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Technology Imports and Employment in Developing Countries: Evidence from Viet Nam

Duc Anh DANG[#§]

National Centre for Socioeconomic Information and Forecast, Viet Nam

Thu Thu VU

Vietnam Social Science Academy, Viet Nam

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Abstract: *Advanced machines and technology replace workers through automation. However, capital–labour substitution need not reduce aggregate labour demand, as it induces simultaneous contrasting effects within industries. To explore these effects, we examine the relationship between employment in Vietnamese manufacturing firms and imported capital goods in 2011–2017. To solve the problem of potential endogeneity and measurement errors, we used Association of Southeast Asian Nations (ASEAN) imported capital goods as an instrument variable for imported capital goods in Viet Nam. We found that imported capital goods do not displace employment and even increase employment and labour productivity. The impacts of imported advanced technology are more pronounced in large firms. More imported technology increases labour productivity in state-owned enterprises and the number of workers in large firms and firms in industrial zones. However, the increase in the level of employment is lower in industries and firms intensively using machines.*

Keywords: Imported capital goods, technology, employment

JEL Classification: F61, F66, J20, O14

[#]Corresponding author. National Centre for Socioeconomic Information and Forecast, D25, 7 Ton That Thuyet, Hanoi, Viet Nam. Phone: 84 24 37957463. Fax: 84 24 37957479. Email: dang.ducanh78@yahoo.com

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1. Introduction

Technology[1] is progressing rapidly and increasingly disrupting production patterns around the world. A recent World Bank study shows that the increasing application of industrial automation, modern robotics, and smart factories is transforming the manufacturing process and changing work (Hallward-Driemeier and Nayyar, 2017). Imports by developing countries of these new technologies can boost productivity, drive down costs, and support the speed of technology diffusion and catch-up. The technologies, however, create risks for those countries to the degree that they might be labour-saving and replace low-skilled jobs (Frey and Rahbari, 2016).

Although imported new technology poses risks to low-skilled workers, there is less consensus on its overall effects on employment. As machines are good at routine tasks, demand for mainly routine jobs will fall. Manual workers are likely to be displaced. From a different perspective, machines improve productivity and lower the price of goods and services, which raises demand for them. Increased demand calls for hiring additional workers, which could compensate for the displacement effect from automation (ADB, 2018). The greater use of machines and technology increases demand for skilled workers and relocates task assignments amongst employees. Whilst machines might reduce the number of traditional manufacturing jobs, new service jobs will be created (Frederick, 2018).

Empirical results analysing the impacts of advanced technology on aggregate employment are mixed. One strand of literature finds that productivity enhancements made possible by machines will create additional demand for labour, offsetting direct job loss. Some occupations with routine tasks have suffered, whilst occupations that entail primarily non-routine tasks and personal interaction have flourished. More machines reallocate labour across industries and occupations (Autor, 2015; Autor and Dorn, 2013; Autor et al., 2015; Autor and Salmons, 2018; Graetz and Michaels, 2018). For example, Autor and Salmons (2018) show that productivity growth was associated with increased employment in Organisation for Economic Co-operation and Development (OECD) countries during 1970–2007. Each 1% increase in total factor productivity was associated with a 0.3% rise in employment. Productivity growth in one industry had positive job spill-over effects in the economy.

[1]The literature has used both indirect and direct measures of technology. Direct measures use data on computers, information and communication technology capital, research and development investments, and industrial robots, amongst other things (for example, Doms et al. [1997], Autor et al. [1998], Acemoglu and Restrepo [2017], Graetz and Michaels [2017]).

Other studies have come to a less optimistic conclusion. For example, Acemoglu and Restrepo (2017) examined the impact of industrial robots in the United States (US) in 1990–2007. Their results suggest that an increase in exposure to robots reduced local employment. Each robot cut six jobs and reduced wages by 0.5% per 1,000 workers. The impacts seemed to be most pronounced in manufacturing and industries most exposed to robots, such as routine manual, blue-collar assembly and related occupations. The estimated impacts were larger for workers with less than a college education.

This study advances the debate on whether employment in developing countries is affected by advanced technology. We used Vietnam Enterprise Survey data for 2011–2017 and matched them with imported capital goods, using the concordance matrix from the United Nations (UN) Statistics Division. We then explored the relationship between technology imports and different employment outcomes of manufacturing firms.

However, the correlation observed here might not be causal because of potential measurement errors or omitted variable problems due to technology shocks (Bloom et al., 2016). To mitigate the potential effects of omitted variable biases, we included a set of firm characteristics in our empirical specification, which include firm and time-fixed effects as well as time-varying firm-level controls. To deal with the remaining sources of endogeneity, we used an instrumental variable (IV) approach, with the level of Association of Southeast Asian Nations (ASEAN) imported capital goods as an instrument variable for imported capital goods in Viet Nam.

Our firm-level findings show several interesting patterns. First, the level of employment and labour productivity increased with the adoption of more advanced technologies. These effects were more pronounced in large firms. Second, more imported technology increased labour productivity in state-owned enterprises and the number of workers in large firms and firms in industrial zones. Third, the increase in employment and labour productivity was lower in industries and firms intensively using machines.

The paper will contribute to the literature. First, we provide evidence of simultaneous effects of trade and technology on employment outcomes in developing countries, which have not been much explored. Second, we complement other studies in examining the impact of technology on different employment outcomes (such as Pierce and Schott [2016]). Finally, we add to studies that investigate the impacts of trade on different aspects of employment (such as Autor and Salomons [2017]).

The paper is organised as follows. Section 2 describes the conceptual framework underlying the paper's hypothesis. Section 3 discusses our data, along with descriptive analyses of trends in imported capital goods and other variables, then presents the empirical model strategy. Section 4 gives the estimation results. Section 5 summarises the key findings and presents policy recommendations.

