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Firm Productivity in Thai Manufacturing Industries: Evidence from Firm-level Panel Data.

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Firm Productivity in Thai Manufacturing Industries:

Evidence from Firm-level Panel Data

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Abstract:

Using firm-level panel data from the Manufacturing Industry Survey of Thailand between 1999 and 2003, this paper estimates the production function and examines the determinants of total factor productivity (TFP) for manufacturing firms in Thailand. Controlling for industry, region, and year fixed effects, production function coefficients and TFP measures are obtained through various estimation techniques including ordinary least squares (OLS), fixed effects, random effects, and the Levinsohn and Petrin (2003) for comparison. For production function estimation, the results illustrate the biases introduced in traditional TFP estimates and we discuss the performance of alternative estimators. For the determinants of TFP, the results show that firm size is associated with firm TFP, with smaller firms being more productive than larger ones. Firm age and TFP are negatively correlated, indicating that newer firms tend to exhibit higher TFP. Firms with a more skilled workforce also show a higher level of production. Moreover, firm TFP benefits from integration into world markets: foreign-owned firms and exporters have significantly higher TFP. The results further reveal that firm TFP varies with the form of organization, with private firms (in terms of legal organization) and Head-Branch typed firms (in terms of economic organization) having higher TFP. Our findings draw attention to some key areas of policy relevance in which policies promoting labor quality may have important benefits for firm TFP. Furthermore, development in the international integration of firms into world markets through their participation in export markets and attraction of foreign capital is also likely to have large payoffs in terms of TFP for Thai manufacturing.

JEL classification: D24, F23, L25

Keywords: Total Factor Productivity, Simultaneity, Production Function, Openness, Thailand

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1. Introduction

Recent years have seen a remarkable increase in studies on productivity using longitudinal micro-level data sets in various aspects for both developed and developing countries. The popularity of this emerging field of research can be attributed, in part, to the increased availability of micro-level data. More importantly, the theory of total factor productivity (TFP) is now widely accepted as an overall measure of the degree of technological advancement in a country's economy. The efficiency of a firm, measured by either TFP or labor productivity, is considered the main indicator of a firm's competitiveness in both domestic and international markets. TFP is also regarded as the main contributing factor to economic growth. While the origin of TFP analysis can be traced back to Solow's seminal papers in Solow (1956; 1957), recent years have witnessed a surge in both new theoretical and empirical studies on TFP, this interest being driven both by the increasing availability of firm-level data in many countries as well as by a number of methodological developments that have emerged from the literature (Bartelsman and Doms, 2000).

Specifically, an increase in TFP growth rate is indicative of higher output being produced with either the same or lower input due to more efficient utilization of inputs based on the enhancements of existing technology. Such improvements in TFP growth allow firms to lower their costs and improve the quality of their products. This, in turn, helps many firms to maintain or increase their competitiveness. For this reason, it is crucial to have a complete understanding of the TFP concept and an accurate measurement of TFP to equip policy makers with appropriate information that can aid in policy-making decisions (Sampat, 2007). Additionally, it is important to note that simply measuring the aggregate productivity of the economy at the macro level does not reveal productivity trends at the micro level and thus cannot yield accurate results for productivity-enhancing policy implications.

Nevertheless, a number of methodological issues emerge when TFP is estimated using traditional methods, i.e. by applying Ordinary Least Squares (OLS) to a balanced/unbalanced panel of (continuing) firms. Since productivity and input choices are likely to be correlated, the OLS estimation of firm-level production functions leads to a simultaneity or endogeneity problem. Furthermore, by using a balanced panel, no allowance is made for entry and exit, resulting in a selection bias. A closer examination of existing studies reveals that many studies do not control for both the biases of selection and simultaneity while measuring TFP. In response to these methodological issues in estimating micro-level TFP, several (parametric and semi-parametric) estimators have been proposed in the literature (Van Beveren, 2012).[1]

The objective of this paper is to provide a reliable measure of both firm-level production function estimation and determinants of TFP for Thai manufacturing firms. Our paper contributes to the existing literature by combining a single analytical framework with various production function estimation techniques and TFP determinants that have been analyzed separately in previous studies. In the case of Thai manufacturing, several industry-level studies on production function estimation and TFP exist but only a few firm-level studies have been conducted. To the best of our knowledge, our paper is one of the first studies for the Thai case to focus on the overall aspect regarding the estimation of production function and TFP determinants of firms in Thai manufacturing. In particular, production function estimates are computed using various estimators; namely, Ordinary Least Squares (OLS), Fixed Effects (FE), Random Effects (RE) and the Levinsohn and Petrin (LP) methodology (Levinsohn and Petrin, 2003). The intent of using many different methodologies is to compare and contrast the advantages and drawbacks of each approach for the Thai case.

Despite the importance of the issue, this topic has not been widely explored, with relatively little known concerning factors affecting TFP and the extent of the methodological

[1] See Van Beveren (2012) for a comprehensive review of the recent literature on TFP estimation.

problems that arise when estimating production function at the firm-level in Thailand. As a result, Thailand can be considered an interesting case study illustrating this issue for at least two reasons. First, empirical evidence on the determinants of firm productivity in developing countries is still relatively scarce. Most firm-level productivity studies have focused on developed countries with greater available data. Second, the manufacturing sector in Thailand is particularly dynamic, having experienced exceptionally strong growth since the 1990s. Furthermore, as suggested by the fact that the Thai manufacturing sector is relatively broad based compared to those of other neighboring countries, the Thai experience regarding industrialization appears to be one of the most successful cases among developing economies. Therefore, this paper aims to provide results for various production function estimations and TFP determinants of firms involved in Thai manufacturing using detailed firm-level data taken from the Manufacturing Industry Survey of Thailand between 1999 and 2003.

This paper aims to push forward a significant coverage in the research area concerning productivity estimation in Thailand. It attempts to provide several contributions to research studies in this field for the case of newly industrialized and developing countries. This study is an empirical one that provides rigorous measurement of production functions and TFP determinants in the Thai manufacturing sector. Therefore, findings from this study may be used for comparison across countries, especially for other developing economies. In addition, our study also tries to expand a new area of empirical research for Thai productivity measurement by introducing the use of both the parametric and semi-parametric approach to analyzing its firm-level data. This exercise enables us to answer some fundamental questions regarding the TFP performance of Thai manufacturing firms and industries in detail.

The next section provides a brief literature review regarding the measurement of firm TFP. Section 3 highlights the data description. Section 4 describes the empirical methodology used in our analysis. Section 5 discusses the estimated results and section 6 concludes.

2. Literature Review: Methodological Issues in Measuring Firm TFP

Firm-level productivity studies usually assume output (typically measured as deflated sales or value added) to be a function of the inputs used by the firm and/or the plant (Katayama et al., 2003). The measure of TFP attained as the residual in this functional relationship is then used to assess the impact of various policy measures, such as the extent of foreign ownership (e.g., Javorcik, 2004) or trade liberalization (e.g., Pavcnik, 2002; Amiti and Konings, 2007; De Loecker, 2011). However, a number of methodological issues become apparent when TFP is estimated using traditional methods, i.e., by applying Ordinary Least Squares (OLS) to a balanced panel of firms. First, because productivity and input choices are likely to be correlated, the OLS estimation of firm-level production functions often leads to a well-known endogeneity problem. Moreover, by using a balanced panel, no allowance is given for entry and exit of a firm and this usually results in a selection bias. Although the endogeneity and selection biases are common, several other methodological issues have emerged more recently. Specifically, the typical practice of proxying for firm-level prices using industry-level deflators has been challenged (Katayama et al., 2003).

In recent years, the availability of firm/plant-level data has allowed researchers all over the world to investigate reasons behind the huge dispersion in productivity performances across firms which lead to the formation of policies capable of improving productivity and ultimately generating economic growth. Some outstanding examples of earlier firm-level productivity studies are Bartelsman and Dhrymes (1998) for the case of U.S. manufacturers, and Tybout (2000) for the case of developing countries. Concerning current empirical studies on production function estimation and TFP determinants, one of the recent studies for developing countries can be found in Fernandes (2008) for the case of Bangladesh. This paper examines the determinants of total factor productivity for manufacturing firms in Bangladesh using survey data. TFP measures are obtained following Olley and Pakes (1996), making use of firm-specific deflators for output and input. Controlling for industry, location, and year fixed effects, the author finds that: (i) firm size and TFP are negatively correlated; (ii) firm age and TFP exhibit an inverse-U shaped relationship; (iii) TFP improves with the quality of the firm's human capital; (iv) global integration enhances TFP; (v) firms with R&D activities and quality certifications have higher TFP, while more advanced technologies improve TFP only in the presence of significant absorptive capacity; (vi) power supply problems cost firms greatly in terms of TFP losses; and (vii) the presence of crime reduces TFP.

Although there have been numerous studies on the productivity of Thailand (i.e., Collins et al., 1996; Sarel, 1997; Dollar et al., 2000), most of these studies only cover the pre-crisis period (before 1997), as most of the research had been conducted in order to examine the productivity growth of Thailand during this timeframe. In addition, most of the studies regarding the measurement of Thai productivity have employed the growth accounting approach, an older concept of TFP analysis with many critical drawbacks. Furthermore, the growth accounting approach is usually based on the strong assumptions of constant return to scales and perfectly competitive markets. These assumptions are often considered too strong in the case of a newly industrialized or developing countries such as Thailand.

Therefore, the use of an alternative approach and analytical framework to productivity measurement, which has not been used before in the Thai case, is proposed in this paper. Both parametric and semi-parametric estimators, applied to production function and TFP estimation, are utilized here. Specifically, four methods will be used to estimate production functions; OLS, FE, RE and LP. The first three methods serve as robustness estimations, which are needed to compare if the LP model behaves as expected. The LP method is used due to the nature of the data set and because it has been empirically used in several other studies as an alternative method in estimating firm-level production function.

3. Data Description: Data Coverage and Variable Definitions

For the manufacturing sector in Thailand, there are three types of data sets which can be used for firm-level analysis. First, the Industry Survey provided by the Office of Industrial Economics, Ministry of Industry (OIE Survey) is available from 2001 to 2006. However, the number of firms covered in the OIE Survey is relatively small and the survey coverage is rather limited (Kohpaiboon, 2009). Second, more comprehensive samples are available in the National Statistical Office's (NSO) Industrial Census for 1997 and 2007 (data collected in 1996 and 2006, respectively). The 1997 and 2007 censuses are by far the most comprehensive data available on Thai manufacturing. However, the main drawback of this census data is that it is cross-sectional data, which limits its use for sophisticated research methodology such as panel data analysis, and so forth. Third, the last resort of micro-level data in Thai manufacturing can be found in the Manufacturing Industry Survey by the NSO, which covers data from 1991 to recent years. In spite of this, the coverage in this survey is somewhat inconsistent in that, although having been collected continuously for many years since 1991, the data for certain years are not electronically accessible by the time of this study, leading to difficulties in creating complete panel data from these surveys. This lack of complete panel data in many developing countries, including Thailand, is one of the main reasons there have been so few studies employing firm-level analysis.[2]

In this paper, the Manufacturing Industry Surveys by the National Statistical Office (NSO) of Thailand from years 1999, 2000, 2001, and 2003 are used.[3] The electronic version of the survey is made available only from 1991 to 2003, but the quality of the survey prior to 1999 (1991-1995) is rather problematic due to incomplete and missing values in the data. Additionally, the industry classification code used in those surveys before 1999 is the old

[2] See Ramstetter (2009) for the details and explanation of firm-level data set of Southeast Asian countries.
[3] The identity code used in the surveys is not consistent over time and the nature of data is rather unbalanced. In this study, after the data-cleaning procedure, we refer to "establishment" and "firm" interchangeably.

industry classification code (TSIC: Thailand Standard Industrial Classification) which does not match with the new industry classification code (ISIC: International Standard Industrial Classification). Furthermore, these surveys are also subject to inconsistency in industry identification of samples, matching problems between sales figures and other firms' basic information allocated in a separate manner, and lastly to a sharp decline in sample number. Hence, only the Manufacturing Industry Survey data during the years 1999, 2000, 2001, and 2003 are effectively used in this paper. The Manufacturing Industry Survey is conducted by the NSO with the main objective of collecting basic industrial information on firm's number of establishments, number of persons engaged, number of employees, compensation, value of raw materials, parts and components purchased, sales value of goods produced and purchased for resale, inventory and value of fixed assets. The establishments under the scope of this survey are those engaged primarily in manufacturing industries (category D International Standard Industrial Classification of All Economic Activities; ISIC: Rev.3). The survey covers all establishments with 10 or more persons engaged in all parts of the country.

