Foreign Direct Investment Spillovers and Technical Efficiency in the Indonesian Pharmaceutical Sector: Firm Level Evidence

Abstract

The spillovers of foreign direct investment (FDI) on domestic firms' performances have been highly debated for many years. This article contributes to this debate by analyzing spillovers effects on technical efficiency of Indonesian pharmaceutical sector using a unique unbalanced panel of highly disaggregated (at five-digit ISIC) 210 firms over the period 1990-1995 (1,001 observations). The Stochastic production frontier (SPF) and the Data envelopment analysis (DEA) based *Malmquist* productivity indices (MPI) have been used to test the spillovers effects of FDI on technical efficiency. The empirical results from the SPF show that foreign firms are more efficient than domestic competitors, and the presence of the former increases the inefficiency of the latter. Similarly the results from the MPI demonstrate that FDI has a negative and significant impact on technical efficiency changes in domestic competitors, but generate positive spillovers to domestic suppliers.

Keywords: FDI spillovers; Technical efficiency; Stochastic frontier; *Malmquist* productivity index

JEL Classification: D24; D29; F23

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1. Introduction

Foreign Direct Investment (FDI) is considered, in most developing countries, to be a driving force of economic growth, and policies are accordingly designed to attract more FDI. Host countries offer a wide range of fiscal and financial incentives to foreign firms. These incentives are justified on a common argument that FDI provides not only capital and additional employment but also new knowledge to recipient economies. The new transferred knowledge from multinational companies (MNCs) to their subsidiaries may spill over entire recipient economies and increase the economic performance of domestic firms (Blomstrom and Kokko, 1998). This knowledge spillover has recently been regarded as an important source of productivity growth for developing countries (Suyanto *et al*, 2009).

Several studies investigate FDI spillovers in recipient countries for the past decades; however, the findings are mixed at best. Cross-sectional intra-industry studies show fairly consistent evidence of positive FDI spillovers (for example, Caves, 1974; Globerman, 1979; Driffield, 2001; Dimelis and Lauri, 2002). In contrast, panel-data firm-level studies provide ambiguous results, particularly from developing countries. A number of panel-data studies confirm that FDI generates positive spillovers (for example, Javorcik, 2004; Chuang and Hsu, 2004; Gorg and Strobl, 2005; Kugler, 2006; Liang, 2007), but some studies provide no evidence (Haddad and Harrison, 1993; Kathuria, 2000; Konings, 2001) or even negative evidence (Aitken and Harrison, 1999; Djankov and Hoekman, 2000; Thangavelu and Pattnayak, 2006; Wang and Yu, 2007). Although cross-sectional studies provide more conclusive evidence, these studies tend to overstate the positive spillover effects. An observation on one point in time in cross-sectional studies provides only 'snap shot' evidence and is unable to control for unobservable industries' or firms' heterogeneity (Gorg and Strobl, 2001). In contrast, panel-data studies that focus on a disaggregate industry reduce bias due to the persistent heterogeneity and, therefore, provide a unique picture of spillover effects in a specific industry (Bartelsman and Doms, 2000).

Although the empirical literature shows mixed evidence of FDI spillovers, the policy makers in developing countries, including Indonesia, continue competing for FDI inflows. As noted by Harding and Javorcik (2007), there was a significant increase in the number of national investment promotion agencies between 1990 and 2005, and these agencies provided a variety of incentives for foreign investors. The contrast between the mixed evidence from empirical studies and the actions of policy makers has lead researchers to question whether the existing studies have simply failed to uncover spillover effects that indeed exist or the huge range of incentives provided by government is not warranted. To contribute to this debate, the present study utilizes a firm-level survey data from the Indonesian central board of statistics to examine FDI horizontal and backward spillovers and their impact on firm-specific technical efficiency. It focuses on a highly disaggregated industrial sector (at five-digit ISIC), namely the pharmaceutical industry (ISIC 35222). As argued by Balsterman and Doms (2000), disaggregated sectors are preferable for analyzing firms' efficiency (or productivity), particularly if related to FDI spillover effects. Since high-technological firms, such as pharmaceuticals, tend to have a different capability to absorb FDI spillovers compared to low-technological firms, such as bakeries, pooling them together tends to understate the spillover effects that might exist.[1]

