FOREIGN OWNERSHIP, PRODUCTIVITY, AND ECONOMIC CRISIS

Suyanto
Faculty of Business and Economics, Universitas Surabaya, email: suyanto@ubaya.ac.id

Abstract

This paper evaluates the productivity benefit from the present of foreign ownership in manufacturing firms. The productivity benefit is analysed for the period before crisis (1988-1996) and the period crisis onwards (1997-2000). Using the methodology of stochastic production frontier, the results show that foreign ownership generates positive productivity benefit to local manufacturing firms, both during the before crisis period and during the crisis onwards period. An interesting result emerges when comparing the two periods. Although positive spillover benefits exist in both periods, the coefficient of FDI Spillovers is larger during the period of crisis onwards, suggesting that the productivity benefit increase after economic crisis. These findings support an argument by Takii (2007) that economic crisis has positive impact on the productivity spillovers of FDI.

Keywords: foreign ownership, productivity benefits, manufacturing, economic crisis

Abstrak

Tulisan ini mengevaluasi manfaat produktivitas dari kehadiran Penanaman Modal Asing (PMA) dalam perusahaan-perusahaan manufaktur. Manfaat produktivitas ini dianalisis untuk periode sebelum krisis (1988-1996) dan periode krisis dan setelahnya (1997-2000). Dengan mengaplikasikan metodologi Stochastic Production Frontier, hasil yang diperoleh memperlihatkan bahwa kepemilikan asing menghasilkan pengaruh produktivitas positif terhadap perusahaan-perusahaan manufaktur , baik periode sebelum krisis dan periode krisis dan setelahnya. Hal menarik muncul ketika hasil dari kedua periode tersebut dibandingkan. Meskipun pada kedua periode terdapat manfaat rembesan positif dari kehadiran kepemilikan asing, pengaruh rembesan ini lebih besar pada periode krisis dan setelahnya, yang menerangkan bahwa manfaat produktivitas meningkat setelah krisis ekonomi. Penemuan ini mendukung pendapat yang dikemukakan oleh Takii (2007) bahwa krisis ekonomi memiliki dampak positif pada produktivitas rembesan dari PMA.

Kata kunci: foreign ownership, productivity benefits, manufacturing, economic crisis

JEL Classification: F21, F23

1. Introduction

It has been long argued in the literature that foreign ownership will generate positive benefits to local firms. The benefits can either direct, which take the forms of new capital and new fund for financing saving-investment gap, or indirect, in the forms of new knowledge that increase productivity of local firms. Although the direct benefits has widely believe been valuable for host economies, the preferential policies toward foreign direct investment (FDI) rest in the common argument that FDI generates externalities in the forms of new knowledge, including modern technology, advanced managerial expertise, and scale-efficiency knowledge (Blomstrom, 1986; Blomstrom and Kokko, 1998; Liu, 2008). These externalities are mainly due to foreign subsidiaries being unable to internalize the new transferred knowledge from their parent companies, and this transferred knowledge spills over to domestic firms, raising productivity.

A large number of empirical studies have been conducted to evaluate the productivity benefits of foreign investment. Caves (1974), Globerman (1979), Driffield (2001), and Girma and Gorg (2007) show that positive productivity benefits exist in developed countries, such as Australia and UK. Blomstrom (1986), Kokko (1996), Javorcik (2004), and Kugler (2006) demonstrate that positive productivity benefits exist in developing countries, such as Mexico, Lithuania, and Colombia. In Indonesia, Blomstrom and Sjoholm (1999), Sjoholm (1999a, 1999b), Taki (2005), and Blalock and Gertler (2008) do the similar tests and conclude positive productivity spillovers in manufacturing firms. All these studies examine the productivity spillovers for a specific country at a specific time period. What less visible is these studies, particularly those on Indonesia, do not take into account economic shocks in examining the productivity spillover. This present study extends the literature by including economic crisis into the analysis of productivity spillovers.

The rest of this paper proceeded as follows: (a) a brief literature review is presented, (b) it is followed by the model, (c) the dataset is discussed, (d) the empirical results is presented, and (e) concluding remarks are given the last section.

2. Literature Review

The literature on the spillover effects of foreign ownership on local firm productivity can be trace back to the seminal dissertation of Hymer (1960). Based on this dissertation, theoretical literature extends the analysis of productivity benefits through various channels of spillover effects. Findlay (1978) demonstrates that foreign investments play an important role in motivating domestic firms to increase their productivities through technological improvements. Das (1987) presents a model showing that a foreign presence in an economy generates spillover effects for domestic firms through increases in efficiency. Kaufmann (1997) and Fosfuri et al. (2001) introduce models of productivity spillovers through labour mobility. Rodriguez-Clare (1996) points out that productivity benefits from foreign investment can be transferred through suppliers or industrial linkages.

Empirical literature grows following the theoretical literature. The pioneering papers in this field are Caves (1974), Globerman (1979), and Blomstrom and Persson (1983). Following these three papers, the empirical studies then develop in the various directions with various methodology and dataset. However, the results of the empirical studies are diverse, whereas some studies demonstrate positive productivity spillovers and some others show no spillovers or even negative spillovers. Todo and Miyamoto (2006) and Suyanto et al. (2009) are two empirical studies that support the positive productivity spillovers, while Aitken and Harrison (1999) and Djankov and Hoekman (2000) find negative spillover effects of FDI. The mix evidence reflects that an empirical study that uses a new methodology and takes into account some specific mediating factor, such as economic shock, is expected to contribute in the literature.

Empirical studies on productivity benefits in Indonesia manufacturing firms have been conducted by some researchers. Blomstrom and Sjoholm (1999), Sjoholm (1999a; 1999b), Takii (2005), Blalock and Gertler (2008), and Suyanto et al. (2009) are among them. Blomstrom and Sjoholm (1999) and Sjoholm (1999a; 1999b) utilize cross-sectional data and OLS regression to estimate the productivity benefits. Takii (2005) and Blalock and Gertler (2008) apply panel data and OLS regression. Only Suyanto et al. (2009) and Suyanto and Salim (2010) that applies a stochastic frontier method to examine the productivity benefits. The chief advantage of the stochastic frontier method if compared to the classical regression is that the former take into account the disturbance variable, which is separated into two components (inefficiency term and stochastic term). A more detailed discussion on the stochastic frontier method is presented in the second part of the following section.