Originally, there were 8,552, 9,360, 9,294, and 8,862 entries in the 1999, 2000, 2001, and 2003 surveys, respectively. Of these, we only use observations which are enumerated in the survey (i.e., by a firm which really exists and responds to the survey). The sample observations were therefore lowered to 8,552, 4,658, 4,962, and 8,862 observations in the 1999, 2000, 2001, and 2003 surveys, respectively. After that, the survey was first cleaned up by identifying duplicated samples (i.e., firms belonging to the same firm which fill in the questionnaire using the same records) in the survey. The procedure followed in dealing with this problem was to treat the records that reported the same values of the five key variables of interest in this study, namely registered capital, output value, domestic sales, domestic raw materials, and imported raw materials as duplicates. Second, firms which had not responded to one or more of key questions and/or which had provided seemingly unrealistic information such as a negative value added, no report of worker numbers, and unlikely initial capital stock and total sales (less than 100 baht) were all dropped from the sample observation. Finally, we also excluded micro-enterprises which are defined as a firm with less than 2 workers. After the data-cleaning procedure, the total number of samples dropped from 27,034 to 18,078 observations from a total of four years. Regarding the data used in this study, Table 1 provides a summary of survey characteristics and the extent to which it represents the whole Thai manufacturing sector during this period.

Table 1: Statistical Summary of the Key Variables

Variable	Unit	Obs	Mean	Std. Dev.	Min	Max
ln*Y* (Output)	(ln) baht	18078	16.5179	2.4994	8.0064	25.2085
ln*K* (Capital)	(ln) baht	18078	15.9849	2.3500	5.1930	24.9428
ln*L* (Labor)	(ln) baht	18078	3.8546	1.4098	1.0986	9.7658
ln*M* (Materials)	(ln) baht	18078	15.8708	2.7421	5.7038	25.0273
Small	zero-one dummy	18078	0.2889	0.4532	0.0000	1.0000
Medium	zero-one dummy	18078	0.6073	0.4884	0.0000	1.0000
Large	zero-one dummy	18078	0.1039	0.3051	0.0000	1.0000
Foreign	zero-one dummy	18078	0.1604	0.3670	0.0000	1.0000
Exporters	zero-one dummy	18078	0.2877	0.4527	0.0000	1.0000
Importers	zero-one dummy	18078	0.3249	0.4684	0.0000	1.0000
Central	zero-one dummy	18078	0.4620	0.4986	0.0000	1.0000
Municipal	zero-one dummy	18078	0.4670	0.4989	0.0000	1.0000
Government	zero-one dummy	18078	0.0511	0.2201	0.0000	1.0000
Head Branch	zero-one dummy	18078	0.5183	0.4997	0.0000	1.0000
ln*Age*	(ln) years	18078	2.2751	0.7720	0.0000	4.5951
ln*LQ*	(ln) proportion	17378	0.4410	0.1668	0.0022	0.6931
ln*HERF*	(ln) proportion	18078	0.0441	0.0492	0.0078	0.3635

Notes: Mean = simple average; Std. Dev. = standard deviation; Min = minimum; and Max = maximum; Variables in the unit of (ln) proportion are the variables which are converted from original units into logarithmic form as ln (x) where x is the variable.
Source: Author's calculation

In this paper, we will attempt TFP estimation for industrial level as well as for the whole economy. However, due to the shortage of sample observations in some industries in the survey, we combined several similar industries into one industry classification for simplicity. Some industries are combined to achieve a sufficiently large number of observations and only grouped together based on similarities in the type of activity and factor intensity. Eventually, there are 19 industries included in our analysis for the estimation; namely, manufacture of food and tobacco products (ISIC 15-16), manufacture of textiles (ISIC 17), manufacture of wearing apparel (ISIC 18), manufacture of leather products (ISIC 19), manufacture of wood products (ISIC 20), manufacture of paper products (ISIC 21), manufacture of publishing, printing and media (ISIC 22), manufacture of petroleum products (ISIC 23), manufacture of chemical products (ISIC 24), manufacture of rubber and plastic products (ISIC 25), manufacture of non-metallic mineral products (ISIC 26), manufacture of basic metals (ISIC 27), manufacture of fabricated metal products, machinery and equipment (ISIC 28-29), manufacture of office and computing machinery (ISIC 30), manufacture of electrical machinery (ISIC 31), manufacture of communication equipment (ISIC 32), manufacture of medical instruments (ISIC 33), manufacture of motor vehicles (ISIC 34), and manufacture of transport equipment and furniture (ISIC 35-36).

For the computation of total factor productivity (TFP), total sales net of changes in inventories of a firm is used as a measure of output (*Y*) and were deflated using industry specific whole sale price indices. Total employment at the firm level is used to capture the labor (*L*) component which includes both male and female workers. Total cost and purchase of materials and components are used to calculate the material (*M*) component. The measure used for capital stock (*K*) was constructed using the average value of fixed assets of firms at the beginning and at the end of each year.

As for other variables used in the analysis of TFP determinants, *HERF* is the Herfindahl index of industry concentration constructed using the data from total sales at the 4-digit ISIC classification, and *LQ* is the labor quality index measured as the share of male workers in the total workforce in each firm. Lacking sufficient data on the number of managers, technicians, or engineers (white-collar workers) in the original dataset, this proxy was deliberately chosen because, like some other middle income countries, Thailand has experienced a reversal in the education gender gap, as more male students than female ones enroll in higher education. Lower female participation in higher education is linked to lower enrollment rates of females at the secondary level, due to higher secondary school dropout rates and greater participation in the labor market (Edstat – The World Bank Group, 2009). *Foreign* is the share of foreign ownership (equal to 1 if foreign investment in a firm is reported and zero otherwise). *Exporter* is exporting status of a firm (equal to 1 if a firm is exporting and zero otherwise). *Municipal* is an area dummy (equal to 1 if a firm is in a municipal area and zero otherwise). *Central* is an area dummy which is equal to 1 if a firm is in the central area - Bangkok and the central region, and zero otherwise. *Head Branch* is the form of economic organization dummy variable (equal to 1 if firms are Head Branch type and zero if they are Single Unit type). *Government* is the form of legal organization dummy variable (equal to 1 if firms are state-owned and zero if they are privately owned).

Lastly, while the total observation in this study is summarized as in Table 1, it is important to note that the number of actually used observation when regressing and estimating each model may differ depending on the variables used in the specification. The reasons for changing number of observations are twofold. First, observations with extreme values (heavily influential outliers that have extreme values of observed variables distorting estimates of regression coefficients) may be dropped during the estimation to preserve the reliable and consistent estimation results. Second, depending on the variable and estimation technique utilized in the calculation, estimated results may demonstrate slightly fewer observations than the original observation shown in Table 1 because some observations are naturally omitted due to insufficient information and missing values.

4. Empirical Methodology

4.1 Estimating Production Function and TFP

While firm TFP measures are not directly observable to the researcher, they can be estimated as residuals from production function. Following Fernandes (2008), we estimate the following Cobb-Douglas production function in which output (Y_{ijt}) is produced by a combination of three inputs: labor (L_{ijt}), materials (M_{ijt}), and capital (K_{ijt}):

$$\ln Y_{ijt} = A_{ijt} + \beta_L \ln L_{ijt} + \beta_M \ln M_{ijt} + \beta_K \ln K_{ijt} \quad (1)$$

where subscripts *i*, *j* and *t* stand for firm, industry and time, respectively, and A_{ijt} is TFP which represents the efficiency of the firm in transforming inputs into output. Next, we will discuss the empirical methodology used in our analysis. The details are as follows.

4.1.1 The OLS Approach

A commonly used practice for estimating productivity is ordinary least squares (OLS). This technique requires estimating the output as a function of the input and then subtracting the estimated output from actual output to calculate productivity as the residual. However, several problems have been raised since this traditional estimation technique may suffer from simultaneity (endogeneity) and selection bias. The simultaneity problem was first identified by Marshack and Andrews (1944) who pointed out that inputs in the production function are not independently chosen. If the firm has knowledge of the productivity level while making a decision regarding the quantity of input utilization, then the OLS estimation of production function will result in biased estimates of the coefficients of each input (Van Beveren, 2012).

The second problem is related to the so-called sample selectivity bias: The researcher only has knowledge of firms that remain in the market in each period, whereas a firm's decision to stay in the market depends on its productivity and expected future profitability. If there is a positive correlation between greater capital stocks and future profitability, then firms with higher capital stock, at any productivity level, will have a higher survival rate in the market. The expectation of productivity, contingent upon the firm's survival, would then be decreasing in capital. The OLS estimates of the production function would thus lead to a negative bias in the capital coefficient (the capital coefficient will be biased downwards in a balanced sample).

4.1.2 Fixed Effects Estimation

By assuming that A_{ijt} is firm-specific, but time-invariant, it is possible to estimate Equation (1) using a fixed effects estimator (Pavcnik, 2002; Levinsohn and Petrin, 2003). Equation (1) can be estimated in levels using a Least Square Dummy Variable Estimator (LSDV, i.e., including firm-specific effects) or in first (or mean) differences. Provided unobserved productivity in A_{ijt} does not vary over time, estimation of (1) will result in consistent coefficients on labor, capital and materials (Van Beveren, 2012). By using only the within-firm variation in the sample, the fixed effects estimator overcomes the simultaneity bias discussed in the previous section. Moreover, to the extent that exit decisions are determined by the time-invariant, firm-specific effects, this within estimator also eliminates the selection bias caused by endogenous exit in the sample. As a result, estimation of Equation (1) using either the balanced or unbalanced (i.e. allowing for entry and exit) sample should result in similar estimates for the coefficients (Van Beveren, 2012).

4.1.3 The Levinsohn and Petrin (LP) Approach

Alternative approach was suggested by Levinsohn and Petrin (LP) (2003) who extend and build upon the methodology used by Olley and Pakes (OP) (1996). As outlined above, the endogeneity bias can be partly corrected using fixed effects estimation for the production function, which eliminates unobserved *fixed* firm characteristics that may simultaneously affect input choices and TFP. However, there may still be unobserved *time-varying* firm characteristics simultaneously affecting input choices and TFP. The estimation methodology proposed by Olley and Pakes (1996) is to correct for this potential simultaneity bias generated by such time-varying unobservable firm characteristics. Specifically, the main idea behind this methodology is that an observable firm characteristic – investment – together with capital input can be used to proxy for the unobserved firm productivity and estimate unbiased production function coefficients. However, our data includes only operating firms and no information is provided from the survey in terms of firm investment and firm dynamics (the entry and exit of the same firm in each year of the survey). As a result, it is impossible in our paper to utilize the estimation methodology by Olley and Pakes (1996) due to the limitation and nature of the data provided by the National Statistical Office of Thailand (NSO).

