14, F31, F41

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1. Introduction

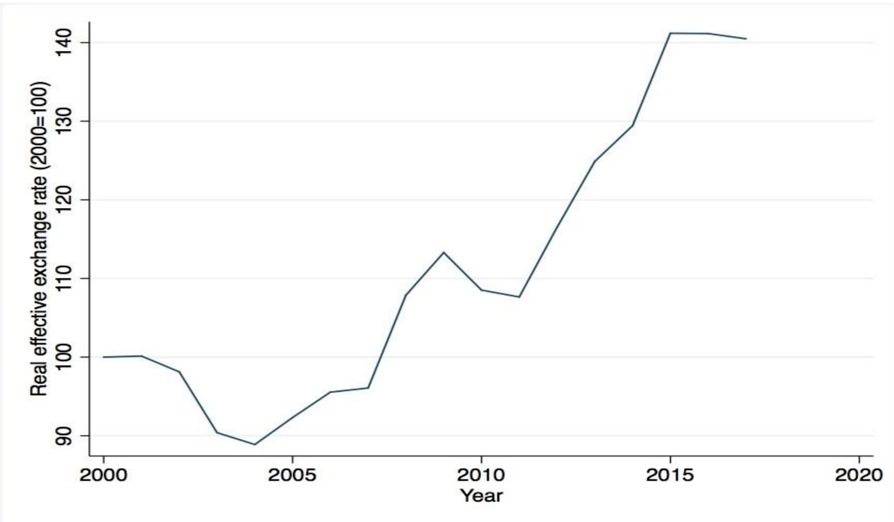
The welfare of a nation depends on many factors of which the aggregate productivity growth is considered to be one of the most important elements. Therefore, throughout history, many scholars have tirelessly tried to discover the essential factors that promote productivity growth. A large literature supports the benefits of free trade policies on productivity growth through firm dynamic (Pavcnik, 2002), or better firms' reallocation of resources (Aghion, Blundell, Griffith, Howitt, and Prantl, 2009; Melitz, 2003). This impact is evidenced in either developed countries (Lileeva and Trefler, 2010; Trefler, 2004) or emerging ones (Amiti and Konings, 2007; Pavcnik, 2002; Topalova and Khandelwal, 2011). Firms can also improve their productivity through the so-called learning-by-exporting mechanism (Atkin, Khandelwal, and Osman, 2017; De Loecker, 2007; Harrison and Rodríguez-Clare, 2010). Some other factors boosting firm productivity are documented such as foreign direct investment (Haskel, Pereira, and Slaughter, 2007; Smarzynska Javorcik, 2004), R&D investment (Aw, Roberts, and Xu, 2011; Bøler, Moxnes, and Ulltveit-Moe, 2015; Doraszelski and Jaumandreu, 2013). Recently, the real exchange rate became a factor of interest in explaining the changes in firm productivity in either developed or developing countries. While other trade-policy instruments such as export subsidies and import tariffs are restricted by WTO membership, real exchange rate policies are not constrained by the WTO (Alfaro, Cuñat, Fadinger, and Liu, 2018).

In this research, our main objective is investigating the impact of the real appreciation in the Vietnamese dong (VND) on productivity using a rich firm-level database in the Vietnamese manufacturing sector. This research covers a long period of 15 years, from 2000 to 2016. As shown in Figure 1, the Vietnamese dong experiences a large and consecutive appreciation from 2004 with an annual growth rate of around 4%, despite a short-run depreciation during the period 2009-2011, which was probably due to the Global financial crisis in 2008. [1] Specifically,

[1] In our research, an increase in the real effective exchange rate (REER) implies an appreciation in VND.

there was a real depreciation of 3% per year before 2004. In this context, we consider 2004 as a milestone in which there was a change in real exchange rate policy. To examine the effect of real appreciation on firm productivity, we decide to use the difference-in-differences methodology, suggested by Trefler (2004). We define the firms' exposure to currency in terms of their trade status instead of net exposure, as in Ekholm, Moxnes, and Ulltveit-Moe (2012). The reason is that the database, unfortunately, does not provide good information on firms' exports and imports in every year. Hence, the treatment group consists of firms having either export or import activities, while the control group includes firms with no external trading activities. We find that a large and persistent real appreciation can significantly increase firm productivity. To check the validity of this effect, we perform various placebo tests: (i) whether there is a common trend in both treatment and control group in the absence of intervention, *i.e.*, before 2004, (ii) whether other policy reforms, such as WTO accession in 2007, or the business conditions such as the world financial crisis in 2008 affect the final results.

Figure 1: Real Effective Exchange Rate Movement (2000=100)



Strongly related to previous studies such as Choi and Pyun (2018); Ekholm et al. (2012), our research contributes to this strand of literature in threefold. Firstly, while previous studies concentrate on upper-middle- or high-income countries, our research, to our best knowledge, is the first one which focuses on a lower-middle-income economy. Secondly, we examine the heterogeneous effect of real appreciation in firm productivity according to their size or ownership status, which has not been documented in literature as yet. Thirdly, we confirm the previous studies in the sense that real appreciation may induce high investment in R&D, hence increasing firm productivity.

This paper is structured as follows. Section 2 reviews literature and the channels through which currency movements can affect firm productivity. In Section 3, we depict our econometric methodology. Section 4 describes the data. After representing the results in Section 5, we discuss further investigation in Section 6. Finally, Section 7 concludes.

2. Literature Review

The question of how RER affects productivity has drawn much more attention in recent years. While extensive studies have investigated the impact of RER on the aggregate level, not many analyses have been based on firm-level data. However, the evidence is far from conclusive. While some studies show a positive (negative) effect of real appreciation (depreciation) on firm productivity (Ekholm et al., 2012; Fung, 2008; Tomlin, 2014), others find an opposite effect (Fung, Baggs, and Beaulieu, 2011; Fung and Liu, 2009) and a mixed impact (Alfaro et al., 2018; Choi and Pyun, 2018). [2]

The direction of the RER impact on productivity might be different, depending on whether firms rely on imported intermediate inputs or they are export-oriented. Using a firm-level database of 76 emerging countries and 23 developed economies, Alfaro et al. (2018) point out the contrast in responses of manufacturing firms to medium-term RER changes between emerging countries in Asia, Latin America, Eastern Europe and industrialised economies. For Asian emerging countries where firms are export-oriented rather than relying much on imported intermediate goods, RER depreciations have, *on average*, a positive effect on firm productivity. It also increases the export entry rate and the probability of R&D. On the contrary, in other emerging countries with heavy dependence on imported intermediate goods, real depreciation slows down TFP and sales growth of manufacturing firms. However, there is no effect of RER depreciation on firms' performance in industrialized countries.