3. Research Method

3.1. Research Questions and Hypotheses Development

It is widely believed that multinational companies (MNCs) possess superior knowledge than local companies. Although multinational companies may have disadvantages in the forms of access to local resources and experience in serving local markets, they could win a competition with local counterparts through superiority in knowledge, advancement in technology, and enhancement in efficiency. Caves (1971) argues that superior knowledge of multinationals is accumulated through long-term experiences, manifesting in learning by doing, development of economic-scales of production, and research and development (R&D). This superior knowledge enriches production capacities of MNCs, and hence enables these companies to produce in large scale and low prices. Wang and Bloomstrom (1992) state that the advancement in technology allows MNCs maintaining a technology gap with local companies. The existence of MNCs in local markets does indeed create a "demonstration" effect and enables local companies to imitate MNCs' technology. However, according to Glass and Saggi (2002), the imitated technology is less up-dated, as MNCs might prevent the leakage of the most-up-dated technology. An implication of this action, MNCs have more advanced technology than their local counterparts. Aitken and Harrison (1999) put forward an argument that superiority of MNCs is reflected on the enhancement in efficiency from time to time. Large-scale productions allow MNCs to spread fixed costs over a large amount of output, and hence the marginal costs of MNCs are lower than those of local companies. The low marginal costs enable MNCs to "steal" market share from local companies.

Based on these related literature, the current study try to test whether an argument of the knowledge superiority is applied in the Indonesian manufacturing industry, by putting forward a research question that: "*Do MNCs posses superior knowledge than local firms?*". To quantify the superior knowledge, efficiency measure is used as a proxy. The corresponding hypothesis is:

H_1: MNCs are more efficient than local firms.

If hypothesis 1 is true, there is a possibility that the superior knowledge of MNCs might spill over local firms and increases their efficiencies (Wang and Blomstrom, 1992; Kokko, 1996). The process of spillovers takes place when MNCs transfer knowledge to their subsidiaries in host countries, and the transferred knowledge has a certain public goods' quality that allow local firms to take benefits via non-market mechanisms (Suyanto et al., 2009). These knowledge spillovers can channelled through imitation, hiring labour whose previously trained by MNCs, competition, and vertical linkages (an excellent review on these four channels is provided by Gorg and Greenaway, 2004).

A number of empirical studies have been conducted to test the spillover effects of MNCs. The notably among them are Caves (1974), Globerman (1979), and Blomstrom and Persson (1983). These three groundbreaking studies attract scholars' attention to investigate in more detail the spillover effects. Both cross-sectional and panel-data studies have extensively conducted to test the spillover effects, and the results are mixed. Some studies show positive knowledge spillovers (such as, Javorcik (2004) for Lithuania, Gorg and Strobl (2005) for Ghana, Tomohara and Yokota (2006) for Thailand, Kugler (2006) for Colombia, Liang (2007) for China, and Suyanto and Salim (2010) for Indonesia), some others find no spillover effect (such as Haddad and Harrison (1993) for Morocco, Kathuria (2000) for India, and Konings (2001) for Poland), and some studies discover negative knowledge spillovers (Aitken and Harrison (1999) for Venezuela, Djankov and Hoekman (2000) for the Czech Republic, and Thangavelu and Pattnayak (2006) for India). Thus, there is no universal consensus regarding the relationship between FDI and knowledge spillovers.

To shade the light on the debate, this current study empirically investigates the spillover effects of FDI in order to answer question that: "is there any positive spillover effects from foreign investments to local firms?". A corresponding hypothesis is proposed:

H_2: There is a positive productivity effect from the presence of foreign investment.

There is an argument that shocks in the economic environment, such as economic crises, might affect the signs and magnitude of FDI spillovers on domestic productivity. A few recent studies have taken into account this factor in investigating FDI spillovers (see for example, Takii, 2007 and Suyanto, 2010). While these studies pointed out the importance of the economic environment, very limited empirical studies have been conducted in addressing this factor. As a contribution to the research in this field, this study examines whether the economic crisis in 2007 influences the sign and magnitude of FDI spillovers. The corresponding research question is that: "*Is there any differences in sign or in magnitude of FDI spillovers between the period before crisis and the period crisis onwards?*". The hypothesis to test the research question is:

H_3: There is a difference in the magnitude of productivity effect between period before crisis and period crisis onwards.

3.2. Research Method

To test the three hypotheses above, this paper employs the time-varying stochastic production frontier (SPF) for panel data proposed by Battese and Coelli (1995). This method is a one-stage method that estimates the production function simultaneously with an inefficiency function using a Maximum Likelihood (ML) method of estimation. The results from a one-stage method, such as Battese and Coelli's model, has been demonstrated in the literature to provide more efficient and consistent estimates than those from a two-stage method (see Kumbhakar et al., 1991; Wang and Schmidt, 2002 for excellent discussions on the superiority of one-stage method).

The Battese and Coelli (1995) model can be written in following equations:

$$Y_{it} = f(X_{it};\beta).\exp(v_{it} - u_{it})$$

$$u_{it} = z_{it}\delta + \omega_{it}$$

where Y_{it} denotes the scalar output of firm i *(i=1, 2, ..., N)* at time t *(t=1,2,...,T)*, X_{it} is a *(1xk)* vector of inputs used by firm i at time t, β is a *(kx1)* vector of unknown parameters to be estimated; the v_{it} is a random error; u_{it} is the technical inefficiency effect; z_{it} is a *(1xm)* vector of observable non-stochastic explanatory variables affecting technical inefficiency for firm i at time t, $\boldsymbol{\delta}$ denotes a *(mx1)* vector of unknown parameters of the inefficiency effect to be estimated; ω is an unobservable random error.