2. Conceptual Framework

The literature proposes several mechanisms through which imported technology might affect labour demand within a firm or industry.[2]

The first channel is the competition effect. More imported technology goods and machines compete with local capital goods producers, inducing inefficient domestic firms to exit and lowering demand for employment. Resources are relocated from the least efficient firms to the more productive ones, creating productivity gains (Melitz, 2003). The overall impact is an increase in the efficiency of domestic firms, which could result in more jobs. However, as most developing countries are technology consumers rather than producers, the effects of imported capital goods through this mechanism could be small.

The second channel is the displacement effect of imported technology. Since machines outperform humans at routine tasks, demand for mainly routine jobs will fall. Manual workers in an industrial warehouse are likely to be displaced (Autor, 2015). The effect could be severe in developing countries, which have many low-skill assembly jobs.

The third mechanism is the productivity effect. As new technology improves productivity and lowers production costs, the price of goods and services will fall and raise demand for them, assuming that the imported technology is of higher quality and more sophisticated than local technology. As more advanced technology is widely used in production lines, the cost of production could go down, lowering prices and increasing demand. If increased demand requires hiring more workers, it could offset the displacement effect from automation (ADB, 2018). If new machines increase labour productivity, however, they might reduce demand for additional workers.

The fourth effect of imported technology is that it might generate new tasks and jobs, raising demand for labour. New job categories could emerge when more sophisticated technology is introduced, which might require a higher demand for high-skill labour (Frederick, 2018).

The literature, therefore, does not clearly predict the effects of imported technology on employment. Whilst higher rates of displacement are likely to decrease employment, other factors, such as the increase in productivity and new-job creation, are likely to increase the number of workers.

[2]This paper focuses on within-firm effects. There might be other cross-sector effects such as spill-over and income effects on other industries (ADB, 2018).

3. Empirical Methodology

3.1. Data Description

This section describes the principal sources of data used in the analysis: imported capital goods data from the UN Comtrade Database (UN-COMTRADE) and employment data from the Vietnam Enterprise Survey in 2011–2017. We first describe the firm-level data and then discuss imported capital goods.

Vietnam Enterprise Survey Data

Our firm-level data are taken from the Vietnam Enterprise Survey from 2011 to 2017. The survey has been conducted annually since 2000 by the Vietnam General Statistical Office. This dataset includes the population of all registered enterprises with 30 employees or more and a representative sample of smaller firms. The surveys cover all enterprises, regardless of size, and all sectors (mining, manufacturing, services, agriculture). The firms can be tracked over time via a unique firm identifier. The survey provides comprehensive information about firms and their activities, including firm demographics, ownership, business activities, employment, wages, assets, capital, business performance, revenue, and profit. We restrict our sample to manufacturing firms, which are most exposed to imported capital goods. The main variables are number of employees, number of foreign workers, labour income, and labour productivity.

Table 1 presents the descriptive statistics of the main employment outcomes. The sample covers 37,994 observations of manufacturing enterprises exposed to imported capital goods. The average firm employment in the sample shows volatility in 2011–2017. The evolution of foreign employment shows an increasing trend in 2011–2015, declining in 2016, and increasing in 2017. Labour productivity increased from 2011 to 2016 before decreasing in 2017. Similarly, labour income increased in the same period, except in 2016.

Table 1. Descriptive Statistics

	2011	2012	2013	2014	2015	2016	2017	Average
Ln (Imported capital goods)	8.94	8.65	7.65	9.23	9.05	8.82	9.38	8.78
	(2.28)	(2.41)	(2.68)	(2.32)	(2.16)	(2.59)	(2.44)	(2.470)
Ln (Imported capital goods from advanced countries)	8.94	8.65	7.65	9.23	9.05	8.82	9.38	8.78
	(2.28)	(2.41)	(2.68)	(2.32)	(2.16)	(2.59)	(2.44)	(2.47)
Ln (Imported capital goods from China)	7.61	7.19	6.15	7.43	7.56	7.55	8.01	7.33
	(2.18)	(2.73)	(3.45)	(2.97)	(2.51)	(3.04)	(3.03)	(2.89)
Ln (Employment)	3.51	3.90	3.90	3.98	4.08	3.51	4.06	3.80
	(1.46)	(1.42)	(1.49)	(1.49)	(1.56)	(1.58)	(1.52)	(1.52)
Ln (Foreign employment)	0.28	0.35	0.42	0.43	0.51	0.35	0.62	0.40
	(0.67)	(0.76)	(0.79)	(0.77)	(0.82)	(0.72)	(0.86)	(0.77)
Ln (Labour income)	2.81	2.88	2.95	3.06	3.22	3.18	3.42	3.04
	(0.67)	(0.73)	(0.71)	(0.71)	(0.70)	(0.76)	(0.73)	(0.74)
Ln (Labour productivity)	3.20	2.98	3.12	3.31	3.39	3.59	3.11	3.26
	(1.75)	(2.20)	(2.06)	(2.00)	(2.13)	(1.75)	(2.47)	(2.02)
Number of observations	7,218	5,595	5,451	5,152	4,526	6,859	3,193	37,994

Notes:
1. Trade data lag by 1 year.
2. Labour incomes are adjusted by inflation.
3. Ln (Foreign employment) is Ln (Number of foreign workers).
4. Advanced countries include Germany, Italy, Japan, the Republic of Korea, and the United States.
Source: Our calculations, based on the Vietnam Enterprise Survey 2011–2017.