Alternatively, Levinsohn and Petrin (2003) proposed using not investment but intermediate inputs as a proxy for unobserved productivity and offer an estimation technique that is very close in process to the Olley and Pakes (1996) approach. This LP estimation method is very attractive as typically, many datasets will contain significantly less zero-observations in materials than in firm-level investment, and therefore suitable for our analysis that envisages the Thailand case. On the other hand, while OP allows for both an unbalanced panel as well as the incorporation of survival probability in the second stage of the estimation algorithm, LP method is only able to address endogeneity problem with much cumbersome estimation algorithm in the second stage than that of OP method. Apart from using materials instead of investment as a proxy and omitting the survival correction in the second stage, the LP estimation is fully analogous to the approach used by OP.[4]

In summary, the discussion above concludes some solutions that have been made to counter the problems of estimating production functions which will be utilized in our analysis. Nevertheless, the methods discussed here mostly deal with the issue of endogenous inputs and selection bias to some extent, which means that the production function estimations are still subject to other biases which we are not able to cover in this study (e.g., multi-product firms and omitted price bias) due to the data limitations. In this paper, only four methods are used to estimate production functions; OLS, FE, RE and LP. The first three methods serve as cross-check and robustness estimations, which are needed to see if the LP model behaves as expected. The OP method is not included in our analysis since the Manufacturing Industry Survey by the NSO does not provide enough data on both the survival of firms in each period and firm-level investment. Instead, the LP method is used because it has been empirically and widely utilized in several papers and the Manufacturing Industry Survey has data, albeit restrictive, to perform the empirical analysis using the LP method.

4.2 Measuring Determinants of Firm TFP

Given the TFP estimates, we will next examine determinants of firm TFP in Thai manufacturing considering a comprehensive set of firm-relevant factors which are proposed in different strands of the literature but have generally not been combined into a single analytical framework. We consider how each of the following factors – firm size, firm age, firm type, firm location, labor quality, integration into world markets, and business environment -

[4] See Petrin et al. (2004) for detailed explanation regarding the Levinsohn and Petrin (2003) estimation.

promote or constrain firm TFP. Using consistent production function coefficients from Equation (1), ($\bar{\beta}_L$ $\bar{\beta}_M$ $\bar{\beta}_K$), we compute time-varying TFP measures for each firm as:

$$A_{ijt} \equiv \ln Y_{ijt} - \bar{\beta}_L \ln L_{ijt} - \bar{\beta}_M \ln M_{ijt} - \bar{\beta}_K \ln K_{ijt} \qquad (2)$$

Following Fernandes (2008), with *i* designating a firm, *j* an industry, *t* a year, and *r* a region, the empirical reduced-form specifications that we estimate are given by:

$$A_{ijt} = \beta_1(X_1)_{ijt} + \beta_2(X_2)_{ijt} + \beta_3(X_3)_{ijt} + \beta_4(X_4)_{ijt} + \beta_5 HERF_{jt} + I^j + I^t + I^r + \sigma_{ijt} \qquad (3)$$

where $(X_1)_{ijt}$ is a vector of firm size variables, $(X_2)_{ijt}$ is a vector of variables related to integration into world markets, $(X_3)_{ijt}$ is a vector of firm location variables, $(X_4)_{ijt}$ is a vector of firm type variables, $HERF_{jt}$ is a business environment variable, and I^j, I^t, and I^r are industry, year, and region fixed effects, respectively. σ_{ijt} is an error term.

Firm size is captured by dummy variables identifying small, medium, and large firms. Integration into world markets is captured by a dummy variable for foreign ownership and a dummy variable for exporters. Firm location is captured by dummy variables for firms located in central and/or municipal areas. Firm type is captured by form of economic organization (Head Branch and Single Unit type) and form of legal organization (state-owned and privately owned). Lastly, the business environment is broadly captured by *HERF* (the Herfindahl index of industry concentration) which corresponds to the competitive environment in terms of total sales in each industry at the 4 digit industry level, since the Manufacturing Industry Survey does not provide any information concerning the institutional and regulatory environment in which firms operate. This constructed HERF variable is used as a proxy for business environment.

The estimation of Equation (2) and Equation (3) may suffer from many potential econometric problems and consequently our results need to be interpreted with caution. First, there is a problem of endogeneity for several determinants. The direction of causality may run from TFP to a given determinant. Our approach towards the endogeneity problem is to include industry, location, year fixed effects, firm age and firm size in our regressions. These variables control for potential unobserved factors that may affect the determinants of TFP and firm TFP itself. The impact of the TFP determinants that is estimated when including all control variables is more likely to reflect causality from the determinants to firm TFP (Fernandes, 2008). Second, given the large number of potential determinants of TFP, our regressions may suffer from a multicollinearity problem. Our approach to address this problem is to estimate regressions that include a single determinant at a time along with basic control variables (industry, region and year fixed effects, firm age and firm size).

5. Main Results and Discussion

5.1 Production Function Estimates: The Whole Sample

The production function coefficients for all observations from our unbalanced panel data are shown in Table 2 for OLS (least squares regression with White's heteroscedasticity robust t-statistics), robust OLS (least squares regression when eliminating from the data set the influential observations, that is, the outliers and/or the explanatory variables significantly deviated from mean judged in terms of Cook's distance measure), fixed effects (FE), random effects (RE), and Levinsohn and Petrin (2003) models (LP). For the LP approach in our analysis, the estimation can be divided into two cases: the gross revenue case and the value-added case, where value-added is defined as the difference between gross revenue (or total sales) and material inputs. Two LP estimators use slightly different techniques to disentangle the effects of the productivity shock, as the dependent variables represent different concepts. Specifically, the revenue case indicates that the dependent variable represents gross revenue (or gross output) and that the GMM estimator will be used in the second stage of the estimation with five variables ($\ln K_{t}$, $\ln L_{t-1}$, $\ln M_{t-1}$, $\ln K_{t-1}$, and $\ln M_{t-2}$) used for instruments. The value-added case indicates that the dependent variable represents value added and that the least-squares estimator will be used both in the first and second stages. As a result, final results will not coincide in these two cases of the LP approach.

The results for the whole sample are shown in Table 2. These estimates are in line with those from previous studies (e.g., Sampat, 2007; Fernandes, 2008). Similar to Fernandes (2008) for the case of Bangladesh manufacturing, for the case of LP(Revenue) estimates, the coefficients on labor and materials are highly significant, while the coefficient on capital is less significant. The LP coefficients on labor (materials) tend to be higher (lower) than those obtained from the OLS estimation. Overall, the coefficients on capital, labor, and materials are all significant. Returns to scale are generally increasing in the whole sample (as indicated by the Wald test) in every regression model, except for the LP approach.

Table 2: Production Function Estimates: The Whole Sample

	(1) OLS	(2) Robust OLS	(3) FE	(4) RE	(5) LP(Revenue)	(6) LP(VA)
ln*K* (Capital)	0.071***	0.056***	0.069***	0.071***	0.093	0.774***
	(31.43)	(32.49)	(23.94)	(31.57)	(0.52)	(70.20)
ln*L* (Labor)	0.167***	0.150***	0.170***	0.167***	0.279***	0.170***
	(46.51)	(56.52)	(37.29)	(46.59)	(7.65)	(46.19)
ln*M* (Materials)	0.785***	0.816***	0.784***	0.785***	0.536**	
	(305.65)	(484.28)	(245.78)	(304.35)	(2.65)	
Constant	2.292***	2.052***	2.209***	2.330***		
	(76.02)	(97.68)	(59.52)	(75.78)		
Wald Test	1.023***	1.022***	1.023***	1.023***	0.908***	0.944***
χ^2 statistics	(502.43)	(570.50)	(371.79)	(502.93)	(29.09)	(83.56)
Hausman [p-value]				0.5118		
Year Effects	Yes	Yes	Yes	Yes	Yes	Yes
Region Effects	Yes	Yes	Yes	Yes		
Observations	17763	17763	17763	17763	8356	17763
Adjusted R^2	0.979	0.985	0.979			

Notes: Heteroscedasticity robust t-statistics in parentheses (z-statistics computed using bootstrapped standard errors for LP estimates). ***, **, and * represent significance at 1%, 5%, and 10% confidence levels, respectively. FE stands for fixed effects and RE stands for random effects. LP(Revenue) stands for Levinsohn and Petrin (2003) estimation for the gross revenue case, and LP(VA-Value Added) for the value-added case. Wald test is used for analyzing if a production function significantly exhibits constant returns to scale or else. The numbers parenthesized below Wald Test are $\chi 2$ statistics testing the null hypothesis that sum of three (or two) elasticities is equal to unity. Hausman indicates Hausman's specification test that tests the null hypothesis of random effect model against alternative FE model, where we report p-value under the null hypothesis.
Source: Author's calculation

As outlined earlier, FE estimates may theoretically be appropriate in that they generate consistent estimates for coefficients on labor, capital and materials to the extent that TFP is deemed constant at least in the short run as in our data set, whereas more efficient estimates could be obtained if the statistical assumption for the RE model is valid. In light of this, we also estimated the RE model (Equation (4) in Table 2). As can be seen, the estimated results are not different from those of the FE model shown in Equation (3) in Table 2, suggesting that the RE model is not rejected at least as a statistical model, and this is indeed so as confirmed by Hausman's specification test reported in the lower portion of Table 2. However, it is important to note that the RE model assumes that (i) the individual effects that may contain firm's TFP are stochastic and that (ii) these (unobservable) stochastic individual effects are independent of the explanatory variables (logs of factor inputs), which seems untenable as LP and OP methods do challenge these presumptions of the RE model.

On the other hand, we should frankly acknowledge limitations of LP(Revenue) method, in particular when applying to the Thai case. First, as suggested by Levinsohn and Petrin (2003, p.328), we use $\{\ln K_t, \ln L_{t-1}, \ln M_{t-1}, \ln K_{t-1}, \ln M_{t-2}\}$ as instrument variables in the second stage of the estimation in which GMM is applied to obtain consistent estimates of β_M and β_K. However, as previously explained in section 3, our data set is comprised of four years (the data for 1999, 2000, 2001 and 2003), so that TFP estimates in terms of LP(Revenue) method are only available for two years 2001 and 2003. Moreover, because we lack the data in 2002, when estimating TFP for 2003, we are forced to use the data pertaining to 2000, 2001 and 2003 as instruments instead of the more consecutive 2001, 2002 and 2003 data. In other words, our LP(Revenue) estimates involve technical difficulties in choosing instruments and if we want to avoid this problem, we are forced to focus on just one year, 2001. Second, while our data set is unbalanced panel comprising of 8,109 firms, the number of observations in OLS, FE and RE in Table 2 is 17,763, which indicates that the average number of observations per firm is 2.2 (=17,763/8,109). However, as indicated by the actual number of samples associated with LP(Revenue) estimates (8,356) reported in the bottom of Table 2, usable sample per firm is much smaller than this average number, only 1.03 (=8,356/8,109) assuming that all the firms are included in 2001 and 2003 data. This in turn implies that a large portion of firms contained in the data do not report complete consecutive information required for estimation, which seems to significantly undermine TFP estimates in case of using LP(Revenue) method.

