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Plant Productivity, Producer Concentration and Trade Policy Regime: Evidence from Thai Manufacturing

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Abstract

This paper examines the impacts of producer concentration on Thai manufacturing productivity. The key hypothesis highlights the role of trade policy regime in conditioning the impact of producer concentration. Inter-plant cross-sectional econometric analysis is undertaken, using 1996 industrial census, the only census available so far. The key finding suggests the impact of producer concentration on plant productivity is not consistent and depends on the nature of trade policy regime. Tariff reduction must reach a certain level before the potential positive impact of producer concentration on productivity is observed. These results further highlight the relative importance of the trade policy regime for productivity enhancement and thus development policy. Although high levels of producer concentration can result in productivity gains, the competition fostered by open trade policies is required in high concentration is to be translated into higher productivity.

JEL Classification: F14, F23, O24, D24, L11

Key words: Producer Concentration, Trade Policy Regime, Thai Manufacturing

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1. Introduction

Understanding productivity determinants is an immense policy relevant in economic development as productivity plays a pivotal role in generating long-term and sustainable economic growth. Whilst the extent to which firms involve productivity enhancing activities depends on various firm-specific factors such as age, market orientation (Lall 1992; Roberts & Tybouts, 1996), it can be also influenced by industry-specific factors.

Producer concentration is one of the industry-specific factors, widely discussed in the policy circle. Because of its visible measurement, producer concentration is often used by policy makers to signal the intensity of product market competition and justify any action in preventing any possibly anti-competitive behaviors. Nonetheless, its net impact on plant productivity is ambiguous. Pioneered by Schumpeter (1942), on the one hand, productivity-enhancing activities typically involve large fixed and irrecoverable upon exit. They are also subject to a large degree of risk and uncertainty. Therefore, the expectation of some forms of transient *ex post* market power is required for firms to undertake such activities. This is especially true in the context of developing countries whose domestic market is limited (Roberts & Tybout, 1996). On the other hand, market power on final goods is not a sufficient condition for firms undertaking these activities as suggested by a number of empirical studies (Symeonidis, 1996; Ahn, 2002). In fact, as these activities are costly, certain degree of market competition is needed to force each individual firm to commit its resources to these activities (Porter, 1990; Aghion, *et al.* 1999). In many circumstance, the high level of producer concentration could retard productivity improvement. As a result, it seems that impact of producer concentration on productivity is not automatic, depending on the degree of competition.

Therefore, this paper examines the impacts of producer concentration on Thai manufacturing productivity where the role of trade policy regime is highlighted. An cross-sectional econometric analysis of plant productivity determinants is undertaken, using industrial census 1996, the only available and most comprehensive industrial census in Thailand so far (Ramstetter, 2006: p. 117). A measure of producer concentration index is based at the firm level in order to mitigate possible bias emerged from multi-plant firm cases. In addition, the industry classification used is mixed between 3- and 4-digit ISIC to ensure that two reasonably substitutable goods are not treated as two different industries according to the conventional industrial classification at 4 digit level.

Thai manufacturing is a good sample for the issue in hand. To the best of our knowledge so far, there has not been any systematic analysis of productivity determinant at the plant level where the role of producer concentration is examined while controlling for firm- and industry-specific factors. While there were several previous studies of plant productivity determinants in Thailand such as Khanthachai et al. (1987), Ramstetter (1993), Ramstetter & Tambunlertchai (1991) and Ramstetter (2006), all of them exhibited the lopsided nature, solely focusing on the influence of multinational enterprises (MNEs).

The paper is organized as follows. Analytical framework is presented in the following section to illustrate the impact of producer concentration on plant productivity (Section 2). In Section 3, how producer concentration index is measured is discussed, followed by its pattern across industries. The model is presented in Section 4, followed by discussion of the data set (Section 5). Econometric procedure and Results are discussed in Section 6. Conclusion and policy inferences are in the final section.

2. Analytical Framework

To substantially gain productivity, an individual firm must commit resources to a long-term, incremental and cumulative effort (Bell *et al.*, 1984; Eveson & Westphal, 1995). This is true even in the imitative type of productivity-enhancing activities. To a large extent, they involve risk and uncertainty. Continuity is needed in these activities in order to gain tacit experience with particular technologies. Even though they must be undertaken by individual firms, decision to allocate resources to them can be influenced by industry-specific factors that could have considerable impact on net expected return.

A link between producer concentration and productivity was firstly proposed by Schumpeter (1942), known as the 'creative destruction' proposition. Productivity-enhancing activities typically involve large fixed and irrecoverable upon exit and are subject to a large degree of risk and uncertainty. Scale and scope economies are also important. The expectation of some forms of transient *ex post* market power is required to encourage firms to invest in such activities. In a circumstance where capital markets are imperfect, economic rents in relatively less competitive environment can be used as the internal source of fund to finance innovative activities. This link between producer concentration and productivity can be related to the Structure-Conduct-Performance Paradigm in the field of industrial organization (IO) as indicated by the relation between producer concentration and firm's profitability. Despite unclear whether to interpret high accounting profits as a sign of good or bad performance of a market, to a large extent, high accounting profit is often regarded as a sign of market power and could also be a result of high efficiency of firms.

However, the expected positive relation between producer concentration and productivity-enhancing activities has not been supported in the empirical study.[1] Several sensible explanations for the unfound positive relationship are provided. Firstly, Schumpeter's proposition had never claimed a continuous relationship between productivity and firm size. What Schumpeter focused on is said to be the qualitative differences between small, entrepreneurial enterprises and large, modern corporations in their innovative activities (Cohen & Levin, 1989). Secondly, when productivity enhancing activities occur in step-by-step manner, competition between firms is needed for them to carry on such activities (Aghion and Howitt, 1998, Aghion *et al.* 1999).[2] This is different from a simple model of creative destruction where the incumbent firm unlike the new entrant has no incentives to innovate because productivity enhancing activities occur in once-and-for-all manner (i.e. poison process). Once the incumbent firm discovers, it will maximize benefit to cover its

[1] See Symeonidis (1996) and Ahn (2002) and works cited therein.