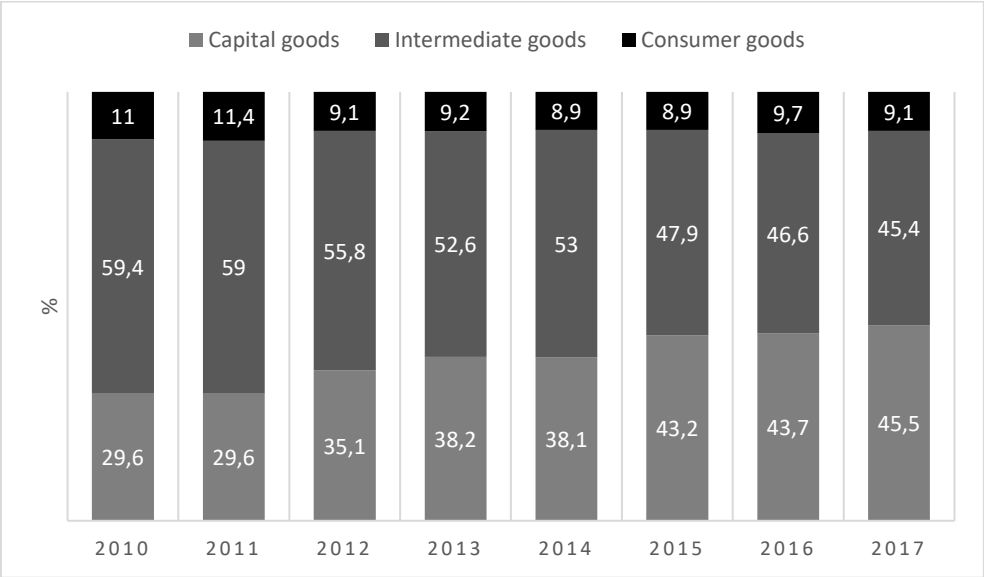
Imported Capital Goods

We use imported capital goods data taken from the UN COMTRADE database, which is the value of capital goods imports by Viet Nam from the rest of the world. We define capital goods based on the Broad Economic Classification (BEC). Capital goods include products that belong to BEC industry 41 (capital goods), BEC industry 42 (parts and accessories of capital goods), and BEC industry 521 (transport equipment used for the industry).

We converted UN-COMTRADE commodity classifications by using the UN Statistics Division concordance matrices in the corresponding International Standard Industrial Classification (ISIC) Revision 4 to merge industry-level imported capital goods data with the firm-level dataset.[3] We then calculated imported capital goods intensity by taking imported capital goods as the proportion of total capital in the sector.

[3] Viet Nam's industrial classification code is similar to ISIC Revision 4.

Figure 1. Viet Nam's Composition of Imports (%)



Source: General Statistics Office of Vietnam. http://www.gso.gov.vn

The evolution of capital goods imports in Viet Nam is presented in Figure 1. As in many developing countries, capital goods imports play an important role in the Vietnamese economy. Viet Nam has seen extremely fast growth in capital goods imports in the last few years. Figure 1 shows that the share of capital goods in Viet Nam's total value of imports increased substantially, reaching nearly 46% in 2016, 15 percentage points higher than in 2011. Imports of advanced technology and machines, therefore, are important for Viet Nam's industrial development. We expect that they will have profound effects on the labour market and firm employment, especially in manufacturing. In Viet Nam, which is a technology importer, the effects of imported capital goods are more likely through channels other than competition with domestic firms.

Table 2 presents the (average) extent of exposure of each 2-digit sector to imported capital goods. The numbers can be interpreted as the proportion of imported capital goods in the sector. Variation is substantial over time and across sectors. However, the manufacture of electrical equipment and machinery is the most exposed to imported capital goods.

Table 2. Exposure of Manufacturing Sectors to Imported Capital Goods (%)

	2011	2012	2013	2014	2015	2016	2017	Average
Leather and related products	9.98	8.14	3.57	9.04	8.39	4.55	5.66	7.15
Printing and reproduction of recorded media	10.41	8.92	8.90	8.66	8.48	8.20	8.37	8.96
Other non-metallic mineral products	7.11	6.28	6.34	6.97	6.66	7.37	7.06	6.83
Basic and fabricated metal products	9.95	10.96	9.65	11.50	9.95	11.56	10.05	10.57
Computer, electronic, optical products	10.48	9.68	10.40	12.17	12.90	11.40	11.90	11.43
Electrical equipment	10.59	11.12	9.57	11.86	11.38	11.39	11.98	11.09
Machinery and equipment	14.62	14.37	13.43	14.19	13.68	14.33	14.79	14.20
Other transport equipment	10.38	10.18	8.89	9.18	8.98	9.79	10.69	9.70
Furniture	6.04	6.25	6.17	6.52	7.07	7.51	9.41	6.66
Other manufacturing	9.43	8.21	8.73	8.24	8.00	8.82	8.85	8.66

Note: Exposure is defined as the proportion of imported capital goods over the capital stock in one sector.
Source: Authors, based on the Vietnam Enterprise Survey 2011–2017.

3.2. Empirical Model

Our econometric specification, which considers the effects of imported capital goods on employment levels, is represented by the following equation:

$$y_{ijt} = \alpha + \beta KM_{jt-1} + X'_{ijt}\tau + \lambda_i + \theta_t + \varepsilon_{ijt} \quad (1)$$

where y_{ijt} is the firm-level employment outcomes of firm *i* in sector *j* at time *t*, and KM_{jt-1} is the imported capital goods used by sector *j* at time *t-1* (which is normalised as the share of capital goods imports over industrial capital stock). β is the coefficient of our main interest, which represents the relationship between imported capital goods and firm employment outcomes. Our main variable is included in the estimated specification with a one-period lag to reduce potential simultaneity bias.[4] At the same time, the lag of the main variable reflects the possibility that firm employment does not react immediately to imported capital goods. λ_i and θ_t are firm and year dummy fixed effects, of which, year dummies capture time-specific factors that are common to all firms, whilst firm dummies control for time-invariant

[4] Although it is less likely that reverse causality happens. Employment in an individual firm is unable to impact the level of capital goods imports of that sector. This situation happens only when a firm is extremely large or a sector is highly concentrated.

firm-specific characteristics. Standard errors are clustered by industry level.[5] The term X is a vector of industrial zone dummy and firm ownership dummies. To minimise the possibility that parameter estimates are influenced by the exit and entry of firms rather than within-firm variations, we restricted the sample to firms present at least twice in this period.

The challenge in estimating these equations is that there is potential endogeneity between employment outcomes variables and the imported capital goods variable. The source of endogeneity could be omitted variable biases. It is possible that unobserved characteristics of the firms correlate with the imported capital goods variable and affect employment. Using firm-level fixed effects eliminates the potential for any time-invariant characteristics of firms to act as confounding factors. Of course, it is possible that some omitted time-varying variable biases remain.