Given these limitations and considerations, we decide to use TFP estimates from the FE model as our benchmark and report estimation results applying RE and LP(Revenue) methods as supplementary information. Note that while the RE model is not statistically rejected against the FE model as suggested by Hausman's specification test, the analysis of the determinants of TFP based on RE estimates would hardly differ from that using FE estimates simply because elasticity estimates associated with two models are almost the same as can clearly be seen in Table 2. It thus turns out that even though we focus on FE estimates of TFP as a benchmark, our selection is actually innocuous.

5.2 Production Function Estimates: Across Industries

We now extend our analysis into each selected industries. It is useful to report the production function coefficients for each selected industry from our unbalanced panel data, which are shown in Table 3 for OLS, fixed effects (FE), random effects (RE) and Levinsohn and Petrin (2003) models – (LP). For the LP estimation, the calculation is divided into two cases; namely, the case for dependent variable being gross revenue (LP(Revenue)) and value added (LP(VA)). Since many observations do not report the information regarding total revenue, most of the LP estimations are calculated by the value-added case. Due to data limitations and insufficient observations in many industries for the gross revenue case, we can only estimate successfully the gross revenue case for the ISIC 15-16 (Food, Beverage and Tobacco Products) and the ISIC 24 (Chemical Products). Although it is desirable to estimate all the LP procedure using the gross revenue case to preserve consistency among specifications for the production function, the value-added case is utilized here to compare results and present further evidence for the production function estimation in the Thai case. Since our original dataset does not provide enough observations containing a revenue variable, we have no other alternative but to adopt the value-added case as the main procedure for estimating the LP estimator. For this reason, the value-added case is more practicable at the time of this study for most industries (in the case of the value added, material input (ln*M*) disappears on the right hand side of equation in the second stage of the estimation).

In general, all the estimates shown in Table 3 are in line with those from previous theoretical studies (e.g., Van Beveren, 2012). The coefficients on capital, labor, and materials are statistically all highly significant, while that on capital is not significant for the LP method in some industries. Given usual measurement problems with the capital stock, this is not surprising. The LP coefficients on labor (capital) tend to be lower (higher) than those obtained from the OLS estimation, indicating the correction of the simultaneity bias (Sampat, 2007). It should be noted that we cannot control for other biases such as omitted price bias since we do not have the information on firm-level prices at the time of this research. However, if input choices are not correlated with the extent to which firm-level price is different from industry-level price, our estimated input coefficients will not be biased.

Table 3: Production Function Estimates: Across Industries

	Food, Beverage and Tobacco Products (15-16)				Textiles (17)				Leather Products (19)			
	OLS	FE	RE	LP(Revenue)	OLS	FE	RE	LP(VA)	OLS	FE	RE	LP(VA)
ln*K*	0.074***	0.086***	0.075***	0.858**	0.065***	0.153***	0.065***	0.681**	0.037**	0.211**	0.043**	0.851***
	(16.74)	(9.00)	(16.80)	(3.16)	(6.82)	(4.14)	(6.83)	(3.08)	(2.79)	(3.28)	(3.19)	(3.75)
ln*L*	0.132***	0.133***	0.132***	0.330***	0.185***	0.104	0.185***	0.399***	0.235***	0.005	0.223***	0.544***
	(22.85)	(9.49)	(22.72)	(5.81)	(12.29)	(1.76)	(12.21)	(13.55)	(10.66)	(0.08)	(9.73)	(14.59)
ln*M*	0.810***	0.806***	0.810***	0.390*	0.786***	0.741***	0.786***		0.748***	0.686***	0.752***	
	(187.78)	(83.88)	(186.52)	(2.04)	(67.04)	(18.59)	(66.98)		(39.36)	(11.97)	(40.28)	
Wald Test	1.016***	1.025***	1.017***	1.578***	1.036***	0.998***	1.036***	1.081***	1.019***	0.902***	1.018***	1.395***
χ^2 statistics	(284.47)	(111.68)	(281.44)	(4.23)	(128.30)	(23.86)	(127.12)	(6.34)	(85.31)	(13.10)	(82.41)	(3.69)
Observations	4723	4723	4723	1731	1234	1234	1234	1234	509	509	509	509
Adjusted R^2	0.982	0.985			0.979	0.981			0.975	0.994		

	Wood Products (20)				Publishing, Printing and Media (22)				Chemical Products (24)			
	OLS	FE	RE	LP(VA)	OLS	FE	RE	LP(VA)	OLS	FE	RE	LP(Revenue)
ln*K*	0.065***	0.034	0.065***	N/A	0.051**	0.041	0.051**	0.350*	0.093***	0.038	0.093***	0.601*
	(5.87)	(0.92)	(5.81)		(3.15)	(0.61)	(3.15)	(2.04)	(10.35)	(0.86)	(10.27)	(2.25)
ln*L*	0.183***	0.021	0.183***	N/A	0.281***	0.462***	0.281***	0.567***	0.133***	0.050	0.133***	0.171*
	(9.87)	(0.18)	(9.82)		(10.21)	(3.45)	(10.27)	(10.12)	(8.33)	(0.63)	(8.24)	(2.01)
ln*M*	0.764***	0.753***	0.764***		0.697***	0.491***	0.697***		0.799***	0.869***	0.799***	0.899***
	(68.31)	(17.54)	(67.25)		(32.13)	(3.63)	(32.54)		(68.53)	(20.70)	(68.34)	(3.66)
Wald Test	1.012***	0.808***	1.012***	N/A	1.029***	0.994***	1.029***	0.917*	1.025***	0.957***	1.025***	1.671***
χ^2 statistics	(88.80)	(8.39)	(91.69)		(75.81)	(11.38)	(75.16)	(2.12)	(104.34)	(18.00)	(104.50)	(3.86)
Observations	770	770	770	N/A	396	396	396	396	848	848	848	493
Adjusted R^2	0.974	0.984			0.967	0.983			0.982	0.985		

Notes: Heteroscedasticity robust t-statistics in parentheses in the columns with OLS estimates (z-statistics computed using bootstrapped standard errors for LP estimates). ***, **, and * represent significance at 1%, 5%, and 10% confidence levels, respectively. FE stands for fixed effects. RE stands for random effects. LP(VA) stands for Levinsohn and Petrin (2003) estimates for the value-added case, and LP(Revenue) for the gross revenue case. Year and region effects are included in every specification for the OLS, FE, and RE estimation. Wald test is used for analyzing if a production function exhibits constant returns to scale or else. All constants in each industry are omitted to save space.
Source: Author's calculation

Table 3: Production Function Estimates: Across Industries (Continued)

	Rubber and Plastics (25)				Non-Metallic and Mineral Products (26)				Basic Metals (27)			
	OLS	FE	RE	LP(VA)	OLS	FE	RE	LP(VA)	OLS	FE	RE	LP(VA)
ln*K*	0.056***	0.0387	0.0558***	0.380*	0.063***	0.068**	0.063***	0.485***	0.065***	0.438***	0.0653***	N/A
	(7.02)	(1.20)	(6.99)	(2.33)	(8.84)	(2.98)	(8.82)	(3.52)	(4.92)	(3.66)	(4.95)	
ln*L*	0.201***	0.188***	0.202***	0.582***	0.258***	0.242***	0.257***	0.577***	0.205***	-1.069***	0.205***	N/A
	(15.13)	(3.65)	(15.27)	(15.47)	(20.56)	(6.33)	(20.57)	(21.04)	(7.43)	(-6.82)	(7.43)	
ln*M*	0.782***	0.822***	0.782***		0.738***	0.741***	0.738***		0.784***	0.736***	0.784***	
	(68.01)	(23.65)	(68.38)		(91.05)	(36.98)	(90.50)		(50.63)	(9.12)	(50.81)	
Wald Test	1.039***	1.048***	1.039***	0.962***	1.059***	1.051***	1.059***	1.062***	1.054***	0.104	1.054***	N/A
χ^2 statistics	(173.64)	(32.59)	(174.21)	(6.34)	(138.72)	(44.45)	(140.80)	(9.66)	(62.93)	(1.09)	(63.18)	
Observations	1162	1162	1162	1162	1828	1828	1828	1828	394	394	394	N/A
Adjusted R^2	0.98	0.986			0.971	0.977			0.984	0.995		

	Fabricated Metals, Machinery, Equipment (28-29)				Motor Vehicles and Trailers (34)				Transport Equipment and Furniture (35-36)			
	OLS	FE	RE	LP(VA)	OLS	FE	RE	LP(VA)	OLS	FE	RE	LP(VA)
ln*K*	0.065***	0.0746***	0.066***	0.547***	0.043***	0.0176	0.043***	N/A	0.0545***	0.037	0.0546***	0.824***
	(9.32)	(5.23)	(9.51)	(11.63)	(3.58)	(0.32)	(3.59)		(6.13)	(1.14)	(6.16)	(3.90)
ln*L*	0.218***	0.240***	0.219***	0.488***	0.243***	0.237	0.243***	N/A	0.126***	0.110*	0.125***	0.282***
	(17.33)	(7.22)	(17.49)	(19.51)	(8.86)	(1.39)	(8.76)		(8.91)	(2.55)	(8.87)	(8.70)
ln*M*	0.753***	0.739***	0.752***		0.750***	0.738***	0.750***		0.814***	0.875***	0.816***	
	(87.90)	(34.05)	(87.24)		(44.94)	(13.05)	(44.97)		(85.14)	(25.26)	(85.08)	
Wald Test	1.036***	1.054***	1.037***	1.035***	1.036***	0.993***	1.036***	N/A	0.994***	1.022***	0.996***	1.106***
χ^2 statistics	(152.87)	(56.57)	(152.42)	(19.51)	(76.52)	(7.89)	(76.05)		(123.39)	(41.48)	(124.49)	(7.27)
Observations	2073	2073	2073	2073	564	564	564	N/A	1490	1490	1490	1490
Adjusted R^2	0.973	0.98			0.976	0.992			0.972	0.984		

Notes: Heteroscedasticity robust t-statistics in parentheses in the columns with OLS estimates (z-statistics computed using bootstrapped standard errors for LP estimates). ***, **, and * represent significance at 1%, 5%, and 10% confidence levels, respectively. FE stands for fixed effects. RE stands for random effects. LP(VA) stands for Levinsohn and Petrin (2003) estimates for the value-added case, and LP(Revenue) for the gross revenue case. Year and region effects are included in every specification for the OLS, FE, and RE estimation. Wald test is used for analyzing if a production function exhibits constant returns to scale or else. All constants in each industry are omitted to save space.
Source: Author's calculation

Generally, returns to scale are increasing in most industries as confirmed by the Wald test. The labor and capital coefficients from the LP estimation differ from the direction that would be expected from theory. As can be seen from Table 3, only in ISIC 15-16 and ISIC 24 the LP(Revenue) estimates were successfully calculated and obtained. This is due to data limitation and insufficient observations when estimating the production function using the LP procedure. With more complete panel data, the LP method seems to be the best method for productivity estimation. A problem with using the LP estimation, however, is that Levinsohn and Petrin (2003) make the assumption that materials is a perfectly variable input, meaning that it is determined when the firm observes its productivity. Since materials usually include rent, supplies and utilities, the materials variable is no longer freely variable, but at least some of them probably have dynamic implications. Thus, the LP assumption that materials are freely variable may not hold, which will lead to problems when inverting out investment (Ackerberg et al., 2007).