Equation (1) represents the production frontier of an output given some input factors. Equation (2) represents the inefficiency function. These two equations are estimated simultaneously using a computer program FRONTIER 4.1 provided in Coelli (1996). This program follows a three-step procedure in estimating the parameters in Equations (1) and (2). In the first step, ordinary least squared (OLS) is used to estimate the stochastic production function. All parameters β obtained are consistent, except for the intercept α. In the second step, a two-phase grid search of γ is conducted, with β parameters (except the intercept) set to OLS values and the intercept α and σ^2 parameters are adjusted using the corrected ordinary least squared formula, as explained in Coelli (1995). All other parameters (μ, η, and δ) are set to zero during the grid search. In the third step, the final ML estimates are obtained using the Davidon-Fletcher-

Power Quasi-Newton method, with the values selected from the grid search as a starting value in the iterative procedure.

3.3. Variables and the Empirical Model

Variables for analysis in this paper are divided into two categories: variables of production function and variables of inefficiency. Variables of production function include output (Y), labour (L), capital (C), material (M), and energy (E). Variables in inefficiency function include Foreign Ownership (FO), FDI Spillovers (FS), and Age of Firm (AGE). Table 1 provides definitions and sources of each variable.

Table 1. Definitions of Variables and Sources of Data

Variables	Definition	Source
Production frontier		
Y	Output (in million rupiah), which is deflated using a wholesale price index (WPI) at a constant price of 1993	Survey of Large and Medium Manufacturing Industries, published by Badan Pusat Statistik (BPS), and Wholesale Price Index, published by BPS
L	Labor (number of workers) is the total number of employees directly and indirectly engaged in productions	Survey of Large and Medium Manufacturing Industries, published by BPS
K	Capital (million rupiah), which is deflated using WPI for machinery at a constant price of 1993	Survey of Large and Medium Manufacturing Industries, published by BPS, and Wholesale Price Index, published by BPS
M	Material (million rupiah), which is deflated using a wholesale price index at a constant price of 1993	Survey of Large and Medium Manufacturing Industries, published by BPS, and Wholesale Price Index, published by BPS
E	Energy (million rupiah) is the sum of electricity and fuel expenditures, which are deflated using a WPI for electricity and fuel price index at a constant price of 1993	Survey of Large and Medium Manufacturing Industries, published by BPS, and Wholesale Price Index, published by BPS
Inefficiency function		
FO	Foreign ownership, which is measured by a dummy variable: 1 if the share of foreign ownership is greater than 0 percent; and 0 if otherwise.	Survey of Large and Medium Manufacturing Industries, published by BPS
FS	Spillovers of FDI on domestic firms in the same industries, which is measured by the share of foreign firms' output over total output of the five-digit industry	Survey of Large and Medium Manufacturing Industries, published by BPS
AGE	Age of firms is measured by the different between year of survey and year of starting production	Survey of Large and Medium Manufacturing Industries, published by BPS
CRISIS	A dummy variable for economic crisis, which takes value of 0 for the years before 1997 and takes value of 1 for the years after 1997.	Survey of Large and Medium Manufacturing Industries, published by BPS

Using the defined variables, the empirical model of the *translog* stochastic production frontier is written as:

$$\ln y_{it} = \beta_0 + \beta_L \ln L_{it} + \beta_K \ln K_{it} + \beta_M \ln M_{it} + \beta_E \ln E_{it} + \beta_{LL}\left[\ln L_{it}\right]^2 + \beta_{LK}\left[\ln L_{it} * \ln K_{it}\right]$$
$$+ \beta_{LM}\left[\ln L_{it} * \ln M_{it}\right] + \beta_{LE}\left[\ln L_{it} * \ln E_{it}\right] + \beta_{KK}\left[\ln K_{it}\right]^2 + \beta_{KM}\left[\ln K_{it} * \ln M_{it}\right]$$
$$+ \beta_{KE}\left[\ln K_{it} * \ln E_{it}\right] + \beta_{MM}\left[\ln M_{it}\right]^2 + \beta_{ME}\left[\ln M_{it} * \ln E_{it}\right] + \beta_{EE}\left[\ln E_{it}\right]^2 + \beta_t t$$
$$+ \beta_{Lt}\left[\ln L_{it} * t\right] + \beta_{Kt}\left[\ln K_{it} * t\right] + \beta_{Mt}\left[\ln M_{it} * t\right] + \beta_{Et}\left[\ln E_{it} * t\right] + \beta_{tt} t^2 + v_{it} - u_{it}$$

and the inefficiency function is written as:

$$u_{it} = \delta_0 + \delta_1 FO_{it} + \delta_2 FS_{it} + \delta_3 AGE_{it} + \delta_4 CRISIS + w_{it}$$

where y represents output, L represents labour, K is capital, M is material, E is energy, t is time, i is firm, βs are parameters to be estimated, ln denotes natural logarithm, v_{it} is the stochastic error term, u_{it} is the technical inefficiency, FO is foreign ownership, FS is spillover from foreign investment, AGE is the age of firms, CRISIS is a dummy variable for economic crisis, and w is an error term of the inefficiency function.

3.4. Construction of Dataset

The primary data is taken from the Annual Survey of Large and Medium Manufacturing Industry (*Survey Tahunan Industri Besar dan Menengah* - SI) published by Indonesian Central Board of Statistics (*Badan Pusat Statistik* – BPS).[1] The data are available in electronic format (softcopy) and are given under licence. Information included in the data are the basic information of each establishment (such as specific identification code, industrial classification, year of starting production, and location), the production information (gross output, number of workers in production and non-production, value of fixed capital and investment, material, and energy consumption), ownership information (domestic and foreign ownership), and other information (such as share of production exported and value of material imported). The numbers of establishments surveyed vary with the year of survey, with the minimum number of 7,469 manufacturing establishments in 1975 and the maximum number of 21,671 establishments in 1996.[2] The annual surveys have been conducted since 1975, and the recent available data are for the year 2008. This study uses only the surveys from 1988 to 2000.

