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Firm-Specific Characteristics and Technical Efficiency of Electronics Manufacturing Firms in China

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ABSTRACT

This paper analyses the technical efficiency and total factor productivity (TFP) growth in China's electronics industries from 2006 to 2010 by using the stochastic production frontier model. The estimated results show that the mean technical efficiency scores of electronics firms in Hong Kong and Mainland China are 63% and 90%, respectively. The estimation using the technical inefficiency effects model further reveals that firm specific characteristics, namely the capital structure, profitability, firm size and regional location are crucial determinants of firms' efficiency. Since firm size has a positive effect on inefficiency, small and medium-sized electronic firms appear to demonstrate a higher level of efficiency than their larger counterparts. In the TFP analysis, Hong Kong firms recorded both higher TFP growth and technological progress compared to their Chinese counterparts. In contrast, Mainland China firms performed better in the context of managerial and scale efficiency.

Keywords: Firm-Specific Characteristics, Stochastic Frontier Analysis, Electronics Manufacturing Firms, Technical Efficiency, Total Factor Productivity, China.
JEL Classification: D24, L25, L63.

1. Introduction

China has emerged as the world's factory, especially in the production of textiles and clothing, toys, leather products, and electronic appliances, a few decades after the liberalization of the economy. The China electronics information industry in particular, has captured a major market share in the world, mostly in the form of original equipment manufacturing (OEM). Evidently, China is a major world-class player in the electronics industry in terms of manufacturing volume, accounting for more than 25% of the world's overall manufacture of electronics. Nevertheless, with regards to the export amount, these products only represent about 9% of the world's total export value of electronics. In view of the rapid growth and development of the industry, the contributing factors, other input costs, have aroused the interest and attention of researchers.

The main aim of this paper is in two folds. First, it is to determine the technical efficiency of the Chinese electronics sector. Secondly, it is to investigate whether firm-specific characteristics such as capital structure, profitability, firm size and regional location are significant factors to its efficiency.

This study is expected to shed some light on issues pertaining to the growth and development of electronic industry in China, especially given the dearth in literatures examining the productive efficiency and competitiveness of this sector. This paper employs stochastic production frontier analysis (SFA) to estimate the technical efficiency of electronics firms in China, and subsequently investigates whether certain firm-specific features actually influence the firm's efficiency using the technical inefficiency effects model[1]. Being the first study to estimate the technical efficiency of the China's electronics firms, this study is expected to provide some crucial insights on the potential pathway that the Chinese electronics sector can explore to move up its value-added chain and consequently improve on its long-term competitiveness standing in the world market.

The remainder of the paper is structured as follows. Section 2 explains the possible factors that contribute to firm's efficiency and the hypotheses. Section 3 and 4 cover the methodology and data while the empirical findings are reported in Section 5. Section 6 concludes.

2. Factors Contributing To Firm's Efficiency And Hypothesis

Several aspects influence the productive efficiency of firms. Under this study, we emphasize the impacts of the four specific features that firms have on the employment of production sources. They are the firm's capital structure, their profitability, size and regional location.

For the case of capital structure, the agency costs hypothesis by Jensen and Meckling (1976) pointed out that higher leverage generates incentives for managers to perform more in the interests of shareholders (thus decreases the propensity to commit moral hazard), which in turn should raise the firm's performance. However, it is widely recognized that the effect of leverage on total agency costs is expected to be non-monotonic that when leverage exceeded the optimal capital structure, it may raise costs of financial distress, liquidation or bankruptcy. As such the agency costs of outside debt may overwhelm the agency costs of outside equity[2], so further increases in leverage actually result in higher agency costs overall. The first argument leads to the following null hypothesis:

> H_{01}*: Firm with lower leverage is expected to lower agency costs, increase efficiency and thereby lead to an improvement in firm's performance.*

In the literature, various measures of firm performance have been used in testing the predictions of the agency-cost hypothesis. Among others, Demsets and Lehn (1985) used financial ratios from balance sheet and income statements; Cole and Mehran (1998) meanwhile, opted for stock market returns and their volatility but (Himmelberg *et al.*, 1999) and (Zhou, 2001) utilized Tobin's q instead (which mixes market values with accounting values). Elsewhere, Becchetti and Sierra (2003) argued the significance of non-financial data as predictors of firm successes. The mix bag of opinions is unsurprising given that the empirical evidence on the agency costs hypothesis in the finance literature as a whole is mixed and inconclusive. In view of this, we address this measurement issue by using efficiency levels derived from Stochastic Frontier Analysis (SFA) as the indicator of firm performance. This is based on the fact that efficiency is a measure that is related to the concept of value maximization, and it is therefore a reliable barometer on the efficacy of managers raising revenues while also controlling costs.

