ERIA-DP-2023-07

ERIA Discussion Paper Series

No. 479

Capital Cost, Technology Choice, and Demand for Skills in Industries in Viet Nam*

Diep PHAN
Ian COXHEAD
University of Wisconsin-Madison and
Institute of Developing Economies (IDE-JETRO), Tokyo
.

July 2023

Abstract: *This paper explores the consequences of a policy regime in which state firms enjoy privileged access to capital while private firms are crowded out. Consequently, state firms choose technologies that are capital-intensive and thus demand more skilled labour. Econometric estimates using Viet Nam's enterprise censuses confirm some of the propositions generated by the model. Relative to private firms, state firms have higher fixed capital stocks but do not have lower variable capital costs; they also employ more skilled labour. Also, as predicted, there is a U-shaped relationship between production scale and skills intensity; many private firms (which are mostly small) are limited to labour-intensive techniques and increase output simply by adding unskilled labour, whereas larger firms are more likely to operate at scales at which it is profitable to employ more skills-intensive and efficient technologies.*
.

Keywords: state-owned enterprises, Viet Nam, skills intensity, technological choice
JEL Classification: O14, O25, J24, L25.

* The authors acknowledge the financial support from the Economic Research Institute for ASEAN and East Asia (ERIA) through the project, Sustaining Viet Nam's Economic Miracle: The Role of Productivity Growth. They thank project participants for helpful comments on earlier drafts.

1. Introduction

The importance of human capital and skills development for economic growth and development is well known. Human capital investment is thought to be especially critical for developing economies seeking to raise labour productivity and to avoid falling into a middle-income trap. To promote human capital, governments often focus on supply-side interventions, for example, by building schools and training more teachers. These measures to improve school access and quality may be important to raising enrolment rates (e.g. Duflo, 2001). Yet the incentive to invest in skills – that is, a demand for education – is equally important. If physical capital and skills are complements in production, then in the aggregate, the skills premium is an increasing function of the stock of physical capital. As a result, policies and institutions that affect capital investment are likely to also have consequences in the market for skills and thus to influence individual decisions on education and training. Investments in capital and human capital will affect long-term labour productivity.

While there is significant literature on aggregate capital–skills complementarity, it is common in developing and transitional countries that the distribution of capital investments is crucial. This is because in relatively shallow financial systems, capital markets display a variety of imperfections. Nowhere is this more evident than in economies where government policy operates to direct investment towards a subset of favoured industries and firms, thereby crowding out others.

Viet Nam is often cited as a successful case of liberalisation in a transitional economy. It has experienced rapid economic growth since the 1990s, when it embarked on an ambitious programme of economic reform. However, the impressive pace of reform in trade, foreign investment, and labour markets has not been matched in its domestic market for land and capital, nor in the reform of the state-dominated system of enterprise ownership. Recent rapid growth of the private sector and foreign-invested activities notwithstanding, Viet Nam's state-owned enterprises (SOEs) and trading companies retain privileged access to domestic credit from the state-owned banking system. State banks, in turn, engage heavily in 'policy lending' or the systematic favouring of SOEs in the allocation of domestic credit.[1]

[1] According to the General Statistics Office, in 2017, state firms comprised 0.4% of all enterprises and contributed 15.1% of revenue but accounted for as much as 28.8% of capital and only 8% of employment (Dang, Nguyen, Taghizadeh-Hesary, 2020). State firms accounted for 17% of outstanding debt in the economy but were responsible for 60% of non-performing loans (Dang, Nguyen, Taghizadeh-Hesary, 2020).

Viet Nam's SOEs have also been relatively well insulated from the country's broader programme of economic reform. During the early reform period, many – mainly smaller – SOEs were dissolved, equitised (i.e. partially privatised), and/or merged into larger entities known as state economic groups (SEGs). However, the surviving SOEs – and the SEGs – continue to receive preferential treatment in forms ranging from easier and cheaper credit to favourable access to land, markets (including government procurement), and research and development resources (Vu, 2014).[2] In the domestic capital market, privileged access to capital by these state firms has crowded out borrowing by small and medium-sized enterprises (SMEs), most of which are privately held (Nguyen and Freeman, 2009). Easy credit and lower borrowing rates help explain why state firms tend to be larger and to adopt more capital-intensive production technologies. In addition, they typically employ more skilled labour than private firms. Yet state firms in Viet Nam are also known for being less efficient in their use of capital and other resources. During the reform period, they displayed persistently low capital productivity and contributed little to total employment growth (World Bank, 2012).[3] Their continued existence – despite persistent inefficiency – has thus earned them the nickname 'zombie companies'.

Against this background, this paper examines what a more equitable capital market would mean for state and private firms' labour and capital productivity as well as for overall productivity in the economy. The consequences of Viet Nam's capital market distortions for firms' technology choices are first explored. These, in turn, affect firms' factor demand, particularly the demand for capital and relative demand for skilled labour, which has implications for capital and labour productivity both at the firm level and in the economy as a whole.

This topic relates to the literature on credit-based industrial policy, in which governments use policy interventions to allocate capital to favoured firms and industries with the aim of promoting industrialisation and economic growth. However, this literature has

---

[2] Although overt interest rate subsidies to SOEs have been largely removed in recent years, their successors – the SEGs – have found numerous ways to maintain equivalent credit market advantages. Amongst the most significant innovations, SEGs and SOEs have diversified their activities to include wholly owned finance and insurance companies and banks, from which they borrow (and lend to each other) at rates and on terms that are not disclosed (Vu, 2014).

[3] From 2000 to 2008, SOEs' average capital per enterprise increased sixfold, from D130 billion to D768 billion, with no accompanying increase in output or labour productivity. In fact, in 2000, SOEs' labour productivity was only one-quarter that of non-state-owned firms. By 2008, despite increases in capital intensity, SOEs' labour productivity lagged further to be only one-tenth of that of non-state firms (World Bank, 2012).

focussed primarily on the efficacy of such policies and the institutional conditions under which they advance development policy objectives (e.g. Quinn and Jacobson, 1989; Pack and Saggi, 2006; Dinh et al., 2013). This paper, in contrast, examines the effects of credit market interventions on the demand for and use of skilled and unskilled labour by heterogeneous firms. Despite its importance in a transitional economy context, other studies that have examined this link are not evident.

This topic also relates to the literature on capital accumulation, technological advances, capital–skills complementarity, and their impact on the relative demand for skilled labour. Some studies have questioned whether the capital–skills complementarity hypothesis holds (e.g. Bergstrom and Panas, 1992; Goldin and Katz, 1998; Duffy, Papageorgiou, Perez-Sebastian, 2004; Zhou, 2001; Henderson, 2009; Akay and Yuksel, 2009). This hypothesis found moderately strong support in wealthy and developing countries. Many empirical studies also assumed that the hypothesis holds; then, they examined the impact of capital accumulation and technological advances on the relative demand for skilled labour and on wage inequality or the skills premium in wealthy countries (e.g. Autor, Katz, Krueger, 1998) and in developing countries (e.g. Mazumdar and Agnoli, 2004; Yasar and Morrison-Paul, 2008). This paper, however, adds an industrial policy dimension. It assumes capital–skills complementarity and examines how credit-based industrial policies affect firms' technological choices and – through them – the demand for skilled labour.