To sum up the analyses from Table 2 and Table 3, it is clearly found that using OLS will generally lead to the estimated results that are subject to input endogeneity bias, resulting in an upward bias on the labor coefficients and a downward bias on the capital coefficients. Nonetheless, the advantage of using OLS and FE is that they are able to use a larger sample than both the OP and LP methods. Furthermore, in our analysis, because the LP method sometimes excludes many observations, the use of the semi-parametric methods is still restrictive for the case of Thailand.

5.3 Characteristics of TFP for Thai Manufacturing Industries

Before going forward to the analysis of determinants of firm TFP, it is interesting to present and depict the general characteristics of TFP in Thailand. To begin with, for previous empirical studies in the Thai case concerning TFP at the macro level, a number of studies have found that the main factor of economic growth for Thailand can be derived from capital contribution. Generally, the National Economic and Social Development Board of Thailand has regularly calculated the TFP growth in Thailand using the growth accounting approach, assuming that in the equilibrium factor elasticity is equal to factor share. It is found that capital input has been the main source of growth in Thailand (Kraipornsak, 2011).

At the micro level, policy makers and economists in Thailand have become familiar with measures of TFP in discussions of competitiveness in recent years. In brief, important characteristics of firm-level TFP for Thai manufacturing can be described as follows. Firm age, measured by firm operating years, is usually associated with labor productivity and TFP. Firm size, measured by the number of employees also affects TFP in a significant way. Foreign firms tend to be more productive as they often have access to more advanced technology and management. Exporting firms normally gain productivity from exposure to international markets. Productivity usually differs considerably across industries. Firms operating in capital-intensive industries (e.g., basic metals and motor vehicles) typically have the highest labor productivity and TFP, while firms producing in labor-intensive industries (e.g., textiles and leather products) generally have the lowest labor productivity and TFP. Moreover, TFP in Thai manufacturing industries is relatively constant and high in food processing and non-metallic mineral industries. This implies that Thailand commands a reasonable TFP premium relative to competitors in these industries (World Bank, 2008). As can be seen from the estimated mean values of TFP for the whole sample in the appendix, estimated values of TFP by the FE (Panel 1) and RE (Panel 2) models yield similar results and pattern in our analysis. For each ISIC industry (Panel 4 to Panel 15), decreasing patterns of mean TFP are revealed in ISIC 17, ISIC 19, and ISIC 22. In contrast, increasing patterns of mean TFP are found in ISIC 20, ISIC 24, ISIC 27, ISIC 28-29, and ISIC 34. Interestingly, mean values of TFP are relatively high and stable in ISIC 15-16, ISIC 25 and ISIC 26.

Comparing our TFP estimates across industries to those of Fernandes (2008) which use exactly the same time span (1999-2003), our results for firm TFP across industries differ from the results in Fernandes (2008) for Bangladesh. Notable differences can be described as follows. First, in the textiles industry, our TFP estimates illustrates a downward trend, while those of Fernandes (2008) exhibit a constant trend of mean values of TFP. Second, in the leather product industry, average TFP estimates are obviously decreasing in the Thai case, but are explicitly increasing in the Bangladesh case. Third, in the chemical product industry (pharmaceuticals industry for Bangladesh), average TFP estimates are gradually rising in Thailand, but are slowly declining in Bangladesh. Both textiles and leather product industries can be considered as labor-intensive industries in both countries. The comparison reveals that labor-intensive industries in Bangladesh manufacturing are generally more productive and exhibit higher TFP on average. On the contrary, capital-intensive industries in Thailand (i.e., the chemical product industry) are comparatively more productive when compared to these industries in Bangladesh. Our findings are consistent with the findings reported in World Bank (2008) in that TFP in Thai manufacturing is relatively higher in capital-intensive industries when compared to resource-intensive and labor-intensive industries. In recent years, the Thai manufacturing sector have also dominated and accounted for a majority of total exports in Thailand, especially since the trade liberalization in the 1990s. Specifically, the electronics and electrical appliances industry is the largest component of exports (around 20%) followed by the automotive industry (around 15%). These exporting industries (firms) are usually categorized as more productive industries (firms) in Thailand.

Lastly, we should note that the increase and decrease in industry TFP, as depicted in Panel 1 to Panel 15, can be derived from the increase and decrease in the unweighted average (mean) firm TFP and actually not by the reallocation of output across firms (Fernandes, 2008). Therefore, understanding the determinants of within-firm TFP is vital and imperative.

5.4 Determinants of Firm TFP: The Whole Sample

In this subsection, we report the empirical results regarding the determinants of firm TFP in Thai manufacturing for the whole sample. The estimated results for Equation (3) are shown in Table 4 and the estimated values of TFP by FE, RE and LP(Revenue) models are reported in Panel 1, Panel 2 and Panel 3, respectively, in the appendix at the end of this paper. While the time span and data used are fairly short and old by the time of this study, the estimated TFP values should be interpreted with knowledge of the Thai economy in the aftermath of the 1997 Asian financial crisis as we observe both decreasing and increasing mean values of TFP in this period.

Table 4: Determinants of Firm TFP (Whole Sample)

Firm TFP	TFP by FE		TFP by RE		TFP by LP(Revenue)	
	(1)	(2)	(1)	(2)	(1)	(2)
Small	0.0581***	0.0671***	0.0554***	0.0669***	-5.295	-18.08
	(5.34)	(5.79)	(5.10)	(5.77)	(-0.52)	(-1.36)
Medium	0.0364***	0.0485***	0.0363***	0.0483***	7.553	-4.279
	(4.36)	(5.29)	(4.36)	(5.27)	(1.69)	(-0.79)
Age	-0.0129***	-0.010*	-0.014***	-0.0102**	1.893	0.0992
	(-3.37)	(-2.58)	(-3.63)	(-2.63)	(1.60)	(0.09)
Labor Quality	0.0411*	0.0407*	0.0460*	0.0339	-22.08***	-16.19*
	(2.26)	(2.04)	(2.53)	(1.70)	(-3.67)	(-2.48)
Foreign	0.0863***	0.0861***	0.0891***	0.0843***	-2.562	-1.717
	(12.01)	(11.55)	(12.42)	(11.30)	(-1.02)	(-0.61)
Exporter	0.0332***	0.0389***	0.0322***	0.0379***	11.50***	8.111***
	(4.96)	(5.69)	(4.82)	(5.54)	(5.07)	(3.64)
Central	-0.0142*	0.0134	-0.0228***	-0.0431***	-7.877*	-12.81**
	(-2.53)	(1.07)	(-4.07)	(-3.43)	(-1.98)	(-3.09)
Municipal	0.0270***	0.0132*	0.0151**	0.0134*	3.468	1.683
	(4.89)	(2.20)	(2.73)	(2.22)	(1.06)	(0.71)
Government	-0.0435***	-0.0260	-0.0393**	-0.0259	8.718**	-0.946
	(-3.36)	(-1.95)	(-3.04)	(-1.94)	(2.67)	(-0.34)
Head Branch	0.0169**	0.0143	0.0095	0.0124	-10.03*	-5.671
	(2.77)	(1.60)	(1.56)	(1.38)	(-2.22)	(-1.29)
HERF	-0.0927	-0.257***	-0.128*	-0.250***	-21.31	-17.62
	(-1.59)	(-4.07)	(-2.21)	(-3.97)	(-1.03)	(-0.86)
Constant	-0.0546***	0.0053	-0.039*	0.0208	-8.010	2.057
	(-3.39)	(0.14)	(-2.42)	(0.56)	(-1.44)	(0.10)
Year Effects	No	Yes	No	Yes	No	Yes
Region Effects	No	Yes	No	Yes	No	Yes
Industry Effects	No	Yes	No	Yes	No	Yes
Observations	17120	17120	17120	17120	8204	8204
Adjusted R^2	0.014	0.025	0.014	0.022	0.005	0.011

Notes: OLS estimation is used. We obtain TFP estimates as residuals from production functions estimated by fixed effects (FE), random effects (RE) and Levinsohn and Petrin (2003) – LP(Revenue). Heteroscedasticity robust t-statistics in parentheses. ***, **, and * represent significance at 1%, 5%, and 10% confidence levels, respectively. The omitted size category is large firms (more than 100 workers). The summary of estimated values of TFP used in this table can be found in the appendix of this paper.
Source: Author's calculation

For each model in Table 4, the column (1) is the results from OLS estimation without control for industry, region, and year fixed effects, whereas the column (2) is the results from OLS estimation with control for industry, region, and year fixed effects. As explained earlier, we use the specification of TFP by FE as our benchmark results. Following Fernandes (2008), we focus first on the role of firm size and age for TFP. Theoretical models of industrial dynamics with firm heterogeneity predict that more productive firms are larger (Jovanovic, 1982). We find that, relative to the large-sized firms (more than 100 workers), firms of smaller sizes (small – less than 15 workers, medium – 16 to 100 workers) exhibit higher TFP. Our findings are broadly in line with those from some developing countries for which there is no evidence of a strong size disadvantage for firm productivity (Tybout, 2000; Fernandes, 2008). Our findings also reveal that young firms are more productive than old firms (in terms of operating years). These results are in line with the predictions from industrial evolution models of young firms entering the industry at low productivity, then growing and converging to the average productivity in the industry (Fernandes, 2008).

Next, firms employing a higher fraction of skilled workers (male workers) are relatively more productive. Commonly, firms with more educated and more experienced managers are more productive than other firms. These results point to the importance of labor quality in the performance of manufacturing firms. Although we are not able to directly observe the quality of workers in the data from the Manufacturing Industry Survey, we may in turn refer to the importance of human capital as a determinant of firm TFP in our analysis. Moreover, the significant benefits for TFP from firms' integration into world markets are uncovered. Firms with foreign ownership are significantly more productive than domestically-owned firms. This finding is obtained in regressions that control for year, region, and industry fixed effects, and hence is not driven by macroeconomic fluctuations (i.e., business cycles in the FDI-sending countries that could make some years more prone to FDI), by a composition effect (i.e., more productive industries are more prone to receive FDI), nor by a region effect (i.e., FDI is more likely to be directed at certain regions). Our findings also reveal crucial advantages of exporting for firm TFP. We find that exporters are significantly more productive than non-exporters. The TFP advantage of exporters may be due to technological learning from foreign buyers, but also to the possibility that exporters intentionally improve their own technological capabilities in order to exploit profitable opportunities in export markets. Conversely, we find no clear evidence for the benefit of importers in terms of enhancing firm TFP in our analysis. Specifically, the estimated coefficients for importers are insignificant for all methods and are not included in Table 4 in order to avoid the problem of multicollinearity.

Surprisingly, we find that firms, if located in the central region, tend to exhibit lower TFP in the whole sample and firms in a municipal area with more facilities and improved infrastructure tend to be on average more productive. Concerning the legal organization of firms, private firms are significantly more productive and exhibit higher TFP than state-owned firms (the negative sign on the *Government* variable). Although the results are not highly significant in all cases, in terms of economic organization of firms, head branch-typed firms are generally the source of improved TFP in Thai manufacturing (the positive sign on the *Head Branch* variable). Last of all, business environment as proxied by *HERF* at the firm level shows a negative relationship with firm TFP. This indicates that the more the industry is concentrated in terms of total sales, the less efficiency of firm performance is observed, as demonstrated by firm TFP. In summary, our results reported in Table 4 are very similar to those of Fernandes (2008) who examined the determinants of firm level TFP for Bangladesh using Olley and Pakes (OP) method for correcting the endogeneity bias. Specifically, our results also suggest that relatively smaller and younger firms, foreign and exporting firms all tend to exhibit higher TFP. These findings from empirical results in Thai manufacturing are generally in line with evidence for Bangladesh as shown in Fernandes (2008).

