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The effect of trade policy on firm productivity in Thai manufacturing

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The paper examines the effect of trade policy on firm productivity using two recent industrial censuses of Thai manufacturing (i.e., 2006 and 2011). Trade policy and global participation are treated as two different variables in our analysis. Controlling for firms' global participation, which is defined as export-sale ratio and the extent to which raw materials are imported, our study finds that trade liberalization could induce firms to commit to activities that improve productivity. The effective rate of protection, where output and input tariffs are taken into consideration together, matters in improving firm productivity. Thus, it would be risky to continue tariff reform by focusing solely on a reduction in input tariffs while leaving output tariffs untouched. In fact, both input and output tariffs must be taken into consideration to neutralize incentives in trade policy reform.

JEL classification: F10, N75
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1. Introduction

While tariffs in general went down substantially in the past two decades after the establishment of the World Trade Organization in 1995, much remains to be done in developing countries. In particular, exceptions of liberalization schedules (i.e., tariff peaks) are often found together with an escalating tariff structure, where tariff rates are escalating from raw materials to finished products. This results in nominal protection underestimating actual/effective protection. It is done with a hope that maintaining such cross-border measures would give more time for firms to improve their international competitiveness and survive in the more intense competitive environment.

Whether the hope materializes or not is an empirical research question. Until the new millennium, there were a number of empirical studies examining the relationship between trade liberalization and firm performance. These studies can be categorized into two main groups. The first examines the relationship between trade openness and output growth through cross-countries econometric analyses at the aggregate level.[1] The second is based on case studies of specific countries.[2] The main finding is in favor of the hypothesis that trade protection retards firm performance and, eventually, medium- to long-term growth.

However, both groups of studies are subject to shortcomings. In the first group, the link between trade policy and firm performance is weak and, to a certain extent, treated as a black box. They are subject to serious econometric problems in terms of endogeneity and measurement errors. As argued in Levine and Renelt [1992] and Sala-i-Martin [1997], cross-country econometric analyses are tenuous at best. In the second group, there are policy insights, but their case studies include only a handful of countries and their analytical tools vary significantly across studies. This makes it difficult to generalize the findings of these studies.

From the late 1990s, the proliferation of plant-level data available in many countries allows researchers to re-visit and mitigate some of the above shortcomings. Where the effect of trade policy on firm performance is concerned, there are at least two aspects relevant in policy circles of developing countries.

The first aspect is related to self-selection hypothesis.[3] The positive relationship found between trade liberalization and performance could be due to a self-selection process, in which firms that enter export markets are already more productive than non-exporters before they ever actually begin to export. The self-selection hypothesis suggests that the nature of trade policy and firm market orientation must be treated as two separate explanatory variables in the analysis. While both could be important to productivity, they are two different things. The former refers to the policy environment, while the latter is a firm decision.

The second aspect of research in this field is to examine channels through which trade policy affects firm performance (Amiti and Konings [2007]; Melitz and Redding [2012]). In particular, Amiti and Konings [2007] argue possible different effects of input and output tariffs due to different operating channels. Lower output tariffs can increase productivity by inducing tougher competition, whereas cheaper imported inputs can raise productivity via learning, variety, and quality effects.

[1] See the literature reviews of this group of studies in Edwards [1993].
[2] Two influential works include the Bhagwati-Krueger project for the National Bureau of Economic Research in the 1970s and the Papageorgious-Michalely-Choksi study for the World Bank in the 1980s.
[3] See the literature review in Lopez [2005].

However, a number of case studies[4] point to the fact that introduction of new technologies does not guarantee that productivity increases instantaneously. Most likely, a long process of learning and mastery of skills may be required to reach high levels of productivity. Actually, a long-term commitment and real resources are required to have substantial effects on productivity. This can be influenced by the policy environment such as trade policy. As argued in these case studies, firms receiving the effective rate of protection (ERP) tend to be "unresponsive to improved technological capability". It does not matter whether effective protection is mainly driven by output or input tariffs. Hence, a decomposition of the ERP into output and input tariffs might not be appropriate.

Against this backdrop, the paper aims to examine the determinants of firm productivity with emphasis on the effects of trade policy. The 2006 and 2011 industrial censuses are used in our analysis. Our proposed study has at least three contributions to the existing literature:

- First, we carefully distinguish the possible effects between trade (export and import) and trade policy (e.g. cross-border protection) on productivity. The latter has important policy implications for trade policy reform.
- Second, we examine whether the effect of trade policy varies across firm types by introducing the interaction term between firms' specific and trade policy variable. The former focuses market orientation (whether firms participate in the global market) and input sourcing (whether firms import raw materials or intermediates from abroad).
- Third, the effect of output and input tariffs are re-examined as opposed to a case when using the ERP (both input and output tariffs combined). Whether the effects of output tariffs are actually less than that of input tariffs could have a substantial policy impact as policymakers in developing countries prefer a reduction in tariffs on inputs rather than on output.

Thailand is chosen for this study since trade policy reform remains a challenging issue for policymakers. In particular, efforts to streamline tariff rates to 3 rates (0-1 percent for raw materials, 5 percent for intermediates, and 10 percent for finished products) are at best far from complete. There is almost a fifth of tariff lines subject to a 20 percent tariff rate or higher. In addition, by design, the tariff structure in Thailand is cascading, so that nominal protection tends to underestimate the effective rate. Hence, effective protection seems to vary across industries. This allows us to test the effect of protection on firm productivity.

The remainder of this paper is organized as follows. Section 2 presents the analytical framework. Section 3 briefly discusses trade policy and firm

[4] See the cases of Keesing [1983], Keesing and Lall [1992], Westphal et al. [1979, 1984], Aw and Batra [1998], Wortzel and Wortzel [1981], Hobday [1995], Pietrobelli [1998], Pack and Saggi [1997], and Nelson and Pack [1999].

productivity in Thai manufacturing. Section 4 discusses the model, while section 5 presents the data set used in this study. Section 6 empirically assesses the effects of trade policy on firm productivity. The final section provides some conclusions and policy implications.

2. The analytical framework

Gains from trade in terms of output growth/productivity have been studied for several decades. Beginning with the standard neoclassical trade model, Ricardian comparative advantage model, and/or Hecksher-Ohlin-based comparative advantage, gains from trade are derived from resource reallocation from sectors the country has a comparative disadvantage in to those sectors in which it has comparative advantage. A country's comparative advantage is driven by technology, or resource endowment, or both. Note that under these model settings, trade could lead to output expansion, but it does not have an impact on rate of economic growth. In the 1980s, the source of gains from trade shifted to intra-industry trade. In this model setting, consumers enjoy a variety of products that are close but are not perfect substitutes. As a result, the market is fragmented in response to consumer wants and needs, and differentiated goods are produced under increasing return to scale and traded (Krugman [1979]; Helpman and Krugman [1985]). Fragmentation of the market results in a struggle by firms to attain adequate production volumes to cover fixed costs so that trade enlarges market size.

Note that all the models mentioned above are still based on a representative (homogenous) firm. They cannot explain well why in a given industry only some and not all firms export [Greenaway et al. 2004]. So the assumption of a representative firm is relaxed and the literature on firm heterogeneity has grown (Melitz [2003]; Bernard et al. [2003]). The firm heterogeneity literature argues that even within a narrowly defined industry, some firms are much larger, more productive, and more profitable than the others [Melitz and Trefler 2012]. International trade makes better-performing firms expand their products into larger markets, while resources are re-allocated from less productive firms into productive ones. This, therefore, leads to the improvement of industry efficiency.