Another possible source of endogeneity is measurement error. Our capital goods import variable is measured at the 4-digit industry level, and our dependent variable is at the firm level. From a firm's viewpoint, the main independent variable measure is an aggregation of imported capital goods at the 4-digit industry level, including those without direct relevance to the firm. Capital goods might be imported by intermediaries and not be directly used by firms in these industries. All this means that the imported capital goods variable is measured with error, leading to a downward bias in our ordinary least squares (OLS) estimates.

Instrumental Variable Strategy

To deal with potential endogeneity problems, we used an IV approach. The instrument variable for the level of Viet Nam's imported capital goods in an industry is the level of imported capital goods in that industry in Southeast Asian countries (excluding Viet Nam). The countries included the sample are Cambodia, Indonesia, Malaysia, Myanmar, and Thailand, whose patterns of capital goods imports are similar to those of Viet Nam. This instrument will be correlated with the level of imported capital goods in that sector in Viet Nam because the instrument correlates with the general trend in demand for these goods in the region. Using imported capital goods in regional countries gets rid of the possibility that the instrument is driven by industry-specific shocks that affect Viet Nam as well as other countries in the region (Newman et al., 2016). The level of imported capital goods in that industry in other countries is less likely to have direct impacts on Viet Nam's firm employment. Our first stage specification is as follows:

[5] In our fixed-effect model, clustering standard error matters only if there is heterogeneity in the treatment effects, as suggested by Abadie et al. (2017).

$$KM_{jt} = \omega + \delta KM_{jt}^{ASEAN} + X'_{ijt}\pi + \mu_i + \sigma_t + \epsilon_{ijt} \quad (2)$$

where the variable KM_{jt} is the imported capital goods of industry j and year t in other ASEAN countries. X is a vector of the same firm characteristics in equation (1), which are industrial zone dummy and firm ownership dummies. We control for firm and year fixed effects so the specification captures firm characteristics and common global time trends that affect countries in the region.

4. Empirical Results

4.1. Ordinary Least Squares Estimates

We first present the OLS results as a benchmark. In Table 3, we report an OLS regression with different employment outcomes as dependent variables, which are Ln (Employment), Ln (Foreign employment), Ln (Labour income), and Ln (Labour productivity), where the foreign employment variable is the number of foreign workers, which proxies for high-skill workers. Columns (1) to (4) display results from estimating equation (1), where the only explanatory variables are capital goods import intensity, as well as firm and year fixed effects. In all estimations, standard errors are adjusted for clustering of observations of the same industry. The result in column (1) shows that the coefficient on capital goods import intensity is positive and significantly more than zero, suggesting that imports of capital goods have a positive and significant effect on firm employment. The result indicates that job creation effects might outweigh other displacement channels. However, the magnitude of the coefficient is small, at 0.006. The result in column (4) shows that imported capital goods are associated with an increase in labour productivity.

We checked the robustness of our results. In columns (5) to (8), along with the specification in columns (1) to (4), we expanded the set of regressors to include the set of industrial zone dummy and firm ownership dummies. We found that our result for the impact of imported capital goods is not sensitive to whether we control for other variables. Column (5) of Table 2 shows that firms with more capital goods imports have a higher number of workers. These results indicate that whilst higher rates of displacement are likely to decrease the amount of employment, other channels, such as the increase in productivity, are likely to increase the number of workers. This provides some evidence that the effects of job creation might be higher than the displacement effects. The result in column (8) indicates that imported capital goods associates with higher labour productivity, which supports our argument that the productivity channel might be dominant.

Table 3. Imported Capital Goods and Firm Employment (ordinary least squares estimates)

Variables	(1) Ln (Employment)	(2) Ln (Foreign employment)	(3) Ln (Labour income)	(4) Ln (Labour productivity)	(5) Ln (Employment)	(6) Ln (Foreign employment)	(7) Ln (Labour income)	(8) Ln (Labour productivity)
Ln (Imported capital goods)	0.008*	0.000	-0.001	0.020***	0.008*	0.000	-0.001	0.020***
	(0.005)	(0.001)	(0.003)	(0.005)	(0.004)	(0.001)	(0.002)	(0.005)
Other variables	No	No	No	No	Yes	Yes	Yes	Yes
Observations	37,994	37,994	37,994	37,994	37,994	37,994	37,994	37,994
R-squared	0.003	0.002	0.084	0.020	0.008	0.009	0.084	0.020
Number of firms	10,204	10,204	10,204	10,204	10,204	10,204	10,204	10,204
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummy effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes:
1. Standard errors are robust to heteroskedasticity and clustered at the industry level.
2. Other variables include industrial zone dummy and firm ownership dummies (private firms, firms with state capital, and firms with foreign capital). Ln (Foreign employment) is Ln (Number of foreign workers).
3. ***Significant at the 1% level, **Significant at the 5% level, *Significant at the 10% level.
Source: Authors, based on the Vietnam Enterprise Survey 2011–2017.

4.2. Instrumental Variable Estimates

The next step is to correct for the endogeneity of imported capital goods by using IV estimation. ASEAN's imported capital goods are a potential instrument to predict the level of Viet Nam's imported capital goods, but they might not directly affect firm employment. Therefore, we use ASEAN's capital goods imports as an instrument variable for imported capital goods penetration.