The effect of firm size on technical efficiency is less obvious though. Jovanovic (1982)'s model supports that larger firms are more efficient than smaller ones given that larger firms are more diversified, have better technology and managers, superior training support than smaller firms and more qualified human capital resources. In addition, larger firms are also likely to benefit from innovation for the reason that large firms incur lesser duplicative attempt and investments which in the case of smaller firms would prove less cost-effective (Wu *et al.*, 2007; Tabak and Tecles, 2010). On the contrary, Ma *et al.* (2002) and Aggrey *et al.* (2010) contended that small and medium-sized firms are superior at adjusting to environmental variation than larger firms. In addition, direct involvement of the shareholder in productive operations lessens agency expenses in small companies relative to larger ones, the delegation process in the latter likely to lead to greater incidents of adverse selection and moral hazard. Agell (2004) claimed that workers of small firms are highly induced by competitive-based incentive plans instead of the monetary inducements, therefore suggesting smaller firms as being more efficient. Based on these literatures, we form the following hypothesis:

> H_{02}*: The larger the firm size, the lower the unit cost in terms of the firm's management, lead to higher firm's efficiency than smaller firms.*

In the case of firm profitability, the hypothesis states that efficiency is significantly correlated to expected returns in firms. Efficiency has been found to be directly associated with returns on assets and returns on equity (Fama and French, 2002; Cheng and Tzeng, 2011). Other evidence advocates like (De *et al.*, 2001) states that efficiency is fairly steady over time and high efficiency, presumably would

[1] See Battese & Coelli (1995).

[2] See Jensen (1986) on the discussion of how the use of debt versus equity in raising capital can pose different degrees of agency cost to firms.

translate to higher potential expected returns. It is therefore reasonable for us to set the third hypothesis as:

H_{03}: Profitable firms are more efficient.

Finally, we believe that regional location is also a determinant of efficiency in the production of electronics components. This argument would probably be in line with the many academic papers citing the theory of "location economies" or "clustering"[3]. The null hypothesis is formulated as below:

H_{04}: There are similarities in technical efficiency between the electronics firms in Hong Kong and Mainland China.

3. Methodology

From an economic perspective, all firms are assumed to operate on the frontier in which the highest production is attainable with the existing technology and factors of production. Many past studies on production functions also presume that firms are functioning at this frontier apart from a randomly distributed error term. Conversely, there are ample empirical evidences arguing that firms operating inside the frontier hence are technically inefficient. Consequently, most empirical approaches explicitly let the production to take place beneath the frontier. Among others, the stochastic production frontier developed by Farrell (1957) and later popularized by Aigner *et al.* (1977) and Meeusen and Van Den Broeck (1977). In addition, Battese and Coelli (1995) put forward a random effects model for stochastic frontiers to estimate technical efficiencies that have been adjusted to consider for external factors such as geographical factors or infrastructural conditions.

Our paper follows the approach of Battese and Coelli (1995)[4] as we estimate the coefficients of the stochastic production frontier and the inefficiency model concurrently using maximum likelihood approach. Given Y_{it} (in logarithm) represents the revenue deflated by the Producer Price Index (PPI) at constant 2005 prices of the *i*th firm at time *t*, the stochastic production frontier, which includes a random error term can be formulated as follows:

$$Y_{it} = f(X_{it}, \beta, t)e^{\varepsilon_{it}} \quad \text{with} \quad \varepsilon_{it} = v_{it} + u_{it}, \quad u_{it} \geq 0 \qquad (1)$$

where $i = 1,2,\ldots,m$ represents the electronics firm and $t = 1,2,\ldots,T$ represents the time trend and proxy for technological progress. X_{it} is a vector of inputs which comprises of logarithm net fixed asset (K) and labor force (L) for firm i at time t with β as a vector of unknown parameters identified as elasticity. Ultimately, ε_{it} represents the stochastic composed (random) error term. The random error term is decomposed into two unobservable components, statistical noise (v_{it}) and technical inefficiency (u_{it}) which are independent of each other. The statistical noise, v_{it} is a two-sided error term and is assumed to be independently and identically distributed (i.i.d.), $N(0, \sigma)$. It captures measurement error and random variation in production due to factors beyond the control of firms, such as labour strikes, luck, war, etc, as well as the pooled effects of unidentifiable factors inputs in the production function. The one-sided error term u_{it} captures technical inefficiency in production is assumed to be firm-specific, non-negative random variables, independently distributed as non-negative truncations (at zero) of the distribution $N^{+}(\delta z_{it}, \sigma)$. The one-sided inefficiency effect for the panel data model is specified as follows:

$$u_{it} = \delta z_{it} + \omega_{it} \qquad (2)$$

where z_{it} represents a vector of firm-specific factors that determine the technical inefficiency and δ is a vector of coefficients to be identified in the inefficiency model. Firm-specific factors contributing to inefficiency include capital structure, profitability, size of firm, and regional differences of electronics firms under study. ω_{it} is denoted by the truncations of the distribution $N(0, \sigma)$.

The technical efficiency scores of firm i at time t are denoted as the ratio of the actual output for the *i*th firm relative to the corresponding frontier function/the maximum achievable output, i.e., $TE_{it} = exp(-u_{it}) = exp(\delta z_{it} + \omega_{it})$. This technical efficiency measure takes a value between zero and one, with one signifying the firm being totally productive efficient and, likewise, the actual output attaining its highest achievable amount; while a technical efficiency of less than one signifying the existence technical inefficiency on the component of the firm, i.e. the firm could have produced more output given the inputs being employed.

[3] See Porter (1990;1998). Krugman (1991). on "clustering" theory. This theory in essence, is a basically similar to what Marshall (1920). calls "external economies of scale".

[4] A complete review of stochastic frontier models can be obtained from Coelli *et al.* (2005). and Kumbhakar and Lovell (2000).

The empirical model is a translog production function of $f(X_{it}, \beta, t)$ with the following form:

$$In(Y_{it}) = \beta_0 + \beta_K In(K_{it}) + \beta_L In(L_{it}) + 0.5\beta_{KK} In(K_{it})^2 + 0.5\beta_{LL} In(L_{it})^2 + \beta_{KL} In(K_{it}) In(L_{it}) + \beta_t t + 0.5\beta_{tt} t^2 + \beta_{Kt} In(K_{it}) t + \beta_{Lt} In(L_{it}) t + v_{it} - u_{it} \quad (3)$$

where *Y* is real revenue, *K* is real net value of fixed assets, *L* is labor and subscripts *i* and *t* imply the *i*th firm at *t*th year. This model is employed due to its adequate and flexible functional form which would be confirmed with likelihood ratio (LR) test in the following section[5].

Equation (3) provides us with the inefficiency-effects model to examine the factors affecting technical inefficiency as follows:

$$u_{it} = \delta_0 + \delta_{LEV} LEV_{it} + \delta_{ROA} ROA_{it} + \delta_{SIZE} SIZE_{it} + \delta_T T + \delta_{REG} REG_{it} + \omega_{it} \quad (4)$$

where *LEV* is leverage of the firm, *ROA* is Return on Assets, *SIZE* is size of firm, *T* is time trend, *REG* is regional location dummy variable.

Following Kumbhakar and Lovell (2000), total factor productivity change (TFPC) was decomposed into three sources: technical change (TC), technical efficiency change (TEC) and scale change (*SC*). Technological progress represents the fractional derivative of the production function with respect to time, scale component as the elasticity contribution to the TFP growth (TFP change) and the TEC as the derivative of technical efficiency with respect to time. Thus, TC, TEC and *SC*, respectively, can be measured as follows:

$$TC = \frac{\partial lnf(x_i, t)}{\partial t} = \hat{\beta}_t + \hat{\beta}_{tt} t + \hat{\beta}_{Kt} In(K_{it}) + \hat{\beta}_{Lt} In(L_{it}) \quad (5)$$

$$TEC = \frac{dlnTE}{dt} = \frac{TE_{t+1} - TE_t}{TE_t} \quad (6)$$

$$SC = (e - 1) \sum_j \left(\frac{e_j}{e}\right) \dot{x}_j \quad (7)$$

where e_j, $j = 1, 2, \ldots, J$ are elasticities of output with respect to input *j*, $e = \sum_j e_j$ and $\dot{x}_j$ represents the growth rate of input x_j.