As a supplementary to the SI data, this study also utilizes data from other sources. The wholesale price index (WPI) is used as a monetary deflator for output and material. Similarly, the machinery price index and the electricity price index are used as a deflator for capital and electricity, respectively. To deflate the monetary value of fuel, the fuel price index is calculated from the OPEC fuel basket price from *DX for Windows*.[3]

The final dataset is constructed by following procedure in Suyanto (2010), which include adjustment for industrial code, adjustment for variable definitions, cleaning for noise and typographical errors, back-casting the missing values of capital, matching firms for a balanced panel, and deflating all monetary values into their real values. By doing so, the final consistent panel dataset consists of 3,218 establishments with 43,134 observations.

4. Results and Discussion

4.1. Productivity Benefits from Foreign Investment

The first step in the stochastic production frontier method is to test the appropriateness of the chosen model. The *translog* model, as specified in Equation (3), is tested against four other models: Cobb-Douglas frontier, Hick-Neutral Technology frontier, No Technology Progress frontier and No-inefficiency models. The null hypothesis for testing Cobb-Douglas frontier, given the *translog* model, is $\beta_{LL} = \beta_{LK} = \beta_{LM} = \beta_{LE} = \beta_{KK} = \beta_{KM} = \beta_{KE} = \beta_{MM} = \beta_{ME} = \beta_{EE} = 0$.

[1] The large and medium establishment is defined as a firm with 20 or more workers.

[2] The terms "establishment" and "firm" are used interchangeably for prepositional convenience. It mostly refers to the former term.

[3] The OPEC fuel prices are converted from US$ values to Indonesia rupiah (IDR) using average yearly exchange rates published by the central Bank of Indonesia in Statistics of Economic and Finance Indonesia (*Statistik Ekonomi dan Keuangan Indonesia* or SEKI).

Alternatively, the null hypothesis for testing Hick-Neutral Technology is $\beta_{Lt} = \beta_{Kt} = \beta_{Mt} = \beta_{Et} = 0$. The null hypotheses for testing the No Technology Progress and the no-inefficiency model are $\beta_t = \beta_{tt} = \beta_{Lt} = \beta_{Kt} = \beta_{Mt} = \beta_{Et} = 0$ and $\gamma = \delta_0 = \delta_1 = ... = \delta_6 = 0$, respectively. These four hypotheses are evaluated under the Generalized Likelihood Ratio Statistic (λ), as in Battese and Coelli (1992). The results from the Likelihood Ratio tests are presented in Table 3. Both the results for all manufacturing firms and the results for firms in each two-digit ISIC (Indonesian Standard of Industrial Code) are given in the Table.

Table 3. Log-Likelihood Tests for Testing Appropriateness Transloq Model Against Some Alternative Models

Industry	Alternative Models			
	Cobb- Douglas	Hick-Neutral	No Technology Progress	No Inefficiency
Full Samples	9801.42***	266.34***	69.22***	1403.86***
Foods (ISIC 31)	2643.28***	40.86***	186.26***	375.84***
Textile (ISIC 32)	2346.48***	61.78***	150.32***	212.86***
Woods and Products (ISIC 33)	1243.24***	12.12**	34.52***	157.18***
Paper and Products (ISIC 34)	497.94***	32.46***	126.78***	140***
Chemicals (ISIC 35)	1577.46***	273.76***	286.14***	652.08***
Non-metal Mineral (ISIC 36)	1352.54***	43.46***	232.62***	143.1***
Basic Metals (ISIC 37)	57.98***	8.16*	10.76*	26.6***
Metal Products (ISIC 38)	550.58***	125.74***	14.42**	930.22***
Others (ISIC 39)	119***	9.14*	18.22***	9.48**
Critical Values (α=0.10)	22.31	7.78	10.64	7.09
Critical Values (α=0.05)	25	9.49	12.59	8.76
Critical Values (α=0.01)	30.58	13.28	16.81	12.48
Results	Reject	Reject	Reject	Reject

Source: Author's calculations. Note: ***, **, and * denote significance at 1%, 5%, and 10%, respectively. The critical values are based on Chi-squared distribution. For the null hypothesis of no-inefficiency effect, the critical value is based on a mixed chi-squared distribution provided by Kodde and Palm (1986).

The first row in Table 3 shows the results of testing alternative models against *translog* model for all firms in manufacturing industries. The result for null hypothesis that testing Cobb-Douglas model shows that the null hypothesis is rejected at the level of significance 1%, implying that the Cobb-Douglas model is inappropriate given the translog model. Similarly, the result for null hypothesis of Hick-Neutral frontier is also rejected at 1% level of significance. The same also true for the results of the null hypothesis on No-Technology Progress and the null hypothesis on No Inefficiency models, suggesting that both No-Technology Progress model and No-Inefficiency model are inappropriate, given the *translog* model. As the results, the translog model as specified in Equation 3 is the appropriate model for the dataset.

The second row to the tenth row show the results of hypotheses tests on firms in each two-digit industrial sector. The results confirms that Cobb-Douglas frontier, Hick-Neutral frontier, No-Technology frontier, and No-Inefficiency model are inappropriate given the *translog* model. Unlike the results for the full samples that significant at the 1% level, the results for firms in the two-digit industries have significance that ranging from 1% to 10%. Nevertheless, the results lead to the same conclusion that the translog model is the appropriate model for the data.

Given the results, the next step of the stochastic production frontier is to estimate the parameters of production frontier and the parameters of inefficiency function, simultaneously. The estimation results of parameters of *translog* stochastic production frontier (Equation 3) and parameters of inefficiency function (Equation 4) are presented in Table 4.