Gains from trade are also examined in the economic growth literature. For example, in extensions of neoclassical models, including the Solow-Swan model and the Ramsey growth (optimal-saving) model, trade liberalization increases output level in the economy but not the rate of growth. The rate of growth in these models depends on growth of input and the rate of technological progress (Baldwin [1992]; Srinivasan and Bhagwati [1980]). As argued in the Harrod-Domar model, trade could generate positive growth effects under a circumstance, where the marginal product of capital is bounded by some positive number (Srinivasan [1999]; Lopez [2005]).

The effect of international trade on productivity and on economic growth has been highlighted in the new or endogenous growth theory (Young [1991]; Rivera-Batiz and Romer [1991]; Pack [1994]). Nonetheless, the effect of trade liberalization on productivity and growth in developing countries is still unclear. On the one hand, Rivera-Batiz and Romer [1991] argue that international integration helps to improve technological progress by expanding the size of the market, which helps to expand innovation activity. In addition, cross-border technological spillovers could be created from integration so that economic growth/productivity is promoted. This mechanism occurs in both developing and developed countries. On the other hand, Young [1991] argues that the positive effect of trade on growth would be far less in developing countries. While trade could positively affect labor productivity through learning by doing process, the gains would be larger for developed countries. These countries produce and trade products that still need learning by doing activity. But the products that are usually manufactured in developing countries require less skill and are not much involved with the learning process.

During the 1990s, studies examining the effect of trade on output growth were based on the endogenous growth framework. They can be categorized into two main groups. The first examines the relationship between trade openness and output growth through cross-countries econometric analyses at the aggregate level. The second is based on case studies of specific countries.

In the first group, (real) output growth, especially that at the aggregate level, is used to represent firm performance alongside different measures of trade openness (Edwards [1993]; Sachs and Warner [1995]; Lopez [2005]). In some studies, trade measures are instrumented to redress a possible endogeneity problem (Frankel and Romer [1999]; Alcala and Ciccone [2004]; Noguer and Siscart [2005]).[5] Most of the empirical studies find a positive relationship between trade openness and economic growth.

The second group analyzes the relationship based on case studies of specific countries. Either a survey or an econometric analysis at the aggregate level is used (World Bank [1991]; Kohpaiboon [2003]) . As in the cross-countries analysis, most studies find a positive relationship between trade openness and growth. However, both groups are subject to shortcomings, which make the link between trade policy and firm performance remain a black box to a certain extent.[6] In

[5] For example, Frankel and Romer [1999], Rodriguez and Rodrik [2001], and Irwin and Tervio [2002] use geography as an instrumental variable in examining the relationship between trade liberalization and economic growth.

[6] Note that some scholars (Edwards [1993]; Srinivasan and Bhagwati [2001]) argue that case studies such as those done by the National Bureau of Economic Research [1978] or World Bank [1991] could provide good evidence about the effect of trade on growth. However, drawing conclusions about the role of trade from case studies is still difficult, since they include only a handful of countries while differences in firm/plant characteristics are not taken into account [Lopez 2005].

particular, by using aggregate data either cross-country or within a country, heterogeneity at the firm and industry levels is not taken into account. This tends to mix countries and industries with very different characteristics (Berry [1992]; Tybout [1996]; Lopez [2005]). As mentioned earlier, allocation within an industry is crucial in generating efficiency within an industry and in contributing to a country's economic growth.

As plant/firm-level panel data become increasingly available in many countries, researchers have re-visited the trade-growth nexus. Shortcomings, especially econometric problems, were better addressed. Using the micro data set, a new hypothesis is formed relating to the effects of trade liberalization on firms' performance. The positive relationship found between trade liberalization and performance is explained by two competing theses.

First is the self-selection thesis, in which firms entering the export markets are already more productive than non-exporters. Hence the positive relationship would not be directly related to trade liberalization. Also, the nature of trade policy and firms' market orientation must be treated as two separate explanatory variables in the analysis. They are two different things. The former refers to the policy environment, whereas the latter is a firm's decision.

The second thesis is the learning-by-exporting thesis. In this thesis, firms participating in foreign markets are more likely to experience productivity gains as opposed to non-exporters, as the former would receive new information about technological progress, product designs, and quality of goods from their foreign exposure (Grossman and Helpman [1991]; Aw and Hwang [1995]; Bernard and Wagner [1997]).[7]

When policy implications are concerned, both these groups of studies argue in favor of liberalization of trading partners instead of home countries. Reducing trade barriers between or among trading partners and policies affecting the profitability of being an exporter in the home country would induce more productivity improvement in the home country. Interestingly, Melitz and Trefler [2012] argue for another possible channel where liberalization in the home country could yield productivity gains that may help exporters to import inputs/technology at cheaper costs, which induce higher productivity improvements. Trefler [2004] and Lileeva and Trefler [2010] also argue that liberalization at home could improve the country's overall productivity through better resource reallocation.

Empirical studies (Amiti and Konings [2007]; Melitz and Redding [2012]) further analyze the channels through which trade policy affects firm performance. In particular, Amiti and Konings [2007] argue possible different effects of input and output tariffs due to differences in operating channels. Two possible

[7] See possible explanations of self-selection—for example, sunk costs, imported technology, and increased R&D—in Keesing and Lall [1992], Bernard and Jensen [2004], and Lopez [2005].

explanations are provided. First, it occurs when locally manufactured and imported intermediates are not close substitutes. Any change in input tariffs would have a significant effect only on the firms that actually import them. For those who use locally manufactured intermediates, such change would not have any significant effects on their behavior. Second, as shown in the firm heterogeneity literature, switching market orientation between the domestic market and exports is costly. Hence, changes in output tariffs might not have any significant impact on those who already export. They just continue in business due to the presence of sunk and fixed costs within the export business.

Both circumstances above are often observed in a country that is long engaged with the world and is pursuing a dual-objective trade policy, where being reluctant to lower tariffs is associated with the introduction of input tariff exemption schemes to promote export-oriented activities. Interestingly, based on Indonesian plant level data from 1991 to 2001, Amiti and Konings [2007] show that the effects of input tariffs are more favorable than that of output tariffs in generating firms' productivity improvement. However, some studies[8] argue that firms' productivity improvement is a long process of learning and mastery of skills so that both input and output tariffs facing by a firm should be considered together in affecting firms' performance.

3. Trade policy and firm productivity in Thai manufacturing

In Thailand, a tariff is the core measure in conducting trade policy. Non-tariff measures have been occasionally used in a narrow range of products, mainly in certain sensitive agricultural products such as soybean, palm seed, silk, and milk. Like other developing countries, a high tariff level associated with an escalating tariff structure was used to promote industrialization from the 1960s to the mid-1980s. From 1983 to 1995, tariff levels remained virtually unchanged with few exceptions, whereas the effort to promote Thailand as an export platform for multinationals was done through the introduction of various tariff exemption schemes (Kohpaiboon [2006]; Kohpaiboon and Jongwanich [2007]).