Regarding Viet Nam, Athukorala (2006) documented the persistent bias in trade policy towards state firms, even after extensive reforms in the early economic reform years. Since then, other studies examined the rationale for and effectiveness of Viet Nam's industrial policies (e.g. World Bank, 2012; Vu, 2014). One paper examined the effect of economic freedom – in particular capital freedom and domestic credit freedom – on firms' financial constraints and investments (Le and Kim, 2020). Others quantified trends in the demand for skills and returns to education (e.g. Doan and Tran, 2018; McGuinness et al., 2021), in some cases drawing a causal connection to the special role of capital market policies favouring state firms (Phan and Coxhead, 2013; 2020). In this paper, these contributions are integrated by looking directly at the evolution of skills demand within Viet Nam's highly distorted capital market.

2. Theory

2.1. Context

A theoretical model first examines how differences in capital costs faced by state and private firms drive their technology choices, which then affect their patterns of factor demand, especially the demand for capital and for skilled and unskilled labour. Viet Nam's state firms tend to be larger and have more capital and skills intensity than their private sector counterparts. This can be the result of any combination of the following three choices.

State firms are more likely than private firms to choose to be in industries that are generally more capital- and skills-intensive. Indeed, state firms dominate all capital-intensive sectors such as mining, petrochemicals, energy, and telecommunications.

Within a given industry, state firms are more likely than private firms to use a production technology that is more capital- and skills-intensive (i.e. state and private firms have different isoquants).

Given industry and technology choice, state firms employ capital in a higher ratio to labour – and more skilled labour in a higher ratio to less skilled labour. That is, even when state and private firms coexist in the same industry and use the same technology, state firms select more capital- and skills-intensive techniques (i.e. state and private firms choose to be at different points on the same isoquant).

Of the above three choices, the first is a long-term decision, and the second a medium-term decision. The third is likely the shortest term. In this paper, industry choice is taken as a given; it focusses on examining firms' technology choices, which then affect their demand for capital and skills. In other words, the focus is on examining firms' factor demand behaviour in the medium term.

A model is then proposed with two technologies, one with high fixed costs but greater efficiency, and one with low fixed costs but lower efficiency. As long as the capital cost distortion is large enough (i.e. the cost of capital to state firms is sufficiently low and that to private firms is sufficiently high), state firms will choose the high-efficiency, high fixed-cost technology, while private firms will choose the low-efficiency, low fixed-cost technology. These choices will drive differences in factor employment between state and private firms.

2.2. Model

All firms are assumed to take, as a given, the wages for skilled and unskilled workers, capital prices, and scale of production (or output). The following notation is used: K is capital; S is skilled labour; N is unskilled labour; H is the high fixed-cost/high-efficiency technology; L is the low fixed-cost/low-efficiency technology; w_i is the wage paid to labour of type i, where the subscript denotes skilled or unskilled; r_j (j = state, private) is the capital price faced by firms in either sector; and Q is the quantity of output. Q is not an output level that varies daily or in the short term but with a firm's scale of production in the long term. This, by construction, is exogenous to a firm's medium-term decision on technology choice. A longer-term and more general model would allow a firm to choose output level and technology simultaneously.

Production technologies are such that firms' factor demands are as described below. To simplify the notation, firm-specific subscripts are suppressed. Firm-level capital demand is given by:

$$K = k_i + \gamma(k_i)Q, \qquad (i = H, L) \tag{1}$$

where k_i is the fixed capital investment (in machinery and other productive assets) associated with the use of technology i. It is assumed that $k_H > k_L$. That is, the advanced version of the technology requires a higher fixed cost or larger investment in long-term capital stock. $\gamma(k_i)$ is the unit variable capital cost or the capital needed to produce one unit of output,[4] and $\gamma(k_i)Q$ is the total variable capital cost. $\gamma'(.) < 0$ or $\gamma(k_H) < \gamma(k_L)$ is assumed. That is, the more advanced technology generates greater production efficiency (i.e. lower variable capital cost), although it requires a higher fixed cost.[5] This provides firms with an incentive to use advanced technology. Firm-level demand for skilled labour is given by:

$$S = k_i \cdot \frac{r_j}{w_S} + \beta(k_i)Q \qquad (j = \text{state, private}) \tag{2}$$

[4] One can also think of variable capital as simpler and cheaper machines and tools that do not last long.

[5] The ordinary least squares (OLS) method is used to regress the natural log of fixed capital (proxied by long-term assets) against the natural log of variable capital per unit of revenue (proxied by short-term assets divided by net revenue), controlling for regional and industry dummies. For the 2016 survey year, the coefficient on the log of variable capital per unit of revenue is negative and statistically significant, with a value of –0.56. This means that a 1% increase in fixed capital cost is associated with a 0.56% decrease in unit variable capital cost. This empirical evidence supports the assumption in Section 12.3 that fixed capital cost and variable unit capital cost are negatively related.

The demand for skilled labour has a fixed component, $k_i \cdot \frac{r_j}{w_S}$, which is independent of output level and a variable component $\beta(k_i)Q$ that depends on Q. A fixed amount of skilled labour is needed, because even before any output can be produced, a firm needs engineers and managers. Furthermore, under the assumption of complementarity between capital and skills, this fixed amount of skilled labour should be positively related to fixed capital k_i. On one hand, the more physical capital there is, the more skilled workers are needed to utilise it. On the other hand, physical capital (e.g. plants and equipment) is needed to make skilled labour productive.

In equation (2), for mathematical convenience, the fixed cost of skilled labour is assumed to take a specific functional form, $k_i \cdot \frac{r_j}{w_S}$. Then, $\frac{r_j}{w_S}$ is a coefficient that linearly matches k_i units of capital with a corresponding number of units of skilled labour. More general functional forms can be used; as long as the fixed cost of skilled labour is positively related to the fixed cost of capital, the model's main results are qualitatively unchanged.

The marginal skilled labour cost, $\beta(k_i)$, is the variable skilled labour cost – the amount of skilled labour needed to produce one unit of output. It follows from the assumption of a constant proportion of capital to skills in fixed costs that $\beta'(.) < 0$ or $\beta(k_H) < \beta(k_L)$. That is, high-cost technology is more efficient; after fixed costs have been covered, less skilled labour is needed to produce each additional unit of output. Firm-level demand for unskilled labour is, for simplicity, a linear function of output:

$$N = cQ \qquad (3)$$

where $c > 0$. If there is no production, then no unskilled labour is needed.

The price of output is assumed to be normalised to unity. Thus, the profit of a firm in sector j (state or private) can be expressed as:

$$\begin{aligned} \pi^j(i) &= Q - r_j K - w_S S - w_N N \\ &= Q - r_j[k_i + \gamma(k_i)Q] - w_S\left[k_i \cdot \frac{r_j}{w_S} + \beta(k_i)Q\right] - w_L \cdot cQ \\ &= Q\left[1 - r_j\gamma(k_i) - w_S\beta(k_i) - w_L c\right] - 2k_i r_j \end{aligned}$$

Regarding the technology choice by state firms, for a state firm with a given level of long-run output Q, the difference in profit between the high- and low-efficiency technologies is:

$$\pi_H^{state} - \pi_L^{state}$$
$$= Q\{-r_{State}[\gamma(k_H) - \gamma(k_L)] - w_S[\beta(k_H) - \beta(k_L)]\} - 2r_{State}[k_H - k_L] \quad (4)$$

Since $k_H > k_L$, $\beta'(.)$, and $\gamma'(.) < 0$, the term within parentheses is expected to be positive. So, as long as r_{State} – the unit cost of capital to a state firm – is small enough, π_H^{state} is greater than π_L^{state} *ceteris paribus*, and a state firm will choose the high-efficiency technology. This can be formally stated as in Proposition 1a and Proposition 1b below.