Table 4. Parameter Estimates of Stochastic Production Frontier on the FDI Spillover Effects in the Indonesian Manufacturing Firms

Variable	All Firms	Local Firms	Foreign Firms
Production Frontier (Dependent Variable: lnY)			
Constant	1.144***	1.128***	0.468*
	(37.08)	(34.42)	(1.66)
lnL	0.601***	0.595***	0.315***
	(32.87)	(28.85)	(2.97)
lnK	0.180***	0.197***	0.186***
	(17.34)	(17.42)	(2.63)
lnM	0.212***	0.175***	0.616***
	(19.41)	(15.27)	(8.22)
lnE	0.244***	0.263***	0.285***
	(26.16)	(27.79)	(3.66)
$[lnL]^2$	0.014**	0.012	0.055**
	(2.42)	(2.00)	(2.35)
lnL*lnK	0.043***	0.043***	0.018
	(9.73)	(8.83)	(0.85)
lnL*lnM	-0.174***	-0.172***	-0.083***
	(-39.88)	(37.12)	(-3.93)
lnL*lnE	0.067***	0.068***	-0.005
	(13.93)	(13.10)	(-0.21)
$[lnK]^2$	-0.003**	-0.002*	0.013**
	(-2.38)	(1.81)	(2.41)
lnK*lnM	-0.071***	-0.074***	-0.081***
	(-28.17)	(-27.50)	(-7.33)
lnK*lnE	0.057***	0.055***	0.035***
	(22.86)	(19.93)	(2.51)
$[lnM]^2$	0.164***	0.167***	0.116***
	(98.82)	(97.94)	(16.19)
lnM*lnE	-0.143***	-0.141***	-0.142***
	(51.52)	(-49.49)	(-10.15)
$[lnE]^2$	0.023***	0.021***	0.051***
	(17.69)	(14.00)	(5.25)
T	0.006***	0.011***	-0.011
	(3.79)	(6.20)	(-0.94)
lnL*T	-0.001	-0.000	-0.002
	(0.54)	(-0.78)	(-0.49)
lnK*T	-0.000	-0.001	0.009***
	(-0.26)	(-1.11)	(4.31)
lnM*T	0.001*	0.001***	-0.006***
	(1.83)	(2.95)	(2.68)
lnE*T	-0.004	-0.001	0.001
	(-1.05)	(-1.77)	(0.26)
T^2	-0.001***	-0.001***	-0.000
	(-5.81)	(-7.59)	(0.76)
Inefficiency Function (Dependent Variable: u)			
Constant	0.078***	0.053***	0.222***
	(21.59)	(23.54)	(13.93)
FO	-0.008***	-	-
	(-6.56)		
FS	-0.126***	-0.150***	-0.261***
	(-88.00)	(-6.56)	(-14.59)
AGE	0.002***	0.0003***	0.00002
	(3.30)	(2.10)	(0.07)
CRISIS	0.015***	0.007***	0.004
	(6.91)	(10.31)	(0.28)
Sigma-squared	0.033***	0.031***	0.047***
	(195.31)	(142.70)	(37.90)
Gamma	0.005***	0.137***	0.009***
	(20.78)	(18.23)	(5.60)

Source: Author's Calculation using the model specified in equation (3) and (4). Notes: The t-statistics are in parenthesis. *** denotes 1% significance level, ** denotes 5% significance level, and * denotes 10% significance level.

There are three groups of estimation results that presented in Table 4. The first group, which is presented in the second column of the Table, is the estimation results for the total sample of firms. The second group, that presented in the third column, is the results for the local firms only. The third group, which is in the last column of the Table, is the results for the foreign firms only.

Starting from the estimation results of the first group, it is found that the first degree input variables (*lnL, lnK, lnM*, and *LnE*) have positive signs, as in economic theory. These results suggest that the input variables have a positive effect on output. The second degree variables, both the interacting variables between inputs and the interacting variables between input and time, also have expected signs and are statistically significant.

Moving to the inefficiency function (the lower part of Table 4), the estimated coefficients of *FO* (which take the value of one if the firm is a foreign-owned firm and zero if the firm is a domestic firm) are negative and highly significant at the 1% level, suggesting that foreign-owned firms are, on average, less inefficient than domestic firms, keeping other variables constant. This result supports the mainstream premise that foreign firms generally possess more updated knowledge and have more experience in serving markets, so that they are more efficient than domestic firms.

As expected, the coefficient of *FS* has a negative sign and is statistically significant at the 1% level, meaning that the presence of FDI reduces inefficiency of firms in the same five-digit industries. Although this study uses a longer time period by including the period of crisis, the findings are in line with Blalock and Gertler (2008) and Takii (2005) on the ground that FDI at the industrial level generates positive spillovers to firms in the same industries.

With regard to variables not associated with foreign ownership, the coefficient of Age is positive and statistically significant. This is not a surprise since the impact of age to firms' efficiencies is still a matter of debate in the literature. An older firm could have a higher efficiency due to knowledge accumulation through learning experience, while a younger firm might be more efficient because of possessing up-dated knowledge. Nevertheless, the result is consistent with findings in Lundvall and Battese (2000) for Kenya and Kathuria (2001) for India. Similarly, the coefficients of crisis also show positive and significant effects on inefficiency. This demonstrates the argument in literature that the economic crisis might reduce efficiency of firms (for example, Takii, 2007).

When the samples of firms are divided into local firms and domestic firms, and the estimations of stochastic frontier are performed into these two groups of samples, the results are almost similar as the results for the total samples. There are some interesting findings emerge. The first noTable finding is that the estimated coefficients of *FS* are negative and significant for both the model for only local firms and the model for only foreign firms. The implication of these findings is that the entry of foreign firms in the domestic market reduces inefficiency of local firms as well as other foreign firms. This is in line with the argument that foreign firms brings positive externalities to local firms and other foreign firms, as the presence of new foreign firms force domestic firms and the existed foreign firms to increase their efficiency.

The second impressive finding is that the magnitude of spillover effects from new foreign firms on other foreign firms is greater than the magnitude of the spillover effects from new foreign firms on local firms. This is reflected from the higher coefficient of *FS* for the model of samples of only foreign firms (the last column of Table 5) if compared to those of *FS* for the model of samples of only local firms (the second last column of Table 5). The indirect implication is that the reduction of inefficiency of foreign firms is larger than the reduction of inefficiency of local firms, when new foreign firms enter the domestic market. This could be explained by the argument that foreign firms are more ready for competition with new foreign firms if compared with the local firms.