As part of its commitments under the World Trade Organization, a comprehensive plan for tariff reduction and rationalization was proposed in 1990 and implemented in 1995 and 1997. Maximum tariffs were reduced from 100 percent to 30 percent. Tariffs were significantly lowered on some 4,000 items (at the 6-digit HS level) or 75 percent of total tariff lines. By the end of the 1990s, the tariff bands were reduced from 39 to six (0, 1, 5, 10, 20, and 30 percent). Nonetheless, there were numerous exceptions whose tariff rates exceed 30 percent. Tariff restructuring has received renewed emphasis as an essential part of the overall economic reforms aimed at strengthening efficiency and

[8] See details in footnote 6.

competitiveness (Warr [2000]; World Trade Organization [1999]) . The Thai government introduced tariff cuts, commencing in June 2003 (implemented in October 2003), followed by a four-year period of tariff reduction from 2004 to 2008. In 2010, there are around 900 items involved in tariff reduction process, covering a wide range of manufacturing intermediates such as rubber and articles thereof (HS40), glass and glassware (HS70), knitted fabrics (HS60), other base metals (HS81), woven fabrics (HS58), articles of stone (HS68), man-made staple fiber (HS55), wadding yarns (HS56), cotton (HS52), and miscellaneous vegetable preparations (HS21) [Kohpaiboon and Jongwanich 2007].

Table 1 presents the average of most-favored-nation tariffs of Thailand and selected Asian economies in 2010. It is clear that average tariffs in Thailand are relatively high compared with other middle-income countries in the region. Interestingly, the weighted average was lower than the unweighted one, implying that tariffs imposed on certain products are redundant. In general, agricultural products are subject to higher tariffs than manufacturing products.

TABLE 1. Weighted average of most-favored-nation tariff rate of RCEP members during 2010-2012

Country (year)	Unweighted	Weighted	Agricultural products	Non-agricultural products
Thailand (2011)	8.7	5.0	9.0	4.9
Viet Nam (2010)	9.8	12.2	24.4	10.7
Singapore (2011)	0	0	0	0
Philippines (2011)	6.2	12.2	23.2	10.4
Myanmar (2011)	5.6	6.6	12.6	4.9
Malaysia (2012)	5.3	6.7	8.7	6.5
Indonesia (2012)	6.6	9.8	1.8	11.1
Laos (2008)	9.7	13.6	19.3	12.6
Brunei (2011)	2.5	1.7	0	2.6
Cambodia (2012)	10.9	12.0	14.7	11.1
Australia (2011)	2.8	3.8	1.6	3.9
New Zealand (2011)	2.0	2.7	1.9	2.8
China (2010)	9.9	8.6	21.5	7.4
India (2012)	13.3	9.4	48.6	7.7
Japan (2011)	3.0	2.1	7.0	1.3
South Korea (2011)	11.2	9.6	34.1	5.6

Source: Authors' calculations using most-favored-nation tariff rates from the World Trade Organization

Table 2 presents the distribution of tariff lines in Thailand over the past two decades. Clearly, the distribution changed as a result of the comprehensive tariff reform in the mid-1990s. During the pre-1997 period, more than a quarter of total HS6 tariff lines had tariff rates in the category of more than 30 percent. The bracket of 15-30 percent also accounted for 30 percent of total tariff lines. After 1997, there was a dramatic shift of tariff lines to lower brackets. For example, more than 50 percent of tariff lines are in the 0-10 percent bracket. This is followed

by 3.9 percent in the 10.1-15 percent bracket and 21.4 percent in the 15.1-20 percent brackets. The share of tariffs above 20 percent dropped from 40 percent in the pre-1997 period to around 20 percent during the post-1997 period. The 2003 tariff reduction plan marginally changed the distribution of tariff lines. Tariff reductions in 2003 have basically involved shifting the tariff lines from the 16-20 percent bracket to a lower bracket, with little impact on those belonging to the above 20-percent brackets. The proposed changes from the next two years seem to follow the same pattern, while changes proposed for 2006-2008 seem negligible.

TABLE 2. Share of 4-digit HS categories of applied tariff rates in Thailand, 1989–2008

Tariff bands	1989	1995	2002	2003	2004 to 2008
0	2.5	2.6	5.6	5.7	6.0
0.1 - 5	14.4	17.3	33.3	37.7	48.8
5.1 - 10	14.2	17.6	14.1	14.2	14.8
10.1 - 15	12.7	3.2	3.9	4.5	3.6
15.1 - 20	15.4	16.4	21.4	17.9	8.4
20.1 - 30	15.8	16	13.8	14.3	12.7
30 - 100	25	26.8	7.8	5.8	5.7

Source: Data for 1989 and 1995 from World Trade Organization. Data for 2002 to 2008 are from the authors' compilation from Official Document provided by Ministry of Finance.

Table 3 presents statistical indicators of how firms engage globalization, i.e., export-sales ratio and ratio of raw material imports to total materials used, both measured in percent. They are reported in terms of average, maximum, and minimum. They are classified into 5 categories across the ERP figures. Patterns observed in Table 3 tend to be in line with the theoretical postulations of the firm heterogeneity literature. Engaging exports incurs fixed and sunk costs. Therefore, in a given industry, regardless the ERP figure, only some firms export. There is a vast difference between maximum and minimum values in all ERP categories. In theory, industries subject to high and positive ERP tend to sell their products locally in order to reap economic rents induced by protection. This pattern is, to a certain extent, found in Table 3. The mean value of the export-sales ratio of firms located in industries with around zero ERP and negative ERP is higher than those experiencing positive ERP. Interestingly, such a pattern is not clearly observed when using a raw material import criterion. The mean value of percent of raw material imports to total used swings up and down across the ERP categories. Industries subject to around zero ERP exhibit the highest raw material import ratio, followed by those in highly positive ERP. Firms in highly negative ERP and moderate positive ERP have the same figure of raw material import ratio. The unclear pattern is due to the extent to which domestic and imported raw materials are substituted varies across industries instead of protection.

TABLE 3. Market orientation and raw material sourcing behavior of Thai manufacturing firms in 2011

Export-sale ratio (percent of total sales)	Mean	Max	Min
Highly Negative ERP (<-10%)	9.1	88.8	0.0
Moderately Negative ERP (-2% to 10%)	8.3	85.5	0.0
Around Zero ERP (-2% to 2%)	9.0	81.3	0.0
Moderate Positive ERP (2% to 10%)	7.1	79.6	0.0
Highly Positive ERP (>10%)	8.8	85.9	0.0
Raw material import as a percentage of total raw materials used			
Highly Negative ERP (<-10%)	8.6	90.3	0.0
Moderately Negative ERP (-2% to 10%)	6.8	81.3	0.0
Around Zero ERP (-2% to 2%)	9.5	87.9	0.0
Moderate Positive ERP (2% to 10%)	8.6	86.4	0.0
Highly Positive ERP (>10%)	9.3	83.6	0.3

Source: Authors' compilation from the 2011 industrial census

4. The model

The model used here starts with trans-log production function of the firm. The plant's value added is a function of two primary inputs (labor and capital), their squared terms, and their interaction. Labor is further disaggregated into production (PL_{ij}) and nonproduction (NL_{ij}) workers to capture their difference in contributing to firm productivity. Blue-collar workers are regarded as the former and white-collar ones are the latter. Over and above, a set of firm- and industry-specifics as well as the trade policy variables are included as controlling variables as expressed in Equation 1.