This article contributes to the literature in several ways. So far, firm-level studies on FDI spillovers in Indonesia and elsewhere generally pool all manufacturing firms together. This is one of the first attempts to examine disaggregated industries using the 5-digit firm-level panel data. Secondly, it employs two rigorous productivity analysis methods, namely stochastic production frontier (SPF) and data envelopment analysis (DEA), instead of using the commonly used production function. The authors know no study on FDI spillovers in Indonesia uses both parametric (SPF) and non-parametric (DEA) approaches. These two approaches may shed light on the continuing debate related to spillover effects from FDI.

[1] The OECD classifies industries based on their technology-intensity into three categories: high, middle, and low industries. The pharmaceutical industry is classified as high-technology industry, while bakeries are grouped as a low-technology industry. A detailed discussion of this classification can be found in Hatzichronoglou (1997).

The rest of this paper is structured as follows. Section two provides a literature review, followed by model and estimation strategy in Section three. Section four presents data sources and measurement of variables followed by estimation and analysis of empirical results in Section five. The conclusion, policy implications and focuses for further studies are presented in the last section.

2. Review of Earlier Literature

FDI and Spillover Effects

FDI provides direct and indirect benefits for recipient economies. The direct benefits are often in the form of additional capital and employment, while the indirect benefits arise from the externalities resulting from the foreign presence (Hymer, 1960). The argument for the indirect benefits is that the presence of multinational corporations (MNCs) due to FDI may generate non-market impacts on domestic firms, as the latter may experience increasing efficiency or productivity (*i.e*. efficiency or productivity spillovers), rising ability to gain profits (pecuniary spillovers), and gaining knowledge to enter international markets (market-access spillovers) (Blomstrom and Kokko, 1998; Lipsey and Sjoholm, 2005). Of these three spillover effects, the efficiency (or productivity) spillover has been of major concern for researchers in the last two decades. This attention is not surprising because efficiency of manufacturing firms is an important aspect of production functions which throws light on the efficiency of the production environment and assesses whether the existing resources are being used efficiently in the post FDI regime.

Theoretical literature on FDI has identified three channels of intra-industry spillovers. The first channel is demonstration effects, when the presence of foreign firms in domestic markets encourages domestic firms to imitate directly the new knowledge or to develop their-own innovations, raising their efficiency or productivity (Das, 1987). The second channel is labor mobility, which happens when the workers trained by MNCs move to domestic firms or establish their own business and bring with them the knowledge (Glass and Saggi, 2002). The third channel is competition, when the entry of foreign firms increases competition in product markets and forces domestic firms to utilize their resources in a more efficient way (Wang and Blomstrom, 1992).

Several empirical studies have been conducted to test the presence of spillovers through these three channels. Cross-sectional studies mostly confirm an unambiguously positive relationship between the presence of FDI and efficiency (or productivity). However, more recent studies using panel data analysis show mixed evidences. Thus, the linkage between FDI presence and firms' efficiency (or productivity) still remains an unsettled issue. Lipsey and Sjoholm (2005) rightly point out that an effort to find universal evidence of spillover effects may be ineffectual. The evidence of spillovers tends to vary across countries and across industries within countries. Therefore, a focus on a specific disaggregated sector might reveal the uniqueness of the sector in response to the entry of foreign firms. An empirical assessment on a highly disaggregated industry, as in this study, might provide an interesting contribution to the existing literature.

FDI Spillovers and the Role of Vertical Linkages

Some researchers argue that negative spillovers of FDI on domestic competitors are not surprising. Aiken and Harrison (1999), for example, note that the net spillover effects of FDI may be negative in the short run, because foreign firms can steal market share. Foreign firms with a lower marginal cost have an incentive to increase production relative to their domestic competitors. The efficiency of domestic firms might fall because these firms have to spread a fixed cost over a smaller amount of output. In a highly capital-intensive industry, where the fixed costs are significant, the negative spillover effects on domestic competitors would be more severe.