Next, we refer to the case using LP(Revenue) estimates. As expected, the estimated results using TFP by LP(Revenue) generate strange-looking results, this is not surprising given the limitations of our LP method for the Thai case as explained earlier. On balance, the coefficients for the case of TFP by LP(Revenue) are not statistically significant and exhibit contradictory results when compared to both the TFP by FE and RE models. Only the coefficients on *Exporter* and *Central* are in line with the estimated results from the case of dependent variable being TFP by FE and TFP by RE. That said, exporting firms tend to be one of the most important determinants of TFP at the establishment level in all cases.

5.5 Determinants of Firm TFP: Across Industries

In this subsection, we further extend our analysis and report the empirical results regarding the determinants of firm TFP in across industries. The estimated results are shown in Table 5, and the estimated values of TFP by FE in each ISIC industry are shown in Panel 4 to Panel 15 (total 12 industries) in the appendix. In short, the estimated values of firm TFP across industries are in line with the main results from the whole sample (Panel 1 to Panel 3 in the appendix). The mean values of TFP by FE over years look relatively stable in most industries (being consistent with the assumption of the FE model). Specifically, estimated values of mean TFP for ISIC 17, ISIC 19 and ISIC 22 exhibit an explicit downward trend, and estimated values of mean TFP for ISIC 20, ISIC 27 and ISIC 34 reveal an obvious upward trend in this period. From the estimated results in Panel 4 to Panel 15, we can broadly observe that increasing trends or upward patterns in mean TFP can generally be found in relatively capital-intensive industries. Conversely, decreasing trends in mean TFP are usually revealed in moderately labor-intensive industries. Additionally, our findings in Table 5 from the estimated results derived from various ISIC industries yield many fascinating and attention-grabbing details compared to the results from the whole sample in Table 4. These findings can be used to carefully evaluate and design appropriate industrial policies concerning a way to promote and enhance firm TFP in each corresponding industry for Thailand. The details from Table 5 can be described as follows.

Table 5: Determinants of Firm TFP (Across Industries)

TFP by FE	TFP Determinants for each ISIC Industry											
	15-16	17	19	20	22	24	25	26	27	28-29	34	35-36
Small	0.0712***	-0.118*	-0.413***	-0.469***	-0.0598	-0.0598	0.0993*	0.0714	-2.385***	0.145***	-0.174*	0.219***
	(3.31)	(-2.30)	(-4.77)	(-7.22)	(-0.63)	(-1.18)	(2.48)	(1.78)	(-10.46)	(4.30)	(-2.47)	(5.05)
Medium	0.0580**	-0.0316	-0.190***	-0.180***	0.0751	-0.0382	0.0906**	0.0825*	-1.097***	0.0737**	-0.191***	0.0748*
	(3.19)	(-0.79)	(-3.53)	(-3.43)	(0.86)	(-0.97)	(3.02)	(2.44)	(-5.66)	(2.75)	(-3.46)	(2.32)
Age	-0.0169*	-0.0192	-0.0215	0.0349	0.0482	0.0241	-0.0284*	0.0147	0.187**	-0.00562	-0.00748	-0.0382*
	(-2.45)	(-1.05)	(-0.67)	(1.90)	(1.60)	(1.56)	(-2.23)	(1.13)	(3.14)	(-0.49)	(-0.31)	(-2.18)
Labor Quality	0.0285	0.0284	-0.347*	-0.155	0.106	-0.141	0.0211	0.161*	-0.681	0.132*	0.417**	-0.224**
	(0.80)	(0.34)	(-2.27)	(-1.36)	(0.52)	(-1.58)	(0.32)	(2.24)	(-1.46)	(2.14)	(3.18)	(-3.08)
Foreign	0.0894***	0.0461	0.106*	0.0922	0.0234	0.0625*	0.0826***	0.140***	0.0665	0.125***	0.159***	0.0289
	(5.57)	(1.40)	(2.28)	(1.76)	(0.31)	(2.18)	(3.50)	(3.94)	(0.57)	(5.89)	(3.59)	(1.04)
Exporter	-0.00555	0.0640*	0.110*	0.204***	0.191**	0.0737**	0.0251	0.0875**	0.464***	0.0388*	0.117**	0.0189
	(-0.42)	(2.23)	(2.47)	(6.25)	(3.21)	(2.70)	(1.10)	(3.20)	(3.89)	(1.97)	(2.96)	(0.68)
Central	0.0283	0.479***	0.0419	1.908***	0.243**	0.0417	0.255***	-0.119*	-0.258	-0.0595	-0.161*	-0.157***
	(1.73)	(4.27)	(0.43)	(34.52)	(3.18)	(0.61)	(5.06)	(-2.37)	(-1.00)	(-1.54)	(-2.18)	(-3.33)
Municipal	0.0217*	-0.00895	0.0153	-0.0106	0.0542	0.0251	0.00301	-0.00128	0.0660	0.00310	0.0227	-0.0104
	(1.98)	(-0.35)	(0.34)	(-0.34)	(0.90)	(0.90)	(0.16)	(-0.06)	(0.70)	(0.18)	(0.65)	(-0.41)
Government	-0.0484*	-0.00274	0.326**	-0.174*	0.208	-0.175***	-0.0438	-0.000926	0.151	-0.113**	-0.00628	-0.0506
	(-2.14)	(-0.05)	(3.24)	(-2.00)	(1.21)	(-4.31)	(-1.44)	(-0.02)	(0.71)	(-2.92)	(-0.06)	(-0.82)
Head Branch	-0.0155	-0.0278	-0.00114	0.134**	0.222***	0.101*	-0.00702	-0.0566*	0.391*	0.0736**	-0.00636	0.0544
	(-1.00)	(-0.66)	(-0.02)	(2.94)	(3.71)	(2.01)	(-0.22)	(-2.15)	(2.35)	(2.70)	(-0.14)	(1.64)
HERF	-0.205*	-1.333	8.456	-1.926	14.95	-0.470*	1.561	-1.085*	-1.421	0.903*	0.688	0.0792
	(-2.50)	(-0.81)	(0.94)	(-1.24)	(1.07)	(-2.13)	(0.36)	(-2.03)	(-1.72)	(2.41)	(0.70)	(0.55)
Constant	-0.0876*	0.103	0.370	0.301**	-1.517	0.0328	-0.233**	-0.0671	1.200*	-0.348***	-0.0362	0.163*
	(-2.48)	(0.72)	(1.43)	(2.96)	(-1.37)	(0.35)	(-3.11)	(-0.80)	(2.36)	(-4.79)	(-0.23)	(2.02)
Observations	4470	1029	503	747	394	827	1159	1824	394	2073	564	1438
Adjusted R^2	0.025	0.285	0.474	0.871	0.613	0.222	0.167	0.029	0.625	0.127	0.653	0.106

Notes: OLS estimation, with year and region dummies included, is used. Heteroscedasticity robust t-statistics in parentheses. ***, **, and * represent significance at 1%, 5%, and 10% confidence levels, respectively.
Source: Author's Calculation

Comparing Table 4 (the whole sample) with Table 5 (across industries), the empirical results are slightly mixed. In contrast to the results from the whole sample, for firm size effects, smaller firms tend to exhibit higher TFP only in ISIC 15-16 (manufacture of food and tobacco products), ISIC 25 (manufacture of rubber and plastic products), ISIC 26 (manufacture of non-metallic mineral products), ISIC 28-29 (manufacture of fabricated metal products, machinery and equipment) and ISIC 35-36 (manufacture of transport equipment and furniture). On the contrary, smaller firms are less productive in ISIC 17 (manufacture of textiles), ISIC 19 (manufacture of leather products), ISIC 20 (manufacture of wood products), ISIC 27 (manufacture of basic metals) and ISIC 34 (manufacture of motor vehicles). No clear size effects are found in ISIC 22 (manufacture of publishing, printing and media) and ISIC 24 (manufacture of chemical products). Besides, only in ISIC 15-16, ISIC 25 and ISIC 35-36 are younger firms more productive. However, firms in ISIC 27 reveal a positive relationship between firm age and TFP, indicating that older firms in this industry are more productive. Remarkably, labor quality is positively associated with firm TFP in relatively capital-intensive industries (i.e., ISIC 26; ISIC 28-29; and ISIC 34). On the contrary, labor quality is negatively related with firm TFP in relatively labor-intensive industries (i.e., ISIC 19).

Interestingly, while firms with foreign ownership are significantly more productive than domestically-owned firms in the whole sample, not all industries have the advantage of foreign presence. We observe that only in ISIC 15-16, ISIC 19, ISIC 24, ISIC 25, ISIC 26, ISIC 28-29, and ISIC 34 are firms with foreign equity participation more productive. As can be anticipated, exporting firms are significantly more productive than non-exporting firms in most industries. Our findings indeed highlight crucial benefits of exporting for firm TFP. The advantage of exporters might be a result of technological learning from foreign buyers or the possibility that exporters improve their own technological capabilities to exploit profitable opportunities in the export market (Fernandes, 2008). Surprisingly, while we find that firms in the central region are less productive in the whole sample in Table 4, the findings from Table 5 inconsistently indicate that firms in the central region are likely to be more productive in some industries; namely, firms in ISIC 17, ISIC 20, ISIC 22, and ISIC 25. Furthermore, firms in ISIC 15-16 clearly benefit from being in a municipal area. As expected, state-owned firms are less productive compared with private firms in almost every industry, except for state-owned firms in ISIC 19. Head Branch typed firms are also more productive in most industries that have statistically significant readings, except for ISIC 26. Lastly, for the industry concentration as proxied by *HERF*, we observe a negative relationship between TFP and *HERF* in ISIC 15-16, ISIC 24 and ISIC 26, and a positive relationship in ISIC 28-29.

Finally, although the estimation method and empirical results from Table 2 to Table 5 in the analysis that we have adopted may not be novel when compared to the case for other developed countries, it is still very important to provide with empirical results and estimated fundamental parameters for many developing countries, such as Thailand, which have less statistical data and very few empirical firm-level studies. Particularly, the results reveal that, contrary to the tendency observed in the advanced countries, the productivity of the small-and-medium sized firms is higher than that of the large firms; the productivity of the firms with greater linkage with the global economy in the form of export activity and/or foreign affiliates is significantly higher than those without that; the productivity of the firms hiring more skilled labor is higher than those who do not hire or have less skilled workforce. These results point to the importance of Thailand's economic policies such as the promotion of small and potential firms, encouraging the globalization of manufacturing firms, policies towards generating skill formation, human capital, and so forth. In order to design more efficient industrial policies, thorough understanding of productivity at the micro level is essential. These are implications that could not be obtained through a simple macroeconomic growth accounting and deserve the merit of our micro data analysis for the Thai case.

6. Conclusion

This paper uses data from the Manufacturing Industry Survey in Thailand to obtain TFP measures for 1999-2003 following various estimations for production function and firm TFP, and empirically investigates the determinants of firm TFP at the establishment level. Our main findings can be summarized as follows. In our analysis, the results identify many important determinants of firm TFP, controlling for industry, location, and year fixed effects. Specifically, smaller firms are significantly more productive than larger ones. Firm age and TFP exhibit a negative relationship. Firms with a more educated workforce are also more productive. Firm TFP benefits from integration into world markets: foreign-owned firms and exporters have significantly higher TFP. Private and Head Branch-typed firms are more productive than other firms on average. However, firms in the central region and firms in industries faced with fierce competition for total sales are less productive in terms of TFP.