[2] This is different from what proposed in a simple model of creative destruction. The incumbent firm unlike the new entrant has no incentives to innovate because productivity enhancing activities occur in once-and-for-all manner. Once the incumbent firm discovers, it will maximize benefit to cover its cost. Economic rent will disappear when there is new invention by the new entrant.

cost. Economic rent will disappear when there is new invention by the new entrant. In addition, the competition could also mitigate principal-agent problems occurring in the organization (Nickel *et al.* 1997).

Thirdly, productivity-enhancing activities undertaken in a large firm can be affected by presence of scale diseconomies referred to as the bureaucratization of inventive activity (a′la in Cohen & Levin, 1989), in which benefits derived from these activities could be undermined through loss of managerial control. In addition, the incentives of individual scientists and entrepreneurs become weaken as their ability to capture the benefits from their effort diminishes.

Over and above, a major weakness of producer concentration in measuring the degree of product market competition is inability to capture dynamic aspects of competition especially from import (i.e. market contestability). Given the level of producer concentration, its impact on plant productivity could be different according to the degree of market competition. In the competitive environment, the less productive firms tend to be weeded out so a highly concentrated industry structure would be more conducive for firms to continue their innovative activities. By contrast, in absence of significant market competition, economic rents generated as a result of highly producer concentration are likely to be captured by its managers (and workers) in the form of managerial slack or lack of efforts. All in all, this suggests that the impact of producer concentration tends to be conditioned by the degree of market competition.

3. Producer Concentration of in Thai Manufacturing: Measurement and Pattern

Estimating industry-level variables like the four-firm concentration ratio and related indicators is extremely difficult in the Thai case. For example, the only known official time series on industry output (revenue) comes from national accounts' estimates made by the National Economic and Social Development Board (NESDB) and the only known comprehensive industrial census is for 1996 from the National Statistics Office (NSO). Unfortunately, however, estimates of industry output from these two sources differ greatly for a number of industries in 1996.[3] In order to circumvent this constraint, we use data on large corporations from Business On-Line (2008), supplemented by a large number of related sources, to estimate sales of the largest firms in each industry. This firm-level compilation is of course very different than corresponding compilations from the industrial census and the national accounts.[4]

Because the data for the largest firms and industry output are not compiled consistently, it is impossible to consistently calculate four-firm concentration ratios that cover all of Thai manufacturing in 1996. Hence, producer concentration in this paper is calculated as the share of the largest 4 firms in the sales of all large firms in our database.[5] However, this large firm estimate also greatly overestimates the level of concentration in industries dominated by small firms relative to those dominated by large firms. Nevertheless, the alternative NESDB-adjusted estimates are calculated as the ratio of the revenue of the 4 largest firms to total market revenues, which are

[3] The NSO also provides estimates extrapolated from sample surveys for 1998, 1999, 2000, and 2002 (National Statistics Office 2001, various years) but these estimates also differ greatly from corresponding NESDB estimates in many industries.

[4] The existence of multi-plant firms can create large differences between firm-level compilations and plant-level compilations such as in the industrial census. The methodology for constructing national accounts estimates differs from either firm- or plant-level compilations.

[5] In principle, the sample of large firms consisted of the largest 15 firms in each industry as identified by Business On-Line (2008). However, cross checks of alternative sources revealed several hundred firms larger than the cutoffs implied by Business On-Line and these firms were thus added to the sample. On the other hand, a few firms included in the Business On-Line sample were clearly not engaged in manufacturing and omitted from the sample. Moreover, if two or more majority-owned firms belonging to same corporate group were included in an industry, data for these firms were combined and the combined entity was treated as a single firm. See Appendix A in Kohpaiboon and Ramstetter (2008) for more details.

estimated as the larger of total revenues of all firms in our large-firm database or gross output estimates from National Economic and Social Development Board (2008). Not surprisingly, NESDB-adjusted estimates suggest much lower values for *CR4* in many industries (Table 1). However, the patterns observed in the changes in *CR4* are remarkably similar to the corresponding patterns in the large-firm estimate in important respects. In the following discussion, we will discuss only CR4 of the large firm for the consistent purpose.

We start with the 4-digit ISIC classification and then group two or more reasonably substitutable goods into an industry. For example, firms in manufacture of tapioca (ISIC 1532) are likely to compete with those in other animal feeds manufacture (ISIC 1533). Treating them as distinguish industries in the analysis of industrial concentration could mislead the outcome. As a consequence, the final sample contains 58 industries, many of which remain at the 4-digit disaggregation level and some of which are at the 3-digit level (See details in Appendix 1). The freshly proposed industrial classification here is done to mitigate possible problems arising from the fact that two reasonably substitutable goods are treated as two different industries according to the conventional industrial classification at high level of disaggregation. Such problems are important in measuring producer concentration for market power purpose.

CR4 of 58 industries are reported in Table 1. Electronics, electrical appliances, motor vehicles, machinery, chemical and basic industries have the high level of producer concentration. *CR4* in these industries all exceeds 60 per cent with the peak of 99 per cent found in insulted wire and cable industries.[6] Interestingly, the output share of foreign plants to total industry (covering both foreign and local plants) is relatively large, accounting for more than 70 per cent of total industry. This is due to the fact that production technology *per se* seems to be a proprietary asset and is dominated by a handful of MNEs. These MNEs are probably more concerned with preventing the leakage of their asset (Kohpaiboon, 2006, 2008; Ramstetter& Sjöholm,

[6] Even thought there is no consensus of a critical value of CR4 firms would have oligopolistic, dominant and monopoly behavior, it would be in a range of between 60 and 75 per cent (Shephard, 1997; Baldwin & Gorecki, 1994). Hence, we use 60 per cent as a cutting point.

2006). By contrast, traditional labour intensive industries like apparel, foods, furniture, leather products, jewelry experience lower *CR4*, averaging out at 40 per cent. Production technology in these industries is relatively stable and widely available. The role of foreign plants as measured their output share is around 30 per cent.

Table 2 provides international comparison of *CR4* across selected developing countries. Note that a cross-country comparison of *CR4* must be interpreted with cautious as methods and procedures employed in each study in constructing CR4 would have a significant effect on the estimated figures. Nevertheless, it could provide a reasonable benchmark of producer concentration in the developing country world. Producer concentration in Thai manufacturing averages out at 61 per cent in 1996. The level seems to be relatively high by a standard of developing countries (Table 2).