These negative spillovers occur mostly to domestic firms in the same sector (*i.e.*, horizontal spillovers) since they are potential competitors for foreign firms (Javorcik, 2004). In contrast, positive spillovers are more likely to occur to domestic firms those supply inputs for foreign firms (*i.e.* backward spillovers). The positive spillovers on domestic suppliers might happen through a requirement for high quality inputs and technical training provided by foreign firms to domestic firms' employees. A high-quality input requirement forces domestic firms to utilize resources in a more efficient way, leading to efficiency improvement (Rodriguez-Clare, 1996). Similarly, the training from foreign buyers updates the knowledge of domestic suppliers, which in turn raises the efficiency and productivity of domestic suppliers (Javorcik, 2004).

The positive backward spillovers have been identified in a number of empirical studies. Kugler (2006) examines Colombian manufacturing and finds that positive FDI spillovers occurred mainly between industries and negative spillovers within industries. According to Kugler foreign firms tend to be rivals of domestic firms in the same industry but become channels of knowledge diffusion for domestic firms in upstream industries. In a similar vein, Liang (2007) tests the spillover hypothesis for Chinese manufacturing industries and discovers that positive productivity spillovers take place only from foreign firms to local suppliers, but there is no spillover to domestic firms in the same industries. In a study on Indonesian manufacturing firms, Blalock and Gertler (2008) also find that there are positive productivity spillovers to local suppliers, but negative productivity spillovers exists on firms in the same sectors. Blalock and Gertler's study focuses on all manufacturing firms and three selected two-digit industries. This present study extends Blalock and Gertler (2008) by examining a more detailed five-digit industry, namely pharmaceuticals.

Foreign Firms and Technical Efficiency

In the early literature on FDI, productivity spillovers are often regarded synonymously as technology spillovers. The use of a standard production function, which assumes full efficiency production, makes the impact of FDI on domestic firms' productivity appear solely as a shift in the production curve. Positive productivity spillovers are represented by an upward shift of the production curve while the negative spillovers are reflected in a downward shift.

The recent literature focuses on both technology and technical efficiency. In this literature, the assumption of full efficiency is relaxed, and therefore, the externalities of FDI appear both as technological advancement (*i.e.* a shift in the production curve) and technical efficiency improvement (*i.e.* movement to the most efficient level given a set of inputs). Although FDI spillovers on technical efficiency are a relatively new issue, there is growing concern about this field. In a study on 4,056 Greek firms in 1997, Dimelis and Lauri (2002) identify positive FDI spillovers on domestic firms' efficiencies. A similar finding is made by Ghali and Rezgui (2008) when they analyze the Tunisian manufacturing sector. Dimelis and Lauri (2004) extend their previous study and find that efficiency spillovers stem from foreign firms with minority holdings.

3. Estimation Methods and Empirical Models

Focusing on FDI spillovers that appear through technical efficiency, this study adopts two productivity methods: a stochastic production frontier (SPF) with inefficiency effects and a DEA based *Malmquist* productivity index (MPI). In the SPF, FDI productivity spillovers are estimated through the relationship between the FDI-spillover and technical inefficiency. FDI-spillover variables are included in the technical inefficiency effect as contributing factors, together with other firms' specific variables. If the estimate of FDI-spillovers shows a negative sign and is statistically significant, it is argued that FDI generates positive technical efficiency spillovers. In the MPI, the technical efficiency change is calculated using the DEA approach and panel analysis is employed to estimate the spillover effects.