[2] In the case of Taiwanese manufacturing firms, Fung (2008) points out a positive impact of RER appreciation following the 1986 Plaza Accord on firm productivity using the 1986, 1991 and 1996 census data; Fung and Liu (2009) use a more restricted number of firms on the Taiwan Stock Exchange between 1991 and 2001 and find a positive effect of real depreciation on firm productivity.

The different impacts of the RER on productivity could depend on how its movement persists. Using firm-level data of South Korean manufacturing industries, Choi and Pyun (2018) find a considerable productivity gain following an immediate RER depreciation. However, a *persistent* depreciation in currency harms productivity since it decelerates innovation effort and prevents efficient resource allocation in firms. This result supports the previous finding of Ekholm et al. (2012) in the case of Norway. They found that a *sharp* real appreciation of Norwegian Krone could trigger an increase in productivity but also lead to a reduction in employment.

Some studies attempt to figure out the channels through which real appreciation (or depreciation) might affect productivity. Industry-wide, Tomlin (2014) points out the impact of exchange rate movement on the entry and exit decisions of individual plants, leading to a change in productivity. Including plant entry and exit components in a dynamic empirical structural model, he finds that an appreciation can decrease the probability of surviving of lower productivity firms (i,e. less productive firms are more likely to exit the market) and increase the chance for more productive firms to enter the market. Indeed, a currency appreciation induces the falling of aggregate demand for exported goods and then reduces the firm's output and market share. It can, at the same time, increase imported goods, contributing to a decrease in market share. This pressure forces less productive firms to leave the market and sets a higher threshold of productivity and competitiveness for newly entering firms in the new strong currency environment. The reactions of both incumbents and potential entrants will increase average productivity.

The exchange rate movement may also affect the exporting firm's efficiency through its allocation of resources. Several studies suggest that high competition forces firms to eliminate their lowest-performing products and pay close attention to their more competitive ones. In other words, firms go through re-allocative changes in terms of the scope of products. An appreciation, at first, can have less benefits for exporters. But the persistent high competition in foreign markets may increase firm productivity since it boosts the efficient internal reallocation of resources among exporters. On the other hand, according to Choi and Pyun (2018), a negative effect of persistent change in exchange rate depreciation on innovation might lower productivity because it restrains firms from a more effective allocation of resources.

Another channel that should be thoroughly considered is the impact of exchange rate movement on imported input prices. For example, an appreciation might make imported goods less expensive. as a result, lower input costs would increase productivity, especially for firms with higher intermediate input import shares.

There is a large set of literature that is related to this research. One strand of literature exploits the heterogeneous reactions of firms following exchange rate movements. Berman, Martin, and Mayer (2012) investigate the response of exporters in terms of prices, quantities, and firms' dynamics. On average, real depreciation increases both export prices and volumes. Moreover, larger firms can incorporate an exchange rate variation in their markups to offset its impact. Li, Ma, and Xu (2015) also confirm the heterogeneous reaction from Chinese exporters. Berthou and Dhyne (2018) find that in each country and sector, the least productive firms seem to have more intense responses to real exchange rate movements than the most productive firms. Furthermore, different works point out the impact of exchange rate changes on the intensive margin (variation of firms' exports) and the extensive margin (firms' entry and exit).

3. Econometric Strategy

3.1 Model Specification

To investigate the impact of a large and persistent real appreciation in VND on firm productivity, we use the difference-in-differences specification suggested by Trefler (2004). Because the Vietnamese Dong (VND) appreciated consecutively from 2004, we define the years 20002004 as the pre-RER shock period, and the years 2004-2015 as the RER shock period. Using a difference-in-difference methodology, one could be concerned about issues related to the standard error of the estimate. One of the two techniques that help to solve the serial correlation problem is removing the time-series dimension by aggregating the data into two periods: pre and post-intervention (Bertrand, Duflo, and Mullainathan, 2004). Therefore, we consider the outcome as the average annual growth rate of productivity of firm *i* in period *s*, denoted as Δy_{is} where *s* = 1 indexes the RER shock period and *s* = 0 indexes the pre-RER shock period. Δy_{is} is then defined as:

$$\Delta y_{i1} \equiv \left(lnY_{i,2015} - lnY_{i,2004}\right)/(2015 - 2004)$$

(1

$$)\Delta y_{i0} \equiv \left(lnY_{i,20045} - lnY_{i,2000}\right)/(2004 - 2000)$$

Since we are interested in the effect of change in RER shock on firm productivity, we define Δrer_s as average annual change in RER in period *s*, that means:

$$\Delta rer_1 \equiv (lnREER_{2015} - lnREER_{2004})/(2015 - 2004)$$

$$\Delta rer_0 \equiv (lnREER_{2004} - lnREER_{2000})/(2004 - 2000) \tag{2}$$

The linear model that specifies the impact of RER shock on the change in firm outcome is provided as:

$$\Delta y_{is} = \alpha_i + \theta_s + \beta D_{i0} \Delta rer_s + \epsilon_{is} \tag{3}$$

where α_i is fixed effect at firm level, θ_s is a period-specific effect. To estimate consistently the coefficient β, we differentiate Equation 3 and obtain the baseline difference-in-differences (DD) specification:

$$\Delta y_{i1} - \Delta y_{i0} = \theta + \gamma D_{i0}^{trade} (\Delta rer_1 - \Delta rer_0) + v_i \tag{4}$$

where $\theta \equiv \theta_1 - \theta_0$, D_{i0}^{trade} is an indicator that equals 1 if firm *i* trades in base year 2000. The firm-fixed effect α_i is ruled out in the equation. The coefficient of interest, β, indicates the effect of RER movement on the change in firm productivity. It is natural that one could use a period dummy, that equals 1 in RER-shock period and 0 otherwise, to distinguish the pre- and postintervention, as in the standard difference-in-differences approach. The use of $(\Delta rer_1 - \Delta rer_0)$, however, stresses the effect of the change in RER shock on firm outcome. Thus, γ reflects the difference in change in average productivity growth between trade and non-trade firms following a certain degree of RER shock. A positive sign of the coefficient implies a positive effect of real appreciation on firm productivity. Following Trefler (2004) and Ekholm et al. (2012), we introduce a vector of firm level control, x_{i0}, from the base year 2000. The control variables include number of employees, capital (in logs) and the Herfindahl index which represents the market power of industry *j*. We also control for industry fixed effects, η_j, in regression results. Our difference-in-differences model become then:

$$\Delta y_{i1} - \Delta y_{i0} = \theta + \gamma D_{i0}^{trade} (\Delta rer_1 - \Delta rer_0) + \phi x_{i0} + \eta_j + v_i \tag{5}$$