$$\begin{aligned}\ln VA_{ij} &= \beta_0 + \beta_1 \ln K_{ij} + \beta_2 (\ln K_{ij})^2 + \beta_3 \ln PL_{ij} + \beta_4 \ln NL_{ij} + \beta_5 (\ln PL_{ij})^2 \\ &+ \beta_6 (\ln NL_{ij})^2 + \beta_7 \ln PL_{ij} * \beta_8 \ln NL_{ij} * \ln K_{ij} + \gamma_1 FS_{ij} + \gamma_2 IS_{ij} \\ &+ \gamma_3 tradepolicy_j + \varepsilon_{ij} \qquad (1)\end{aligned}$$

where VA_{ij} = Value added of firm i in industry j
K_{ij} = Capital used by firm i in industry j
PL_{ij} = Production workers employed by firm i in industry j
NL_{ij} = Non-production workers employed by firm i in industry j
FS_{ij} = Firm-specific characteristics of firm i in industry j
IS_{ij} = Industry-specific characteristics of industry j
$tradepolicy_{ij}$ = The nature of trade policy of industry j

Firm-specific characteristics (FS_{ij}) include market orientation, foreign ownership (own_{ij}), and R&D investment (RD_{ij}). In this study, two aspects of market orientation are captured: the export-sales ratio; and how much finished products are exported as a percentage of total sales (mktij). Both are introduced in the model. International competition would make firms alert to any productivity improvement and eventually enhance firm productivity so that the coefficient associated with mktij is expected to be positive. The second aspect of market orientation is the extent to which imported raw materials are used as a percentage of total raw materials ($rawm_{ij}$). Firms that import raw materials would benefit from technology embodied in them, thus improving their productivity. The coefficient associated rawmij is also expected to be positive.

The consensus in the foreign direct investment literature [Caves 2009] suggests that foreign firms (ownij) are generally more productive than indigenous counterparts so own_{ij} is expected to be positive. own_{ij} is measured by firms' foreign equity (percent) share. RD_{ij}, measured here by the firm's research, planning, and development expenditure to total sales, would raise firm productivity so that the coefficient associated is expected to be positive.

Three industry-specific factors are controlled in our analysis. The first is the extent to which an industry engages into a global production network. This can have an implication on productivity as reviewed in part 2, under gains from intra-industry trade. Ideally, details at the firm level (e.g., whether firms are actually engaged in multinational enterprises' (MNEs) production sharing and whether they import tailor-made raw materials for specific customers, etc.) are needed. Unfortunately, such details at the firm level are not available within the Thai dataset. To overcome the unavailability of perfect measures of global production sharing, two alternative proxies are used in this study. The first two proxies are shares of parts and component in total imports ($GPN1_j$) and total trade ($GPN2_j$) as reflected in Equations 3 and 4:

$$(GPN1_j) = \text{P\&C Imports}_j \,/\, \text{Total Imports}_j \tag{3}$$

$$(GPN2_j) = \text{P\&C trade (import + export)} \,/\, \text{Total Trade} \tag{4}$$

The higher the share, the more important the global production sharing is to the industry. The parts list is the result of a careful disaggregation of trade data based on the Revision 3 of the Standard International Trade Classification extracted from the UN Comtrade database. It is important to note that the UN Comtrade database does not provide for the construction of data series covering the entire range of fragmentation-based trade. The parts list used here is from that developed in Athukorala and Kohpaiboon [2009].[9] To convert Standard International Trade

[9] The use of lists of parts in the Board Economics Classification 42 and 53 is a point of departure. Note

Classification to International Standard Industrial Classification (ISIC) , standard concordance is applied.

The second industry-specific factor is producer concentration (CR_j). Its effect on productivity is ambiguous. Industries with high barriers to entry are likely to be concentrated and are often capital- and/or skill-intensive. Hence, this could make firms less responsive to any technological improvement so it negatively affects productivity (negative sign). On the other hand, as argued in the well-known creative destruction thesis by Schumpeter, a highly concentrated industry would give firms incentive to innovate. If so, the coefficient associated with producer concentration could be positive. Producer concentration is measured by the sum of the sales share of the top-4 firms in total.

$tradepolicy_j$ is introduced to examine the study's main hypothesis. Two alternatives of trade policy are used in this study. Effective rate of protection (ERP_j) is used as the first measure of trade policy due to its theoretical superiority. In theory, policy-induced incentives from cross-border protection measures like tariffs would not be different, regardless of the incentives generated by either input or output tariffs. Hence, it would be theoretically superior to employ an effective rate of protection (*ERP*), instead of separating input and output tariffs.

$$ERP_j = (t_j - \sum_{k=1}^{n} a_{kj} t_k) / (1 - \sum_{k=1}^{n} a_{kj}) \quad (6)$$

where t_j = Tariff on outputs on industry j
t_k = Tariff on inputs k
a_{kj} = A value share of inputs k used in finished products on industry j

To examine whether the effect of trade policy varies across firms, the interaction term between firm specific and trade policy variable is introduced; $ERP_j * mkt_{ij}$ and $ERP_j * rawn_{ij}$ are introduced. The former implies that giving protection to an industry of interest, the effects could vary according to the extent to which firms export their products to the world. Similarly, in the latter, the effect of protection on firm productivity could depend on how much a firm is integrated globally through importing raw materials and intermediates. In addition, the interaction term between the ERP and ownership ($ERP_j * own_{ij}$) is introduced because a foreign firm might behave differently under different trade

that the parts in Board Economics Classification 211 are not included as they are primary products that are usually classified as traditional, rather than fragmented-intermediates. The additional lists of parts are included based on firm interviews reported in Kohpaiboon [2010]. Data on trade in parts are separately listed under the commodity classes of machinery and transport equipment (Standard International Trade Classification 7) and miscellaneous manufacturing (Standard International Trade Classification 8) and are based on firm interviews elaborated in Kohpaiboon [2010]. The list of parts and components is available on request.

policy environments (known as Bhagwati's hypothesis).[10] Trade liberalization could provide an incentive for foreign firms to behave productively. By contrast, rent-seeking behavior of foreign firms, which is more likely to occur under trade restriction, could retard overall productivity improvement.

As discussed in Section 2, input and output tariffs could have different impacts on firm productivity improvement, hence, $inputtariff_i$ and $outputtariff_i$, are separately introduced as alternative measures of trade policy here. That is,

$$ERP_j + ERP_j * mkt_{ij} + ERP_j * rawn_{ij};$$
$$\left(t_j - \sum_{k=1}^{n} a_{kj} t_k\right) + \left(t_j - \sum_{k=1}^{n} a_{kj} t_k\right) * mkt_{ij} + \left(t_j - \sum_{k=1}^{n} a_{kj} t_k\right) * rawn_{ij} \quad (7)$$

where $outputtariff_j$ = Tariff on outputs of industry j (t_j)
$inputtariff_j$ = The weighted average of input tariff from k = 1,…,n. $\left(\sum_{k=1}^{n} a_{kj} t_k\right)$

Note that to mitigate any possible endogeneity problem from these industry-specific factors, all of them are lagged.