The Stochastic Production Frontier Model

The frontier analysis suggests numerous estimation models. Each model has its own merits and limitations, and the debate over which model is superior continues (see, for example, Kumbhakar and Lovell (2000) and Coelli *et al* (2005) for excellent discussions on advantages and disadvantages of each model). This study adopts Battese and Coelli's (1995) model because it is applicable to unbalanced panel data and uses a single-stage estimation approach.[2]

The Battese and Coelli's model can be written in a functional form as:

$$Y_{it} = f(\mathbf{X}_{it};\boldsymbol{\beta}).\exp(v_{it} - u_{it}) \tag{1}$$

$$u_{it} = \mathbf{z}_{it}\boldsymbol{\delta} + \omega_{it} \tag{2}$$

where Y_{it} denotes the scalar output of firm i $(i=1, 2, \ldots, N)$ at time t $(t=1,2,\ldots,T)$, $\mathbf{X}_{it}$ is a $(1xk)$ vector of inputs used by firm i at time t, $\boldsymbol{\beta}$ is a $(kx1)$ vector of unknown parameters to be estimated; the v_{it} is a random error; u_{it} is the technical inefficiency effect; $\mathbf{z}_{it}$ 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.

[2] A stream of stochastic production frontier with inefficiency effects can be divided into two groups based on the stage of estimation: the earlier two-stage approach and the more recent one-stage approach. The one-stage approach was introduced when researchers discovered that there were problems with the two-stage approach, which can lead to bias in estimations (Kumbhakar, Ghosh, and McGuckin 1991; Wang and Schmidt 2002).

Equation (1) shows the stochastic production frontier in terms of the original production value, and Equation (2) represents the technical inefficiency effects. The parameters of both equations are estimated simultaneously by the maximum-likelihood method. The variance parameters of the likelihood function are estimated in terms of $\sigma^2_s \equiv \sigma^2_v + \sigma^2_u$ and $\gamma \equiv \sigma^2_u/\sigma^2_s$ (see Battese and Coelli 1993 for a detailed explanation of the log likelihood functions and the variance parameters).

Assuming that the production frontier takes the form of a Cobb-Douglas technology with two inputs, labor (L) and capital (K), the empirical model for the production frontier can be expressed in a natural logarithm (ln) as follows:

$$\ln Y_{it} = \beta_0 + \beta_1 \ln L_{it} + \beta_2 \ln K_{it} + v_{it} - u_{it} \quad (3)$$

To test a hypothesis of FDI spillovers on technical efficiency, FDI variables are incorporated in the inefficiency function. Hence, the exogenous variables affecting inefficiency in this study are separated into two groups: FDI variables and other exogenous variables. The inefficiency function can be rewritten as

$$u_{it} = \mathbf{FDI}_{it}\boldsymbol{\tau} + \mathbf{g}_{it}\boldsymbol{\delta} + \omega_{it} \quad (4)$$

where **FDI** is a *(1xj)* vector of FDI variables of firm *i* at time *t*, **τ** is a *(jx1)* vector of intercepts, **g** is a *(1xp)* vector of other exogenous variables of firm *i* at time *t*, and **δ** is a *(px1)* vector of intercepts for other exogenous variable.

The estimation procedure for the chosen stochastic frontier model is as follows:

i. All variables are conversed into logarithm natural (ln).
ii. The stochastic frontier production function and the inefficiency function are estimated simultaneously using a single-stage method introduced by Battese and Coelli (1995). FRONTIER4.1 computer software is used to conduct the estimation.[3]
iii. The estimated parameters of the stochastic production frontier, which represent the elasticity of inputs to output, are used to set a frontier, and the most efficient firm is assumed to be on the frontier.

[3] FRONTIER4.1 was developed by Tim Coelli in the Department of Econometrics, University of New England. The program, written in Shazam, can be run on an IBM-PC. In this program, the execution of a stochastic frontier model can be done either by modifying the available instruction file or writing a program language. This program is available online on the Centre for Efficiency and Productivity Analysis website (http://www.uq.edu.au/economics/cepa/frontier.htm). A detailed procedure for running FRONTIER4.1 is discussed in Coelli (1996).

iv. The sign of estimated parameters for FDI variables in the inefficiency function indicate the spillover effects on technical efficiency. If the sign is negative and statistically significant, it is taken as evidence of positive FDI spillovers on domestic firms' efficiency.[4] Likewise, if the sign is positive and statistically significant, it might suggest negative FDI spillovers on efficiency. In contrast, if the estimated parameter of a FDI-spillover is insignificant, it indicates no FDI spillovers.