4. The Model

To examine factors determining productivity dispersion across firms, this study begins with translog production functions. Translog functional form is chosen to free from restriction imposed in Cobb Douglas ones that were popular in the previous empirical studies (e.g. Khanthachai *et al.*, 1987; Ramstetter, 1993; Ramstetter & Tambunlertchai, 1991), i.e. unity of elasticity of substitution and log-linear relationship between inputs and outputs. In the former, such restrictions can be tested statistically.

It is specified as equation (1);

$$\begin{aligned} \ln Y_{ij} &= \beta_0 + \beta_1 \ln K_{ij} + \beta_2 \ln PL_{ij} + \beta_3 \ln NL_{ij} + \beta_4 \ln K_{ij} \ln PL_{ij} + \beta_5 \ln K_{ij} \ln NL_{ij} + \\ &\quad + \beta_5 \left(\ln PL_{ij}\right)^2 + \beta_6 \left(\ln NL_{ij}\right)^2 + \beta_7 \left(\ln K_{ij}\right)^2 + \beta_8 X_{ij} \end{aligned} \tag{1}$$

where Y_{ij} = value added of plant *i* of industry *j*

PL_{ij} = number of production workers of plant *i* of industry *j*

NL_{ij} = number of non-production workers of plant *i* of industry *j*

K_{ij} = fixed assets of plant *i* of industry *j*

X_{ij} = controlling variables in affecting plant productivity of plant *i* of industry *j*.

In equation 1, there are three primary inputs, physical capital and two types of labour (i.e. production and non-production workers). The latter is done to allow marginal products from them to be different. Producer concentration is introduced as a controlling variable in equation 1.[7] As argued above, the impact of producer concentration on plant productivity is conditioned by the nature of trade policy regime so that an interaction term between producer concentration and trade policy regime variable is introduced with is the negative expected sign.

Introducing plant ownership variable is to capture any impact of foreign firms on productivitiy. *OWN* is a binary dummy variable, which equals to one for foreign plants and zero otherwise. All plants with FDI (regardless of the magnitude of the foreign share in capital stock) are considered to be foreign plants for the identification of local plants. The cutting point (i.e. zero per cent) seems to be slightly higher than what is widely used by the International Monetary Fund (IMF) and other institutes such as the Organization for Economic Co-operation and Development (OECD), the US Department of Commence as well as several scholars studying multinational firms (IMF, 1993; Lipsey, 2001), i.e. 10 per cent. However, the choice is dictated by data availability. Information of foreign ownership is reported with a wide range, i.e. zero, less than 50, greater 50 and 100 per cent foreign shares. It is theoretically expected that MNE affiliates are more productive than locally non-affiliated firms (Caves, 2007) so that a sign of the corresponding coefficient is expected to be positive.

As guided by the theory and previous empirical works on the determinants of plant productivity differences, a set of plant- and industry-specific factors are taken into consideration. Three plant-specific factors are introduced. They are the nature of market orientation, age and government promotion. Firstly, one clear-cut finding in the literature of export-productivity nexus is that exporters are found to have higher

[7] In addition as argued by Hall (1988), the impact of any possible exogenous factors on industry productivity would be conditioned by the degree of market concentration.

productivity than non-exporters after controlling for observed plant characteristics (Wagner, 2007: 66).[8] Hence, the nature of market orientation is included in the plant productivity equation with the theoretical expected positive sign. The nature of market orientation is measured by a binary dummy variable. Firms exporting regardless the extent to which they export are treated as exporting firms and the dummy variable is assigned to be one. Otherwise is zero. Information about the firm's market orientation in the census is reported in five wide ranges; no export, less than 50, 50, less than 100 and 100 per cent export. Hence, the choice of cut-off point is dictated by data availability. The second plant-specific variable is the firm's age (*AGE*). As argued in firm dynamic literature (e.g. Roberts & Tybout, 1996; Tybout, 2000), the general young plants are systematically less productive than mature plants hence the positive relationship between age and productivity is expected. Finally, the zero-one dummy variable is introduced to examine whether firms granted privileges from Board of Investment (BOI) tend to perform differently from those that were not.

Two industry-specific factors, protection and output growth, are introduced. The role of protection on plant productivity has been long recognized in numerous previous studies (e.g. Corden, 1974: Hart, 1983; Martin & Page, 1983; Scharfstein, 1988; Rodrik, 1991). While protection can create economic rents that can be used for productivity improving activities, in practice this could run the opposite. By insulting firms from foreign competition, high protection tends to induce producers to become 'unresponsive' to improved technological capability as well as requests for improvement in the quality and price of what they offer (de Melo and Urata, 1986; Moran, 2001). This in turn results in a general deterioration of technological and management skills Hence, the sign of trade protection is theoretically ambiguous. The trade policy regime (TP) is proxied by effective rate of protection (ERP). Even though, there is no consensus between *ERP* and nominal rate of protection (*NRP*) amongst economists as to choice of one over the other (Corden, 1966; Cheh, 1974), Jongwanich & Kohpaiboon (2007) argue that political bargains in Thai manufacturing are struck over *ERP* rather than *NRP*.

[8] Even though there is ongoing debate whether firms become more productive before export (self-selection) or experience productivity gains after export (learning from export). See the recent survey in Wagner (2007).

The second industry-level factor is growth prospect of an industry. Its rationale relates to the nature of productivity improving activities which incur considerable fixed costs, most of which are irrecoverable, i.e. sunk costs. A large volume of sales over which to spread the fixed cost of innovation are needed. Hence, in this study, the industry's growth prospect is proxied by annual growth of gross output. The higher the annual growth the more the likelihood firms commit resources to productivity enhancing activities.