All in all, the empirical model to be estimated is as follows:

$$\begin{aligned} \ln VA_{ij} = {} & \beta_0 + \beta_1 \ln K_{ij} + \beta_2 (\ln K_{ij})^2 + \beta_3 \ln PL_{ij} + \beta_4 \ln NL_{ij} + \beta_5 (\ln PL_{ij})^2 \\ & + \beta_6 (\ln NL_{ij})^2 + \beta_7 \ln PL_{ij} * \beta_8 \ln NL_{ij} * \ln K_{ij} + \gamma_1 own_{ij} + \gamma_2 R\&D_{ij} \\ & + \gamma_3 rawn_{ij} + \gamma_4 mkt_{ij} + \lambda_1 CR_{j,\,t-j} + \lambda_2 GPN_{j,\,t-j} + \lambda_4 tradepolicy_{j,\,t-j} \\ & tradepolicy_j * mkt_{ij} + \varphi_2 tradepolicy_{j,\,t-j} * rawn_{ij} + \varepsilon_{ij} \end{aligned} \quad (8)$$

where $\ln VA_{ij}$ = Value added of firm i in industry j (in natural log)
$\ln K_{ij}$ = Capital used by firm i in industry j (in natural log)
PL_{ij} = Production workers employed by firm i in industry j
NL_{ij} = Non-production workers employed by firm i in industry j
$tradepolicy_{j,\,t-j}$ = Lag variable of trade policy measured alternatively by
1. Effective rate of protection (ERP)
2. $Outputtariff_i(t_j)$ and $Inputtariff_i(t_j)\left(\sum_{k=1}^{n} a_{kj} t_k\right)$
mkt_{ij} = Market orientation of firm i of industry j measured by a percentage of export to total sales
$rawm_{ij}$ = Input sourcing of firm i of industry j measured by a percentage of imported raw materials and intermediates to total inputs
own_{ij} = Ownership of firm i of industry j measured by a share of foreign owners in total capital

[10] See the discussion in Kohpaiboon [2006].

$R\&D_{ij}$ = A share of R&D expenditure as a percent of total sales of firm *i* of industry *j*

$CR_{j,\,t-j}$ = Producer concentration ratio of industry *j* at time *t-j*

$GPN_{j,\,t-j}$ = The degree of industry involved in the global production networks of industry *j* at time *t-j*, measured by two alternatives:

$GPN1_{j,\,t-j}$ = The share of parts and components imports to total import at the 4-digit ISIC

$GPN2_{j,\,t-j}$ = The share of parts and components trade (export+import) to total trade at the 4-digit ISIC

5. Data set and cleaning procedure

The data set suitable for the current purpose is a long-panel data of establishments in Thai manufacturing, covering before and after major trade reform. Unfortunately, such a data set is not available in the country. So far Thailand has three industrial censuses—1996, 2006, and 2011—all of which are cross-sectional in nature. These three censuses are not able to formulate as a panel data set as the identification number used in each census is assigned differently. In particular, a given identification number of two different censuses does not necessarily refer to the same firm.

The latest census (2011) contains 98,482 observations. Out of the total, 71,387 observations are self-employed (zero record of paid workers) or micro-enterprises (less than or equal to 10 workers). Given the current research focus, we exclude these self-employed and micro-enterprises. Hence, the remaining observations number 27,095. Similar to what occurred in the censuses in 1996 and 2006, there are many duplicate samples in which at least two observations report the same value in most of variables. To identify the duplicated observations, the criterion is if samples report identical values of 7 key variables, they are treated as duplicated samples. The 7 key variables include total workers, female workers, initial fixed asset, ending fixed asset, registered capital, sale value, and input values. In this case, we count only one firm. According to this criterion, there are 4,418 duplicated samples to be removed. The remaining observations number 22,677.

Next, we drop observations reporting unrealistic values of the key variables. They include negative value added, low value added (less than 10,000 baht), and low fixed assets (less than 10,000 baht). Finally, 8 industries that either serve niches in the domestic market (e.g. processing of nuclear fuel, manufacture of weapons and ammunition), in the service sector (e.g. building and repairing of ships, manufacture of aircraft and spacecraft, and recycling), or are explicitly reserved for local enterprises (e.g. manufacture of ovens, furnaces and furnace burners, manufacture of coke oven products) are excluded. All in all, 13,593 observations remain. Summary statistics and correlation of variables are shown in Tables 4 and 5.

TABLE 4. Data summary statistics

Variables	Mean	Std. Dev.	Min	Max
VA_{ij}	15.88	2.40	9.21	25.26
PL_{ij}	0.99	1.39	0	8.88
NL_{ij}	3.67	1.13	0	9.50
K_{ij}	15.84	2.32	9.21	26.32
own_{ij}	4.19	17.21	0	100
mkt_{ij}	7.430	21.90	0	100
$rawm_{ij}$	6.27	18.53	0	100
$R\&D_{ij}$	-11.87	6.85	-13.82	20.51
ERPj	0.05	0.17	-0.58	0.60
$cr4_{j,t-j}$	0.45	0.09	0.32	0.65
$GPN1_{j,t-j}$	0.04	0.12	0	1
$GPN2_{j,t-j}$	0.03	0.11	0	1

Note: All variables are in logarithm, with the exception of ownership, market-oriented, imported raw material, trade policy, concentration ratio, and production network.
Source: Authors' calculations

6. Results

Initially, the equations are estimated using the ordinary least squares method while paying attention to the possible presence of heterogeneity and outliers. Due to the nature of cross-sectional data, it is likely that outliers could have an impact on the estimated parameters and lead to misleading inferences. Therefore, careful treatment of outliers is needed. Cook's Distance[13] is used to identify suspected outliers. The intra-class correlation or the clustered data, based on industry level, is tested (Table 6). The results show a low level of the correlation (0.267).

Tables 7 and 8 present estimation results where trade policy is measured by the ERP and tariffs of output and inputs are separately introduced. Column A in both tables is based on GPN1, whereas Column B is based on GPN2. The overall results from both tables are largely similar. The estimation results are not sensitive to choices of GPN. Hence, the following result interpretation will be discussed, based on these two tables. Coefficients corresponding to the interaction term between nonproduction workers and capital as well as the squared terms of two types of workers are statistically significant, suggesting that the translog production function fits the data well, relative to the more restrictive Cobb-Douglas one. The statistical difference of coefficients associated with production and nonproduction workers supports the hypothesis that quality of labor matters in determining firm productivity. The higher the number of white collar workers employed by firms, the greater the productivity improvement expected, all other things remaining constant.