Proposition 1a

As long as

$$r_{state} < \bar{r} = \frac{w_S[\beta(k_L) - \beta(k_H)]}{\frac{2(k_H - k_L)}{Q} + \gamma(k_H) - \gamma(k_L)} \quad (5)$$

state firms choose high fixed costs and high-efficiency technology.

Proof: This follows from equation (4).

Proposition 1b

As the long-term production level Q increases, state firms can bear higher unit capital costs and still adopt high-efficiency technology.

Proof: See Appendix.

Proposition 1a establishes the maximum unit capital cost $\bar{r}$ above which state firms will not adopt high-efficiency technology, because high fixed costs – driven by the high cost of capital – is not worth the efficiency gained, given the scale of operation. Proposition 1b implies that a higher level of production allows state firms to bear more of the fixed cost of adopting high-efficiency technology. Hence, at higher levels of long-run output, a lower subsidy rate is sufficient to induce state firms to adopt the more efficient technology. Average costs that decline with scale suggest that state firms could take advantage of cheaper capital to establish themselves as exporters to the world market. To date, however, no state-owned Vietnamese manufacturing enterprise has succeeded as a global exporter, which likely indicates that the cost of capital is not the binding constraint on their expansion.

Regarding technology choice by private firms, analogously to state firms, the difference in profit between high- and low-efficiency technologies is:

$$\pi_H^{private} - \pi_L^{private} = Q\{-r_{private}[\gamma(k_H) - \gamma(k_L)] - w_S[\beta(k_H) - \beta(k_L)]\} - 2r_{private}[k_H - k_L] \quad (6)$$

If $r_{private}$ is big enough, *ceteris paribus*, then $\pi_H^{private} < \pi_L^{private}$. This leads to Proposition 2 below.

Proposition 2

As long as

$$r_{private} > \bar{r} = \frac{w_S[\beta(k_L) - \beta(k_H)]}{\frac{2(k_H - k_L)}{Q} + \gamma(k_H) - \gamma(k_L)} \quad (7)$$

private firms choose the low-efficiency technology.

Proof: See Appendix.

It is imperative that the impact of a capital market intervention on a firm's technology choice be understood, as it then affects its demand for and employment of skilled labour and capital. This impact can be summarised in Proposition 3 and Proposition 4 below.

Proposition 3

Relative to private firms, state firms have higher fixed costs of capital but lower unit variable costs of capital.

Proof: When the conditions in Proposition 1a and Proposition 2 are satisfied, state firms choose high technology, while private firms choose low technology, leading directly to Proposition 3.

Proposition 4

There is a U-shaped quadratic relationship between the long-run output level and ratio of skilled to unskilled labour. As the output increases, this ratio first diminishes then increases.

Proof: See Appendix.

The intuition for Proposition 4 is as follows. There may be some firms that operate at a production scale so low that they never choose high-efficiency technology, regardless of the prices of capital and labour. For such firms, a larger production run (i.e. a higher Q) simply translates into the increased employment of unskilled labour, which causes their share of skilled labour in total labour to decline. However, once Q becomes large enough to make the fixed costs worthwhile, firms start adopting high-efficiency technology, growing their employment of skilled labour as required to cover the fixed cost of doing so. At this point, growth in skilled labour employment begins to outpace that of unskilled labour, and the firm's share of skilled labour starts to rise.

In the next section, the hypotheses implied by Proposition 3 and Proposition 4 are empirically tested.

3. Empirics

3.1. Data Sources

Data from Viet Nam's enterprise censuses – in particular the years 2007, 2011, and 2016 – are used, as data were collected during these years on the skills composition of workers at each firm surveyed. These empirical results for these 3 survey years are then presented, but the discussion focusses on 2016, because the results do not vary much across the years.

The enterprise censuses covered all enterprises with independent accounting systems that were established under and governed by the Law on SOEs, Law on Cooperatives, Law on Enterprises, and Law on Foreign Investment in Viet Nam. In other words, the censuses covered firms with various forms of ownership in all sectors and industries. A shortcoming is that they largely ignored informal enterprises, because the criterion for inclusion in the censuses was establishment and governance under the above laws.[6] Firms self-reported data by filling out questionnaires, which asked for information on employment, incomes of employees, number of establishments and equipment, assets and liabilities, investments, capital stock, production costs, turnover, products, profits, inventories, taxes, research and development investments, information technology applications, and other details.

[6] This shortcoming is not a problem for this study, because the current study focusses more on large firms.

3.2. Descriptive Statistics

Table 1 provides summary statistics of the 2016 enterprise census for the main variables of interest, and Figures 12.1a–1e help visualise those statistics. Long-term assets (excluding long-term receivables) are used as a proxy for fixed capital, and short-term assets (excluding short-term receivables and inventories) are used as a proxy for variable capital. Skilled labour is defined as all workers with any kind of tertiary credential.