3.2 Production Function Estimation

The primary outcome of this research is related to the firms' productivity. One of the most widely used techniques to estimate the production function is the "proxy variable" approach pioneered by Olley and Pakes (1996) and then augmented by Levinsohn and Petrin (2003) (hereafter OP, LP). The common feature of these two approaches is that the unobserved productivity shock can be controlled for by conditioning on a non-parametric representation of an inverse demand function. While OP use the inverse investment demand function, LP invert the intermediate input function to control for unobserved productivity shock. In both approaches, the inverted demand functions are unconditional on the labour input, which is criticized by Ackerberg, Caves, and Frazer (2015). The authors, augmenting the OP and LP methodologies, use the conditional demand function to produce consistent estimates in more general cases [3]. On the identification of production function, one could rely on three alternative technologies: gross output, restricted profit value-added, and structural value-added production functions, that depends on how intermediate inputs are introduced in the model Gandhi, Navarro, and Rivers (2018). [4] Since the ACF methodology doesn't specify the gross output production functions, we use the structural value-added production function in the main analysis. [5] This approach relies on the assumptions that intermediate inputs are perfect complements to the combination of labour and capital (*i.e.*, Leontief). So, the production function for each industry is specified as follows:

$$z_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \omega_{it} + \epsilon_{it} \tag{6}$$

where z_{it} is firm sales, l_{it}, k_{it} denote labour, capital, ω_{it} is productivity. All variables are taken in natural logarithm.

We start with the insight of Levinsohn and Petrin (2003) by relying on intermediate input demand to proxy for productivity:

$$m_{it} = m_t(k_{it}, \omega_{it}) \tag{7}$$

where m_{it} is intermediate input. The firm's intermediate input demand must be strictly increasing in productivity ω_{it} for all relevant k_{it} in order to be considered as an applicable proxy. Conditional on capital, more productive firms while trying to maximize profit will use more

[3] This approach allows unobserved, autocorrelated, firm-specific shocks to the price of labour; firm chooses other variable inputs after labour; dynamic labour; unobserved firm-specific adjustment costs of labour.

[4] The intermediate inputs are introduced in the gross output production function, while removed from the profit value-added specification. The structural value-added technology is the gross output production function that is Leontief in the intermediate inputs.

[5] The profit value-added are used for robustness check. In this case, z_{it} indicates firm value-added.

intermediate input. Note that the input demand function under LP approach is unconditional on l_{it}. However, it is natural that m_{it} can be chosen after l_{it}. Based on this insight, to control for unobserved productivity, one can use an input demand function conditional on l_{it} by introducing l_{it} in the right-hand side of Equation 7 (Ackerberg et al., 2015). In the case that m_{it} and l_{it} are chosen at the same time, this conditional input demand function can also qualify as in LPs less conditional input demand function. [6] Besides, we can use further variables which possibly influence the differences in input demand choices of firms as suggested by De Loecker and Warzynski (2012). The inclusion of these variables depends on the application but will certainly catch the variables resulting in differences in optimal input demand across firms. In our research, we include export dummies, which influence a firm's residual demand and therefore determine the firms optimal input demand. The intermediate input demand becomes:

$$m_{it} = m_t(k_{it}, l_{it}, \omega_{it}, e_{it}) \tag{8}$$

where e_{it} is export dummy, which equals to 1 if firm *i* exports in time t and 0 otherwise.

Since the input demand function is monotonic in ω_{it}, we can invert function 8 to proxy for productivity [7], *i.e.*,

$$\omega_{it} = m_t^{-1}(m_{it}, k_{it}, l_{it}, e_{it}) = h_t(m_{it}, k_{it}, l_{it}, e_{it}) \tag{9}$$

The production function becomes:

$$\begin{aligned} z_{it} &= \beta_0 + \beta_l l_{it} + \beta_k k_{it} + h_t(m_{it}, k_{it}, l_{it}, e_{it}) + \epsilon_{it} \\ &= \phi_t(l_{it}, k_{it}, m_{it}, e_{it}) + \epsilon_{it} \end{aligned} \tag{10}$$

Then, we use the two-step approach proposed by Ackerberg et al. (2015) to estimate the consistent parameters of production function. The conditional input demand function distinguishes this approach from that of LP. Instead of identifying the coefficient of labour input in the first stage, we will estimate all coefficients in the second stage. In the first stage, we estimate the model:

$$z_{it} = \phi_t(l_{it}, k_{it}, m_{it}, e_{it}) + \epsilon_{it} \tag{11}$$

where $\phi_t(l_{it}, k_{it}, m_{it}, e_{it})$ can be approximated by a polynomial of l_{it}, k_{it}, m_{it}. We then obtain estimates of expected output, $\hat{\phi}_t$, and the residuals $\hat{\epsilon}_t$.

[6] We assume that the input and output prices are the same across firms.

[7] LP's approach allows us to introduce additional variables without revisiting whether the invertibility is preserved, see De Loecker (2011).

In the second stage, we rely on the law of motion of productivity, that means the AR(1) process, to get consistent coefficients. The function of productivity is then:

$$\omega_{it} = g_t(\omega_{it-1}) + \xi_t \tag{12}$$

From the first stage, with each value of β, where $\beta = (\beta_0, \beta_l, \beta_k)$, we can calculate the productivity:

$$\omega_{it}(\beta) = \hat{\phi}_t - \beta_0 - \beta_l l_{it} - \beta_k k_{it} \tag{13}$$

By applying a nonparametrical regression of $\omega_{it}(\beta)$ on its lags, $\omega_{it-1}(\beta)$, we obtain the estimates of idiosyncratic shock to productivity given β, $\hat{\xi}_{it}(\beta)$. For labour to have dynamic implications, firms can choose l_{it} at period t, or $t-1$ or at some point in-between. Therefore, to obtain estimates of production function, we base on the moment conditions as follows:

$$E\left(\hat{\xi}_{it}(\beta)\begin{pmatrix}1\\ l_{it-1}\\ l_{it}\\ k_{it}\end{pmatrix}\right) = 0 \tag{14}$$

For the estimation of the production function, we apply standard GMM techniques, and for the standard errors, we use on block bootstrapping. In this specification of production function, the output elasticity of labour, θ_{it}^{L}, is simply $\hat{\beta}_l$.

4. Data

4.1 Source

At the micro-level, we rely on a comprehensive dataset covering all registered firms in Vietnamese manufacturing over the period 2000-2015. The data are taken from the Vietnamese Enterprise Survey and collected annually by the General Statistics Office of Vietnam (GSO). The unit of observation in the survey is an establishment (or a plant). In this research, we choose to refer to this unit of observation as a firm. For the data cleaning process, we consider only firms with a number of employees not less than 10 and drop out re-entry firms. So, we obtained the dataset with information on more than 5000 firms, and it is an unbalanced panel, *i.e.*, we also observe the information on firms' dynamics (entry and exit). Since the difference-in-differences methodology is based on firms operating in three years, 2000, 2004, and 2015, the sample is restricted in about 900 continuing firms. [8] We can extract from the data relevant firm-level information, including firms' sales, number of employees, wages, capital, and other variables.[9] All monetary variables are deflated by the producer price index of two-digit industrial products.[10] Moreover, the dataset provides information on the ownership of a firm and on its trade status. This information is crucial in the context of an emerging Asian country that uses exports to boost economic growth, such as Vietnam. Unfortunately, the firms' export and import status are not recorded in some years. Therefore, defining trading firms is based on other information such as firm export/ import tax incurred in the operating years. Even so, the firm trade status is well defined in a limited number of years (2000, 2002-2004, 2010-2015). However, this does not have much influence on this research since the econometric methodology relies on the information on trade status in just 2000, 2004, and 2015.