TABLE 5. Correlation matrix

Variables	VA*ij*	PL_{ij}	NL_{ij}	K_{ij}	own_{ij}	mkt_{ij}	$rawm_{ij}$	$R\&D_{ij}$	*ERP*j	Output tariff	Input tariff	$cr4_{j,t-j}$	$GPN1_{j,t-j}$	$GPN2_{j,t-j}$
VA*ij*	1.00													
PL_{ij}	0.61	1.00												
NL_{ij}	0.54	0.46	1.00											
K_{ij}	0.81	0.57	0.49	1.00										
own_{ij}	0.23	0.22	0.23	0.21	1.00									
mkt_{ij}	0.29	0.33	0.24	0.25	0.37	1.00								
$rawm_{ij}$	0.25	0.22	0.23	0.23	0.34	0.36	1.00							
$R\&D_{ij}$	0.23	0.20	0.19	0.21	0.05	0.11	0.11	1.00						
*ERP*j	-0.01	0.003	0.01	-0.01	0.08	0.02	0.05	-0.02	1.00					
Output tariff	0.08	0.06	0.07	0.08	0.07	0.09	0.04	0.02	0.73	1.00				
Input tariff	0.14	0.10	0.10	0.12	0.04	0.06	0.00	0.03	-0.19	0.32	1.00			
$cr4_{j,t-j}$	0.02	-0.01	0.01	0.06	-0.004	0.02	0.02	-0.02	0.06	0.04	-0.05	1.00		
$GPN1_{j,t-j}$	0.14	0.12	0.10	0.10	0.11	0.08	0.07	0.03	0.14	0.17	0.24	0.13	1.00	
$GPN2_{j,t-j}$	0.13	0.13	0.09	0.10	0.11	0.05	0.08	0.03	0.20	0.21	0.24	0.14	0.92	1.00

Source: Authors' calculations

TABLE 6. Intra-group correlation

Number of obs = 13593
R-squared = 0.26

Source	SS	Df	MS	F	Prob>F
Between isic_obs	22120.752	60	368.679	80.13	0.000
Within isic_obs	62257.048	13532	4.601		
Total	84377.8	13592	6.21		

Intra-class correlation	Asy. S.E.	95% Confidence Interval	
0.267	0.056	0.16	0.37
Estimated SD of isic_obs effect			1.29
Estimated SD within isic_obs			2.14
Est. reliability of a isic_obs mean (evaluated at n = 217.59)			0.98

Source: Authors' estimates

TABLE 7. Productivity determinants based on the ERP and 2011 census

Variables	Column A		Column B	
	Coefficient	t-statistics	Coefficient	t-statistics
Intercept	2.17*	4.27	2.12*	4.18
PL_{ij}	2.27*	23.86	2.27*	23.85
NL_{ij}	0.41*	3.51	0.41*	3.50
K_{ij}	0.82*	12.18	0.82*	12.26
$PL_{ij}*K_{ij}$	-0.12*	-20.46	-0.12*	-20.42
$NL_{ij}*K_{ij}$	0.0007	0.07	0.0007	0.08
PL_{ij}^2	0.04*	6.36	0.04*	6.24
NL_{ij}^2	0.003	0.28	0.003	0.30
K_{ij}^2	-0.003	-1.22	-0.004	-1.29
own_{ij}	0.003*	3.55	0.003*	3.65
own_{ij}, $ERP_{j,\,t-j}$	0.001	0.18	0.001	0.18
mkt_{ij}	0.002*	3.89	0.002*	4.09
$rawm_{ij}$	0.002*	3.05	0.002*	2.96
$R\&D_{ij}$	0.013*	8.13	0.013*	8.16
$ERP_{j,\,t-j}$	-0.30*	-3.83	-0.29*	-3.78
$ERP_{j,\,t-j}*mkt_{ij}$	-0.01**	-1.97	-0.006**	-2.13
$ERP_{j,\,t-j}*rawm_{ij}$	0.003	0.77	0.003	0.83
$cr4_{j,\,t-j}$	-0.35*	-3.05	-0.32*	-2.79
GPN1j, t-j	0.64*	6.95		
GPN2j, t-j			0.55*	5.08
# obs		13593		13593
Ad-R		0.73		0.73
F-stat	1717 (p-value = 0.00)		1711 (p-value = 0.00)	

Notes:
* statistically significant at 1 percent ** statistically significant at 5 percent
An increase in the ERP reflects higher trade protection.
Source: Authors' estimates

TABLE 8. Productivity determinants based on ERP decomposition and 2011 census

Variables	Column A		Column B	
	Coefficient	t-statistics	Coefficient	t-statistics
Intercept	2.17*	4.26	2.12*	4.17
PL_{ij}	2.26*	23.74	2.26*	23.74
NL_{ij}	0.41*	3.53	0.42*	3.53
K_{ij}	0.80*	11.86	0.80*	11.91
$PL_{ij}*K_{ij}$	-0.12*	-20.37	-0.12*	-20.34
$NL_{ij}*K_{ij}$	0.00	0.00	0.00	0.01
PL_{ij}^2	0.04*	6.39	0.04*	6.29
NL_{ij}^2	0.004	0.39	0.004	0.39
K_{ij}^2	-0.003	-1.01	-0.003	-1.06
own_{ij}	0.003*	4.12	0.003*	4.23
mkt_{ij}	0.004*	2.53	0.004*	2.62
$rawm_{ij}$	0.006*	4.12	0.006*	4.05
$R\&D_{ij}$	0.013*	8.22	0.13*	8.25
$outputtariff_j$	-0.27	-1.02	-0.27	-1.00
$inputtariff_j$	3.02*	4.90	3.26*	5.30
$Outputtariff_j*mkt_{ij}$	-0.02*	-2.16	-0.02*	-2.33
$Inputtariff_j*mkt_{ij}$	-0.01	-0.30	-0.007	-0.27
$Outputtariff_j*rawm_{ij}$	-0.004	-0.30	-0.003	-0.25
$Inputtariff_j*rawm_{ij}$	-0.09*	-2.79	-0.09*	-2.76
$cr4_{j,\ t-j}$	-0.32*	-2.77	-0.29	-2.48
GPN1j, t-j	0.54*	5.78		
GPN2j, t-j			0.43*	3.89
# obs		13593		13593
Ad-R		0.73		0.73
F-stat	1572 (p-value = 0.00)		1568 (p-value = 0.00)	

Notes:
* statistically significant at 1 percent ** statistically significant at 5 percent
Source: Authors' estimates

In both tables, the coefficients corresponding to own_{ij}, mkt_{ij}, and $rawm_{ij}$ turn out to be positive and significantly different from zero at 5 percent. This finding is in line with previous studies. That is, foreign firms tend to be more productive than indigenous ones, all other things remaining constant. Meanwhile, whether domestic or foreign, the firms that engaged in international business (either exporting their products, or importing raw materials, or both) tend to be more productive than those strictly engaged in local markets. Similarly, everything else being equal, the positive sign of R&D suggests firms spending more on R&D tend to have higher value added.

For industry-specific factors, our study finds a negative and statistically significance effect of CR4 at the 1 percent. The negative sign suggests that industries with high barriers to entry or are concentrated tend to make firms less responsive to any technological improvement. Both GPN1 and GPN2 are positive and significant at 1 percent, confirming the robustness of the finding that participating in global production networks could result in higher firm productivity improvement. This finding is consistently with Kohpaiboon and Jongwanich [2014] that Thai firms participating in global production networks go beyond simple assembly, and a statistically significant wage premium in the industries engaged in such networks is found.

Regarding the effects of trade policy, the coefficient corresponding to ERP turns out to be negative and statistically significant (Table 7). All other things unchanged, firms operating under a regime of higher cross-border protection have lower productivity. In other words, protection can retard the process of productivity improvement. This finding is consistent with the findings of previous studies. The negative effect of the ERP on productivity tends to be higher on exporting firms, as suggested by its statistical significance of the interaction term between the ERP and mkt_{ij}. When the ERP is decomposed into output and input tariffs, the coefficient associated with $Outputtariff_i$ attains the theoretically expected sign, but it is not statistically significant (Table 8).