4. Description of Data Used

The panel data is provided by Economic Databases for Emerging and Developed markets (CEIC). The balanced panel data of 350 observations in total for a sample of 70 Chinese electronics manufacturing firms over the period 2006 to 2010 are used to measure the co-efficients of the stochastic frontier production function explained above. Gross total output, *Y*, is the total revenue of firm; capital, *K*, the net value of fixed assets; *L*, is the total number of employees. Number of employees is used in lieu of man hours owing to the inaccessibility of the data. All monetary variables are controlled for inflationary effects by deflating by a PPI deflator and hence these variables are in 2005 Chinese Yuan price (RMB). The deflator is provided by OECD Stat (www.stats.oecd.org). The leverage of the firm (LEV) is measured as the ratio of total debts to total assets and the return on Assets (ROA) denoted by the ratio of total returns to total assets. The firm size and the regional location of a firm are denoted by dummy variables. The binary variable for size, SIZE, is denoted as: $SIZE_i$ = -1 if the number of full-time employees of the *i*th firm is less than 50 (small firm), $SIZE_i$ = 0 if the number of fulltime employees of the firm is in the range of 51 and 150 (medium firm) and $SIZE_i$ = 1 if the number of fulltime employees of the firm is more than 150 (large firm). The regional location (REG) variable takes the value 1 if a firm is located in the Mainland China and 0 for a firm located in Hong Kong. The descriptive statistics for the electronics firms in our sample are presented in Table 1. The substantial diversity in size between the sample firms is exhibited by the values of the standard deviations of the variables for output and capital, which are greater than twice of their respective averages. It is also observed that the mean and median are not equal, implying that the variables may not be normally distributed; this could be a problem if ordinary least squares (OLS) regression is employed.

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[5] Sharma (2007). supported translog model by given four reasons: (1) it provides a local second order approximation to an arbitrary functional form and so gives for some generality; (2) CES and Cobb-Douglas production functions are also special cases of the translog and so the translog includes these frequently employed specifications; (3) it allows for nonconstant returns to scale as well as for technical change to be both neutral and factor augmenting; and (4) partial elasticities of substitution among inputs are allowed to vary and elasticity of scale can vary with output and input proportions.

Table-1. Summary statistics for electronics firms in China

Variables	Mean	Median	Standard Deviation	Minimum	Maximum
Y	55,269	15,011	104,836	71	905,364
K	9,414	2,799	20,295	40	159,740
L	9,891	4,357	17,854	5	126,687
LEV	0.5195	0.4895	0.2964	0.0720	4.2510
ROA	1.2120	2.5180	13.4837	-120.4800	27.3200
SIZE	0.9143	1.0000	0.3686	-1.0000	1.0000
REG	0.5428	1.0000	1.0000	0.0000	1.0000

Note: 350 observations.

5. Results and Discussion

5.1. Results From the Stochastic Production Frontier Estimations

The Stochastic Frontier Analysis Program (FRONTIER 4.1)[6], developed by Coelli (1996), was used to estimate the model specified in Eq. 3. The coefficients of the model thus obtained are presented in Table 2.

Table-2. Panel estimation of stochastic frontier production function for Chinese electronic firms

Variable	Parameter	Coefficient	Standard error	t-ratio
Production function				
Intercept	β_0	2.1080*	0.0927	22.7280
In(K)	β_K	0.3712*	0.0380	9.7773
In(L)	β_L	0.5740*	0.0382	15.0204
0.5In(K)^2	β_{KK}	0.1337*	0.0487	2.7454
0.5In(L)^2	β_{LL}	0.1107*	0.0206	5.3719
In(K)In(L)	β_{KL}	-0.1187*	0.0275	-4.3159
t	β_t	0.3319*	0.0563	5.9001
0.5(t)^2	β_{tt}	0.0243	0.0556	0.4369
ln(K)t	β_{Kt}	-0.0655*	0.0241	-2.7216
ln(L)t	β_{Lt}	0.0634*	0.0162	3.9248
Variance parameters				
Sigma-squared	σ^2	0.6733*	0.0501	13.4320
Gamma	γ	0.9999*	0.0000	10318935
Log-likelihood function	*LR*	-394.4706		

Note: The asterisk * indicates that coefficients are statistical significant at the 1% level of significance

At the first glance, the parameter of gamma (γ) is 0.9999 and decisively rejected at 1% level significance level. This indicates that the deviation from the frontier is due entirely to inefficiency. The huge value of γ also implies that the stochastic frontier is superior to the OLS approach in modeling the production function of the China electronics firms thus confirming that the technical inefficiency effects have significant impact on the output. The significant and positive value of variance parameters (σ^2), on the other hand, also confirms that some proportions of the total variability in productions are interrelated with technical inefficiency and signifying that the observed output diverged from frontier output due to factors which are perhaps within the control of the firms. Meanwhile, all the other estimated parameters (i.e. all the β_K and β_L) are not only statistically significant but also have the positive signs, which are expected in production functions.