The third interesting finding is that the *Age* variable is found to be insignificant for sample of only foreign firms, suggesting that older foreign firms does not have significant different in efficiency compared to younger ones. This could be true because older and younger foreign firms have up-dated and homogenous technological advancement.

The last noTable finding is that the estimated coefficient of *Crisis* has a positive sign for both the sample of only local firms and the sample of only foreign firms. However, it is insignificant for the sample of only foreign firms while it is significant for the sample of only local firms. These findings suggest that economic crisis increase inefficiency of local firms, but give no significant effect on inefficiency of foreign firms.

4.2. Productivity Spillovers Before and After the Economic Crisis

This study takes into account the economic crisis by estimating Equations (3) and (4) on observations before the economic crisis (1988-1996) and those from the economic crisis onward (1997-2000). The estimated parameters for these two periods are presented on Table 6. For both periods, the coefficients of spillover variables are negative and statistically significant, suggesting positive FDI spillovers. Comparing the results for the two periods, the coefficients of *FS* are larger for the crisis period. These results suggest that there are positive productivity spillovers, and the magnitude of spillovers increased after the economic crisis.

Although this current study applies a different methodology, the finding is consistent with the previous studies in Indonesia in that FDI generates positive spillovers during the economic crisis (for example, Takii 2007). However, unlike Takii (2007), the current study finds that the magnitude of horizontal spillovers increased during the crisis. The differences in the method of estimations, the measure of FDI spillovers, and the measure of productivity are perhaps the reasons for the differences in findings. While Takii uses a panel data OLS estimation, measures FDI spillovers using the share of labour, and calculates productivity using value added, the present study employs a stochastic production frontier, measures FDI spillovers using the share of output, and calculates productivity using gross outputs, respectively.

Table 6. Estimates of Stochastic Production Frontier on the Sample of Period Before Crisis and the Sample of Crisis Onwards

Variable	Period Before Crisis (1988-1996)	Period of Crisis Onwards (1997-2000)
Production Frontier (Dependent Variable: lnY)		
Constant	1.105***	2.767***
	(28.71)	(11.11)
lnL	0.601***	0.701***
	(30.80)	(11.13)
lnK	0.203***	0.091**
	(16.88)	(2.31)
lnM	0.213***	0.258***
	(17.42)	(6.91)
lnE	0.239***	0.213***
	(22.27)	(6.19)
$[\ln L]^2$	0.007	0.025**
	(1.06)	(2.25)
lnL*lnK	0.031***	0.080***
	(5.70)	(8.38)
lnL*lnM	-0.162	-0.172***
	(-33.83)	(-20.29)
lnL*lnE	0.073***	0.033***
	(12.77)	(3.59)

Table 6, Continued...

Variable	Period Before Crisis (1988-1996)	Period of Crisis Onwards (1997-2000)
$[lnK]^2$	-0.001	-0.006**
	(-1.11)	(-2.01)
lnK*lnM	-0.072***	-0.080***
	(-23.85)	(-15.82)
lnK*lnE	0.058***	0.057***
	(18.94)	(10.07)
$[lnM]^2$	0.161***	0.158***
	(92.81)	(51.35)
lnM*lnE	-0.138***	-0.143***
	(-47.79)	(-27.21)
$[lnE]^2$	0.017***	0.034***
	(10.59)	(11.94)
T	0.030***	-0.262***
	(9.99)	(-6.77)
lnL*T	0.003**	-0.021***
	(2.36)	(4.92)
lnK*T	-0.003***	0.009***
	(-4.74)	(3.13)
lnM*T	-0.004***	0.007**
	(-5.73)	(2.50)
lnE*T	0.003***	-0.001
	(4.30)	(-0.12)
T^2	-0.001**	0.009***
	(02.36)	(5.71)
Inefficiency Function (Dependent Variable: u)		
Constant	0.078***	0.081***
	(2.86)	(8.06)
FO	-0.145***	-0.611***
	(-132.45)	(73.74)
FS	-0.146***	-0.426***
	(-25.00)	(7.49)
AGE	0.00006	-0.001***
	(0.52)	(-9.73)
Sigma-squared	0.032***	0.036***
	(257.44)	(79.74)
Gamma	0.009***	0.127***
	(20.23)	(36.79)

Source: Author's Calculation using the model specified in equation (3) and (4). Notes: The t-statistics are in parenthesis. *** denotes 1% significance level, ** denotes 5% significance level, and * denotes 10% significance level.

4.3. Robustness Test

For checking the robustness of the above findings, this chapter estimates an alternative two-stage stochastic frontier model proposed by Cornwell et al. (1990), with the first stage estimation. The equations for Cornwell et al. model can be formulized as:

$$y_{it} = \alpha_{0t} + x_{it}\beta + v_{it} - u_{it}$$
$$= \alpha_{it} + x_{it}\beta + v_{it}$$

and

$$\alpha_{it} = \Omega_{i0} + \Omega_{i1}t + \Omega_{i2}t^2$$

where α_{0t} is the production frontier intercept common to all firms in time t, $\alpha_{it} = \alpha_{0t} - u_{it}$ is the intercept for firm i ($i=1,2,...,I$) that varies through time t ($t=1,2,...,T$). Following Cornwell et al. (1990), Equation (5) is first estimated using the panel data fixed-effect model. After obtaining estimated βs, the residuals ($y_{it} - x_{it}\beta$) are used to derive establishment-specific time-

variant TE using Equation (6). If $\alpha_{1t}, \alpha_{2t}, \alpha_{3t}, ..., \alpha_{Nt}$ are establishment-specific time-variant TE, then the most-efficient firm (MEF) in the industry at the time t would be:

$$\hat{\alpha}_t = \max(\alpha_{1t}, \alpha_{2t}, \alpha_{3t}, ..., \alpha_{Nt})$$

The technical inefficiency indexes for each establishment at time t are measured from:

$$\hat{u}_{it} = (\hat{\alpha}_t - \hat{\alpha}_{it})$$

These technical inefficiency indexes are then used as a dependent variable in the second-stage for estimating the FDI spillover effects. The estimated parameters of FDI spillovers for the Cornwell et al. (1990) model are presented in Table 7.