For macro-level data, we use the data on the VND real effective exchange rate (REER) from Bruegel. The dataset provides the annual and monthly consumer price index (CPI)-based REER of VND with 172 trading partners from 1992. Moreover, we consider the change in the most-favoured-nation (MFN) tariff rate at a two-digit industry-level as a proxy for the effect of trade liberalization. This data is collected from the World Integrate Trade Solution (WITS) developed by the World Bank and available in 2001-2015. [11]

4.2 Descriptive Statistics

Table 1 provides the price elasticities of input for manufacturing industries at the two-digit level. It is obvious that the price elasticities of labour are higher than that of capital, and this indicates that Vietnamese manufacturing industries are mainly labour-intensive. In term of productivity, the firm-level productivity is calculated as: [12]

$$tfp_{it} = y_{it} - \hat{\beta}_l l_{it} - \hat{\beta}_k k_{it} \tag{15}$$

[8] We use the unbalanced panel instead to estimate the production function.

[9] Since we cannot observe intermediate inputs, we calculate it as: Intermediate input$_{it}$ = Sales$_{it}$ − Wages$_{it}$ −Depreciation$_{it}$ − Pre-tax Profit$_{it}$

[10] Throughout the period studied, there are two different industrial classification, the Vietnam Standard Industrial Classification (VSIC) 1993 and that 2007. We choose VSIC 1993 as classification and convert VSIC 2007 to that 1993.

[11] The data in 2011 is interpolated by using that in 2010 and 2012.

[12] All variables are taken in log.

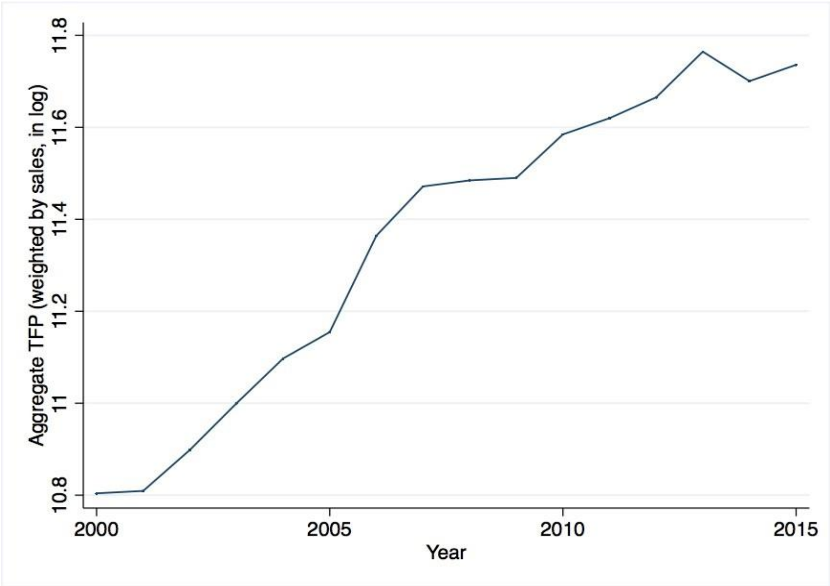
The aggregate productivity is computed as the sales-weighted average of firm productivity tfp_{it}. Figure 2 shows the evolution of aggregate TFP overtime. When considering all firms in the manufacturing sector, the (weighted) aggregate TFP increases significantly, with an annual growth rate of 6% approximately (Figure 2). Interestingly, dividing the sample into two groups of firms according to their trade status D_i^{trade}, the patterns of TFP evolutions between the treatment ($D_i^{trade} = 1$) and control ($D_i^{trade} = 0$) groups seem to be different after the RER-shock in 2004 (Figure 2b). However, in the absence of real appreciation shock (i.e, before 2004), these two groups share the same pattern of TFP evolution. This figure supports the crucial assumption of parallel trends for difference-in-differences approach. [13] That means, the difference-in-differences estimator is consistent only when the outcome treatment and control group have similar evolution in the absence of intervention (in this case, the real appreciation shock in VND).

Table 1: Industry Output Elasticities of Inputs

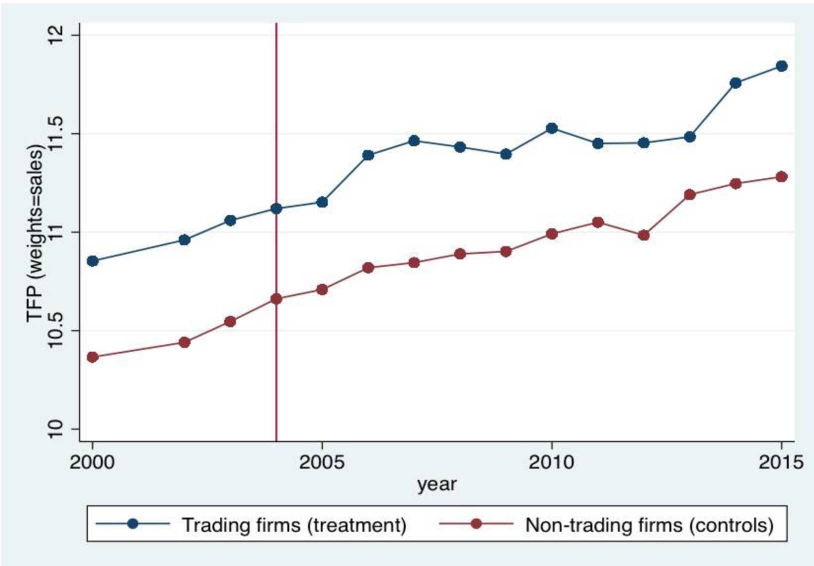
VSIC 1993	Industry name	L	K	RS
15	Food products and beverage	0.865	0.345	1.210
16	Tobacco products	0.736	0.291	1.026
17	Textiles	0.592	0.366	0.958
18	Wearing products	0.720	0.172	0.892
19	Leather products	0.639	0.210	0.849
20	Wood and cork manufacturing	0.786	0.311	1.097
21	Paper products	0.829	0.198	1.027
22	Publishing, printing, recording media	0.788	0.207	0.996
23	Manufacture of coke, refined petroleum products and nuclear fuel	0.605	0.475	1.080
24	Chemical manufacturing	0.877	0.268	1.145
25	Rubber and plastics products	0.773	0.237	1.010
26	Other non-metallic mineral products	0.825	0.334	1.159
27	Basic metals manufacturing	0.828	0.271	1.099
28	Fabricated metal products, except machinery and equipment	0.807	0.232	1.038
29	Machinery and equipment	0.849	0.165	1.014
30	Office, accounting and computing machinery	0.775	0.185	0.960
31	Electrical machinery and apparatus	0.731	0.249	0.980
32	Radio, television and communication equipment	0.760	0.309	1.069
33	Medical, precision and optical instruments, watches and clocks	0.767	0.203	0.970
34	Motor vehicles, trailers and semi-trailers	0.869	0.279	1.148
35	Other transport equipment	0.892	0.225	1.117
36	Furniture	0.789	0.203	0.992