The Malmquist Productivity Index

The *Malmquist* productivity index (MPI) has recently gained increasing popularity in efficiency and productivity analysis. This method is adopted in this study for decomposing total factor productivity (TFP) growth into technical efficiency change (TEC) and technological change (TC). The calculated TEC indices are then used to examine the FDI spillovers on efficiency change (EC) using a panel data analysis.[5]

The MPI is defined using the Shephard (1970) distance function.[6] The distance functions can be generalized from either an input-oriented or an output-oriented objective. From the input orientation, the distance function is defined as the minimum feasible contraction of the input vector with the output vector held fixed (*i.e.*, the input minimization objective). Likewise, the output distance function is defined as the maximum feasible expansion of the output vector given a fixed input vector (*i.e.*, the output maximization objective). In this study, the output-oriented Shepard's distance function is adopted since the focus is on output productivity.

Consider a panel of i $(i=1,\dots,N)$ producers observed in t $(t=1,\dots,T)$ periods, transforming input vectors $x_i^t = (x_{1i}^t,\dots,x_{ni}^t) \in \Re_+^n$ into output vectors $y_i^t = (y_{1i}^t,\dots,y_{mi}^t) \in \Re_+^m$. Given this information, technology can be represented by the production possibility set of feasible input-output combinations

[4] Note that the FDI-spillover variables are regressed on the inefficiency indexes. The negative and significant of FDI-spillover estimates imply a reduction in inefficiency (or increasing in efficiency), which indicate positive FDI spillovers on efficiency.

[5] This method involves a two-stage estimation procedure. The first stage is to decompose the total factor productivity into efficiency change and technological progress. The second stage is to estimate the spillover effects of FDI to efficiency change.

[6] For a comprehensive survey on the development of *Malmquist* Productivity Index, please see Zofio (2007).

$$S^t = \left\{ \left(x^t, y^t \right); x^t \in \Re_+^n \text{ can produce } y^t \in \Re_+^m \right\}, \quad t = 1, \ldots, T \tag{6}$$

which are assumed to satisfy the usual regularity axioms of production theory (Fare and Primont 1970). Within this framework, a valid representation of the technology from the *i*-th firm perspective using the output oriented Shephard's (1970) distance function $D_O^t(x_i^t, y_i^t): \Re_+^n \times \Re_+^m \rightarrow \Re_+^1 \cup \{\infty\}$ is defined as

$$D_O^t\left(x_i^t, y_i^t\right) \equiv \inf_{\theta} \left\{ \theta > 0 : \left(x_i^t, y_i^t / \theta\right) \in S^t \right\} \qquad (7)^7$$

The technology in equation (6) is assumed linearly homogenous of degree +1 in *y* and non-increasing in *x*. For any period of time *t*, a complete characteristisation of the technology of firm *i*, is expressed as

$$D_O^t\left(x_i^t, y_i^t\right) \le 1 \quad \Leftrightarrow \; \mathrm{y_i^t} \in S^t \tag{8}$$

Equation (7) serves as a criterion for measuring the relative distance from the frontier of the technology set to any point of input-output combination inside the set. Following an output distance function of Shepard (1970), the maximum feasible expansion of the output vector with the input vector held fixed is $D_O^t(x_i^t, y_i^t) = 1$. In this condition, the evaluated firm is said to be efficient belonging to the best practice technology, which is represented by the subset isoquant $S^t(x,y) = \left\{ \left(x,y\right) : D_O^t(x_i^t, y_i^t) = 1 \right\}$. In contrast, if $D_O^t(x_i^t, y_i^t) < 1$, a radial expansion of the output vector y_i^t is feasible within the production technology for the observed input level x_i^t and the evaluated firm is said to be inefficient.