Table 4. Imported Capital Goods and Firm Employment (instrumental variable estimates)

	(1)	(2)	(3)	(4)
Variables	**Ln (Employment)**	**Ln (Foreign employment)**	**Ln (Labour income)**	**Ln (Labour productivity)**
Ln (Imported capital goods)	0.011***	0.000	-0.001	0.022***
	(0.004)	(0.002)	(0.003)	(0.007)
	First stage: Ln (Imported capital goods)			
Ln (Imported capital goods by ASEAN countries)	0.961***	0.961***	0.961***	0.961***
	(0.08)	(0.08)	(0.08)	(0.08)
Other variables	Yes	Yes	Yes	Yes
Observations	37,697	37,697	37,697	37,697
Number of firms	9,907	9,907	9,907	9,907
Firm fixed effects	Yes	Yes	Yes	Yes
Year dummy effects	Yes	Yes	Yes	Yes
F-test for an excluded instrument:139				

ASEAN = Association of Southeast Asian Nations.
Notes:
1. Standard errors are robust to heteroskedasticity and clustered at the industry level.
2. Other variables include industrial zone dummy and firm ownership dummies (private firms, firms with state capital, and firms with foreign capital).
3. Ln (Foreign employment) is Ln (Number of foreign workers).
4. ASEAN countries include Cambodia, Indonesia, Malaysia, Myanmar, and Thailand.
5. ***Significant at the 1% level, **Significant at the 5% level, *Significant at the 10% level.
6. In the first stage of instrumental variation estimation, Ln (Imported capital goods by ASEAN countries) is used as an instrument for Ln (Imported capital goods).
7. The F-test for an excluded instrument is larger than 10, implying the instrument is strong (see Staiger and Stock [1997]).
Source: Authors, based on the Vietnam Enterprise Survey 2011–2017.

Table 4 presents our IV results. The reported coefficient in the lower panel is the first-stage result. The instrument variable has the expected sign. The coefficient of ASEAN's imported capital goods is positive and highly significant. The F-statistic of excluded instruments is well above the critical values identified by Staiger and Stock (1997), indicating

that the problem of a weak instrument is not our concern. In columns (1) to (4) in the upper panel of Table 4, we report a regression with the imported capital goods intensity, as well as firm and year fixed effects, and industrial zone dummy and firm ownership dummies as independent variables. The coefficients on the imported capital goods intensity variables are positive and significantly different from zero, suggesting that importing capital goods has a positive impact on firm employment and labour productivity, as shown in columns (1) and (4). The magnitudes of coefficients are higher than those in OLS estimates and show that OLS estimates might be downward biased. The result in column (1) indicates that each 10% increase in capital goods import intensity is associated with a 0.11% increase in the number of firm employees and a 0.22% increase in labour productivity.

4.3. Heterogeneity

To explore the heterogeneity of the impacts across firms, we present the findings separately for different sub-samples of firms.

We expect that firms operating in industrial zones might use more advanced technology, which might have different effects than those of other firms operating outside. The IV estimates in column (1) in Table 5 indicate that employment of firms in industrial zones increases more than that of other firms when more capital goods are imported from outside. Labour productivity reduces as the importation of capital goods intensifies although the coefficient is not statistically significant. One potential explanation is that the new-job creation effects result from using more advanced technology and machines, offsetting the displacement effect for manufacturing firms in industrial zones.

We expect capital goods imports from more advanced countries to have a larger impact on unskilled and skilled employees than those from other countries because such capital goods use the most advanced technology (Eaton and Kortum, 2001). We focus on capital goods imported from leading countries producing machine tools, including Germany, Italy, Japan, the Republic of Korea (henceforth, Korea), and the US. Table 6 shows that the impact of capital goods imports from these countries is similar to the impact of those from the whole sample. One potential explanation is that the share of capital goods imported from other advanced countries, except Korea, by Viet Nam's manufacturing firms is not significant. We examined the impacts of imported capital goods from China, which account for more than 30% of Viet Nam's total imported capital goods (Figure 2 and Table 7). Compared with the results in column (1) and (4) in Table 6, the magnitude of the coefficient is almost the same, showing that imported capital goods from China do not have different effects on labour employment and productivity than those from other advanced countries.

Table 5. Imported Capital Goods and Firm Employment in Industrial Zones

Variables	(1) Ln (Employment)	(2) Ln (Foreign employment)	(3) Ln (Labour income)	(4) Ln (Labour productivity)
Fixed Effect Estimation				
Ln (Imported capital goods)	0.010*	0.003	-0.006	-0.008
	(0.006)	(0.005)	(0.004)	(0.023)
IV Estimation				
Ln (Imported capital goods)	0.018**	0.004	-0.011***	-0.029
	(0.008)	(0.005)	(0.004)	(0.027)
Other variables	Yes	Yes	Yes	Yes
Observations	9,006	9,006	9,006	9,006
Number of firms	2,554	2,554	2,554	2,554
Firm fixed effects	Yes	Yes	Yes	Yes
Year dummy effects	Yes	Yes	Yes	Yes

ASEAN = Association of Southeast Asian Nations.

Notes:

1. Standard errors are robust to heteroskedasticity and clustered at the industry level.
2. Other variables include industrial zone dummy and firm ownership dummies (private firms, firms with state capital, and firms with foreign capital).
3. Ln (Foreign employment) is Ln (Number of foreign workers). ***Significant at the 1% level, **Significant at the 5% level, *Significant at the 10% level.
4. In the first stage of instrumental variable estimation, Ln (Imported capital goods by ASEAN countries) is used as an instrument for Ln (Imported capital goods).
5. ASEAN countries include Cambodia, Indonesia, Malaysia, Myanmar, and Thailand.
6. The F-test for an excluded instrument is larger than 10, implying the instrument is strong (see Staiger and Stock [1997]).

Source: Authors, based on the Vietnam Enterprise Survey 2011–2017.