The positive and statistical significance of $Inputtariff_i$ must be interpreted with care. First, this finding is in line with that in Table 7, i.e., we found a negative effect of protection on productivity as discussed above. Consider the ERP formula expressed in Equation 6 above The negative coefficient associated with the ERP will result in a negative coefficient on output tariffs and a positive coefficient on input tariffs. This suggests that for a given level of output tariffs, lowering input tariffs would simply increase effective protection to producers. Thus, the productivity of firms would decline, when output tariff maintained at the same level. This finding would be highly relevant to policymakers in developing countries, where policymakers emphasize input tariff reduction while expressing reluctance to lower output tariffs.

As revealed intensively in a number of case studies as discussed above, the greater protection granted producers makes them unresponsive to any productivity improvement activities, including the long process of learning and mastery of skills, which require long-term commitment and real resources. This finding is in line with that in Kohpaiboon and Jongwanich [2007]. In particular, when firms lobby for protection, they consider both input and output tariffs together to attain the expected effective protection.

Second, the net effect on productivity remains ambiguous as the interaction term between $Inputtariff_i$ and $rawm_{ij}$ turns out to be negative and statistically significant. When firms import raw materials at an amount greater than 33.6 percent, an increase in input tariffs would have a net negative effect of productivity,

all other things equal. In addition, domestically manufactured and imported intermediates in Thai manufacturing are not close substitutes. Any change in input tariffs will have a significant effect only on the firms that actually import. For those who use domestically manufactured intermediates, such a change would not impact those relying entirely on domestic raw materials.

With regards to output tariffs, the negative effect would occur only in exporting firms. The coefficient corresponding to the interaction term between and is negative and statistical significant. For a country like Thailand, which has been long engaged in international markets, firms already make their decisions taking market orientation and where to sell their products. In a case where output is subject to higher tariff rates than inputs are, and various tariff exemption schemes are available, firms choose to either export or sell domestically.[11] These firms are operating in different environments. Exporting firms are more productive than domestic-oriented ones as the former usually face more intense competition from the world. Granted protection could keep allow domestic-oriented firms to remain in business, produce products serving local niches, and compete with the former on primary inputs like labor. This is especially true for Thailand, where the labor market has tightened in recent years. This would inflate wages to a certain extent and unevenly affect these two groups of firms. It is the exporting firms that are adversely affected by the inflated wage as their output price is given by the world. To a certain extent, domestic-oriented firms would pass inflated wages on to output prices.

A reduction in output tariffs could generate a tougher competitive environment in domestic markets. The less productive firms that are likely to be purely oriented to the domestic market may be forced out of business. For exporting firms, such a reduction in output tariffs would not have any direct effect as they sell at the world price. Instead, the reduction in output tariffs would lower the inflated wage and relocate workers from less productive and more domestically oriented firms to more productive and export-oriented ones (i.e., resource reallocation).

Another interesting finding is that interaction term between ownership and trade policy (both the ERP and disaggregated one) is statistically insignificant (Tables 9 and 10, respectively). This would reflect the dominant role of export-oriented and efficiency-seeking foreign direct investment, which is motivated by strengthening global competitiveness. These foreign firms tend to be eligible for tariff exemption schemes so that their behavior would not be altered by granted protection.

[11] It would be costly for a firm to sell to both domestic and foreign markets simultaneously as they must deal with administrative complications—such as how much output is to be sold locally, how to refund the portion of input tariffs paid—as well as cumbersome tariff exemption schemes. This is especially true for small and medium firms.

TABLE 9. Productivity determinants based on ERP decomposition, interaction with ownership and 2011 census

Variables	Column A		Column B	
	Coefficient	t-statistics	Coefficient	t-statistics
Intercept	2.16*	4.24	2.11*	4.15
PL_{ij}	2.26*	23.79	2.26*	23.79
NL_{ij}	0.42*	3.54	0.42*	3.55
K_{ij}	0.80*	11.89	0.81*	11.93
$PL_{ij}*K_{ij}$	-0.12*	-20.41	-0.12*	-20.38
$NL_{ij}*K_{ij}$	-0.0002	-0.02	-0.0001	-0.01
PL_{ij}^2	0.04*	6.37	0.04*	6.26
NL_{ij}^2	0.004	0.41	0.005	0.42
K_{ij}^2	-0.003	-1.02	-0.003	-1.07
own_{ij}	0.001	0.46	0.001	0.41
own_{ij},$outputtariff_j$	-0.009	-0.57	-0.009	-0.56
$own_{ij}*inputtariff_j$	0.06	1.58	0.06	1.68
mkt_{ij}	0.004*	2.78	0.005*	2.90
$rawm_{ij}$	0.007*	4.32	0.007*	4.27
$R\&D_{ij}$	0.013*	8.24	0.013*	8.28
$outputtariff_j$	-0.27	-1.01	-0.27	-0.99
$inputtariff_j$	-2.98*	-4.83	-3.21*	5.22
$Outputtariff_j*mkt_{ij}$	-0.02**	-1.99	-0.02**	-2.16
$Inputtariff_j*mkt_{ij}$	-0.02	-0.68	-0.02	-0.67
$Outputtariff_j*rawm_{ij}$	-0.003	-0.22	-0.002	-0.17
$Inputtariff_j*rawm_{ij}$	-0.098*	-3.06	-0.098*	-3.06
$cr4_{j,\ t-j}$	-0.33*	-2.82	-0.29*	-2.54
GPN1j, t-j	0.54*	5.71		
GPN2j, t-j			0.42*	3.84
# obs		13593		13593
Ad-R		0.73		0.73
F-stat	1447 (p-value = 0.00)		1444 (p-value = 0.00)	

Notes:
* statistically significant at 1 percent ** statistically significant at 5 percent
Source: Authors' estimates

As a robustness check, the empirical model (Equation 8) is re-estimated by using the previous industrial census (2006). Tables 10 to 12 correspond to Tables 7 to 9, respectively, but they use the 2006 census. To a certain extent, the results are in line with what are found in the recent census, with a few exceptions of statistical insignificance in some coefficients. The main finding of Tables 10 to 12 supports the crucial role of trade liberalization on productivity improvement. Despite being smaller in magnitude, the coefficient associated with the ERP is negative and statistically significant (Table 10). The difference is that the coefficient corresponding to the interaction term ERP_j*mkt_{ij} in Table 10 is not

statistically significant. It becomes statistically significant when the 2011 census is used. The difference in the results between the 2006 and 2011 industrial censuses could be due to the differences in labor market conditions. Another difference is that all interaction terms with input and output tariffs turn out to be statistically insignificant, although the coefficients corresponding to them attain theoretical expected sign when 2006 census data are used.