The MPI measures TFP growth for two adjacent time periods by calculating the ratio of the distance of each data point relative to a common technology. Following Färe *et al* (1994), the output-oriented MPI between period t and period *t+1* is defined as

$$M_o\left(x_i^{t+1}, y_i^{t+1}, x_i^t, y_i^t\right) = \left[\left(\frac{D_o^t\left(x_i^{t+1}, y_i^{t+1}\right)}{D_o^t\left(x_i^t, y_i^t\right)} \right) \left(\frac{D_o^{t+1}\left(x_i^{t+1}, y_i^{t+1}\right)}{D_o^{t+1}\left(x_i^t, y_i^t\right)} \right) \right]^{\frac{1}{2}} \tag{9}$$

[7] The symbol of *inf* denotes "infimum" or "the greatest lower bound".

where $M_o\left(x_i^{t+1}, y_i^{t+1}, x_i^t, y_i^t\right)$ is a MPI for period *t* to *t+1*, $D_O^t\left(x_i^{t+1}, y_i^{t+1}\right)$ represents a distance function that compares the *t+1* period firms to the *t* period technology, $D_O^t\left(x_i^t, y_i^t\right)$ is a distance function for firm *i* at the *t* period technology, $D_O^{t+1}\left(x_i^{t+1}, y_i^{t+1}\right)$ denotes a distance function for firm *i* at the *t+1* period technology, and $D_O^{t+1}\left(x_i^t, y_i^t\right)$ is a distance function that compares the *t* period firms to the *t+1* period technology.

An equivalent way to express Equation (9) is

$$M_o\left(x_i^{t+1}, y_i^{t+1}, x_i^t, y_i^t\right) = \left(\frac{D_o^{t+1}\left(x_i^{t+1}, y_i^{t+1}\right)}{D_o^t\left(x_i^t, y_i^t\right)}\right) x \left[\left(\frac{D_o^t\left(x_i^{t+1}, y_i^{t+1}\right)}{D_o^{t+1}\left(x_i^{t+1}, y_i^{t+1}\right)}\right)\left(\frac{D_o^t\left(x_i^t, y_i^t\right)}{D_o^{t+1}\left(x_i^t, y_i^t\right)}\right)\right]^{\frac{1}{2}} \qquad (10)$$

where the first part of the right-hand side of the equation measures the change in the output-oriented measure of Farrell (1957) technical efficiency between period *t* and *t+1*, and the second part measures the geometric mean of the technological change between two periods, evaluated at x_{t+1} and x_t. Hence, the MPI is the product of the change in relative efficiency (TEC) that occurred between period *t* and *t+1*, and the change in technology (TC) that occurred in the same periods, which can be written as:

$$M_o\left(x_i^{t+1}, y_i^{t+1}, x_i^t, y_i^t\right) = TEC_i^{t,t+1} \times TC_i^{t,t+1} \qquad (11)$$

where $$TEC_i^{t,t+1} = \frac{D_o^{t+1}\left(x_i^{t+1}, y_i^{t+1}\right)}{D_o^t\left(x_i^t, y_i^t\right)} \qquad (12)$$

and $$TC_i^{t,t+1} = \left[\left(\frac{D_o^t\left(x_i^{t+1}, y_i^{t+1}\right)}{D_o^{t+1}\left(x_i^{t+1}, y_i^{t+1}\right)}\right)\left(\frac{D_o^t\left(x_i^t, y_i^t\right)}{D_o^{t+1}\left(x_i^t, y_i^t\right)}\right)\right]^{\frac{1}{2}} \qquad (13)$$

The MPI, TEC and TC indexes are calculated using data envelopment analysis (DEA).

The technical efficiency change (TEC) obtained from Equation (11) is used as a dependent variable in a model for estimating the FDI spillovers on technical efficiency change. The empirical model can be written as:

$$TEC_i^{t,t+1} = \mathbf{FDI}_{i,t}\boldsymbol{\alpha} + \mathbf{g}_{i,t}\boldsymbol{\beta} + \zeta_{it} \qquad (14)$$

where $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ denote parameter to be estimated, ζ is random error, and other variables are defined as previous.