Our findings point to several key areas of policy relevance in which improvements are likely to bring benefits for firm TFP in Thailand. Policies promoting labor quality and human capital formation at various levels may have significant benefits for firm TFP. Additionally, progress in international integration of firms into international markets through their participation in export markets and attraction of foreign capital is also likely to affect firm TFP. Finally, we should mention that while this paper conveys valuable information on the dynamics of firms in Thai manufacturing industries, it is based on a survey that covers rather short time span and relatively few firms in terms of sample coverage. In fact, no data set is ideal for every question because of issues related to frequency, coverage, sampling, and missing variables. As a result, engaging in a similar type of analysis using manufacturing census data, collected in a more comprehensive fashion, will be more beneficial. However, since the census data for Thai manufacturing is cross-sectional, it is still impossible to conduct such research at the time of this study for the Thai case.

Furthermore, the correlation between unobservable productivity shocks and input levels is one of the main concerns in the estimation of production function. Profit-maximizing firms usually act in response to positive productivity shocks by expanding output, which typically requires additional inputs. On the contrary, negative productivity shocks lead firms to cut back output, decreasing their input usage. Regarding the production function estimation, Olley and Pakes (1996) develop an estimator that uses investment as a proxy for these unobservable shocks. More recently, Levinsohn and Petrin (2003) introduce an estimator that uses intermediate inputs as proxies, arguing that intermediates may respond more smoothly to productivity shocks (Arnold, 2003). Occasionally, our LP procedure may generate strange-looking results and the reason may be that there is not enough variation in the data for a separate identification of all coefficients in our analysis due to data limitation.

Although the simultaneity and selection biases are well-known as explained throughout the paper; many other methodological issues have emerged recently in the literature. Specifically, Bernard et al. (2009) note that firms' product choices are likely to be related to their productivity. Nevertheless, as described earlier, omitted input/output price bias and multi-product firm bias are not covered in our analysis due to data availability. Despite some limitations, we hope that this study may be treated as a new aspect for examining empirically and systematically the production function and the determinants of total factor productivity (TFP) for manufacturing firms in Thailand. Lastly, it should be noted that results may also vary due to differences in research design and the quality of data, and cautious interpretation of estimated results should be emphasized in the future work.

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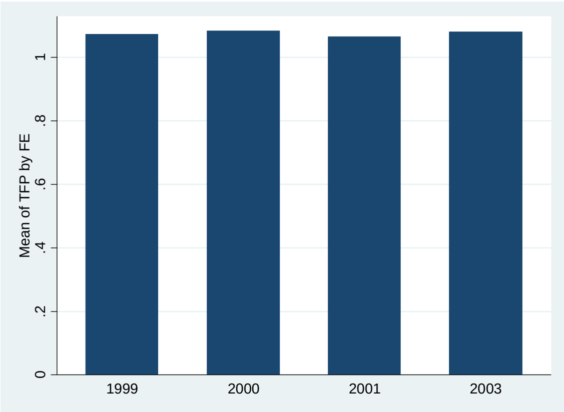
Appendix

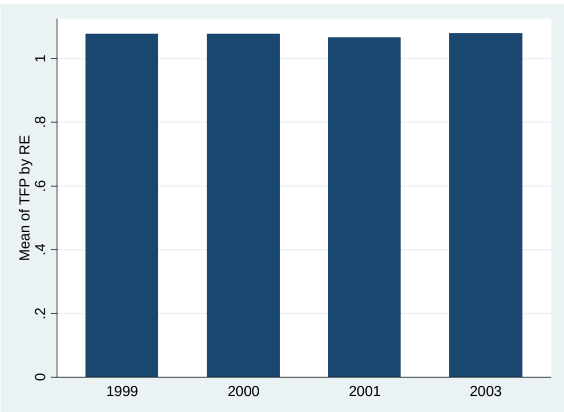
Panel 1: Summary of Estimated Values of TFP by FE for the Whole Sample



TFP by FE (Whole Sample)					
Year	Obs	Mean	Std. Dev.	Min	Max
1999	6417	1.07297	0.47731	0.28447	4.35134
2000	2981	1.08326	0.48072	0.30462	4.19782
2001	3230	1.06542	0.45008	0.30057	3.93284
2003	5135	1.07981	0.48381	0.29084	4.21130

Source: Author's calculation

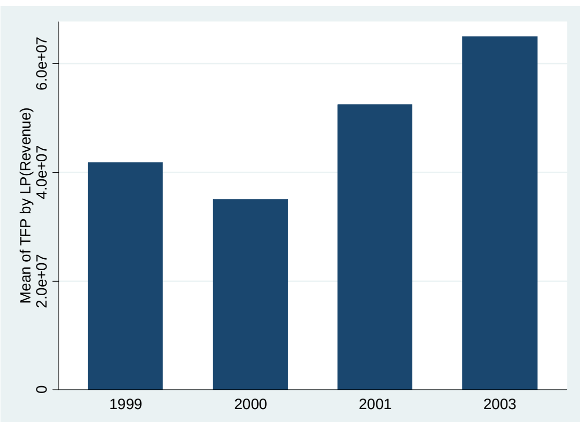
Panel 2: Summary of Estimated Values of TFP by RE for the Whole Sample



TFP by RE (Whole Sample)					
Year	Obs	Mean	Std. Dev.	Min	Max
1999	6417	1.07633	0.47826	0.28915	4.44046
2000	2981	1.07664	0.47875	0.29864	4.10968
2001	3230	1.06566	0.45162	0.30804	3.86515
2003	5135	1.07893	0.48583	0.28642	4.28908

Source: Author's calculation

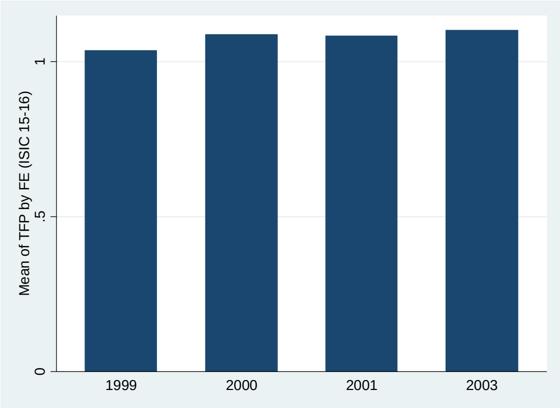
Panel 3: Summary of Estimated Values of TFP by LP(Revenue) for the Whole Sample



TFP by LP(Revenue) (Whole Sample)					
Year	Obs	Mean	Std. Dev.	Min	Max
1999	2854	4.18E+07	2.68E+08	0	6.98E+09
2000	1245	3.50E+07	2.00E+08	0	4.94E+09
2001	1676	5.25E+07	2.70E+08	0	4.95E+09
2003	2581	6.50E+07	1.14E+09	0	5.67E+10

Source: Author's calculation

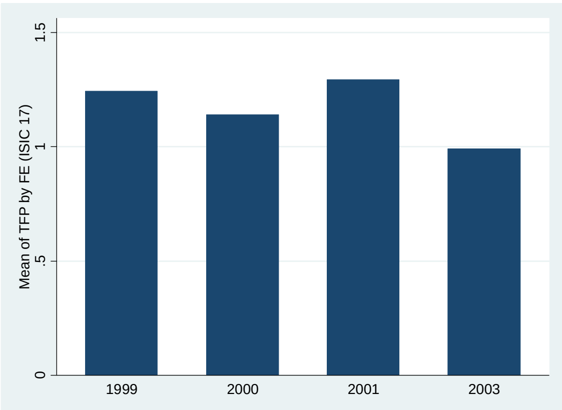
Panel 4: TFP by FE for ISIC 15-16 (Manufacture of Food and Tobacco Products)



TFP by FE (ISIC 15-16)					
Year	Obs	Mean	Std. Dev.	Min	Max
1999	1604	1.03542	0.45560	0.36795	4.27931
2000	826	1.08762	0.49457	0.38306	4.84172
2001	946	1.08287	0.43048	0.40223	4.04666
2003	1347	1.10155	0.53382	0.34022	4.46297

Source: Author's calculation

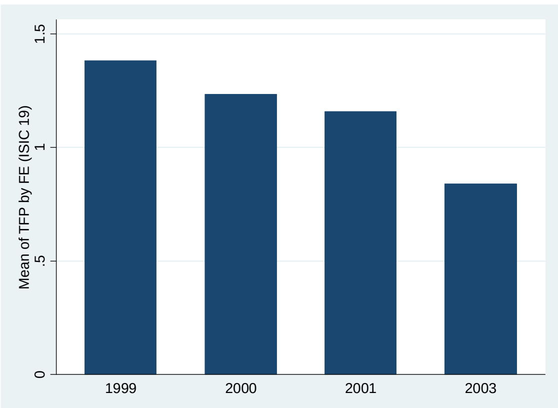
Panel 5: TFP by FE for ISIC 17 (Manufacture of Textiles)



TFP by FE (ISIC 17)					
Year	Obs	Mean	Std. Dev.	Min	Max
1999	407	1.24328	0.78925	0.32166	7.47702
2000	200	1.14019	0.75432	0.31031	6.17706
2001	206	1.29405	0.73692	0.49120	5.20862
2003	421	0.99126	0.63764	0.20930	5.24931

Source: Author's calculation

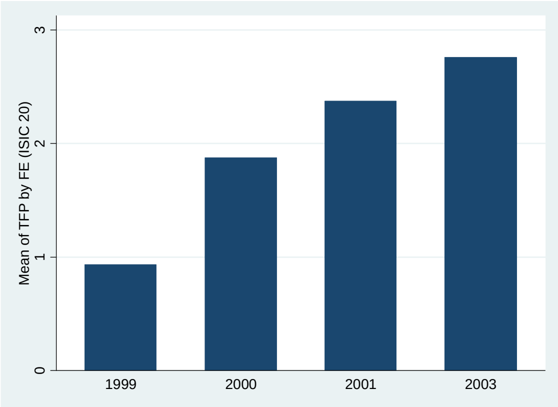
Panel 6: TFP by FE for ISIC 19 (Manufacture of Leather Products)



TFP by FE (ISIC 19)					
Year	Obs	Mean	Std. Dev.	Min	Max
1999	191	1.3827	0.6781	0.3333	4.7223
2000	87	1.2349	0.7509	0.1748	4.6733
2001	91	1.1585	0.7140	0.1866	4.7994
2003	140	0.8401	0.4771	0.2000	3.2693

Source: Author's calculation

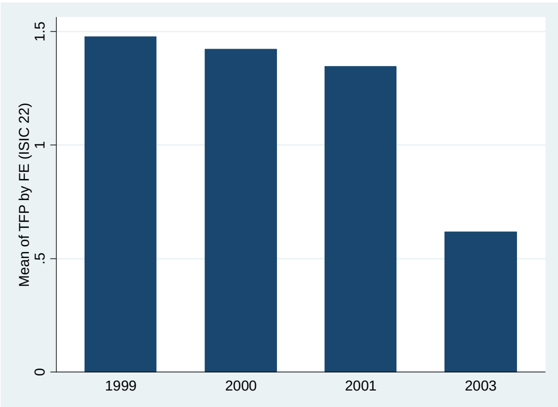
Panel 7: TFP by FE for ISIC 20 (Manufacture of Wood Products)