[13] In the Figure 2b, we drop out the year 2001 due to no information on import status. Nevertheless, as mentioned above, it does not impact on the difference-in-differences estimators. For further check on the parallel trends assumptions, we perform the placebo test later.

Figure 2: Aggregate Productivity Evolution



(a) Aggregate TFP (weighted by sales)



(b) Aggregate TFP (weighted by sales) by trade status

Table 2: Productivity Decomposition

t_1	t_2	Survivors	Entrants	Exiters	TFP growth
2000	2004	0.289	−0.0015	0.0059	0.293
Number of firms		2 154	7 076	3 091	
2004	2015	0.670	−0.107	0.076	0.639
Number of firms		2 705	20 884	6 525	

Since we could observe the entry and exit firms through the data, it is worth investigating the contribution of firm dynamics to the aggregate productivity growth to get a better understanding of the sector's reaction in terms of the intensive and extensive margin in response to the real appreciation. To do so, we follow the methodology of productivity decomposition suggested by Melitz and Polanec (2015). [14] The results are recorded in Table 2. Although the number of entrants is large, the aggregate productivity growth is contributed mostly by continuing firms. In this line, as in the study of Ekholm et al. (2012), we restrict this main research to firms that survive throughout the period 2000-2015. However, we will discuss more on firm dynamics in Section 5.

5. Results

Table 3 represents the estimation results of model 5. The coefficient of interest, γ, is statistically significant in all cases (including or not firm and industry controls). Therefore, there is evidence that real appreciation policy affects firm productivity growth. Moreover, the positive sign of coefficient γ implies that the "large and persistent" real appreciation increases the productivity growth of manufacturing firms. These results coincide with previous studies of Ekholm et al. (2012) and Choi and Pyun (2018).

The difference-in-differences methodology is performed under the assumption of parallel trends, that means, firms in the treatment group ($D_i^{trade} = 1$) and the control group ($D_i^{trade} = 0$) share the same pattern of outcome (productivity growth) in the absence of RER shock, *i.e.*, before 2004. In other words, the difference-in-differences estimator is consistent only if this assumption holds. Therefore, it is necessary to conduct some falsification tests to examine the consistency of coefficient γ.

Table 3: RER Shock on Firm Productivity

Variables	Dependent variable: Change in productivity growth			
	(1)	(2)	(3)	(4)
$D_{i0}^{trade}(\Delta rer_1 - \Delta rer_0)$	0.721***	0.929***	0.920***	1.190***
	(0.206)	(0.235)	(0.236)	(0.267)
l_{i0}		0.026***	0.025***	0.027***
		(0.007)	(0.007)	(0.008)
k_{i0}		−0.024***	−0.023***	−0.025***
		(0.005)	(0.005)	(0.006)
H_{j0}			−0.074	−14.420***
			(0.175)	(4.063)
Constant	−0.058***	0.223***	0.222***	0.497***
	(0.012)	(0.072)	(0.072)	(0.110)
Observations	892	892	892	892
R-squared	0.014	0.039	0.039	0.067
Industry fixed effect	No	No	No	Yes

Note: Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Firstly, one could be concerned that the increase in productivity growth might occur before the RER shock. To deal with this problem, we consider the period before 2004, such as 20002004, and 2002 as a "placebo" year of currency policy, then we re-estimate Equation 5. If the coefficient of interest is statistically significant in this case, the real appreciation policy is not a reason to boost firm productivity, the estimator in Table 3 become inconsistent. As shown in Table 4, since the coefficient in this placebo test is statistically insignificant, the effect of currency shock on firm productivity growth is valid.

Secondly, another issue in this research is that the increase in firm-level productivity growth might be due to another policy, not to the real appreciation one since various economic events occur during the 2000s, such as WTO accession in 2007 and the global financial crisis in 2008 (We will discuss more about controlling these events later). To deal with this problem, we choose another similar period which does not cover the events, *i.e.*, 2010-2015, and considered 2011 as the year of intervention. Indeed, as shown in Figure 1, VND slightly depreciated two years before 2011 and turned to appreciate again from 2011. We also observe a similar TFP pattern for the treatment and control groups during 2010-2011, the TFP evolution diverged after 2011 (Figure 2b). Because of the similar periods, the difference-in-differences estimator is expected to be the same as in Table 3. Obviously, according to Table 5, the positive and statistical significance of the coefficient γ support the main finding.

The third way to examine the methodological consistency is by choosing another group of firms that might be influenced by the RER shock. If real appreciation increases firm productivity in the new treatment group, the estimator is consistent. To do so, we replace the trade status dummy by an export and import one at the base year 2000. The results are recorded in Table 6. By distinguishing firms, according to their export and import status, we obtain positive and statistically significant difference-in-differences estimators, that means, the positive effect of real appreciation on firm productivity is confirmed.

Table 4: RER Shock on Firm Productivity in pre-RER Shock Period

Variables	Dependent variable: Change in productivity growth			
	(1)	(2)	(3)	(4)
$D_{i0}^{trade}\,(\Delta rer_1 - \Delta rer_0)$	0.899	1.299	1.331	2.988
	(1.671)	(1.990)	(1.995)	(2.129)
l_{i0}		0.031**	0.032**	0.042***
		(0.014)	(0.014)	(0.016)
k_{i0}		−0.027***	−0.028***	−0.034***
		(0.010)	(0.010)	(0.011)
H_{j0}			0.088	−12.250
			(0.356)	(7.689)
Constant	0.005	0.319**	0.319**	0.656***
	(0.020)	(0.132)	(0.132)	(0.211)
Observations	2,152	2,152	2,152	2,152
R-squared	0.000	0.004	0.004	0.027
Industry fixed effect	No	No	No	Yes

Note: In this case, we consider the period 2000-2004, the base year is 2004, the treatment is assumed to be occured in 2002. Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

For a further robustness check, we also use alternative production function specification to estimate the change in firm productivity growth. Besides the gross output production function that is Leontief in intermediate inputs, Ackerberg et al. (2015)'s methodology could be applied to the profit value-added specification, which rules out intermediate inputs. According to Table 7, the positive effect of real appreciation on firm productivity growth is consistent.