[6] The authors would like to thank Tim Coelli for providing Frontier 4.1.

5.2. Factors contributing to technical inefficiencies and hypotheses testing: The Technical Inefficiency Model

Table 3 presents the estimation of technical inefficiency effects model which is triangulated by the maximum likelihood estimates for the translog stochastic frontier production function in Table 2. The results reveal that most of the parameter estimated are significant with the expected signs. Not surprisingly, the leverage coefficient is negative, which indicates that leverage is negatively related to technical inefficiency for all electronics firms in China. As such, the null hypothesis H_{01} rejected and is in line with the agency cost hypothesis that leverage is positively affects a firm's efficiency until it reaches the optimal capital structure. This is consistent with the findings of Jensen and Meckling (1976), Myers (2001) and Berger and Bonaccorsi (2006), which stated that leverage can reduce the agency costs of equity by raising a manager's share of ownership in the firm. In addition, leverage can mitigate the manager-shareholder conflict and it may be used as a disciplinary device to reduce managerial cash flow waste through the threat of liquidation[7]. As discussed above, the effect of leverage on total agency costs is expected to be non-monotonic, under certain extreme condition where bankruptcy and distress become more likely, the agency costs of outside debt overwhelm the agency costs of outside equity, thus additional increase in leverage result in a higher total agency costs (Berger and Bonaccorsi, 2006), but this extreme condition is not detected as far as our paper is concerned.

Table 3 Inefficiency model for Chinese electronic firms

Variable	Parameter	Coefficient	Standard error	t-ratio
Intercept	δ_0	1.4543*	0.2890	5.0324
Leverage of the firm	δ_{LEV}	-0.8879*	0.1968	-4.5121
Return on Assets	δ_{ROA}	-0.0417*	0.0044	-9.3941
Size	δ_{SIZE}	1.7402*	0.2789	6.2392
Trend	δ_T	0.3427*	0.0704	4.8663
Region	δ_{REG}	-0.6165*	0.1086	-5.6788

Note: The asterisk * indicates that the coefficient is statistical significant at the 1% level.

As expected, the coefficient representing a firm's return on assets (ROA) is negative, suggesting that profitable firms are more efficient in comparison to less profitable firms. This is consistent with the arguments of Fama and French (2002) and Cheng and Tzeng (2011) that firm profitability is positively related to efficiency as more profitable firms in general, are better managed and hence are expected to be more efficient. This finding rejects the null hypothesis H_{03}.

In the case of firm size on inefficiency, we find that the small and medium-sized electronics firms are much more scale efficient than large electronics firms in China. This undermines the argument of scale economies and is inconsistent with Jovanovic (1982)'s model although is in line with most of the recent studies which found that small and medium-sized firms have more flexible organizational structure and decision-making process thus are better equipped to response to market changes. This allows them to undertake tactical actions in grasping opportunities in emerging market, and to generate a niche market position that enable them to be highly efficient (Ma *et al.*, 2002). In addition, direct involvement of shareholders in business operation reduces agency conflicts in small firms relative to big firms, the latter suffering from organizational moral hazard and adverse selection issues. The executives in smaller firms in contrast, may be shareholders thus are more motivated to maximize their earnings as well as having more loyalty. Furthermore, in China, firms of different sizes are subjected to different degrees of accessibility to bank loans and support from the local governments. All of the above are sources that enable small firms to be more efficient. Conversely, large firms with hierarchical structure are highly bureaucratized with forms and procedures often taking priority instead of the ultimate results and profits. This hinders them from better responding to changing market preferences thus explains why some of these firms continue to produce homogeneous bulk-produced products rather than exploring more personalized and stylized goods that are demanded by customers. These arguments may be the reasons why it is harder for a big firm to maintain a high efficiency levels, in line with our findings which rejects the null Hypothesis H_{02}.