Table 1: Summary Statistics from the Enterprise Censuses

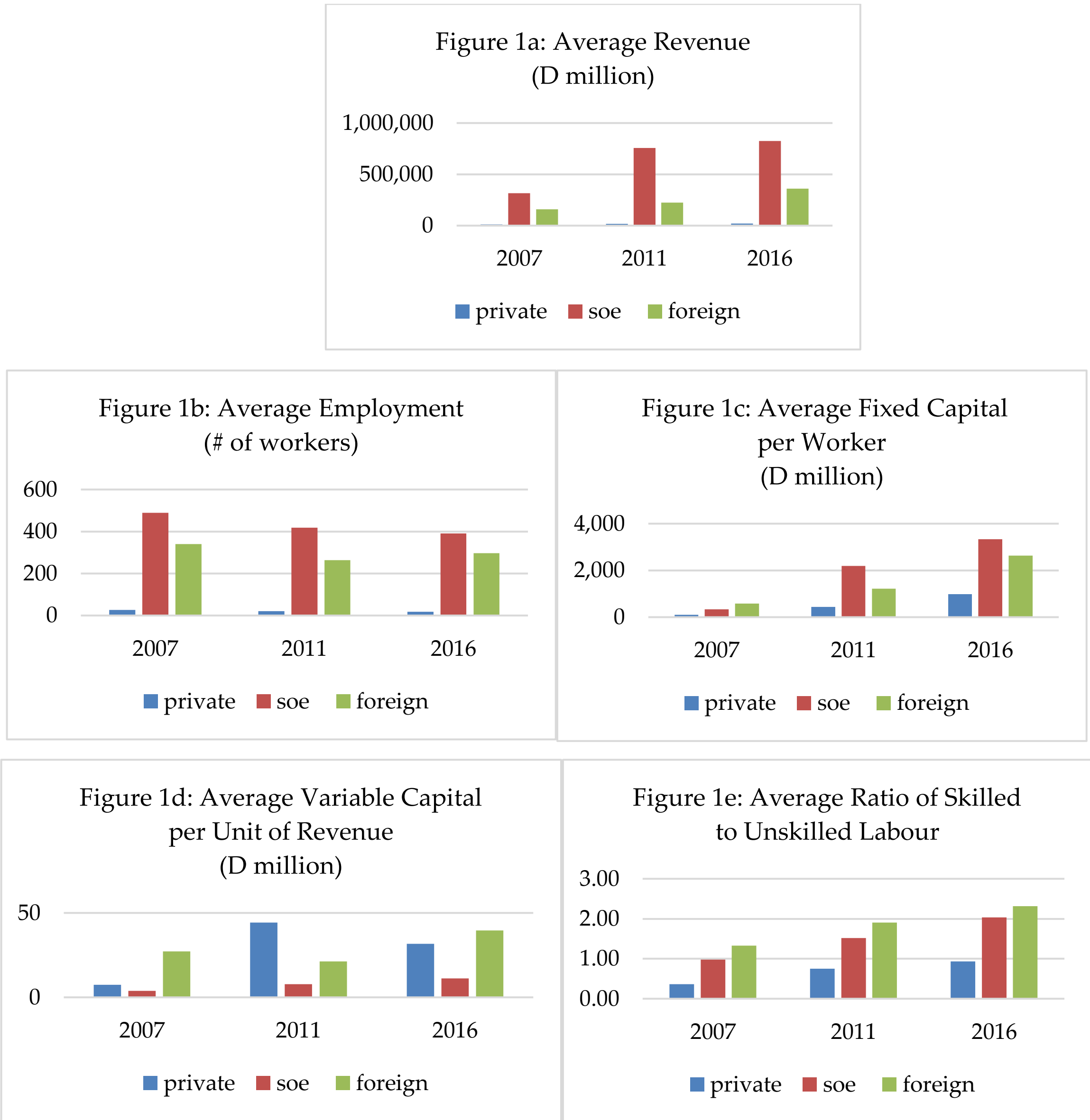
	2007				2011				2016			
	Full Survey Year	Private	SOE	Foreign	Full Survey Year	Private	SOE	Foreign	Full Survey Year	Private	SOE	Foreign
# of obs	155,663	146,968	3,735	4,960	339,265	325,432	3,627	10,206	517,675	501,016	2,649	14,010
%	100.0	94.4	2.4	3.2	100.0	95.9	1.1	3.0	100.0	96.8	0.5	2.7
Average revenue	23,352	11,934	315,149	159,353	32,007	18,061	756,846	224,251	34,551	20,879	824,651	361,609
Standard deviation	411,268	95,292	2,078,094	1,310,375	702,739	262,693	5,217,721	2,088,105	989,600	239,509	4,160,230	5,471,972
# of obs	154,988	146,386	3,726	4,876	332,547	319,369	3,606	9,572	494,185	477,932	2,632	13,621
Average employment	47	26	490	340	32	21	418	263	27	17	391	296
Standard deviation	436	117	2,240	1m240	283	102	1m324	1,298	276	115	973	1,437
# of obs	155,715	147,020	3,735	4,960	338,796	325,466	3,627	9,703	517,632	500,974	2,649	14,009
Average fixed capital per worker	129	107	342	585	490	446	2,190	1,213	1,046	982	3,340	2,640
Standard deviation	1,460	1,236	1,970	4,225	18,499	17,957	46,026	15,942	31,466	29,318	24,284	72,109
# of obs	148,669	140,057	3,721	4,891	297,041	284,541	3,603	8,897	451,156	434,799	2,635	13,722
Average variable capital per unit of revenue	8	7	4	27	43	44	8	21	32	32	11	40
Standard deviation	160	153	77	326	772	785	241	298	724	721	231	869
# of obs	153,735	145,214	3,709	4,812	315,291	303,036	3,576	8,679	442,232	426,521	2,608	13,103
Average ratio of skilled to unskilled labour	0.41	0.36	0.98	1.33	0.79	0.75	1.52	1.90	0.98	0.94	2.04	2.31
Standard deviation	2.04	1.75	4.12	5.30	2.68	2.27	4.65	8.61	2.85	2.37	6.07	9.23
# of obs	151,798	143,579	3,692	4,527	289,966	278,871	3,527	7,568	385,016	371,634	2,564	10,818

SOE = state-owned enterprise.

Source: GSO (2007, 2011, 2016).

Data from the first row in Table 1 reveal that there are many more private firms than state or foreign-invested firms in Viet Nam. Figures 12.1a and 12.1b confirm that private firms, on average, are much smaller than state firms in terms of both revenue and employment. In accordance with Proposition 3, private firms have significantly less fixed capital per worker but higher variable capital per unit of revenue than state firms (Figures 12.1c and 12.1d). Also in accordance with Proposition 4, private firms employ less skilled labour; in 2016, private firms' average ratio of skilled to unskilled labour is 0.94, compared to 2.04 of state firms (Table 1 and Figure 1e).

Figure 1: Summary Statistics from the Enterprise Census



SOE = state-owned enterprise.
Source: GSO (2007, 2011, 2016).

Although the focus is not on foreign-invested firms, data are presented on them. It is clear that foreign-invested firms are more like state firms than to private firms; they are larger than private firms in terms of both revenue and employment, and they also have higher fixed capital and employ more skilled labour. Their unit variable capital, however, is more like that of private firms.

Several important trends can also be seen in the data. From 2007 to 2016, firms of all ownership types increased their employment of fixed capital (Figure 1c), while the ratio of skilled to unskilled labour also increased for all three types of firms (Figure 1e). These two trends suggest that the Vietnamese economy has become both more capital- and skills-intensive over the years; this makes sense for a growing and industrialising economy and accords with the assumption that capital and skills are complements. No clear trend can be observed for variable capital (Figure 1d).

3.3. Estimation Strategy

To test Proposition 3, the following two equations are estimated:

$$\text{Fixed } K = \alpha_0 + \alpha_1 \text{SOE} + \alpha_2 \text{foreign} + \alpha_3 \text{Revenue} + \alpha_4 Z + \epsilon \tag{8}$$

$$\frac{variable\ K}{Revenue} = \beta_0 + \beta_1 \text{SOE} + \beta_3 \text{foreign} + \beta_4 Z + \epsilon \tag{9}$$

where Z is a set of regional and industry dummies. These dummies account for industry fixed effects because the model assumes that industry choice is a given.