Based on the above discussion, the estimating equations are specified as follows;

$$\begin{aligned}\ln Y_{ij} &= \beta_0 + \beta_1 \ln K_{ij} + \beta_2 \ln PL_{ij} + \beta_3 \ln NL_{ij} + \beta_4 \ln K_{ij} \ln PL_{ij} + \beta_5 \ln K_{ij} \ln NL_{ij} + \beta_6 \left(\ln NL_{ij}\right)^2 \\ &+ \beta_7 \left(\ln PL_{ij}\right)^2 + \beta_8 \left(\ln K_{ij}\right)^2 + \beta_9 CON_j + \beta_{10} ERP_j + \beta_{11} CON_j * ERP_j \\ &+ \beta_{12} GMS_j + \beta_{13} OWN_{ij} + \beta_{14} AGE_{ij} + \beta_{15} MKT_{ij} + \beta_{16} BOI_{ij} + \varepsilon_{ij}\end{aligned} \quad (4)$$

where

$\ln Y_{ij}$ = Value added of plant *i* in industry *j* (in natural log)

$\ln PL_{ij}$ = Number of production workers of plant *i* in industry *j* (in natural log)

$\ln NL_{ij}$ = Number of non-production workers of plant *i* in industry *j* (in natural log)

$\ln K_{ij}$ = Fixed assets of plant *i* in industry *j* (in natural log)

CON_i (+/-) = Producer concentration of industry *j* (in natural log)

ERP_j (-) = Effective rate of protection (in natural log)

OWN_{ij} (+) = Foreign ownership dummy variable of plant *i* in industry *j*, which equals to one for foreign plants and zero otherwise.

AGE_{ij} (+) = years of operations (in natural log)

MKT_{ij} (+) = market orientation dummy variable of plant *i* in industry *j*, which equals to 1 for exporting plants and zero otherwise.

BOI_{ij} (+/-) = BOI-promotion status of plant *i* in industry *j*, which equals to 1 for BOI promoted plants and zero otherwise.

GMS_j (+) = Annual growth rate of gross output of industry *j* (in natural log)

ε_{ij} = A stochastic error term, representing the omitted other influences.

(the expected sign of explanatory variable is in the bracket)

5. Data Description

The ideal dataset for examining determinants of plant productivity is the panel data set compiled by pooling cross-industry and time-series data. Particularly, in the nature of productivity improving activities that involves a time-consuming process, panel data are more appropriate. Unfortunately, given the nature of data availability in this case, this preferred data choice is not possible. The second best available is the 1997 industrial census, primarily because this is by far the most comprehensive source available to date (Ramstetter, 2006: p. 117). Even though there are alternative datasets available (e.g. industrial surveys in 1998 and 2000 by National Statistics Office (NSO) and those in 2001-04 by Office of Industrial Economics (OIE)), their coverage is far shorter than that in the 1997 census. For example, the 2001-04 industrial survey by OIE covered 3,000 plants, accounting around 35 per cent of the estimated manufacturing value added from National Account (TDRI, 2006). Hence, the 1997 census is our preferred data set.

The census covers 32,489 plants, belonging to 125 4-digit industries of TSIC. Of these, 23,677 plants responded to the questionnaire. The census was cleaned up by firstly deleting plants which had not responded to one or more the key questions and which had provided seemingly unrealistic information such as the negative value added. As has been described in more detail elsewhere (Ramstetter, 2001 and 2004), there are some duplicated records in survey return, presumably because plants belonging to the same firm filled the questionnaire using the same records. The procedure followed in dealing with this problem was to treat the records that report the same value of the ten key variables of interest in this study, as one record.[9] 12 industries that are either to serve niches in the domestic market (e.g. processing of nuclear fuel-TSIC 2330, manufacture of weapons and ammunition-TSIC 2927), in the service sector (e.g. reproduction of recorded media-TSIC 2230, publishing of recorded media-TSIC 2213, building and repairing of ships-TSIC3512) or explicitly preserved for local enterprises (e.g. tobacco-TSIC 1600, manufacture of articles of fur-TSIC 1820; manufacture of ovens, furnaces and furnace burners-TSIC 2914, manufacture of coke oven products-TSIC 2310, building and repairing of ships-TSIC 3511; railway/tramway locomotives and rolling stock-TSIC 3520, aircraft and spacecraft-TSIC 3530) are excluded. As a consequence, the final dataset contains

[9] See detail in Ramstetter (2004) footnote 5. In addition, there are the near-duplicate records. A careful treatment to maximize the coverage of the samples is used as described in more detail in Ramstetter (2004: p.9-10).

8,471 plants (1,684 foreign-owned plants and 6,787 domestic-owned plants) in 113 industries.

Despite being far more comprehensive than alternative sources, the coverage of the industrial census estimates reported only 1.8 million workers or 38.8 per cent of corresponding estimates from the labour force surveys. Similarly the gross output and value added reported in the census was only 76.2 and 59.2 per cent of their corresponding estimates in national accounts reported by National Economics and Social Development Board (NESDB).

To estimate the foreign presence, the ratio of sales of foreign plants to total sales (local and foreign) is measured. All plants with FDI (regardless of the magnitude of the foreign share in capital stock) are considered to be foreign plants for the identification of local plants. Value added is defined as the difference between gross output and raw materials net of changes in inventories, whereas capital stock is represented by the value of fixed assets at the initial period.

As discussed above *CR4* is based on the BOL database from Kophaiboon and Ramstetter (2008). As the concentration is in the centre of the paper's discussion, two alternative measures are used in order to examine the results' robustness. Specifically, *CR4* (referred as *CRA)* and the Herfindahl-Hirshman index of producer concentration (*HHI*) are constructed, using the industrial census at the 4-digit TSIC classification. For measuring labor quality, the supervisory and management workers are defined as employees not directly engaged in production or other related activities. The actual number of supervisors and management workers are not available in the census. So the number of non-production workers reported would also include clerical and administrative staff. Nevertheless, the number of non-production workers could still to some extent be a reasonable proxy of that of available supervisors because the number of support staff is likely to go hand in hand with that of supervisors and management workers. The other information related to plant-specific variables (i.e. *OWN*, *AGE*, and *MKT*) are reported in the census.

Data on ERP estimates are from Athukorala, Jongwanich and Kohpaiboon (2004). They reflect the protection structure in 1997. Even though ERP estimates mainly capture the only tariff protection, this is not a major limitation because there are not many quantitative restrictions (QRs) and subsidies in Thai manufacturing. In addition, the ERP series used is the weighted average of import-competing and export-oriented ERP, so that the impact of various tariff rebate programs is incorporated in ERP estimates. Since ERP is based on the input-output (IO) industrial classifications, the official concordance is used to convert them into 4-digit TSIC. Since a number of industries in the IO industrial classification are far lower than those in the 4-digit TSIC, it is likely that there is not one-to-one matching in the concordance. In cases where an item of TSIC belongs to more than one IO item and vice versa, ERP in the latter is averaged with value added as a weight.