Table 7 Robustness Check using the Cornwell et al. (1990) Model

	All Firms	Local Firms	Foreign Firms	Period Before Crisis	Period Crisis Onwards
Inefficiency function *(Dependent variable: u)*					
FS	-0.021***	-0.016***	-0.050***	-0.003***	-0.023***
	(-23.19)	(-19.87)	(-13.12)	(-2.80)	(-11.23)

Source: Author's Calculation. Notes: The estimations consist of two-stages. The first-stage estimates the production frontier, as in Equation (5), and calculates the technical inefficiency indexes by following Cornwell et al. (1990). The second-stage estimates the inefficiency function, as in Equation (6). The complete set of estimated parameters is not presented here due to the space limitation, but can be obtained upon requests to the Author. The t-statistics are in parenthesis. *** denotes 1% significance level.

Estimates in Table 7 confirm the empirical findings with a few small differences. The differences are related to the changes in significance of the *FS* estimates, particularly for a few two- and three- digit industries. However, the essence of the findings is basically the same. For all manufacturing establishments, estimates from the Cornwell et al. (1990) model show that the *FS* variables have a negative sign and are highly significant, indicating positive productivity spillovers from FDI to domestic firms in the same industries.

4.4. Conclusions

This current study investigates the productivity benefits from FDI on local firms. Employing the one-stage Battese and Coelli's (1995) model, this study has shown that the presence of new FDI provides positive externalities effects on local firms as well as the existing foreign firms, via the reduction in the inefficiency of firms. This finding reassures the argument of positive externalities benefits from FDI on local firms' productivity, that have been founded in some earlier studies, such as Takii (2005), Blalock and Gertler (2008), and Suyanto et al. (2009). It is also found that during both the period of before crisis and the period of crisis onwards, FDI reduces inefficiency of local firms. The magnitude of the effect is more profound during the economic crisis, suggesting that the presence of FDI during the period of crisis onwards has a greater impact on the reduction of inefficiency of firms compared to those during the period before crisis. These findings ensure the existence of productivity spillovers from FDI on local firms, which can be in the forms of competition that rises the efficiency of local firms, employing labours whose previously trained by foreign firms, and adoption of new technology.

Findings of this study have two important policy implications. Firstly, the finding of positive productivity effects from FDI on local firms suggests that the government should provide incentives to FDI. Foreign investment that generates productivity benefit to local firms should be encouraged, in a purpose to reduce the inefficiency of local firms. Secondly, findings that FDI generates productivity benefits to local firms in both the period of before crisis and the period of crisis onwards suggest the importance of FDI either before or after crisis. As the magnitude of FDI effects on firms' productivity is greater for the period of crisis onwards, further incentives should be provided to attract more foreign investments in the future.

References

Aitken, B.J. and A.E. Harrison, 1999, Do Domestic Firms Benefit from Direct Foreign Investment? Evidence from Venezuela, *The American Economic Review*, 89/3, 605-618.

Battese, G.E. and T.J. Coelli, 1992, Frontier Production Function, Technical Efficiency and Panel Data: With Application to Paddy Farmers in India, *Journal of Productivity Analysis*, 3/1-2, 153-169.

Battese, G.E. and T.J. Coelli, 1995, A Model for Technical Inefficiency Effects in a Stochastic Frontier Production Function for Panel Data, *Empirical Economics*, 20/2, 325-332.

Blalock, G., and P.J. Gertler, 2008, Welfare Gain from Foreign Direct Investment through Technology Transfer to Local Suppliers, *Journal of international Economics*, 74/2, 402-421.

Blomstrom, M., 1986, Foreign Investment and Productive Efficiency: the Case of Mexico, *Journal of Industrial Economics*, 35/1, 97-112.

Blomstrom, M. and A. Kokko, 1998, Multinational Corporation and Spillovers. *Journal of Economic Surveys*, 12/2, 247-277.

Blomstrom, M. and H. Persson, 1983, Foreign Investment and Spillover Efficiency in an Underdeveloped Economy: Evidence from the Mexican Manufacturing Industry, *World Development*, 11/6, 493-501.

Blomstrom, M. and F. Sjoholm, 1999, Technology Transfer and Spillovers: Does Local Participation with Multinationals Matter?, *European Economic Review*, 43/4-6 , 915-923.

Caves, R.E., 1971, International Corporations: The Industrial Economics of Foreign Investment, *Economica*, 38/149, 1-27.

Caves, R.E., 1974, Multinational Firms, Competition and Productivity in Host Country Markets, *Economica*, 41/162, 176-193.

Coelli, T.J., 1995, Estimators and Hypothesis Tests for A Stochastic: A Monte Carlo Analysis, *Journal of Productivity Analysis*, 6/3, 247-268.

Coelli, T J., 1996, A Guide to Frontier Version 4.1. A Computer Program for Stochastic Frontier Production and Cost Function Estimation, *CEPA Working Paper* No. 07/96, University of New England.

Das, S., 1987, Externalities and Technology Transfer through Multinational Corporations, *Journal of international Economics*, 22/1-2, 171-182.

Djankov, S. and B. Hoekman, 2000, Foreign Investment and Productivity Growth in Czech Enterprises, *World Bank Economic Review*, 14/1 , 49-64.

Driffield, N., 2001, The Impact on Domestic Productivity of Inward Investment in the UK, *Manchester School*, 69/1, 103-119.

Findlay, R., 1978, Relative Backwardness, Direct Foreign Investment, and the Transfer of Technology: A Simple Dynamic Model, *Quarterly Journal of Economics*, 92/1 , 1-16.

Fosfuri, A., M. Motta, and T. Ronde, 2001, Foreign Direct Investment and Spillovers through Workers' Mobility, *Journal of international Economics*, 53/1 , 205-222.

Girma, S. and H. Gorg, 2007, Multinational's Productivity Advantage: Scale or Technology, *Economic Inquiry*, 42/2, 350-362.