If this paper aims to explore the effect of the real exchange rate on firm productivity, it is, however, worth discussing further the mechanism of this effect. Some recent studies show that R&D might be the channel through which the real exchange rate affects firm productivity (Alfaro et al., 2018; Choi and Pyun, 2018). In Table 8, we point out the evolution of R&D growth rate and the share of the R&D expenditure in some critical years. In the pre-RER shock, R&D expenditures declined sharply with the average annual growth rate of -12%, but then increased with a rate of 2.71%. This pattern is also recorded for the share of R&D expenditure. Moreover, together with real appreciation after 2004, the share of R&D expenditure increases considerably from 0.16% in 2004 to 10.55% in 2011. Although the dataset does not allow an investigation of the transmission mechanism in a more structural way, the similar change in R&D expenditure and VND currency after 2004 implicitly reflects the fact that real appreciation might boost firm productivity through R&D.

Table 5: RER Shock on Firm Productivity in RER Shock Period

Variables	Dependent variable: Change in productivity growth			
	(1)	(2)	(3)	(4)
$D_{i0}^{trade}(\Delta rer_1 - \Delta rer_0)$	0.838***	0.782***	0.789***	0.882***
	(0.182)	(0.219)	(0.219)	(0.228)
l_{i0}		0.017**	0.017**	0.023***
		(0.007)	(0.007)	(0.008)
k_{i0}		−0.011**	−0.010**	−0.012**
		(0.005)	(0.005)	(0.005)
H_{j0}			−0.165	−15.382**
			(0.158)	(7.601)
Constant	−0.146***	−0.036	−0.038	0.111
	(0.009)	(0.069)	(0.069)	(0.096)
Observations	8,424	8,424	8,424	8,424
R-squared	0.003	0.003	0.003	0.011
Industry fixed effect	No	No	No	Yes

Note: In this case, we consider the period 2010-2015, the base year is 2010, the treatment is assumed to be occured in 2011. Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Table 6: RER Shock on Firm Productivity with Export/ Import Status

Variables	Dependent variable: Change in productivity growth							
	Export status				Import status			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$D_{i0}^{export}(\Delta rer_1 - \Delta rer_0)$	0.919***	1.047***	1.045***	1.261***				
	(0.200)	(0.226)	(0.228)	(0.258)				
$D_{i0}^{import}(\Delta rer_1 - \Delta rer_0)$					0.303	0.578**	0.582**	0.865***
					(0.203)	(0.237)	(0.237)	(0.258)
l_{i0}		0.022***	0.022***	0.025***		0.030***	0.029***	0.031***
		(0.007)	(0.007)	(0.008)		(0.007)	(0.007)	(0.008)
k_{i0}		−0.022***	−0.022***	−0.024***		−0.024***	−0.023***	−0.025***
		(0.005)	(0.005)	(0.005)		(0.005)	(0.005)	(0.006)
H_{j0}			−0.014	−14.693***			−0.144	−13.407***
					(0.203)	(0.237)	(0.237)	(0.258)
Constant	−0.062***	0.213***	0.213***	0.488***	−0.036***	0.219***	0.219***	0.490***
	(0.010)	(0.070)	(0.070)	(0.108)	(0.010)	(0.076)	(0.076)	(0.114)
Observations	892	892	892	892	892	892	892	892
R-squared	0.023	0.045	0.045	0.071	0.003	0.028	0.029	0.057
Industry fixed effect	No	No	Yes	Yes	No	No	No	Yes

Note: Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Table 7: RER shock on firm productivity. Alternative production function estimation.

Variables	Dependent variable: Change in productivity growth			
	(1)	(2)	(3)	(4)
$D_{i0}^{trade}\,(\Delta rer_1 - \Delta rer_0)$	0.680***	0.674***	0.671***	0.796***
	(0.222)	(0.253)	(0.254)	(0.289)
l_{i0}		0.038***	0.037***	0.042***
		(0.008)	(0.008)	(0.009)
k_{i0}		−0.023***	−0.023***	−0.025***
		(0.005)	(0.006)	(0.006)
H_{j0}			−0.019	−9.671**
			(0.188)	(4.390)
Constant	−0.030**	0.193**	0.193**	0.365***
	(0.012)	(0.077)	(0.077)	(0.119)
Observations	892	892	892	892
R-squared	0.010	0.040	0.040	0.063
Industry fixed effect	No	No	No	Yes

Note: Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

6. Discussion

6.1 Selection

The econometric strategy is applied for firms that operated throughout the period 20002015. So those who entered and exited during the sample period are dropped. Although continuing firms contribute mostly to aggregate productivity growth, they may respond differently to shock than those exiting. This could potentially bias the results. To deal with this problem, we use the two-step Heckman (1979) procedure for sample selection bias. We re-run Equation 5 with the Heckman selection equation, where the dependent variable is dummy S_i taking the value 1 if firms are present from the beginning to the end of the sample. S_i equals to 0 if firms were present in 2000 but exited before 2015. Independent variables of the selection equation are firms' labour and capital (in log) at the base year 2000.

Table 8: R&D Expenditure in Vietnamese Manufacturing

(a) R&D expenditure annual growth before and after RER shock in 2004

	Pre-RER shock *2000-2004*	RER shock *2004-2011*
Annual growth rate	-12%	2.71%

Source: GSO and authors' calculations.

(b) Share of R&D expenditures (in percentage)

	Year		
	2000	2004	2011
Share of R&D expenditures	1.93	0.16	10.55

Source: GSO and authors' calculations.

Table 9: Selection Bias

Variables	Dependent variable: Change in productivity growth (1)	(2)	(3)	(4)
$D_{i0}^{trade}\,(\Delta rer_1 - \Delta rer_0)$	0.893**	0.929**	0.920**	1.190***
	(0.409)	(0.391)	(0.379)	(0.420)
l_{i0}		0.026***	0.025***	0.027***
		(0.006)	(0.006)	(0.007)
k_{i0}		−0.024***	−0.023***	−0.025***
		(0.007)	(0.006)	(0.007)
H_{j0}			−0.074	−14.420***
			(0.198)	(1.022)
Constant	−0.106**	0.218**	0.217**	0.498***
	(0.050)	(0.111)	(0.110)	(0.121)
ρ	0.143	0.006	0.005	−0.001
	(0.215)	(0.326)	(0.317)	(0.311)
Observations	5,209	5,209	5,209	5,209
Industry fixed-effect	No	No	No	Yes

Note: Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

The Heckman procedure provides the test on whether ρ (correlation between the errors in main equation and selection one) equals to 0. That means, if the null hypothesis that $\rho = 0$ is rejected, the simple OLS for Equation 5 may face the selection bias, and it is necessary to account for the Heckman procedure. As shown in Table 9, the DID estimators are still statistically significant and positive, confirming the positive impact of RER shock on firm productivity. Moreover, the null hypothesis that $\rho = 0$ is not rejected in all cases (with or without firm and industry controls), so the selection bias is not a problem, and the simple OLS approach is appropriate to estimate Equation 5.