Table 6. Imported Capital Goods from Advanced Countries and Firm Employment

Variables	(1) Ln (Employment)	(2) Ln (Foreign employment)	(3) Ln (Labour income)	(4) Ln (Labour productivity)
Fixed Effect Estimation				
Ln (Imported capital goods from advanced countries)	0.006	0.000	0.000	0.018***
	(0.004)	(0.001)	(0.002)	(0.006)
IV Estimation				
Ln (Imported capital goods from advanced countries)	0.009***	0.000	-0.001	0.019***
	(0.003)	(0.001)	(0.002)	(0.006)
Other variables	Yes	Yes	Yes	Yes
Observations	37,994	37,994	37,994	37,994
Number of firms	10,204	10,204	10,204	10,204
Firm fixed effects	Yes	Yes	Yes	Yes
Year dummy effects	Yes	Yes	Yes	Yes
F-test for an excluded instrument: 476				

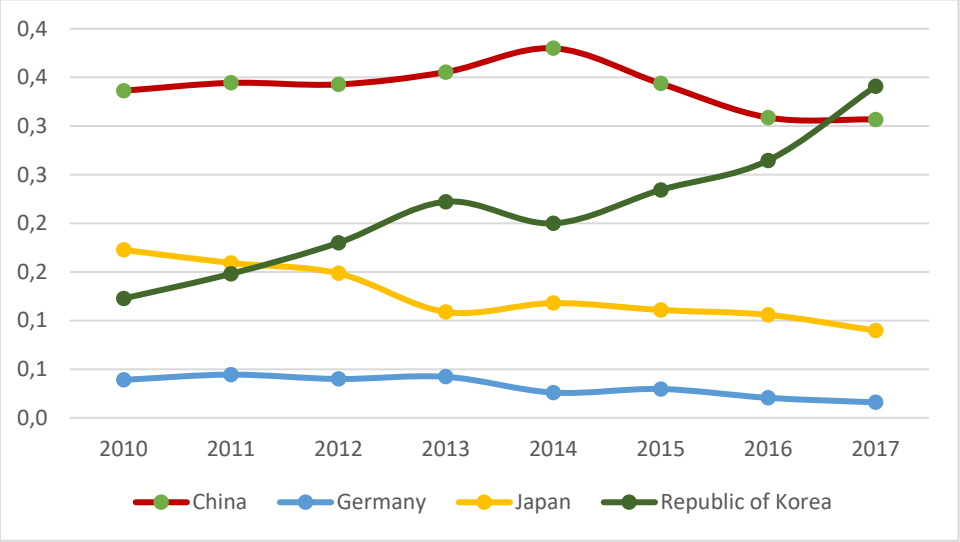
ASEAN = Association of Southeast Asian Nations.

Notes:

1. Standard errors are robust to heteroskedasticity and clustered at the industry level.
2. Other variables include industrial zone dummy and firm ownership dummies (private firms, firms with state capital and firms with foreign capital).
3. Ln (Foreign employment) is Ln (Number of foreign workers). ***Significant at the 1% level, **Significant at the 5% level, *Significant at the 10% level.
4. In the first stage of instrumental variable estimation, Ln (Imported capital goods by ASEAN countries) is used as an instrument for Ln (Imported capital goods from advanced countries).
5. ASEAN countries include Cambodia, Indonesia, Malaysia, Myanmar, and Thailand. Advanced countries include Germany, Italy, Japan, the Republic of Korea, and the United States.
6. The F-test for an excluded instrument is larger than 10, implying the instrument is strong (see Staiger and Stock [1997]).

Source: Authors, based on the Vietnam Enterprise Survey 2011–2017.

Figure 2. Sources of Imported Capital Goods



Notes:
1. The vertical axis shows the share of Viet Nam's imported capital goods by country.
2. Imported capital goods include products that belong to Broad Economic Classification (BEC) industry 41 (capital goods), BEC industry 42 (parts and accessories of capital goods), and BEC industry 521 (transport equipment used for industry).
Source: Authors, based on the UN-COMTRADE database.

Table 7. Imported Capital Goods from China and Firm Employment

	(1)	(2)	(3)	(4)
Variables	**Ln (Employment)**	**Ln (Foreign employment)**	**Ln (Labour income)**	**Ln (Labour productivity)**
Fixed Effect Estimation				
Ln (Imported capital goods from China)	0.006	0.000	-0.001	0.016***
	(0.004)	(0.001)	(0.002)	(0.005)
IV Estimation				
Ln (Imported capital goods from China)	0.010***	0.000	-0.001	0.021***
	(0.004)	(0.001)	(0.003)	(0.007)
Other variables	Yes	Yes	Yes	Yes
Observations	37,994	37,994	37,994	37,994
Number of firms	10,204	10,204	10,204	10,204
Firm fixed effects	Yes	Yes	Yes	Yes
Year dummy effects	Yes	Yes	Yes	Yes
F-test for an excluded instrument: 69				

ASEAN = Association of Southeast Asian Nations.
Notes:
1. Standard errors are robust to heteroskedasticity and clustered at the industry level.
2. Other variables include industrial zone dummy and firm ownership dummies (private firms, firms with state capital and firms with foreign capital).
3. Ln (Foreign employment) is Ln (Number of foreign workers). ***Significant at the 1% level, **Significant at the 5% level, *Significant at the 10% level.
4. In the first stage of instrumental variable estimation, Ln (Imported capital goods by ASEAN countries) is used as an instrument for Ln (Imported capital goods from China).
5. ASEAN countries include Cambodia, Indonesia, Malaysia, Myanmar, and Thailand.
6. The F-test for an excluded instrument is larger than 10, implying the instrument is strong (see Staiger and Stock [1997]).
Source: Authors, based on the Vietnam Enterprise Survey 2011–2017.

We ran a separate regression on some industries such as electronic and machinery production, where substantially imported capital goods and employment could have a greater risk of being replaced by advanced technology and machines (Table 8). The coefficient became insignificant and smaller, indicating that more advanced technology in these sectors might increase labour demand but that the displacement effect from automation is higher than in other sectors.