Finally, the negative regional coefficient reveals significant dissimilarities in technical efficiency scores between electronics firms in Hong Kong and those in Mainland China - Mainland Chinese firms

[7] See also Jensen (1986).

being relatively more efficient that their counterparts in Hong Kong in the production of electronic components (see Table 3). This finding rejects the null Hypothesis H_{04}.

Interestingly, we found the coefficient for the time trend variable in our technical efficiency effects model to be positive and significant, suggesting that the technical efficiency of electronics firms in China tended to deteriorate throughout the phase studied undermining the arguments of learning economics. A possible argument for this finding may be that the growing competition and congestion in product and input markets.

Table-4. Total factor productivity growths and its decomposition for electronics firms in Hong Kong and Mainland of China

Year	Hong Kong				
	TES	**TFPC**	**TC**	**TEC**	**SC**
2007	67.6442	12.0287(0.3219)	15.8366(0.0246)	-1.8349(0.1675)	-1.9730(0.2182)
2008	61.1744	-3.3322(0.4153)	15.4804(0.0257)	-15.6571(0.2795)	-3.1555(0.3389)
2009	56.8272	5.0363(0.3225)	15.4350(0.0274)	-17.5455(0.4731)	7.1468(0.1757)
2010	58.4761	19.1665(0.3271)	15.4811(0.0286)	6.3515(0.2489)	-2.6661(0.2401)
Average	62.5723	8.2248(0.1688)	15.5583(0.0258)	-7.1715(0.1651)	-0.1620(0.1464)
Year	**Mainland of China**				
	TES	**TFPC**	**TC**	**TEC**	**SC**
2007	93.3167	5.9048(0.3249)	2.4197(0.0640)	-0.0805(0.2756)	3.5656(0.1993)
2008	88.9570	-0.9118(0.3590)	2.2864(0.0627)	-4.6167(0.3119)	1.4186(0.1474)
2009	88.8664	7.2377(0.3862)	2.0988(0.0644)	-0.7494(0.3286)	5.8883(0.1750)
2010	87.8019	9.8468(0.5767)	2.0328(0.0712)	-0.1560(0.1607)	7.9701(0.5269)
Average	90.2903	5.5194(0.1487)	2.2094(0.0643)	-1.4006(0.0548)	4.7106(0.1576)

Note: Figures in parenthesis are the standard deviations

5.3. Technical Efficiency Measurements of the Sector and the Total Factor Productivity (TFP) Analysis

Table 4 presents the annual estimates of technical efficiency scores (TES) [column 1 in Table 4] and the total factor productivity change (TFPC). The latter can be decomposed into technical change (technological change, TC), technical efficiency change (TEC) and scale efficiency change (SC) [see Table 4 under columns 2, 3, 4 and 5] for electronics firms in Hong Kong and Mainland China[8].

Table 4 shows that the annual technical efficiency scores for both Hong Kong and mainland China electronics firms from 2007 to 2010. It appears that Mainland China electronics firms are significantly more efficient compared to their Hong Kong counterparts in terms of production. The mean technical efficiency score for mainland China is 90.29% while Hong Kong's average saw only 62.57%. In essence, this means that on average, Mainland China electronics firm are producing 90% of their potential levels while Hong Kong firms can only reach around 63% of their potential production levels.

Meanwhile as reported in Table 4 as well (under TFPC), the total factor productivity (TFP) for both Hong Kong and Mainland China recorded positive growth from 2007 to 2010. However, in 2008, TFP declined by 3.33% in Hong Kong and 0.91% in Mainland China, respectively. Interestingly, from the three sources of TFP growth, we observe that the negative growth of TFP in Hong Kong and Mainland China was due almost exclusively to technical efficiency changes. This deterioration in technical efficiency can be attributable to a few factors. Among others, poor management, inefficient level of production, variations in economic setting, which comprise of public policy, crisis appreciation of the Chinese Yuan (RMB), upsurge salaries and environmental issues in the 2000s all could have accounted for the drop in technical efficiency.