To construct GMS_j, gross output data on 4-digit TSIC industries are obtained from National Economics and Social Development Board (NESDB). The official data series are available in both Revisions 2 and 3 with the different time span. The former includes the early 1980s up to 1996 whereas the latter is available between 1995 and 2005. Since introduction of GMS_j in the model to capture medium- to long-term demand conditions, the annual real growth rate is based on TSIC revision 2 and then the official concordance is applied to converting them to TSIC Revision 3. Nevertheless, there are many cases where TSIC revisions 2 and 3 are not perfectly matched. The gross output weighted average is applied. Table 3 provides a statistical summary as well as a correlation matrix of all relevant variables in this analysis.

6. Econometric Procedure and Results

The equations are estimated using the ordinary least squares (OLS) method while paying attention to the possible presence of outliers. Due to the nature of cross-sectional data, it is likely that outliers could impact on and mislead the estimated parameters and therefore the careful treatment of outliers is needed. Cook's Distance[13] is used to identify suspected outliers. To accommodate the outliers, intercept dummies are introduced and estimated to test both changes in estimated parameters and significance of the interested dummy.

The regression results relating to determinants of plant productivity are reported in Table 4. Equations 4.1 and 4.2 in Table 4 panel A, respectively, are the regression results including and excluding plants that are suspected to be outliers by the Cook's distance. Their results are more or less similar except for minor differences in the coefficients' magnitudes, indicating that the outliers do not have any significant impact on the results. Hence, the following regression analyses will cover the whole sample.

As raised in Cohen & Levin (1989), studies of the firm size-innovative activity relationship need to control for industry effects at a high level of aggregation, e.g. 2-digit level, especially when using a sample covering many industries. It becomes even more important for those undertaken in the context of developing countries where large firms are likely to be diversified and operate in more than one industry.[10] To mitigate such potential problems, 14 industry dummy variables at the 2 digit ISIC industry classification are introduced, over and above the three industry-specific factors included so far (i.e. producer concentration, protection, and output growth. The results with the industry dummies (Equation 4.3 in the panel A) are resilient to that in equation 4.2. Specifically, only a few dummy variables turn to be statistically significant at the conventional level, indicating that three industry-specific factors which are controlled in equation 4.2 seem adequate to take into consideration any industry characteristics.

The regressions are also insensitive to choices of producer concentration measures. The regression results using *CRA* and *HHI* are reported in Equation 4.4 and 4.5, respectively, in Table 4 Panel B. They are resilient to each other but the regression except the key variables i.e. an interaction term between *ERP* and producer concentration and *ERP* exhibit mild statistically significant. Hence, the following discussion will be based on equation 4.1 where outliers are included and *CR4* is used as a proxy of producer concentration.

[10] The conglomerate nature of large firms is very prominent in Southeast Asian economies (Studwell, 2007).

All coefficients corresponding to the plant-specific factors turn out to be statistically significant at the conventional level (5 per cent) with theoretical expected signs. The statistical significance of coefficients corresponding to the primary inputs (capital, production and non-production workers) and their interactions suggests that the assumption imposed in the Cobb-Douglas production function is not supported by data of Thai manufacturing. Even though translog functional form specification is likely to be affected by the multicollinearity problem and standard error is inflated, coefficients associated with the squared values of capital and labour remain statistically significant at the one per cent level or better. As suggested by Johnson (1984), such a multicollinearity problem would not create any severe effect on thr regression outcome. Specifically the effect still shows up because the true value itself is so large. even an estimate on the downside still shows up as significant (Johnson, 1984: 249). The significant coefficient of the firm's age supports the hypothesis that younger firms tend to be less productive than the older ones. Similarly, exporting firms tend to exhibit a higher level of productivity than non-exporting ones as the coefficient corresponding to market orientation variable turns out to be positive and significant. Such evidence supports the consensus in the literature of export-productivity nexus. The statistical insignificance of BOI dummy variable suggests that all other things being equal, there is not significant difference in productivity between BOI and non-BOI plants. We also find that the industry's growth prospect is positively affected the firm's decision to continue their productivity improving activities.

Coefficients corresponding to *CR4*, *ERP*, and their interaction terms are statistically significant at 1 per cent level. This supports the key hypothesis of this paper. The negative coefficient of *CR4*ERP* associated with the positive coefficient of *CR4* suggests that the impact of producer concentration on plant productivity does depend on the degree of market competition from abroad. That is, tariff reduction must reach a certain level (i.e. ERP less than 27) before the potential positive impact of producer concentration on productivity is observed. Even though the coefficient of *ERP* turns out to be positive, their negative coefficient of the interaction term suggests that insulting firms from foreign competition is not sufficient to promote plant productivity improvement. In a highly concentrated industry, high protection tends to induce producers to become 'unresponsive' to improved technological capability and retard productivity growth.

Where ownership mode is concerned, its corresponding coefficient is significant. This supports the proposition that foreign plants tend to be more productively than locally non-affiliated ones. Interestingly, when the whole sample is truncated to individual industry at the two-digit TSIC classification level, there are only 5 out of 14 industries whose ownership coefficient is positive and statistically significant at the conventional level (e.g. 5 per cent). They are textiles, non-metallic products, metal products, general machinery and chemical.[11] The similar findings are also found in Ramstetter (2006). Noticeably, these five industries share three common characters, i.e. high degree of capital intensity, high protection in the mid 1990s, and the relative importance of proprietary assets in determining competitiveness. In addition, these proprietary assets are owned by a handful of MNCs. In this circumstance, MNCs were likely to be enticed by the highly protected domestic market and it is more difficult for the local firm to learn the advanced technology. Instead the highly protected domestic market might encourage the local firm to produce products not directly competitive with those being produced by the foreign affiliate and to enjoy economic rents induced by the regime. Kokko (1994) refers to this as a situation where the foreign affiliate in such an industry may operate in 'enclaves' in isolation from the local firm. They are producing totally different products and employ different production technology, indicated by the statistical significance of ownership variable (*OWN*).