Table 8. Imported Capital Goods and Firm Employment in Electronic and Machinery Sectors

	(1)	(2)	(3)	(4)
Variables	**Ln (Employment)**	**Ln (Foreign employment)**	**Ln (Labour income)**	**Ln (Labour productivity)**
Fixed Effect Estimation				
Ln (Imported capital goods)	0.004	0.005	0.000	0.009
	(0.008)	(0.005)	(0.006)	(0.010)
IV Estimation				
Ln (Imported capital goods)	0.003	0.008	-0.005	0.009
	(0.010)	(0.005)	(0.006)	(0.017)
Other variables	Yes	Yes	Yes	Yes
Observations	15,642	15,642	15,642	15,642
Number of firms	4,403	4,403	4,403	4,403
Firm fixed effects	Yes	Yes	Yes	Yes
Year dummy effects	Yes	Yes	Yes	Yes
F-test for an excluded instrument: 56.96				

ASEAN = Association of Southeast Asian Nations.
Notes:
1. Standard errors are robust to heteroskedasticity and clustered at the industry level.
2. Other variables include industrial zone dummy and firm ownership dummies (private firms, firms with state capital, and firms with foreign capital).
3. Ln (Foreign employment) is Ln (Number of foreign workers). ***Significant at the 1% level, **Significant at the 5% level, *Significant at the 10% level.
4. In the first stage of instrumental variable estimation, Ln (Imported capital goods by ASEAN countries) is used as an instrument for Ln (Imported capital goods).
5. ASEAN countries include Cambodia, Indonesia, Malaysia, Myanmar, and Thailand.
6. The F-test for an excluded instrument is larger than 10, implying the instrument is strong (see Staiger and Stock [1997]).
Source: Authors, based on the Vietnam Enterprise Survey 2011–2017.

We examined the effects of imported capital goods on employment in exporting firms, which might use more advanced machines to produce higher-quality exports to compete in foreign markets. We re-estimated the model given in equation (1) with the exporting firm sample.[6] The results are in Table 9. The IV findings in columns (1) and (4) show a positive but not significant relationship between imported capital goods and the level of employment and labour productivity in exporting firms.

[6] The sample for exporting firms is only until 2015.

Table 9. Imported Capital Goods and Employment of Exporting Firms

Variables	(1) Ln (Employment)	(2) Ln (Foreign employment)	(3) Ln (Labour income)	(4) Ln (Labour productivity)
Fixed Effect Estimation				
Ln (Imported capital goods)	0.001	0.004	0.005**	0.032**
	(0.005)	(0.004)	(0.002)	(0.014)
IV Estimation				
Ln (Imported capital goods)	0.000	0.004	0.002	0.019
	(0.005)	(0.004)	(0.003)	(0.014)
Other variables	Yes	Yes	Yes	Yes
Observations	12,161	12,161	12,161	12,161
Number of firms	4,091	4,091	4,091	4,091
Firm fixed effects	Yes	Yes	Yes	Yes
Year dummy effects	Yes	Yes	Yes	Yes
F-test for an excluded instrument: 107				

ASEAN = Association of Southeast Asian Nations.
Notes:
1. Standard errors are robust to heteroskedasticity and clustered at the industry level.
2. Other variables include industrial zone dummy and firm ownership dummies (private firms, firms with state capital, and firms with foreign capital).
3. Ln (Foreign employment) is Ln (Number of foreign workers). ***Significant at the 1% level, **Significant at the 5% level, *Significant at the 10% level.
4. In the first stage of instrumental variable estimation, Ln (Imported capital goods by ASEAN countries) is used as an instrument for Ln (Imported capital goods).
5. ASEAN countries include Cambodia, Indonesia, Malaysia, Myanmar, and Thailand.
6. The F-test for an excluded instrument is larger than 10, implying the instrument is strong (see Staiger and Stock [1997]).
Source: Authors, based on the Vietnam Enterprise Survey 2011–2015.

Firms might have different capacity and demand for using imported capital goods, which depend on their size. Small firms with limited resources might invest less in imported advanced technologies and focus on the advantage of cheap labour costs. Larger domestic firms might pay more attention to technology improvements to increase their competitiveness and market penetration, which will affect their employment and labour productivity. Table 10 and Table 11 report the estimate of the main equation with fixed effects and IV approaches. The results show that the estimates of the impact of imported capital goods differ by firm size. The results indicate that the impact of imported capital goods on total employment and labour income is more profound in larger firms, which means that larger firms take advantage of technology imports to expand their business and increase labour demand and productivity.

Table 10. Imported Capital Goods and Firm Employment by Firm Size (ordinary least squares estimates)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Small firms				Large firms			
Variables	Ln (Employment)	Ln (Foreign employment)	Ln (Labour income)	Ln (Labour productivity)	Ln (Employment)	Ln (Foreign employment)	Ln (Labour income)	Ln (Labour productivity)
Ln (Imported capital goods)	0.003	0.001	-0.001	0.016***	0.020***	-0.004	-0.001	0.034**
	(0.004)	(0.001)	(0.003)	(0.005)	(0.006)	(0.007)	(0.003)	(0.015)
Other variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	33,642	33,642	33,642	33,642	4,352	4,352	4,352	4,352
R-squared	0.009	0.012	0.075	0.020	0.079	0.006	0.183	0.029
Number of firms	9,643	9,643	9,643	9,643	1,112	1,112	1,112	1,112
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummy effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes:
1. Standard errors are robust to heteroskedasticity and clustered at the industry level.
2. Other variables include industrial zone dummy and firm ownership dummies (private firms, firms with state capital and firms with foreign capital). Ln (Foreign employment) is Ln (Number of foreign workers).
3. Small firms are those with fewer than 300 employees.
4. ***Significant at the 1% level, **Significant at the 5% level, *Significant at the 10% level.
Source: Authors, based on the Vietnam Enterprise Survey 2011–2017.

Table 11. Imported Capital Goods and Firm Employment by Firm Size (instrumental variable estimates)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Small firms				Large firms			
Variables	Ln (Employment)	Ln (Foreign employment)	Ln (Labour income)	Ln (Labour productivity)	Ln (Employment)	Ln (Foreign employment)	Ln (Labour income)	Ln (Labour productivity)
Ln (Imported capital goods)	0.006	0.001	0.000	0.019***	0.021***	-0.003	-0.007	0.026
	(0.004)	(0.001)	(0.003)	(0.007)	(0.004)	(0.008)	(0.006)	(0.036)
Other variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	33,193	33,193	33,193	33,193	4,163	4,163	4,163	4,163
Number of firms	9,194	9,194	9,194	9,194	923	923	923	923
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummy effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-test for an excluded instrument in (1)-(3): 161.67								
F-test for an excluded instrument in (4)-(6): 38.75								

ASEAN = Association of Southeast Asian Nations.