The hypotheses to be tested are:

H1: $\alpha_1 > 0$ (i.e. state firms have higher fixed capital)

H2: $\beta_1 < 0$ (i.e. state firms have lower unit variable capital)

The dependent variables in equations (8) and (9) are both highly positively skewed – even after excluding observations with zero values – so two methods are then employed: (i) taking the natural logs of the dependent variables and revenue (i.e. an important independent variable that is also positively skewed), then using the ordinary least squares (OLS) method; and (ii) using the generalised linear model (GLM) with Gamma distribution and log link.[8]

To test Proposition 4, the following equation using OLS is estimated:

$$\ln\left(\frac{S}{N}\right) = \delta_0 + \delta_1 SOE + \delta_2 foreign + \delta_3 \ln(\text{revenue}) + \delta_4 \ln(revenue)^2 + \delta_5 Z + \epsilon \quad (10)$$

The hypotheses to be tested are:

H3: $\delta_1 > 0$ (i.e. state firms have a higher skilled–unskilled labour ratio)

H4: $\delta_3 < 0$ and $\delta_4 > 0$ (i.e. the skilled–unskilled labour ratio diminishes as the long-term output level increases)

In all survey years, many observations have missing or zero values for important variables. In the 2016 enterprise census, for instance, many firms reported having zero skilled labour (i.e. 66,244 firms or about 12.8% of the sample), zero revenue (i.e. 51,183 firms or about 10.0% of the sample), zero fixed capital (i.e. 109,252 firms or about 32.0% of the sample), or zero unskilled labour (i.e. 132,616 firms, or about 25.0% of the sample). Such firms were excluded from the regressions either because the ratios of skilled to unskilled labour could not be calculated, or because the log functions could not be operated on zero values. An examination of these firms suggests that they are generally very small with either low revenue and/or average employment of only a few workers.[9] As will be discussed in detail in the next section, many of the qualitative results are robust when the sample is restricted to larger firms. So, excluding these very small firms from the regressions do not materially affect the narrative.

For a robustness check, regressions are run for the full samples and the sub-samples of firms with revenue above the 50th percentile and above the 90th percentile. There are two main reasons for this. First, it does not make sense to compare the behaviour of very small firms (most of which are private) to the behaviour of state firms (most of which are medium-sized or large). This model is better used to describe the behaviour of firms that are not too small –

[8] In the GLM with Gamma distribution and log link, the random component follows the Gamma distribution (which works well for data with positive values and that are positively skewed), and the dependent variable is linearly related to the independent variables via the natural log function (which is convenient, as it is free of the retransformation problem associated with taking the log of the dependent variable and using OLS).
[9] For the 2016 enterprise census, the average revenue and employment of firms with zero skilled labour were D6,608 million and 6.5 employees, compared with D38,637 million and 29.7 employees for firms with reported and positive skilled labour.

another reason to exclude all small firms that report zero revenue, zero fixed capital, or zero skilled labour. Second, in the theoretical model, the long-term production level (*Q*) is taken as a given and is considered an important determinant of (medium-term) technology choice. Firms' behaviour therefore would vary; hence, regression estimates could change depending on the firm size. Finally, there are studies in the literature suggesting that firms' financial behaviour – or the effect of financial market imperfections on firms' behaviour – vary by firm size (Beck et al., 2005; 2008).

3.4. Estimation Results

Tables 2a, 2b, 3a, 3.b, and 4 present regression estimates for equations (8), (9), and (10) using the 2007, 2011, and 2016 enterprise censuses.

Table 2a: Determinants of Fixed Capital Demand
(General Linear Model with Gamma Distribution and Log Link)

	2007			2011			2016		
	Full Sample	50th	90th	Full Sample	50th	90th	Full Sample	50th	90th
SOE dummy	2.344	1.105	0.828	2.848	1.488	0.710	3.178	2.209	1.207
Foreign dummy	1.991	1.113	0.574	2.009	0.935	0.427	2.159	0.998	0.421
Log of revenue	0.376	0.843	0.905	0.286	0.774	0.932	0.244	0.754	0.924
# of obs	148,268	75,930	15,310	294,654	156,880	32,356	440,720	229,276	47,989
AIC	16.27	16.90	21.06	17.62	18.11	21.86	18.05	18.55	22.19

AIC = Akaike information criterion, SOE = state-owned enterprise.
Notes:
The dependent variable is fixed capital (proxied by long-term assets excluding long-term receivables).
Constant term, regional dummies, and industries dummies are included but not reported.
All coefficients are statistically significant at a 99% confidence level.
Source: Authors.

Table 2b: Determinants of Fixed Capital Demand

(Ordinary Least Squares)

	2007			2011			2016		
	Full Sample	50th	90th	Full Sample	50th	90th	Full sample	50th	90th
SOE dummy	1.600	1.140	0.910	2.130	1.192	0.861	2.604	1.373	1.040
Foreign dummy	1.650	1.099	0.690	1.566	0.944	0.549	1.450	0.750	0.383
Log of revenue	0.561	0.751	0.902	0.454	0.802	0.940	0.380	0.801	0.949
# of obs	141,825	74,417	15,171	249,187	147,683	31,586	332,134	203,149	45,136
Adjusted R-squared	0.522	0.5987	0.6029	0.4075	0.4736	0.5126	0.3426	0.438	0.4745

SOE = state-owned enterprise.

Notes:

1. The dependent variable is fixed capital (proxied by long-term assets excluding long-term receivables).
2. Constant term, regional dummies, and industries dummies are included but not reported.
3. All coefficients are statistically significant at a 99% confidence level.

Source: Authors.

Tables 2a and 2b show that hypothesis 1 cannot be rejected, as the SOE coefficient is positive and statistically significant in all regressions and subsamples, regardless of the econometric method used. According to regression 7 in Table 2a (i.e. a full sample for 2016), the SOE coefficient is 3.178, which translates to a marginal effect of approximately D47,282 million (at predicted means of fixed capital D16.129 million). That is, an average state firm has a fixed capital stock that is D47,282 million higher than that of an average private firm, controlling for revenue difference and regional and industry differences. If the sample is restricted to the largest firms (i.e. those in the 90th percentile of revenue distribution), then the SOE coefficient is 1.207, which translates to a fixed capital stock that is D192,649 million larger (at predicted means of fixed capital D116,657 million).

Table 3a: Determinants of Variable Capital Demand

(General Linear Model with Gamma Distribution and Log Link)

	2007			2011			2016		
	Full Sample	50th	90th	Full Sample	50th	90th	Full Sample	50th	90th
SOE dummy	–0.738	0.191**	0.464***	–2.310***	0.118	0.616***	–1.760***	–0.250**	0.350***
Foreign dummy	1.897***	0.14*	0.283**	0.082	0.187	0.255***	0.007	–0.094	0.240***
# of obs	153,762	77,446	15,537	315,346	166,184	33,242	442,301	246,955	49,408
Log likelihood	–372,156	41,765	18,743	–1,392,625	–29,045	32,626	–1,885,124	–57,962	46,117

SOE = state-owned enterprise.

Notes:

1. The dependent variable is the natural log of variable capital per unit of revenue (variable capital is proxied by short-term assets, excluding short-term receivables and inventories).
2. Constant term, regional dummies, and industries dummies are included but not reported.

Source: Authors.

Table 3b: Determinants of Variable Capital Demand

(Ordinary Least Squares)

	2007			2011			2016		
	Full Sample	50th	90th	Full Sample	50th	90th	Full Sample	50th	90th
SOE dummy	–0.281***	0.006	0.043***	–0.565***	–0.060***	0.027***	–0.538***	–0.090***	0.028***
Foreign dummy	–0.046***	–0.011**	0.018***	–0.332***	–0.002	0.033***	–0.331***	–0.030***	0.042***
# of obs	153,757	77,444	15,492	315,317	166,182	33,242	442,282	246,955	49,408
Adj. R2	0.17	0.29	0.41	0.09	0.18	0.33	0.06	0.14	0.27

SOE = state-owned enterprise.