Glass, A., and K. Saggi, 2002, Multinational Firms and Technology Transfer, *Scandinavian Journal of Economics*, 104/4 , 495-514.

Globerman, S., 1979, Foreign Direct Investment and 'Spillover' Efficiency Benefits in Canadian Manufacturing Industries. *The Canadian Journal of Economics*, 12/1, 42-56.

Gorg, H. and D. Greenaway, 2004, Much Ado about Nothing? Do Domestic Firms Really Benefit from Foreign Direct Investment? *The World Bank Research Observer*, 19/2, 171-197.

Gorg, H. and E. Strobl, 2005, Spillovers from Foreign Firms through Worker Mobility: An Empirical Investigation, *Scandinavian Journal of Economics*, 107/4, 693-739.

Haddad, M. and A.E. Harrison, 1993, Are there Positive Spillovers from Foreign Direct Investment? Evidence from Panel Data for Morocco, *Journal of Development Economics*, 42/1, 51-74.

Hymer, S.H., 1960, The International Operations of National Firms: A Study of Direct Foreign Investment, *PhD Dissertation*, MIT Mass: Published by MIT Press 1976.

Javorcik, B.S., 2004, Does Foreign Direct Investment Increase the Productivity of Domestic Firms? In Search of Spillovers through Backward Linkages, *American Economic Review*, 94/3, 605-627.

Kathuria, V., 2000, Productivity Spillovers from Technology Transfer to Indian Manufacturing Firms, *Journal of International Development*, 12/2, 343-369.

Kathuria, V., 2001, Foreign Firms, Technology Transfer and Knowledge Spillovers to Indian Manufacturing Firms: A Stochastic Frontier Analysis, *Applied Economics*, 33/5, 625-642.

Kaufmann, L., 1997, A Model Spillovers through Labour Recruitment, *International Economic Journal*, 11/3, 13-34.

Kodde, D.A. and F.C. Palm, 1986, Wald Criteria for Jointly Testing Equality and Inequality Restrictions, *Econometrica*, 54/5, 1243-1248.

Kokko, A., 1996, Productivity Spillovers from competition between Local Firms and Foreign Affiliates, *Journal of International Development*, 8/4, 517-530.

Konings, J., 2001, The Effects of Foreign Direct Investment on Domestic Firms. *Economics of Transition*, 9/3, 619-633.

Kugler, M., 2006, Spillovers from Foreign Direct Investment: Within or between industries?, *Journal of Development Economics*, 80/2, 444-477.

Kumbhakar, S.C., S. Ghosh, and J.T. McGuckin, 1991, A Generalized Production Frontier Approach for Estimating Determinants of Inefficiency in US Dairy Farms, *Journal of Business and Economic Statistics*, 9/3, 279-286.

Liang, F.H., 2007, Does Foreign Direct Investment improve the Productivities of Domestic Firms? Technology Spillovers within and between Industries, *Haas Berkeley Working Paper*, http://faculty.haas.berkeley.edu/fenliang/research/spillover/FDIspillover.pdf accessed July 20, 2007 .

Liu, Z., 2008, Foreign Direct Investment and Technology Spillovers: Theory and Evidence, *Journal of Development Economics*, 85/1-2, 176-193.

Lundvall, K. and G.E. Battese, 2000, Firm Size, Age and Efficiency: Evidence from Kenyan Manufacturing Firms, *Journal of Development Studies*, 36/3, 146-163.

Rodriguez-Clare, A., 1996, Multinationals, Linkages, and Economic Development, *American Economic Review*, 86/4, 852-872.

Sjoholm, F., 1999a, Technology Gap, Competition, and Spillovers from Foreign Direct Investment: Evidence from Establishment Data, *Journal of Development Studies*, 36/1, 53-73.

Sjoholm, F., 1999b, Productivity Growth in Indonesia: The Role of Regional Characteristics and Direct Foreign Investment, *Economic Development and Cultural Change*, 47/3, 559-584.

Suyanto, R.A. Salim, and H. Bloch, 2009, Does Foreign Direct Investment Lead to Productivity Spillovers? Firm Level Evidence from Indonesia, *World Development*, 37/12, 1861-1871.

Suyanto, 2010, Foreign Direct Investment, Spillover Effects, and Productivity Growth in Indonesian Manufacturing Industries, *PhD Thesis Unpublished*, School of Economics and Finance, Curtin University of Technology.

Suyanto and R.A. Salim, 2010, Sources of Productivity Gains from FDI in Indonesia: Is it Efficiency Improvement or Technological Progress?, *The Developing Economies*, 48/4, 450-472.

Takii, S., 2005, Productivity Spillovers and Characteristics of Foreign Multinational Plants in Indonesian Manufacturing 1990-95, *Journal of Development Economics*, 76/2, 521-542.

Takii, S., 2007, *Do FDI Spillovers Vary Among Home Economies?: Evidence from Indonesian Manufacturing*, Kitakyushu, Japan: The International Center for the Study of East Asian Development.

Thangavelu, S.M. and S.S. Pattnayak, 2006, Linkages and Spillovers from Foreign Ownership in the Indian Pharmaceutical Firms, *SCAPE Working Paper Series*, No. 2006/05.

Todo, Y. and K. Miyamoto, 2006, Knowledge Spillovers from Foreign Direct Investment and the Role of R&D Activities: Evidence from Indonesia, *Economic Development and Cultural Change*, 55/1, 173-200.

Tomohara, A. and K. Yokota, 2006, *Does Foreign Direct Investment Benefit Domestic Companies via Increased Productivity: Horizontal, Backward, and Forward Linkages*, *ICSEAD Working Paper Series*. http://www.icsead.or.jp/7publication/workingpp/wp2006/2006-07.pdf.

Wang, J.Y. and M. Blomstrom, 1992, Foreign Investment and Technology Transfer: A Simple Model, *European Economic Review*, 36/1, 137-155.

Wang, H.J. and P. Schmidt, 2002, One-Step and Two-Step Estimation of the Effects of Exogenous Variables on Technical Efficiency Level, *Journal of Productivity Analysis*, 18/2, 129-144.