TABLE 10. Productivity determinants based on ERP and 2006 census

Variables	Column A		Column B	
	Coefficient	t-statistics	Coefficient	t-statistics
Intercept	6.24*	19.89	6.22*	19.79
PL_{ij}	1.77*	29.84	1.77*	29.89
NL_{ij}	1.69*	34.75	1.69*	34.78
K_{ij}	0.02	0.49	0.03	0.55
$PL_{ij}*K_{ij}$	-0.09*	-23.78	-0.09*	-23.82
$NL_{ij}*K_{ij}$	-0.10*	-31.68	-0.10*	-31.70
PL_{ij}^2	0.05*	14.08	0.06*	14.13
NL_{ij}^2	0.06*	18.44	0.06*	18.47
K_{ij}^2	0.03*	15.61	0.03*	15.56
own_{ij}	0.002*	4.02	0.003*	4.24
own_{ij}, $ERP_{j,\ t-j}$	0.01	0.73	0.009	0.64
mkt_{ij}	0.001**	1.82	0.001*	2.06
$rawm_{ij}$	0.004*	7.91	0.004*	7.87
$R\&D_{ij}$	0.01*	10.28	0.01*	10.22
$ERP_{j,\ t-j}$	-0.15*	-2.17	-0.14*	-2.20
$ERP_{j,\ t-j}*mkt_{ij}$	-0.0001	-0.08	-0.0005	-0.23
$ERP_{j,\ t-j}*rawm_{ij}$	-0.45	-1.56	-0.42	-1.46
$cr4_{j,\ t-j}$	0.19*	2.77	0.21*	2.97
GPN1j, t-j	0.52*	6.20		
GPN2j, t-j			0.41*	3.93
# obs		15564		15564
Ad-R		0.76		0.76
F-stat	2731 (p-value = 0.00)		2739 (p-value = 0.00)	

Notes:
* statistically significant at 1 percent ** statistically significant at 5 percent
An increase in the ERP reflects higher trade protection.
Source: Authors' estimates

TABLE 11. Productivity determinants based on ERP decomposition and 2006 census

Variables	Column A		Column B	
	Coefficient	t-statistics	Coefficient	t-statistics
Intercept	6.31*	20.07	6.28*	19.98
PL_{ij}	1.76*	29.70	1.77*	29.74
NL_{ij}	1.69*	34.56	1.69*	34.59
K_{ij}	-0.0004	-0.01	0.001	0.01
$PL_{ij}*K_{ij}$	-0.09*	-23.74	-0.09*	-23.76
$NL_{ij}*K_{ij}$	-0.10*	-31.57	-0.10*	-31.59
PL_{ij}^2	0.06*	14.18	0.06*	14.21
NL_{ij}^2	0.06*	18.49	0.07*	18.50
K_{ij}^2	0.03*	15.86	0.03*	15.84
own_{ij}	0.003*	6.44	0.003*	6.64
mkt_{ij}	0.003*	2.26	0.003*	2.43
$rawm_{ij}$	0.005*	4.31	0.005*	4.14
$R\&D_{ij}$	0.01*	10.15	0.01*	10.08
$outputtariff_j$	-0.26	-1.09	-0.26	-1.09
$inputtariff_j$	3.29*	5.45	3.53*	5.86
$Outputtariff_j*mkt_{ij}$	-0.0002	-0.03	-0.002	-0.23
$Inputtariff_j*mkt_{ij}$	-0.03	-1.10	-0.04	-1.12
$Outputtariff_j*rawm_{ij}$	-0.009	-0.90	-0.008	-0.81
$Inputtariff_j*rawm_{ij}$	-0.02	-0.91	-0.02	-0.77
$cr4_{j,\ t-j}$	0.23*	3.35	0.25*	3.61
GPN1j, t-j	0.43*	5.02		
GPN2j, t-j			0.30*	2.80
# obs		15564		15564
Ad-R		0.76		0.76
F-stat	2486 (p-value = 0.00)		2493 (p-value = 0.00)	

Notes:
* statistically significant at 1 percent ** statistically significant at 5 percent
Source: Authors' estimates

TABLE 12. Productivity determinants based on ERP decomposition, interaction with ownership and 2006 census

Variables	Column A		Column B	
	Coefficient	t-statistics	Coefficient	t-statistics
Intercept	6.31*	20.07	6.28*	19.97
PL_{ij}	1.76*	29.70	1.77*	29.74
NL_{ij}	1.69*	34.56	1.69*	34.61
K_{ij}	-0.002	-0.03	-0.0004	-0.01
$PL_{ij}*K_{ij}$	-0.09*	-23.71	-0.09*	-23.74
$NL_{ij}*K_{ij}$	-0.10*	-31.51	-0.10*	-31.59
PL_{ij}^2	0.06*	14.13	0.06*	14.17
NL_{ij}^2	0.06*	18.42	0.07*	18.44
K_{ij}^2	0.03*	15.86	0.03*	15.84
own_{ij}	0.004*	2.50	0.003*	2.42
own_{ij}.$outputtariff_j$	0.009	0.70	0.008	0.65
own_{ij} *$inputtariff_j$	-0.02	-0.76	-0.01	-0.56
mkt_{ij}	0.003*	2.09	0.003*	2.28
$rawm_{ij}$	0.005*	4.35	0.005*	4.21
$R\&D_{ij}$	0.01*	10.12	0.01*	10.05
$outputtariff_j$	-0.26	-1.06	-0.26	-1.09
$inputtariff_j$	-3.30*	-5.46	3.53*	5.86
$Outputtariff_j*mkt_{ij}$	-0.001	-0.19	-0.003	-0.38
$Inputtariff_j*mkt_{ij}$	-0.04	-1.17	-0.04	-1.13
$Outputtariff_j*rawm_{ij}$	-0.01	-1.02	-0.009	-0.91
$Inputtariff_j*rawm_{ij}$)	-0.02	-0.76	-0.02	-0.67
$cr4_{j,\ t-j}$	0.23*	3.33	0.25*	3.59
GPN1j, t-j	0.43*	5.01		
GPN2j, t-j			0.30*	2.77
# obs		15564		15564
Ad-R		0.76		0.76
F-stat	2281 (p-value = 0.00)		2287 (p-value = 0.00)	

Notes:
* statistically significant at 1 percent ** statistically significant at 5 percent
Source: Authors' estimates

7. Conclusions and policy recommendations

The paper examines the effect of trade policy on firm productivity by using two recent industrial censuses of Thai manufacturing (2006 and 2011). The translog-production function is employed to avoid imposing any coefficient restrictions. Trade policy and global participation are treated as two different variables in our analysis. Foreign firms tend to be more productive than indigenous ones, all other things remaining equal. The firms, whether domestic or foreign, that engaged in global markets tend to be more productive than those strictly engaged in local markets. As expected, firms spending more on R&D tend to have higher productivity. Participating in the global production network could result in firm productivity improvement.

While controlling for firms' global participation, defined as export-sale ratio, and the extent to which raw materials are imported, our study finds that trade liberalization could induce firms to commit to productivity-improving activities. The key finding that is different from previous studies is that when it comes to the decision to commit to productivity improvement, the effective rate of protection, where output and input tariffs are taken into consideration together, matters. Focusing solely on lowering input tariffs while leaving output tariffs untouched could retard the overall productivity improvement. This finding would be highly relevant for policymakers in developing countries, where policymakers generally emphasize input tariff reductions while expressing reluctance to lower output tariff.

Two policy inferences can be made from our study. First, our study supports global integration as this could promote productivity enhancement. Second, it would be risky to continue tariff reform by focusing solely on input tariffs while leaving output tariffs untouched. In fact, both input and output tariffs must be taken into consideration in neutralizing incentives in trade policy reform.

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