Notes:

1. The dependent variable is the natural log of variable capital per unit of revenue (variable capital is proxied by short-term assets, excluding short-term receivables and inventories).
2. Constant term, regional dummies, and industries dummies are included but not reported.

Source: Authors.

Table 3 indicates that the results are robust to the econometric method used. Hypothesis 2 (i.e. the SOE coefficient is negative, or state firms have lower unit variable capital) cannot be rejected when the sample includes smaller firms. However, when the sample includes larger firms (i.e. those in the 90th percentile of revenue distribution), this hypothesis can be rejected, as the SOE coefficient turns positive and is statistically significant. The model possibly does not explain the mechanism behind state versus private firms' demand for capital. Perhaps state firms are very inefficient; they do not seem to be able to achieve lower unit variable capital cost despite the high fixed capital investment that they incur.

Table 4: Determinants of Relative Labour Demand

(Ordinary Least Squares)

	2007			2011			2016		
	Full Sample	50th	90th	Full Sample	50th	90th	Full Sample	50th	90th
SOE dummy	0.333	0.293	0.186	0.510	0.410	0.289	0.560	0.463	0.278
Foreign dummy	0.016	0.023	0.086	0.033	0.019	0.032	0.049	0.048	0.066
Log of revenue	–0.285	–0.608	0.087	–0.164	–0.577	–0.263	–0.116	–0.432	–0.276
Log of revenue squared	0.025	0.029	0.001	0.005	0.027	0.014	0.004	0.020	0.014
# of obs	58,651	43,226	10,774	211,125	112,937	34,299	292,879	188,154	43,097
Adjusted R-squared	0.3386	0.3494	0.4249	0.2687	0.2724	0.3339	0.2161	0.2373	0.3079

SOE = state-owned enterprise.

Notes:

1. The dependent variable is the natural log of ratio of skilled to unskilled labour.
2. Skilled labour includes workers with at least a junior college degree.
3. Constant term, regional dummies, and industries dummies are included but not reported.
4. All coefficients reported in this table are statistically significant at a 99% confidence level, except those in italics (not statistically significant).

Source: Authors.

Table 4 (first row) suggests that hypothesis 3 cannot be rejected as well. The SOE coefficient is positive and statistically significant in all regressions for all survey years and subsamples, confirming that state firms are more skills-intensive than private firms *ceteris paribus*. Like Table 2a and Table 2.b, the magnitude of the SOE coefficient decreases as the sample is restricted to larger firms, but it remains high. For example, in the last column of Table 4, the estimated value is 0.278, which means an average state firm has a skilled–unskilled labour ratio that is exp(0.278) = 1.32 times higher than that of an average private firm, controlling for revenue difference and for regional and industry differences.

Table 4 also shows that hypothesis 4 cannot be rejected for all survey years and subsamples (except the 90th percentile subsample from 2007). The coefficient of log of revenue is negative and statistically significant, while the coefficient of its square is positive and statistically significant, suggesting a quadratic relationship between revenue (a proxy for long-term production level *Q*) and the relative demand for skilled labour (measured by the ratio of skilled to unskilled labour), as hypothesised in Proposition 4. This confirms that smaller firms – which are mostly private – are largely limited to labour-intensive techniques and increase output by adding unskilled labour, whereas large firms are more likely to reach a scale at which it becomes profitable to adopt a more skills-intensive and efficient technology.

In all three estimation tables, moving across the models from left to right, the number of observations drop significantly, yet the regression's goodness-of-fit improves either slightly or significantly. This suggests that the reduction in noise (thanks to larger firms providing better-quality data to the enterprise censuses) outweighs the loss in the number of observations. This also validates the decision to drop observations with zero values for dependent variables; all are very small firms.

4.Welfare and Policy Implications

This study's empirical results detail the state and private firm differences in technology choice and factor demand, as hypothesised by the theoretical model developed in Section 2. These differences may be largely – although not exclusively – driven by differential capital prices faced by state and private firms a result of capital market intervention.

Supposing this to be the case, what would happen if lending policies and practices that favour state enterprises were weakened or eliminated? Holding other factors constant, the removal of a capital market intervention that favours state firms would increase their unit capital costs and may also lower those costs for private firms. This, in turn, would lead to one of the following outcomes:

(i) **Case 1.** Many state firms switch to low-efficiency technology, while very few private firms switch to high-efficiency technology; overall, there are fewer firms using high-efficiency technology. This outcome would be more likely if many private firms are far below the critical production scale threshold needed to cover fixed costs in high-efficiency technology. Thus, the release of capital by state firms is not enough to significantly reduce the unit capital cost faced by private firms in the competitive capital market. This scenario is most believed by policy makers and serves to justify their interventions in the capital market.

(ii) **Case 2.** Some state firms change to low-efficiency technology, and a similar number of private firms change to high-efficiency technology. This happens when enough private firms are close to the critical threshold of adopting high-efficiency technology. The release of capital by state firms lowers private sector capital costs by just enough to induce these firms to cross over.

(iii) **Case 3.** Few state firms change to low-efficiency technology,[10] but many more private firms change to high-efficiency technology; overall, many more firms adopt high-efficiency technology. This happens when many private firms are close to the critical threshold of adopting high-efficiency technology. The release of capital by state firms allows many of them to cross this threshold.

Le and Kim (2020) investigated the effect of relaxing capital market controls in Viet Nam and suggested that removing barriers to capital movement and deregulating the domestic capital market would increase investment. This paper's data, however, do not allow the identification of how many firms are below or above the critical threshold identified in Proposition 1a and Proposition 2 nor how far from the threshold that they are. As a result, which case will occur cannot be predicted if capital market interventions are eliminated. This is an area for future research.

One caveat is that the model and empirical investigations examine firms' factor demand in the medium term only, taking industry choice and scale of production as givens and holding

[10] In reality, it is unlikely that state firms that already adopted high-efficiency technology and incurred such fixed costs would switch to low-efficiency technology. The real impact of the removal of capital market intervention is that new state firms will be less likely to adopt high-efficiency technology.

all other policies constant at their initial values. If the capital market intervention is relaxed, so unit capital costs increase for state firms and decrease for private firms – and if firms believe that this policy change will be long – their long-term behaviour could also change. If Case 3 holds, however, the direction of changes implied by an increased production scale is clear. Private firms that increase their production scales will be more likely to adopt skills-intensive technologies; their decisions, in the aggregate, will drive up the skills premium. Since private firms account for the majority of employment, their decisions should dominate the effects of state firms' contraction. Similarly, if the government implements a package of policies that includes capital market reforms amongst other measures, the effect of state firm contraction on skilled labour demand could, in principle, be more than offset by increased demand elsewhere. These are qualitative predictions; quantifying long-run responses more precisely is a task best addressed with panel or experimental data and is beyond the scope of this paper.

5. Conclusion

In this paper, a model of technological choice with fixed costs was developed, and from that, testable hypotheses were generated on the demand for capital and skills by firms operating in a distorted capital market. Enterprise-level data were then used from Viet Nam to test propositions related to differences in capital and skills intensity and efficiency between state firms (which enjoy privileged access to domestic credit) and private firms (which are crowded out as a result).