By contrast, the other nine industries (foods, clothing, footwear, jewelry, plastics, electronics, rubber, and furniture) are in line with the country's comparative advantage and are the major export items in Thai manufacturing. Even though some of them such as canned tuna, frozen shrimp, clothing, were subject to high tariff rates during the mid 1990s, they were unlikely to discourage export because exporters can mitigate the negative effect of high tariffs by applying for various tariff exemptions/rebates.[12] The interpretation of the statistical insignificance of *OWN*

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[11] Regression results of 14 industries are reported in Appendix

[12] See evidence of unbinding tariffs in processed foods and clothing industries in Kohpaiboon (2006; 2008), respectively.

variable would be all other things being equal it is unlikely that foreign and local plants would use significantly different production technology. Otherwise, poorer performance firms must leave the industry. As a consequence, the significance of foreign ownership variable in the truncated sample would examine whether the production technology employed in foreign and local firms is similar rather than whether there is productivity difference between foreign and local plants. To examine the latter, it would be more appropriate to cover firms in the whole manufacturing sector.

7. Conclusion and Policy Inferences

This paper examines the impacts of producer concentration on Thai manufacturing productivity. Inter-plant cross-sectional econometric analysis is undertaken, using 1996 industrial census, the only census available so far. The key finding is that the impact of producer concentration on plant productivity is not automatic, but does depend on the degree of tariff protection. Tariff reduction must reach a certain level before the potential positive impact of producer concentration on productivity is observed. Even though insulting firms from foreign competition can promote plant productivity improvement, it is not sufficient. In a highly concentrated industry, high protection can retard process of productivity enhancing activities. We also found that exporting and foreign plant tends to be more productively than domestic-oriented and locally owned one. These results further highlight the relative importance of the trade policy regime for productivity enhancement and thus development policy. Although high levels of producer concentration can result in productivity gains, the competition fostered by open trade policies is required if high concentration is to be translated into higher productivity.

Table 1
Producer Concentration and Effective Rate of Protection in Thai Manufacturing

ISIC	Description	*CR4*	*ERP*
1511	Meat products	56.1	-13.0
1512	Fish products	35.2	-7.9
1513+1514	Fruit & vegetable products	25.4	27.1
152	Dairy products	78.1	12.2
1531	Grain mill products	63.4	14.5
1532+1533	Starches, animal feeds	75.2	-7.8
154	Other food products	34.6	37.8
155	Beverages	73.2	45.9
171	Textiles spinning & weaving	47.3	16.6
172	Other textiles	49.4	16.6
173	Knitted fabrics	61.5	27.0
181	Apparel	42.1	45.3
1911	Leather tanning & dressing	46.9	-25.7
1912	Luggage, handbags, etc.	37.8	25.3
192	Footwear	60.7	6.2
201	Wood sawmilling & planing	62.7	2.0
202	Other wood products	44.2	13.9
210	Paper products	64.0	7.8
221	Publishing	81.5	13.4
222	Printing	52.1	17.3
232	Recorded media	86.1	3.7
2411+2412	Basic chemicals	63.5	6.9
2413	Primary plastics' forms	55.9	15.8
242	Other chemical products	43.9	2.1
243	Synthetic fibers	76.0	-9.8
2511	Rubber tyres & tubes	82.1	33.3
2519	Other rubber products	59.4	16.5
252	Plastic products	41.9	14.7
261	Glass products	70.7	2.6
269	Non-metallic mineral products	74.9	4.3
271	Ferrous metals	45.3	6.2
272	Non-ferrous metals	48.5	-0.5
273	Metals' casting	71.9	0.0
281	Structural metal products	46.0	11.8
289	Other metal products	34.5	0.8
291	General purpose machinery	51.0	8.9
292	Special purpose machinery	66.4	1.6
293	Domestic appliances	64.4	5.1
300	Office & computing machinery	75.5	-0.3
311	Electric motors, etc.	55.3	0.3

(Cont.)

Table 1(Cont.)

ISIC	Description	*CR4*	*ERP*
312	Electricity distribution machinery	87.1	-0.8
313	Insulated wire & cable	98.7	6.4
314	Batteries, etc.	76.1	-6.6
315	Electric lamps	75.9	4.1
319	Other electrical machinery	50.0	4.5
321	Electronic components	44.1	1.8
322	Radio & TV transmitters, etc.	66.8	-0.1
323	Radio & TV receivers, etc.	66.5	-0.1
331	Medical machinery	75.1	-2.2
332	Optical & photographic machinery	68.7	-0.2
333	Watches & clocks	71.9	-2.2
341	Motor vehicle assembly, etc.	81.4	0.2
342	Motor vehicle bodies, trailers, etc.	67.7	-0.4
343	Motor vehicle parts	46.0	22.3
359	Other transportation machinery	90.6	46.9
361	Furniture	46.5	21.3
3691	Jewelry	50.8	6.3
3692+3693+3694+3699	Miscellaneous manufacturing	82.1	32.8
	average	61.2	9.2

*Source*s: CR4 from Kohpaiboon and Ramstetter (2008) whereas ERP from Athukorala, Jongwanich and Kohpaiboon (2004)

Table 2

Four-firm Concentration Ratio of Selected Developing Countries

Country (Year)	CR-4(%)	Source
Thailand (1996)	61	Authors' compilation
Malaysia (1996)	55	Bhattacharya (2002)
Malaysia (1986-96)	55-62	-do-
Brazil (1989)	51.1	Willmore (1989)
Argentina (1989)	43	Frischtak (1989)
Indonesia (1993)	53.5	(Bird, 1999).
Indonesia (1975-93)	50.9-63.6	-do-
Taiwan (1997)	45.2	Yang (2007)
Taiwan (1997-2003)	40.9-45.2	-do-
Vietnam (2000)	42.1	Ramstetter and Ngoc (2007)
Vietnam (2004)	35.28	-do-