TFP by FE (ISIC 20)					
Year	Obs	Mean	Std. Dev.	Min	Max
1999	337	0.9348	1.1177	0.0669	8.5331
2000	117	1.8760	2.4831	0.1204	12.4021
2001	119	2.3749	3.2368	0.3777	18.4989
2003	197	2.7586	3.8089	0.2062	25.7710

Source: Author's calculation

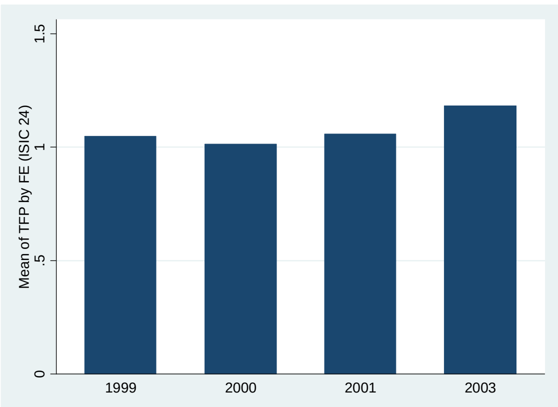
Panel 8: TFP by FE for ISIC 22 (Manufacture of Publishing, Printing and Media)



TFP by FE (ISIC 22)					
Year	Obs	Mean	Std. Dev.	Min	Max
1999	102	1.4774	0.7247	0.2935	4.2037
2000	100	1.4220	0.6983	0.2814	3.2902
2001	85	1.3459	0.6798	0.3185	3.6471
2003	109	0.6176	0.2807	0.1434	1.5297

Source: Author's calculation

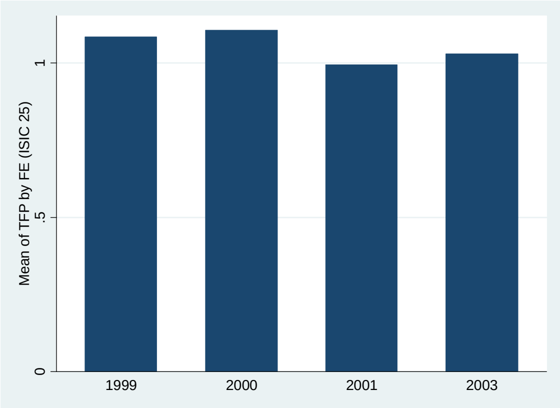
Panel 9: TFP by FE for ISIC 24 (Manufacture of Chemical Products)



TFP by FE (ISIC 24)					
Year	Obs	Mean	Std. Dev.	Min	Max
1999	335	1.0477	0.4652	0.3993	3.4471
2000	136	1.0144	0.4717	0.2937	3.9813
2001	127	1.0586	0.5378	0.4874	4.4968
2003	250	1.1823	0.5621	0.3402	4.5282

Source: Author's calculation

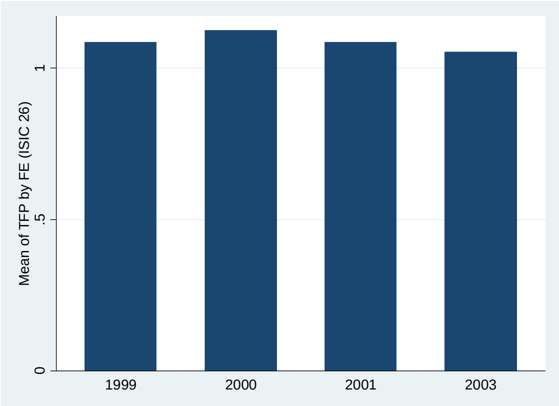
Panel 10: TFP by FE for ISIC 25 (Manufacture of Rubber and Plastic Products)



TFP by FE (ISIC 25)					
Year	Obs	Mean	Std. Dev.	Min	Max
1999	479	1.0852	0.4467	0.4761	4.2622
2000	178	1.1068	0.4832	0.4342	4.2671
2001	196	0.9949	0.2865	0.5587	3.1588
2003	309	1.0295	0.4745	0.4598	4.5441

Source: Author's calculation

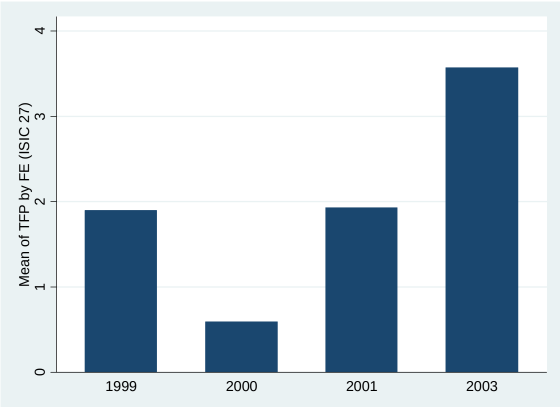
Panel 11: TFP by FE for ISIC 26 (Manufacture of Non-Metallic Mineral Products)



TFP by FE (ISIC 26)					
Year	Obs	Mean	Std. Dev.	Min	Max
1999	805	1.0845	0.5192	0.2547	3.6498
2000	260	1.1239	0.5183	0.3587	3.7407
2001	313	1.0848	0.4430	0.4157	3.2855
2003	450	1.0520	0.4029	0.2770	3.3134

Source: Author's calculation

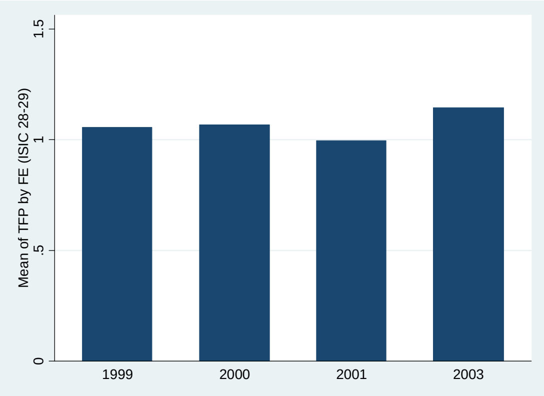
Panel 12: TFP by FE for ISIC 27 (Manufacture of Basic Metals)



TFP by FE (ISIC 27)					
Year	Obs	Mean	Std. Dev.	Min	Max
1999	179	1.8986	2.9684	0.1155	26.9026
2000	56	0.5948	0.6739	0.0180	2.9055
2001	72	1.9296	2.4416	0.0954	11.7287
2003	87	3.5715	4.7173	0.0423	27.8579

Source: Author's calculation

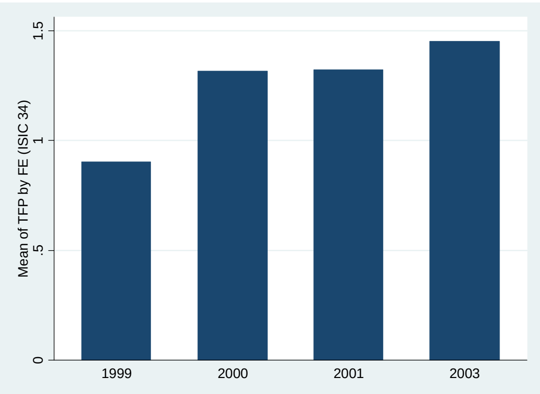
Panel 13: TFP by FE for ISIC 28-29
(Manufacture of Fabricated Metal Products, Machinery and Equipment)



TFP by FE (ISIC 28-29)					
Year	Obs	Mean	Std. Dev.	Min	Max
1999	725	1.0555	0.4671	0.3558	3.4692
2000	378	1.0677	0.4741	0.3554	3.1884
2001	340	0.9968	0.3642	0.3777	2.8625
2003	630	1.1459	0.4676	0.3265	4.5846

Source: Author's calculation

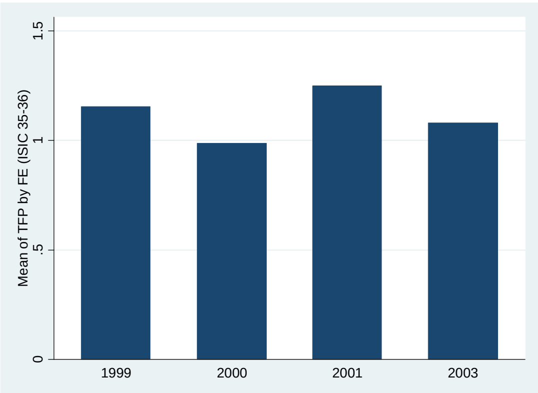
Panel 14: TFP by FE for ISIC 34 (Manufacture of Motor Vehicles)



TFP by FE (ISIC 34)					
Year	Obs	Mean	Std. Dev.	Min	Max
1999	210	0.9032	0.5649	0.1525	3.9545
2000	116	1.3172	0.8457	0.2592	4.2537
2001	116	1.3230	0.7657	0.1893	6.6393
2003	122	1.4523	0.8219	0.3467	4.6827

Source: Author's calculation

Panel 15: TFP by FE for ISIC 35-36 (Manufacture of Transport Equipment and Furniture)



TFP by FE (ISIC 35-36)					
Year	Obs	Mean	Std. Dev.	Min	Max
1999	454	1.1537	0.6646	0.4416	5.4769
2000	240	0.9869	0.5755	0.3457	4.4821
2001	277	1.2489	0.8055	0.4113	5.3720
2003	519	1.0789	0.5905	0.3962	4.9327

Source: Author's calculation

Table A: Correlation Matrix of the Key Variables

	ln*Y*	ln*K*	ln*L*	ln*M*	*Small*	*Medium*	*Large*	*Foreign*	*Export*	*Import*	*Central*	*Municipal*	*Government*	*HeadBranch*	ln*Age*	ln*LQ*	ln*HERF*
ln*Y*	1.00																
ln*K*	0.80	1.00															
ln*L*	0.81	0.70	1.00														
ln*M*	0.98	0.77	0.77	1.00													
Small	-0.58	-0.47	-0.67	-0.55	1.00												
Medium	0.26	0.20	0.27	0.25	-0.78	1.00											
Large	0.43	0.37	0.54	0.40	-0.22	-0.44	1.00										
Foreign	0.43	0.41	0.40	0.40	-0.24	0.08	0.22	1.00									
Export	0.54	0.46	0.58	0.51	-0.35	0.13	0.31	0.46	1.00								
Import	0.44	0.39	0.42	0.42	-0.29	0.14	0.20	0.40	0.45	1.00							
Central	0.21	0.16	0.14	0.21	-0.10	0.09	0.00	0.14	0.13	0.22	1.00						
Municipal	0.00	-0.05	-0.02	0.00	0.03	-0.01	-0.02	-0.05	-0.02	0.03	0.11	1.00					
Government	0.10	0.09	0.11	0.10	-0.07	0.08	-0.04	0.05	0.08	0.05	-0.05	-0.05	1.00				
HeadBranch	0.38	0.28	0.31	0.37	-0.28	0.09	0.26	0.16	0.22	0.13	-0.11	0.07	0.12	1.00			
ln*Age*	0.18	0.16	0.17	0.18	-0.12	0.04	0.10	-0.02	0.06	0.05	0.01	0.17	0.01	0.10	1.00		
ln*LQ*	-0.07	-0.03	-0.28	-0.05	0.17	-0.06	-0.14	-0.15	-0.28	-0.13	-0.01	0.02	-0.01	-0.02	0.05	1.00	
ln*HERF*	-0.12	-0.07	-0.08	-0.12	0.07	-0.05	-0.03	0.01	-0.08	-0.03	-0.05	-0.04	-0.01	-0.05	0.07	0.05	1

Notes: Observations are 17378.
Source: Author's Calculation