Estimation results using Viet Nam's enterprise censuses confirmed most – but not all – of the hypotheses yielded by the theoretical model: (i) state firms in Viet Nam have significantly higher fixed capital stocks; (ii) state firms are much more skills-intensive than private firms for equivalent production scale; and (iii) there may be a U-shaped relation between long-term production scale and skills intensity, as smaller firms (which are mostly private) are largely limited to labour-intensive techniques and increase output by adding unskilled labour, while large firms are more likely to reach a scale at which it becomes profitable to adopt a more skills-intensive and (theoretically) more efficient technology.

Interestingly, the hypothesis about state firms having lower unit variable capital costs was rejected for large firms. This is consistent with the conjecture that large state firms do not achieve greater efficiency despite incurring higher fixed capital investments. This result is perhaps not surprising, as the literature on Viet Nam's state sector often found that state firms are generally less efficient than private firms.

Ex ante, if subsidies are removed, it is not clear from the model whether skilled labour demand would rise or fall. The estimation results do not entirely resolve this ambiguity but do reveal that the most likely outcome of a more level capital market playing field would be a substantial expansion in the technological efficiency of private firms. This effect is likely to dominate the corresponding contraction of state firms. In the longer term, other firm decisions – including the scale of production and even industry-level entry or exit – will also come into play.

It is helpful to compare these results and policy implications with others. Le and Kim (2020) examined a unique firm-level data set from 2006 to 2016, which included listed firms on the Ho Chi Minh City Stock Exchange and Hanoi Stock Exchange, finding that more capital freedom (i.e. fewer barriers on foreign investments) and more domestic credit freedom (i.e. less state ownership in the banking sector and fewer controls on borrowing and lending) reduced firms' financial constraints. They proposed removing barriers to capital movement and deregulating the domestic capital market to increase firms' investments in Viet Nam.

This paper, however, suggests a more nuanced effect on deregulating Viet Nam's capital market and firms' behaviour, including their investment behaviour and demand for skilled and unskilled labour. If the government considers substantial reform in the capital market, it should do so as part of a broader policy package aimed at ensuring that returns to educational investments increase – even if some of the country's largest employers of skilled labour contract. A more level playing field in capital markets – combined with greater access to world export markets – will create conditions under which SMEs perceive positive profits from greater scale and begin to adopt high-productivity technologies, thereby increasing skills demand and premiums.

References

Akay, G.H. and M. Yuksel (2009), 'Capital-Skill Complementarity: Evidence from Manufacturing Industries in Ghana, *Institute for the Study of Labor (IZA) Discussion Papers*, No. #4674 http://ftp.iza.org/dp4674.pdf

Athukorala, P.C. (2006), 'Trade Policy Reforms and the Structure of Protection in Vietnam', *The World Economy*, 29(2), pp.161–87.

Autor, D., L. Katz, and A. Krueger (1998), 'Computing Inequality: Have Computers Changed the Labor Market?', *Quarterly Journal of Economics*, 113(4), pp.1169–1213.

Beck, T., A. Demirguc-Kunt, L. Laeven, and R. Levine (2005), 'Financial and Legal Constraints to Growth: Does Firm Size Matter?' *The Journal of Finance*, 60(1), pp.137–77.

——— (2008), 'Finance, Firm Size and Growth', *The Journal of Money, Credit and Banking*, 40(7), pp.1379–1405.

Bergstrom, V. and E. Panas (1992), 'How Robust Is the Capital-Skill Complementarity Hypothesis?' *Review of Economics and Statistics*, 74(3), pp. 540–6.

Coxhead, I. (2016), 'Vietnam's Zombie Companies Threaten Long-Term Growth', East Asia Forum, 6 July, https://www.eastasiaforum.org/2016/07/06/vietnams-zombie-companies-threaten-long-term-growth/

Dang, L.N., D.D. Nguyen, and F. Taghizadeh-Hesary (2020), 'State-Owned Enterprises Reform in Vietnam: Progress and Challenges', *Asian Development Bank Institute (ADBI) Working Paper Series*, No. 1071, Tokyo: ADBI, https://www.adb.org/sites/default/files/publication/562061/adbi-wp1071.pdf

Dinh, T.M., E. Malesky, T.T. To, and D.T. Nguyen (2013), 'Effect of Interest-Rate Subsidies on Firm Performance and Investment Behavior during Economic Recession: Evidence from Vietnam', *Asian Economic Journal*, 27(2), pp.185–207.

Doan, T., Q. Le, and T.Q. Tran (2018), 'Lost in Transition? Declining Returns to Education in Vietnam', *European Journal of Development Research*, 30, pp.195–216. https://doi.org/10.1057/s41287-017-0080-9

Duffy, J., C. Papageorgiou, and F. Perez-Sebastian (2004), 'Capital-Skill Complementarity? Evidence from a Panel of Countries', *Review of Economics and Statistics*, 86(1), pp.327–44.

Duflo, E. (2001), ‘Schooling and Labor Market Consequences of School Construction in Indonesia: Evidence from an Unusual Policy Experiment’, *The American Economic Review*, 91(4), pp.795–813.

General Statistics Office of Vietnam (GSO), *Enterprise Census* (3 years: 2007, 2011, and 2016), https://www.gso.gov.vn/en/enterprises/

Goldin, C. and L. Katz (1998), ‘The Origins of Technology-Skill Complementarity’, *Quarterly Journal of Economics,* 113(3), pp.693–732.

Griliches, Z. (1969), ‘Capital-Skill Complementarity’, *Review of Economics and Statistics,* 51(4), pp.465–8.

Henderson, D.J. (2009), ‘A Non-Parametric Examination of Capital–Skill Complementarity’, *Oxford Bulletin of Economics and Statistics,* 71(4), pp.519–38.

Le, A.H. and T. Kim (2020), ‘The Effect of Economic Freedom on Firm Investment in Vietnam’, *The Journal of Asian Finance, Economics, and Business*, 7(3), pp.9–15.

Mazumdar, J. and M. Quispe-Agnoli (2004), ‘Can Capital-Skill Complementarity Explain the Rising Skill-Premium in Developing Countries? Evidence from Peru’, *Federal Reserve Bank of Atlanta Working Papers,* No.2004-11, Atlanta, GA: Federal Reserve Bank.

McGuinness, S., E. Kelly, T.T. Pham, T.T.T. Ha, and A. Whelan (2021), ‘Returns to Education in Vietnam: A Changing Landscape’, *World Development*, 138, https://doi.org/10.1016/j.worlddev.2020.105205.

McMillan, M. and D. Rodrik (2011), ‘Globalization, Structural Change and Productivity Growth’, *National Bureau of Economic Research (NBER) Working Papers,* No.17143, Cambridge, MA: NBER.

Nguyen V.T. and N.J. Freeman (2009), ‘State-Owned Enterprises in Vietnam: Are They “Crowding out” the Private Sector?’ *Post-Communist Economies,* 21(2), pp.227–47.

Pack, H. and K. Saggi (2006), ‘The Case for Industrial Policy: A Critical Survey’, *World Bank Policy Research Working Papers,* No.3839, Washington, DC: World Bank.

Phan, D. and I. Coxhead (2013), ‘Long-Run Costs of Piecemeal Reform: Wage Inequality and Returns to Education in Vietnam’, *Journal of Comparative Economics*, 41(4), pp.1106–22.