6.2 WTO Accession and Business Condition Controls

One issue for examining the effect of the RER shock during 2000-2015 is that this period covered the WTO accession of Vietnam in 2007. Since several studies support the positive effect of trade liberalization on firm productivity, one could be concerned about the endogeneity that may bias the estimation. In fact, an extensive literature supports the positive impact of trade liberalization on firms' productivity. To address this problem, we control for industry-specific shocks by introducing industry j 's average tariff changes in pre- and post-RER shock period, δT_{js}, more precisely:

$$\Delta T_{j1} \equiv \left(Tariff_{j2015} - Tariff_{j2004}\right)/(2015 - 2004) \qquad (16)$$

$$\Delta T_{j0} \equiv \left(Tariff_{j2004} - Tariff_{j2000}\right)/(2004 - 2000)$$

We also examine the effect of the RER shock on firms' outcomes in a similar period after WTO accession of Vietnam for robustness checks. To do so, we choose the period 2010-2015, where the currency slightly depreciates during 2009-2011 and then sharply appreciate from 2011.[14]

Another event that occurs in the period studied is the global financial crisis (GLC) in 2008. To account for the GLC, we follow Trefler (2004) by including a regressor Δb_{js}that captures how movements in GDP affect industry j. For each industry j, we regress industry productivity growth Δtfp_{jt} on the GDP growth Δgdp_{jt} , where $\Delta tfp_{jt} = tfp_{jt} - tfp_{jt-1}, \Delta gdp_{jt} = gdp_{jt} - gdp_{jt-1}$. This is a time-series regression, and we then obtain the prediction $\Delta \widehat{tfp}_{jt}$ for each industry j. This represents the effect of business conditions on industry productivity growth.

Adding ΔT_{js} and Δb_{js} into Equation 3 yields:

$$\Delta y_{is} = \alpha_i + \theta_s + \beta D_{i0} \Delta rer_s + \gamma_1 \Delta T_{js} + \gamma_2 \Delta b_{js} + \epsilon_{is} \qquad (17)$$

[14] We choose 2010 as base year instead of 2009 because firms' export status is well defined in 2010. In this case, the base year is 2010.

Differencing Equation 17 and including control variables at base year, we obtain the difference-in-differences specification as follow:

$$\Delta y_{i1} - \Delta y_{i0} = \theta + \gamma D_{i0}^{trade}(\Delta rer_1 - \Delta rer_0) + \gamma_1(\Delta T_{j1} - \Delta T_{j0}) + \gamma_2(\Delta b_{j1} - \Delta b_{j0}) + \phi x_{i0} + \eta_j + v_i \quad (18)$$

Table 10 records the estimation results of model 18. By according for the WTO accession of Vietnam and the GFC, DD coefficient, γ, is still positive and statistically significant. That confirms the finding that a persistent real appreciation increases firms' productivity.

6.3 Heterogeneous Treatment Effect

In order to figure out the heterogeneous effect of real appreciation on firms according to their size, we introduce in model 5 the dummy variable L_{i0}, which equals 1 for large firms at base year, 0 otherwise. To differentiate firms according to their size, we follow the classification criteria in the Vietnamese regulation[15] by defining the large firms as ones with a number of employees higher than 200 *or* total sales of more than 200 billion dong. We then obtain the triple-differences model as follows:

$$\Delta y_{i1} - \Delta y_{i0} = \theta + \delta_0 D_{i0}^{trade}(\Delta rer_1 - \Delta rer_0) + \delta_1 D_{i0}^{trade} L_{i0}(\Delta rer_1 - \Delta rer_0) + \phi x_{i0} + v_i \quad (19)$$

The coefficient of interest, γ_1, refers to the difference in the impact of RER shock on large firms and SMEs in the treatment group. The same methodology is applied to investigate the heterogeneous treatment effect on firm productivity according to their ownership status (state-owned enterprise (SOE) or non-SOE; foreign direct investment (FDI) firms or non-FDI firms).[16] Tables 11 to 13 show the change in different groups of firms' productivity growth (weighted by sales) before and after the currency treatment in 2004. Recall that we consider continuing firms throughout the period 2000-2015, only this group of firms has information in three years 2000, 2004, and 2015. There are some points from these tables: (i) the currency-exposed firms (treatment group) experience a faster annual productivity growth in the RER shock period (after 2004) than in the pre-RER shock period, represented by the fact that $\Delta y_{i1} > \Delta y_{i0}$; (ii) within the trading firms, small and medium firms have a larger change in annual

[15] The Decree No. 39/2018/ND-CP provided in 11/03/2018 by the Vietnamese government.

[16] We rely on firm size and status at the base year to differentiate firms into different groups.

productivity growth before and after the real appreciation in VND than large firms, the change in annual productivity growth in SOEs (or FDI firms) is less remarkable than non-SOEs (or non-FDI firms, respectively).

Table 14 represents the heterogeneous treatment effect in regressing Equation 19. Unfortunately, there is no evidence on the heterogeneous effect of real appreciation on firms according to their ownership status. Meanwhile, the positive impact of a sharp and persistent RER shock on productivity seems to be higher for SMEs than for large firms, although the coefficient δ_1 is less significant.

Table 10: Control for the WTO accession of Vietnam and the Global Financial Crisis

Variables	Dependent variable: Change in productivity growth					
	(1)	(2)	(3)	(4)	(5)	(6)
$D_{i0}^{trade}(\Delta rer_1 - \Delta rer_0)$	0.918***	1.190***	0.900***	1.190***	0.904***	1.190***
	(0.236)	(0.267)	(0.238)	(0.267)	(0.238)	(0.267)
l_{i0}	0.024***	0.027***	0.026***	0.027***	0.024***	0.027***
	(0.007)	(0.008)	(0.007)	(0.008)	(0.007)	(0.008)
k_{i0}	−0.023***	−0.025***	−0.023***	−0.025***	−0.023***	−0.025***
	(0.005)	(0.006)	(0.005)	(0.006)	(0.005)	(0.006)
H_{j0}	0.059	−0.430	−0.060	−1.040	0.062	4.178*
	(0.195)	(0.644)	(0.176)	(0.653)	(0.195)	(2.410)
$(\Delta T_{j1} - \Delta T_{j0})$	−0.016	−0.123***			−0.015	−1.050*
	(0.010)	(0.036)			(0.011)	(0.600)
$(\Delta b_{j1} - \Delta b_{j0})$			−0.031	−0.402***	−0.021	3.036
			(0.044)	(0.117)	(0.044)	(1.921)
Constant	0.202***	0.100	0.218***	0.260***	0.200***	−1.108
	(0.073)	(0.083)	(0.072)	(0.076)	(0.073)	(0.770)
Observations	892	892	892	892	892	892
R-squared	0.041	0.067	0.039	0.067	0.042	0.067
Industry fixed effect	No	Yes	No	Yes	No	Yes

Note: Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Table 11: Productivity Growth (in percentage) and Firm Size

Exposed	Size	Number of firms	Δy_{i0}	Δy_{i1}	$\Delta y_{i1} - \Delta y_{i0}$
No	Small and medium	270	0.542	4.011	3.469
No	Large	75	8.902	3.856	−5.046
Yes	Small and medium	231	−2.727	3.269	5.996
Yes	Large	316	3.447	4.498	1.052

Source: GSO and authors' calculations.