4. Data Sources and Measurement of Variables

Data Sources

The main source of data for this study is the annual survey of Indonesian Medium and Large Manufacturing Industries (*Statistik Industri* or SI hereafter) conducted by the Indonesian Board of Statistics (*Badan Pusat Statistik* or hereafter BPS). The survey covers the basic information of each establishment, such as specific identification code, industrial classification, year of starting production, and location. It also covers the ownership information (domestic and foreign ownerships), production information (gross output, value-added, number of labor in production and non-production, value of fixed capital and investment, material, and energy consumption), and other information (share of production exported, value of material imported, and expenditure on research and development). As supplements to the SI data, this study also utilizes the other sources available in Indonesia. The average Whole Price Index (WPI) and the WPI for machinery are used as deflators for monetary values of output and capital, respectively.

The samples cover an unbalanced panel of 210 pharmaceutical firms operating in the period of 1990 to 1995 (with 1,001 observations). The year of 1990 is chosen as a starting year because it is the first year when the foreign-owned pharmaceutical firms were surveyed. The year of 1995 is used as the last year in order to exclude the period of crisis. From the original data set, this study conducts two adjustments with the intention of obtaining a consistent panel data set. The first adjustment is on the capital data. There are 194 out of 1,001 observations (19.28 percent) reported missing values of capital. This study predicts the missing values using the Vial (2006) methodology, which is explained in a more detail in Appendix A.

Measurement of Variables

Value-added is used as an output variable in this study. Total number of employees (production and non-production staffs) is taken as a measurement for labor. As a proxy for capital, this study uses the replacement values of fixed asset. Output values are deflated using the average wholesale price index (WPI) at a constant price, while capital values are deflated using WPI for machinery.

The key variables in this study are *FDI*, *FDIHorizontal*, and *FDIBackward*. The first variable (*FDI*) is a dummy variable of foreign firms. This variable is assigned one if the share of foreign ownership in a firm is greater than zero percent and it is assigned zero if otherwise. The horizontal spillover (*FDIHorizontal*) variable is to measure the impact of foreign presence on domestic firms in the same market. Following Javorcik (2004) and Blalock and Gertler (2008) the horizontal spillover variable is defined as

$$FDIHorizontal_{jt} = \frac{\sum_{i \forall i \in j} FDI_{it} * Y_{it}}{\sum_{i \forall i \in j} Y_{it}} \qquad (13)$$

where Y is gross output, i denotes the i-th firm, j denotes the j-th industry, and $i \forall i \in j$ indicates a firm in a given industry. Since there is only one industry (*i.e.* ISIC 35222) examined in this study, the j is set to 1. Thus, the value of the *FDIHorizontal* increases with the output of foreign firms in the industry.

Table 1: Summary Statistics of Relevant Variables

Variable	Mean	Standard Deviation	Min	Max
lnY	18.344	1.847	13.292	24.118
lnL	4.802	0.965	2.996	7.542
lnK	16.599	2.631	7.601	26.553
FDI	0.210	0.407	0	1
FDIHorizontal	0.396	0.052	0.336	0.492
FDIBackward	0.003	0.009	0	0.097
Age	18.692	14.915	0	93
No of Observation	1,001			

Note: Author's calculation from the unbalance panel data set using STATA10. The zero value in the minimum value of Age reflects that some firms are just started their operation in the observed year. For example, there are two firms that just starting their production on 1990. Therefore, the value of Age variable for these two firms is zero in year 1990.

The backward spillover (*FDIBackward*) variable is intended to capture the extent of potential contact between domestic suppliers and multinational companies. This variable is defined following Thangavelu and Pattnayak (2006) as:

$$FDIBackward_{jt} = \frac{LRAWM_{it}}{\sum_i FRAWM_{it}} * \frac{output_{it}}{\sum_i output_{it}} \qquad (14)$$

where $LRAWM_{it}$ denotes expenditure incurred in local material by local firms *i* at time *t*, and $\sum_j FRAWM_{it}$ denotes total raw material expenditure of all foreign firms. The *FDIBackward* variable indicates the degree of spillovers and linkages that exist from the procurement activities undertaken by the foreign firms to domestic suppliers.