——— (2020), ‘Persistent Privilege? Institutional Education Achievement Gaps in Vietnam’, *The Developing Economies*, 58(4), pp.33–59.

Phang, S. (2013), ‘Vietnam Gets Tough on State Firms in Economic Growth Push’, *Bloomberg News*, 25 July, https://www.bloomberg.com/news/articles/2013-07-24/vietnam-gets-tough-on-state-firms-in-economic-growth-push#xj4y7vzkg

Quinn, P.D. and R. Jacobson (1989), ‘Industrial Policy through the Restriction of Capital Flows: A Test of Several Claims Made about Industrial Policy’, *American Journal of Political Science*, 33(3), pp.700–36.

Vu, T.T.A. (2014), ‘WTO Accession and the Political Economy of State-Owned Enterprise Reform in Vietnam’, *Global Economic Governance Programme Working Papers*, No. 2014/92, Oxford: Oxford University.

World Bank (2012), *Vietnam Development Report 2012: Market Economy for a Middle-Income Vietnam*, Washington, DC, http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2011/12/13/000333037_20111213003843/Rendered/PDF/659800AR00PUBL0elopment0Report02012.pdf

Yasar, M. and C. Morrison-Paul (2008), ‘Capital-Skill Complementarity, Productivity, and Wages: Evidence from Plant-Level Data for a Developing Country’, *Labour Economics*, 15(1), pp.1–17.

Zhou, H. (2001), ‘The Demand for Labour in Zimbabwe’s Engineering Industry: 1995–1997’, *South African Journal of Economics*, 69(4), pp.734–51.

Appendix: Mathematical Proofs

Proof of Proposition 1a and Proposition 2:

Equation (4) is set to be greater than zero:

$$\pi_H^{state} - \pi_L^{state} > 0$$

$$\leftrightarrow Q\{-r_{State}[\gamma(k_H) - \gamma(k_L)] - w_S[\beta(k_H) - \beta(k_L)]\} - 2r_{State}[k_H - k_L] > 0$$

$$\leftrightarrow -r_{State}\{Q[\gamma(k_H) - \gamma(k_L)] + 2[k_H - k_L]\} > Qw_S[\beta(k_H) - \beta(k_L)]$$

$$\leftrightarrow -r_{State} > \frac{Qw_S[\beta(k_H) - \beta(k_L)]}{Q[\gamma(k_H) - \gamma(k_L)] + 2[k_H - k_L]}$$

$$\leftrightarrow r_{State} < \bar{r} = \frac{w_S[\beta(k_L) - \beta(k_H)]}{\frac{2(k_H - k_L)}{Q} + \gamma_H - \gamma_L}$$

To prove Proposition 2, equation (6) is set to be less than zero. After some algebraic manipulations very similar to the above, the result is achieved.

Proof of Proposition 1b:

The derivative of $\bar{r}$ is taken with respect to Q. After some algebraic manipulation, the following is obtained:

$$\frac{\partial \bar{r}}{\partial Q} = w_S[\beta(k_L) - \beta(k_H)] \cdot \frac{-1}{\left[\frac{2(k_H - k_L)}{Q} + \gamma_H - \gamma_L\right]^2} \cdot 2(k_H - k_L) \cdot \frac{-1}{Q^2} > 0$$

The derivative is always positive, because $\beta(k_L) - \beta(k_H) > 0$ and $k_H - k_L > 0$ by assumption.

Proof of Proposition 4:

The ratio of skilled to unskilled labour is:

$$\frac{S}{N} = \frac{k_i \cdot \frac{r_j}{w_S} + \beta(k_i)Q}{cQ}$$

The first derivative of *S/N* is taken with respect to *Q:*

$$\frac{\partial(S/N)}{\partial Q} = \frac{-k_i \cdot \frac{r_j}{w_S}}{(cQ)^2} < 0$$

The second derivative of *S/N* is taken with respect to *Q:*

$$\frac{\partial^2(S/N)}{\partial Q^2} = \frac{k_i \cdot \frac{r_j}{w_S}}{c^2Q^4} > 0$$

$\frac{\partial(S/N)}{\partial Q} < 0$ and $\frac{\partial^2(S/N)}{\partial Q^2} > 0$

Similar calculations show the same result when taking the derivative of *S/(S + N)* with respect to *Q*.

ERIA Discussion Paper Series

No.	Author(s)	Title	Year
2023-06 (No. 478)	Shandre Mugan THANGAVELU	Structural Changes and the Impact of FDI on Singapore's Manufacturing Activites	June 2023
2023-05 (No. 477)	Yanfei LI, Jia ZHAO, and Jianjun YAN	Technological Innovation and the Development of the Fuel Cell Electric Vehicle Industry Based on Patent Value Analysis	June 2023
2023-04 (No. 476)	Etsuyo MICHIDA	Effectiveness of Self-Regulating Sustainability Standards for the Palm Oil Industry	June 2023
2023-03 (No. 475)	Ian COXHEAD and Nguyen Dinh Tuan VUONG	Does the Skill Premium Influence Educational Decisions? Evidence from Viet Nam	May 2023
2023-02 (No. 474)	Ha Thi Thanh DOAN, Kunhyui KIM and Mahdi GHODSHI	Divergence in Non-Tariff Measures and the Quality of Traded Products	May 2023
2023-01 (No. 473)	Dionisius A. NARJOKO	Foreign Direct Investment, Agglomeration, and Production Networks in Indonesian Manufacturing	May 2023
2022-43 (No. 472)	Peter WARR and Huy Quynh NGUYEN	Productivity Effects of Viet Nam's Rice Land Restrictions	March 2023
2022-42 (No. 471)	Yuki HIGUCHI, Vu Hoang NAM, and Tetsushi SONOBE	Do Management Interventions Last? Evidence from Vietnamese SMEs	March 2023
2022-41 (No. 470)	Huong-Giang PHAM, Tuong-Anh T. NGUYEN, and Hoang-Nam VU	Adoption of Sustainable Practices for Improving Agricultural Productivity in Viet Nam	March 2023
2022-40 (No. 469)	Quang Hoan TRUONG and Van Chung DONG	Impacts of FDI Presence and Product Sophistication on the Demand for Skilled and Unskilled Labour: Evidence from SMEs in Viet Nam	March 2023
2022-39 (No. 468)	Araba SEY	Availability of Gender-Disaggregated Data on the ASEAN Digital Economy	January 2023
2022-38 (No. 467)	Yose R. DAMURI and Deni FRIAWAN	RCEP and Indonesia: Economic Reform and Prospects for Implementation	January 2023
2022-37 (No. 466)	Lurong CHEN	The Indo-Pacific Partnership and Digital Trade Rule Setting: Policy Proposals	December 2022

2022-36 (No. 465)	Araba SEY	Gender Security and Safety in the ASEAN Digital Economy	December 2022
2022-35 (No. 464)	Araba SEY and Sara KINGSLEY	Women and Leadership in the ASEAN Digital Economy: Mapping the Rhetorical Landscape	December 2022
2022-34 (No. 463)	Upalat KORWATANASAKUL and Tran Thi HUE	Global Value Chain Participation and Labour Productivity in Manufacturing Firms in Viet Nam: Firm-Level Panel Analysis	October 2022

ERIA discussion papers from previous years can be found at:
http://www.eria.org/publications/category/discussion-papers