Table 12: Productivity Growth (in percentage) and State-Owned Enterprise

Exposed	SOE	Number of firms	Δy_{i0}	Δy_{i1}	$\Delta y_{i1} - \Delta y_{i0}$
No	No	229	2.235	4.248	1.853
No	Yes	116	8.261	3.761	−4.500
Yes	No	433	−2.483	4.351	1.867
Yes	Yes	114	3.026	4.323	1.297

Source: GSO and authors' calculations.

Table 13: Productivity Growth (in percentage) and Foreign-Owned Enterprise

Exposed	FDI	Number of firms	Δy_{i0}	Δy_{i1}	$\Delta y_{i1} - \Delta y_{i0}$
No	No	337	5.704	3.842	−1.862
No	Yes	8	2.943	5.346	−2.408
Yes	No	312	1.433	4.350	2.917
Yes	Yes	235	3.637	4.335	0.698

Source: GSO and authors' calculations.

Table 14: Productivity Growth (in percentage) and Foreign-Owned Enterprise

Variables	Dependent variable: Change in productivity growth		
	Size	SOE	FDI
	(1)	(2)	(3)
$D_{i0}^{trade} L_{i0} \, (\Delta rer_1 - \Delta rer_0)$	−0.661*		
	(0.347)		
$D_{i0}^{trade} soe_{i0} \, (\Delta rer_1 - \Delta rer_0)$		−0.440	
		(0.346)	
$D_{i0}^{trade} fdi_{i0} \, (\Delta rer_1 - \Delta rer_0)$			−0.078
			(0.295)
$D_{i0}^{trade} \, (\Delta rer_1 - \Delta rer_0)$	1.410***	1.268***	1.215***
	(0.291)	(0.274)	(0.284)
Constant	0.477***	0.518***	0.486***
	(0.110)	(0.111)	(0.118)
Observations	892	892	892
R-squared	0.070	0.068	0.067
Firm controls	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes

Note: Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

7. Conclusion

This research investigates the impact of real exchange rate on firms' productivity, especially in the long-run. With regard to the long and sharp movement of the real exchange rate in the Vietnamese dong after 2004, we use the difference-in-differences approach and find the positive effect of real appreciation on firm productivity. Even accounting for the WTO accession in 2007 and the financial crisis in 2008, the results are still robust. Moreover, we find that the impact of real appreciation is different between large firms and SMEs: the effect is greater for small and medium firms than for large ones. There is, however, no heterogeneous effect on firm productivity in terms of their ownerships. Although this research mainly figures out the effect of real appreciation on firm productivity, we also observe an increase in R&D investment during this period. This suggests that innovation investment might be a channel through which real appreciation boosts firm productivity. However, systematic research would be necessary to clarify the possible channels.

Appendix

Productivity Decomposition

The aggregate productivity at time t, Φ_t is defined as a share-weighted average of firm productivity φ_{it}:

$$\Phi_t = \sum_i \omega_{it}\varphi_{it} \tag{20}$$

where ω_{it} is sales share of firm ($\sum_i \omega_{it} = 1$). The variable of interest is the change in− productivity from t = 1 to 2, that means, $\Delta\Phi = \Phi_2 - \Phi_1$. Surviving firms involve firms which are present in both t = 1 and t = 2, exiting firms designate firms which are present in t = 1 but not in t = 2, entering firms are firms being present only in t = 2.

To decompose aggregate productivity growth, $\Delta\Phi$, into contribution of three groups of firms (survivors, entrants and exiters), Melitz and Polanec (2015) define $\omega_{Gt} = \sum_{i\in G} \omega_{it}$ as market share of a group G and $\Phi_{Gt} = \sum_{i\in G}(\omega_{it}/\omega_{Gt})\varphi_{it}$ as group G's (weighted) average productivity. For each period, aggregate productivity is calculated from (weighted) average productivity of survivors (S), entrants (E) and exiters (X):

$$\Phi_1 = \omega_{S1}\Phi_{S1} + \omega_{X1}\Phi_{X1} = \Phi_{S1} + \omega_{X1}(\Phi_{X1} - \Phi_{S1})$$

$$\Phi_2 = \omega_{S2}\Phi_{S2} + \omega_{E2}\Phi_{E2} = \Phi_{S2} + \omega_{E2}(\Phi_{E2} - \Phi_{S2}) \tag{21}$$

The productivity change is then decomposed as follows:

$$\Delta\Phi = (\Phi_{S2} - \Phi_{S1}) + \omega_{E2}(\Phi_{E2} - \Phi_{S2}) + \omega_{X1}(\Phi_{X1} - \Phi_{S1}) \tag{22}$$

Equation 22 decomposes the aggregate productivity growth into components for the three groups of firms: survivors, entrants and exiters. Different from other decomposition methods (Foster, Haltiwanger, and Krizan, 2001; Griliches and Regev, 1995), Melitz and Polanec (2015) compare productivity of entrants and exiters to that of survivors in the same period. Therefore, each group contribution can be related to a specific counterfactual scenario: the contribution of surviving firms, $(\Phi_{S2} - \Phi_{S1})$ is simply the aggregate productivity that would have been obtained in case of no entry and exit. The contribution of entry, $\omega_{E2}(\Phi_{E2} - \Phi_{S2})$, is the change in aggregate productivity generated by adding or removing the group of entrants. In the same logic, the contribution of exit, $\omega_{X1}(\Phi_{X1} - \Phi_{S1})$, is the change in aggregate productivity generated by adding/removing the group of exiting firms. From this decomposition, entrants positively contribute to productivity growth if (and only if) they have higher productivity Φ_{E2}

than the remaining (surviving) firms Φ_{S2} in the same time period when they enter the market (t = 2).

Exiters positively contribute to productivity growth if (and only if) they have lower productivity Φ_{X1} than the remaining (surviving) firms Φ_{S1} in the same time period when they exit (t = 1).

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