Table 3
Correlation Matrix of the Variables

	$\ln Y_i$	$\ln K_i$	$\ln PL_i$	$\ln NL_i$	OWN_{ij}	AGE_{ij}	BOI_{ij}	$CR4_j$	ERP_j	HHI_j	CRA_j	GO_j	MKT_{ij}
$\ln K_i$	0.70	1											
$\ln PL_i$	0.70	0.64	1										
$\ln NL_i$	0.66	0.61	0.66	1									
OWN_{ij}	0.34	0.35	0.32	0.29	1								
AGE_{ij}	0.13	0.10	0.13	0.16	-0.05	1							
BOI_{ij}	0.33	0.39	0.35	0.28	0.44	-0.12	1						
$CR4_j$	0.02	0.01	-0.02	0.01	0.00	-0.02	0.01	1					
ERP_j	-0.02	-0.08	0.05	-0.03	-0.04	-0.02	-0.05	0.17	1				
HHI_j	0.01	0.02	-0.08	0.00	0.02	0.04	-0.02	0.03	-0.13	1			
CRA_j	0.02	0.05	-0.09	0.02	0.03	0.06	0.00	0.07	-0.20	0.85	1		
GO_j	0.09	0.06	0.04	0.06	0.15	-0.11	0.14	0.00	-0.11	0.04	0.05	1	
MKT_{ij}	0.36	0.34	0.46	0.33	0.40	0.01	0.36	-0.03	0.09	-0.06	-0.09	0.07	1

Note: See variable construction in Section 4.
Source: Data compiled from the Industry Census 1997 (Data for 1996), conducted by National Statistics Office (NSO).

Table 4
Determinants of Plant productivity: Regression Results

Panel A: Sensitivity analysis of presence of outliers and choices of industry Dummies (*CR4*-as producer concentration)

	Equation 4.1		Equation 4.2		Equation 4.3	
	Estimates	*t*-stat	Estimates	*t*-stat	Estimates	*t*-stat
$\ln K_i$	0.16	*5.98*	0.19	*10.03*	0.16	5.99
$\ln PL_i$	0.53	*14.47*	0.60	*26*	0.53	14.53
$\ln K_i \ln PL_i$	-0.03	*-2.29*	-0.04	*-7.4*	-0.02	-1.97
$\ln NL_i$	0.31	*12.11*	0.30	*16.54*	0.30	12.05
$\ln K_i \ln NL$	-0.01	*-1.16*	-0.01	*-2.47*	-0.01	-1.48
$\ln K_i^2$	0.04	*5.73*	0.05	*16.7*	0.04	5.68
OWN_{ij}	0.17	*4.86*	0.18	*7.2*	0.16	4.55
AGE_{ij}	0.004	*3.26*	0.00	*4.08*	0.00	2.77
BOI_{ij}	-0.03	*-0.72*	0.00	*-0.1*	-0.04	-0.94
CON_j	0.70	*4.77*	0.65	*5.47*	1.01	5.38
ERP_j	1.38	*2.6*	1.18	*3.14*	2.59	4.36
$CON_j * ERP_j$	-2.91	*-2.92*	-2.58	*-3.58*	-5.10	-4.43
GMS_j	0.81	*4.83*	0.90	*6.58*	1.06	3.8
MKT_{ij}	0.04	*1.64*	0.05	*2.2*	0.03	1.14
INTERCEPT	-1.39	*-10.9*	-1.61	*-17.68*	-1.56	-11.08
F-test	1002.6	(p= 0.00)	1866.9	(p=0.00)	515.5	(p=0.00)
RESET	1.86	(p=0.14)	1.67	(p=0.17)	1.66	(p=0.17)

Notes: Equation 3.1 is estimated with the whole sample (suspected outlier samples included) but without industry dummies whereas equation 3.2 is equation 3.1 excluding suspected outlier samples. Regression in equation 3.3 is the estimation of the whole sample with the 2-digit TSIC industry dummy variables. *RESET* =Ramsey test for functional form misspecification (F-distribution)
Sources: Author's estimates based on data series discussed in the text.

Panel B: Alternative Measures of Producer Concentration

	Equation 4.4 (*CON=CRA*)				Equation 4.5 (*CON=HHI*)			
	w/o ind dummies		wi inddummies		w/o ind dummies		wi ind dummies	
	Estimates	*t*-stat	Estimates	*t*-stat	Estimates	*t*-stat	Estimates	*t*-stat
$\ln K_i$	0.163	*6.19*	0.161	*6.13*	0.163	*6.17*	0.162	6.17
$\ln PL_i$	0.523	*14.36*	0.519	*14.17*	0.523	*14.34*	0.522	14.21
$\ln K_i \ln PL_i$	-0.024	*-2.19*	-0.021	*-1.91*	-0.024	*-2.23*	-0.022	-1.95
$\ln NL_i$	0.311	*12.35*	0.308	*12.33*	0.310	*12.32*	0.308	12.33
$\ln K_i \ln NL$	-0.011	*-1.33*	-0.013	*-1.57*	-0.011	*-1.3*	-0.013	-1.58
$\ln K_i^2$	0.044	*5.68*	0.044	*5.65*	0.044	*5.7*	0.044	5.66
OWN_{ij}	0.164	*4.79*	0.157	*4.55*	0.166	*4.86*	0.157	4.56
AGE_{ij}	0.003	*2.66*	0.003	*2.38*	0.003	*2.85*	0.003	2.45
BOI_{ij}	-0.035	*-0.92*	-0.049	*-1.28*	-0.034	*-0.89*	-0.048	-1.25
CON_j	**0.328**	***3.1***	**0.164**	***1.31***	**0.443**	***3.3***	**0.351**	**2.36**
ERP_j	**0.289**	***1.44***	**0.618**	***1.77***	**0.111**	***1.01***	**0.310**	**1.92**
$CON_j * ERP_j$	**-1.154**	***-2.09***	**-1.490**	***-1.80***	**-2.021**	***-3.02***	**-1.973**	**-2.64**
GMS_j	0.776	*4.61*	0.776	*2.82*	0.793	*4.72*	0.782	2.87
MKT_{ij}	0.038	*1.42*	0.021	*0.77*	0.034	*1.26*	0.019	0.70
INTERCEPT	-1.167	*-9.68*	-1.118	*-8.68*	-1.100	*-9.48*	-1.111	*-9.12*
F-test	1004.09	(p= 0.00)	514.8	(p=0.00)	1003.49	(p=0.00)	515.25	(p=0.00)
RESET	2.12	(p=0.10)	1.68	(p=0.17)	2.76	(p=0.04)	1.79	(p=0.15)

Notes: *RESET* =Ramsey test for functional form misspecification (F-distribution) and *t*-stat is based on the White's Heteroscedasticity standard error.
Source: Author's estimates based on data series discussed in the text.