As observed, the contribution of technical (technological) progress (under TC) to positive the overall TFP growth was higher in the case of Hong Kong (15.5%) compared to Mainland China (2.2%). But, the contribution of the scale efficiency (scale change, SC) component to the overall TFP growth was significant only in 2009 for Hong Kong while this was the case for Mainland China in 2009 and 2010. The overall negative scale efficiency change in the case of Hong Kong (-0.16) as opposed to the positive one in the case of Mainland China (4.71) indicates the existence of scale economies in the latter's firms. Table 4 also reveals that on average there is high volatility in technical efficiency changes (TEC) as compared to technological progress (TC) and scale efficiency change (SC) in the case of Hong Kong. This indicates it is the technical efficiency in firms that distinguishes the high productive firms from the

[8] The detailed results are available upon request.

lower ones. In contrasts, Mainland China recorded significant volatility in scale efficiency change (SC) thus it is the firm size which explains the cross-firm differences in productivity.

5.4. Output Elasticity and Returns to Scale

For the elasticity and returns to scale components, it is revealed from Table 5 that all the elasticity of output with respect to capital and labor have the expected positive signs indicating that an increase in inputs ultimately increase the output level. Interestingly, labor input appears to be more crucial than capital input; as the elasticity of output with respect to labor is greater than the elasticity of output with respect to capital for all firms irrespective of their region. This implies that these electronics firms are labor-oriented. On the other hand, it is also worth noting that as the firm size became larger both the elasticity of output with respect to capital and labor increases. From the results, we also observed that the output of large firms is driven more by labor as compared to smaller and medium firms, both of which had greater elasticity of capital than of labor.

Interestingly, the sum of the input elasticities for Mainland China (1.0681) suggests that the electronics firms in Mainland China were operating with almost constant returns to scale (efficient). In contrast, the sum of the coefficients of labor and capital for Hong Kong electronics firms is 0.4732, indicating suboptimal production levels (decreasing returns to scale). Finally, the results also revealed the larger electronics firms in the sample achieved economies of scale but the small and medium ones did not have minimum efficient scale, especially in the case of small firms.

Table-5. Elasticity and returns-to-scale of the stochastic frontier production function model for Chinese electronics firms

Variable	Region		Firm Size		
	Hong Kong	Mainland China	Small	Medium	Large
Capital elasticity	0.1471	0.4317	0.1368	0.3749	0.3923
Labor elasticity	0.3261	0.6365	0.3423	0.4657	0.7408
Returns-to-scale	0.4732	1.0681	0.4790	0.8406	1.1331

6. Conclusions

This paper applied a translog stochastic frontier with inefficiency effects to a panel of China firm-level data. The results revealed that the average technical efficiency of Hong Kong and Mainland China were 63% and 90%, respectively thus implying that firms in these two regions produce 63% and 90% of their potential output levels. The inefficiency effects model also revealed a decrease of efficiency over time in addition to also identifying several other factors that explained firm performance differences. Firstly, we observed that small and medium-sized firms are more efficient than large firms while the issue of location also had a similar implication. In the context of the latter, firms located in Mainland China are generally more efficient than those located in Hong Kong. In addition, we also observe that profitable firms tend to outperform their less-profitable counterparts in terms of efficiency. This finding supports the agency cost hypothesis but does not support the interest-tax shield hypothesis. These results not only shed some light on the relationship between China's electronic production and capital structure, they also revealed some useful insights into the decision-making process in firms.

This paper is the first to use a stochastic frontier production function to examine the issues of productivity growth, technical change, and other economic measures of electronics firms in China. The SFA approach, besides allowing for the relaxation of the assumption that electronics firms are successful profit maximizers, also measures the output function and presents estimates of each firm's inefficiency, in relation to the estimated function. In terms of the TFP results, the figures revealed that the negative TFP growth across firms is mostly due to technical efficiency changes both in the case of Hong Kong and Mainland China thus managerial inefficiency appeared to a major shortcoming in productivity issues. Technological progress appeared to be the catalyst of the TFP growth in Hong Kong but scale efficiency changes is the main driver for TFP growth in the case of Mainland China firms. To elevate and sustain a high TFP growth, the authority should adopt further development plan that promote competition and intensify better use of technology in the electronics industry, the latter especially for Mainland China. The private sector, meanwhile can contribute by developing various incentive systems to upgrade managerial efficiency.

The returns-to-scale analysis for the electronics firms in China reveal that firms in Mainland China exhibit increasing returns to scale while firms in Hong Kong exhibited decreasing returns. Interestingly, the elasticity of output with respect to the respective inputs revealed that the output of all firms are driven more by labor than capital. In addition, as firms become larger, the elasticity of their outputs with respect to capital and labor also increases. This indicates that there are still significant economies of scale in the sector yet to be realized.

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