Notes:

1. Standard errors are robust to heteroskedasticity and clustered at the industry level.
2. Other variables include industrial zone dummy and dummies for firm ownership (private firms, firms with state capital and firms with foreign capital). Ln (Foreign employment) is Ln (Number of foreign workers).
3. Small firms are those with less than 300 employees.
4. In the first stage of instrumental variable estimation, Ln (Imported capital goods by ASEAN countries) is used as an instrument for Ln (Imported capital goods).
5. ASEAN countries include Cambodia, Indonesia, Malaysia, Myanmar, and Thailand.
6. The F-test for an excluded instrument is larger than 10, implying the instrument is strong (see Staiger and Stock [1997]).
7. ***Significant at the 1% level, **Significant at the 5% level, *Significant at the 10% level.

Source: Authors, based on the Vietnam Enterprise Survey 2011–2017.

Table 12. Imported Capital Goods and Firm Employment by Firm Ownership (ordinary least squares estimates)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	State-owned firms				Other firms			
Variables	Ln (Employment)	Ln (Foreign employment)	Ln (Labour income)	Ln (Labour productivity)	Ln (Employment)	Ln (Foreign employment)	Ln (Labour income)	Ln (Labour productivity)
Ln (Imported capital goods)	-0.000	0.005	-0.010	0.138***	0.008*	0.000	-0.000	0.018***
	(0.011)	(0.007)	(0.007)	(0.049)	(0.004)	(0.001)	(0.002)	(0.006)
Other variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	798	798	798	798	37,196	37,196	37,196	37,196
R-squared	0.313	0.011	0.114	0.045	0.006	0.002	0.084	0.021
Number of firms	239	239	239	239	10,115	10,115	10,115	10,115
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummy effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes:
1. Standard errors are robust to heteroskedasticity and clustered at the industry level.
2. Other variables include industrial zone dummy.
3. Ln (Foreign employment) is Ln (Number of foreign workers). ***Significant at the 1% level, **Significant at the 5% level, *Significant at the 10% level.
Source: Authors, based on the Vietnam Enterprise Survey 2011–2017.

Table 13. Imported Capital Goods and Firm Employment by Firm Ownership (instrumental variable estimates)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	State-owned firms				Other firms			
Variables	Ln (Employment)	Ln (Foreign employment)	Ln (Labour income)	Ln (Labour productivity)	Ln (Employment)	Ln (Foreign employment)	Ln (Labour income)	Ln (Labour productivity)
Ln (Imported capital goods)	-0.008	0.005	-0.019	0.156***	0.011***	0.000	-0.000	0.021***
	(0.008)	(0.006)	(0.013)	(0.052)	(0.004)	(0.002)	(0.003)	(0.007)
Other variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	757	757	757	757	36,860	36,860	36,860	36,860
Number of firms	198	198	198	198	9,779	9,779	9,779	9,779
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummy effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-test for an excluded instrument in (1)-(3): 53.83								
F-test for an excluded instrument in (4)-(6): 140.86								

ASEAN = Association of Southeast Asian Nations.

Notes:

1. Standard errors are robust to heteroskedasticity and clustered at the industry level.
2. Other variables include industrial zone dummy.
3. Formal employment refers to workers with social insurance.
4. In the first stage of instrumental variable estimation, Ln (Imported capital goods by ASEAN countries) is used as an instrument for Ln (Imported capital goods).
5. ASEAN countries include Cambodia, Indonesia, Malaysia, Myanmar, and Thailand.
6. The F-test for an excluded instrument is larger than 10, implying the instrument is strong (see Staiger and Stock [1997]).
7. ***Significant at the 1% level, **Significant at the 5% level, *Significant at the 10% level.

Source: Authors, based on the Vietnam Enterprise Survey 2011–2017

Table 12 presents the OLS estimates broken down between state-owned and other firms. The results are mixed. Findings in columns (1) and (5) indicate that higher imported capital goods intensity has more effects on the number of employees in other firms than in state-owned ones. The coefficient magnitude for other firms is higher than for state-owned firms, indicating that other firms are more responsive to imported capital goods than state-owned enterprises. The reason might be that other firms with a more flexible structure can react more quickly to a new situation. However, the productivity of state-owned firms that have greater imported capital goods intensity is much higher than that of other firms , as shown in columns (4) and (8). The IV estimates in Table 13 provide similar results.

5. Conclusion

This empirical analysis will provide insights into the evolution of capital goods imports and firm employment in Viet Nam. Using the Vietnam Enterprise Survey data for 2011–2017, this study examined the consequences of technology imports for firm employment, labour composition, labour income, and manufacturing productivity. We matched firm-level data with trade data from UN-COMTRADE for the same period and restricted our sample to imported capital goods. We found that imports of capital goods have a positive and significant effect on firm employment and labour productivity. To address potential endogeneity, we used ASEAN imported capital goods as an instrument varible for imported capital goods in Viet Nam. The results from IV estimation confirm our previous results: imported capital goods indeed lead to higher employment and labour productivity in manufacturing firms. We explored the heterogeneity of the impacts of imported capital goods on different samples of firms. We found that the impacts of imported advanced technology are more pronounced in large firms. More imported technology results in greater labour productivity in state-owned enterprises. It leads to a higher number of workers in large firms and firms in industrial zones. The impacts are less profound in electronics and machinery firms.

The results imply that productivity-improving technology might not lead to unemployment in all the affected industries. Instead, the effects of new-job creation could be higher than the displacement effects in developing countries such as Viet Nam. However, the effects might not be distributed equally amongst industries, leading to higher employment in some industries and lower in others. The findings suggest policies should support workers transitioning to new industries and new occupations requiring new skills.

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