Appendix: Productivity Determinants Equations at the 2-digit TSIC Classification

Panel A: Foreign ownership is statistically significant at 10 per cent or better

	Textile		Non-metalics		Metal products		General Machinery		Chemical	
	Estimates	*t*-stat	Estimates	*t*-stat	Estimates	*t*-stat	Estimates	*t*-stat	Estimates	*t*-stat
$\ln K_i$	0.10	1.01	0.18	1.66	0.20	1.86	0.19	2.56	0.12	1.08
$\ln PL_i$	0.35	3.03	0.60	4.84	0.48	4.15	0.38	3.2	0.58	4.09
$\ln K_i \ln PL_i$	0.06	1.84	-0.02	-0.57	-0.03	-0.74	0.03	0.89	-0.04	-1.23
$\ln NL_i$	0.46	4.33	0.29	3.04	0.36	4.12	0.37	4.13	0.43	4.65
$\ln K_i \ln NL$	-0.06	-1.84	-0.02	-0.72	-0.03	-0.89	-0.04	-1.4	-0.04	-1.27
$\ln K_i^2$	-0.01	-0.47	0.04	2.1	0.04	2.36	0.02	0.86	0.07	4.54
OWN_{ij}	**0.38**	**3.34**	**0.31**	**1.68**	**0.35**	**3.13**	**0.24**	**1.76**	**0.46**	**3.39**
AGE_{ij}	0.001	0.13	0.01	1.05	0.003	0.76	-0.004	-0.68	0.005	1.39
BOI_{ij}	0.02	0.15	-0.27	-1.42	-0.001	-0.01	0.041	0.25	-0.32	-2.11
MKT_{ij}	0.22	2.51	-0.24	-2.21	-0.02	-0.24	-0.039	-0.34	0.10	0.86
INTERCEPT	-0.90	-2.64	-1.26	-3.15	-0.89	-2.6	-0.594	-1.68	-1.29	-2.83
F-Stat	121.39	(p=0.00)	104.34	(p=0.00)	110.27	(p=0.00)	148.51	(p=0.00)	70.91	(p=0.00)
R-squared	2.06	(p=0.10)	0.60	(p=0.61)	1.64	(p=0.18)	1.02	(p=0.38)	0.16	(p=0.92)

(contd.)

Appendix (contd.)

Panel B: Foreign ownership is not statistically significant at the 10 per cent.

	Foods		Furniture		Apparel		Leather &Footwears		Plastics	
	Estimates	*t*-stat	Estimates	*t*-stat	Estimates	*t*-stat	Estimates	*t*-stat	Estimates	*t*-stat
$\ln K_i$	0.14	2.11	0.15	1.04	0.20	1.96	0.06	0.26	0.06	0.69
$\ln PL_i$	0.50	5.23	0.56	3.19	0.60	6.01	0.51	3.28	0.39	3.55
$\ln K_i \ln PL_i$	-0.04	-1.73	-0.02	-0.33	-0.03	-0.84	0.03	0.45	0.02	0.53
$\ln NL_i$	0.31	4.87	0.15	1.69	0.15	2.01	0.56	4.12	0.29	3.36
$\ln K_i \ln NL$	-0.01	-0.66	0.01	0.41	0.04	1.23	-0.12	-2.47	-0.02	-0.66
$\ln K_i^2$	0.07	5.75	0.03	0.84	-0.001	-0.04	0.05	1.2	0.03	1.7
OWN_{ij}	**-0.02**	**-0.15**	**-0.01**	**-0.08**	**0.02**	**0.21**	**0.08**	**0.47**	**0.000**	**0**
AGE_{ij}	0.001	0.45	0.01	0.9	0.01	2.25	-0.01	-0.5	0.02	2.93
BOI_{ij}	0.004	0.03	-0.25	-1.51	0.10	0.81	0.02	0.1	0.05	0.34
MKT_{ij}	-0.02	-0.28	-0.19	-1.18	0.07	0.94	0.02	0.12	0.25	2.75
INTERCEPT	-0.87	-2.95	-0.79	-1.32	-1.05	-3.27	-1.04	-1.93	-0.66	-1.85
F-Stat	241.81	(p=0.00)	41.46	(p=0.00)	108.93	(p=0.00)	42.02	(p=0.00)	119.21	(p=0.00)
R-squared	3.63	(p=0.01)	0.57	(p=0.64)	0.32	(p=0.81)	1.65	(p=0.18)	0.15	(p=0.93)

(contd.)

Appendix (contd.)

	Jewellry		Electrical Machinery		Automotive		Rubber	
	Estimates	*t*-stat	Estimates	*t*-stat	Estimates	*t*-stat	Estimates	*t*-stat
$\ln K_i$	0.66	2.05	0.17	1.74	0.03	0.3	-0.03	-0.16
$\ln PL_i$	1.00	4.95	0.25	2.02	0.65	4.05	0.84	2.96
$\ln K_i \ln PL_i$	-0.19	-2.12	0.06	1.75	0.002	0.06	-0.10	-1.41
$\ln NL_i$	0.51	2.15	0.34	3.93	0.05	0.51	0.39	1.39
$\ln K_i \ln NL$	-0.07	-0.89	-0.02	-1.01	0.04	1.3	-0.03	-0.44
$\ln K_i^2$	0.12	2.19	-0.002	-0.08	0.02	1.38	0.12	3.36
OWN_{ij}	**0.05**	**0.28**	**0.16**	**1.32**	**0.15**	**0.89**	**0.07**	**0.32**
AGE_{ij}	0.01	0.47	0.01	1	0.002	0.47	0.000	0.02
BOI_{ij}	0.21	1.04	-0.26	-2.11	0.31	1.62	0.05	0.22
MKT_{ij}	0.16	0.73	0.11	0.8	0.14	1.07	0.25	1.39
INTERCEPT	-2.89	-3.93	-0.24	-0.55	-0.97	-2.18	-1.58	-2.22
F-Stat	21.65	(p=0.00)	139.96	(p=0.00)	149.82	(p=0.00)	37.55	(p=0.00)
R-squared	0.30	(p=0.83)	0.88	(p=0.45)	1.06	(p=0.37)	0.47	(p=0.71)

Sources: Author’s estimates based on data series discussed in the text.

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