This study includes also age of firm (*AGE*) as a variable contributing to inefficiency. The *AGE* variable is measured by the time period between the year of survey and the year of starting production. The summary statistics of the panel data set for the relevant variables is presented in Table 1 above. The mean value of *FDIHorizontal* shows that, on the average, the percentage of foreign assets in the observed firms is 39.6%. *FDIBackward* has a mean value of 0.003, suggesting that 0.3% of the expenditure in raw material is local content. The zero value of the AGE in the MIN column of the table suggests that some firms included in this study are just starting at the first year of observation (i.e. 1990). Thus, in 1990 these firms are recorded as having value zero for AGE variable.

5. Estimation and Analysis of Results

The Estimates of Stochastic Frontier with Inefficiency Effect

Using the stochastic frontier specified in Equations (3) and (4) this study begins the estimation of FDI spillovers with samples of all pharmaceutical firms. The estimates are presented in Table 1. The upper part of the table shows the estimates of production frontier and the second part presents the estimates of inefficiency function. From the production frontier estimates, the coefficients of labor and capital are positive and statistically significant at the 1 percent level, suggesting that these two inputs variables contribute positively and significantly to output. The output elasticity of labour is 0.982 and the output elasticity of capital is 0.211.[8] As the frontier estimated using the Cobb-Douglas production function, the sum of the output elasticity of labour and the output

[8] A relatively low of output elasticity of capital should be treated with caution, as capital is a key factor in pharmaceutical firms. However, this finding is somehow unsurprising as the share of capital in total industry outputs is relatively low in the Indonesian pharmaceuticals, where the environment is a more labour intensive if compare to pharmaceutical firms in other more developed countries, such as Japan. As argued by Wacker et al. (2006), high elasticity of capital is usually observed in advanced technology industries in developed countries.

elasticity of capital resulted on the return to scale, which is larger then one, showing the increasing return to scale of the pharmaceutical firms.

In the inefficiency function, the negative sign and the highly significant *FDI* estimate indicates that foreign-owned firms are, on average, less inefficient than domestic firms, keeping other variables constant. This finding supports the mainstream argument that foreign firms generally possess more updated knowledge and have more experience in serving the market, so that they are more efficient than domestic firms (Caves, 1974; Dunning, 1988; Kathuria, 2001; Wang, 2010). In previous research using a different methodology, Narjoko and Hill (2007) found foreign ownership to have a positive effect on efficiency. The coefficient of *FDIHorizontal* is positive and statistically insignificant, indicating no significant spillover effects from foreign firms to domestic firms in the same market. This might be because a little learning of domestic competitors from the foreign firms' presence. Thus, this result validates the hypothesis given by Aiken and Harrison (1999) and is consistent with the findings of Blalock and Gertler (2008). For *FDIBackward*, the negative and marginally significant of the coefficient suggests the existence of positive spillovers from foreign firms to domestic suppliers. This finding confirms the arguments in Rodriquez-Clare (1996) and the finding of Javorcik (2004), that foreign firms tend to provide new knowledge for their suppliers in relation to a demand for high quality inputs. Furthermore, the coefficient of *AGE* is negative and insignificant, indicating no significant difference in technical inefficiency between older and younger firms. As has been long debated in literature, the effect of age on technical efficiency is ambiguous. Arrow (1962) and Malerba (1992) argue for positive relationship between age and efficiency, while Teece (1977) and Winter (1987) state an opposing argument that younger firms tend to have up-dated knowledge, which make them are more technically efficient than older firms. The evidence of negative relationship between age and technical efficiency is found in Chen and Tang (1987) and Balcombe *et al* (2008), while the positive relationship is observed in Pitt and Lee (1981) and Salim (2008). Nevertheless, some previous empirical studies have recorded no significant effect of age in Indonesia (Jacob, 2006) and other countries (*e.g.* Kathuria, 2001).

There is an argument in the literature that the inclusion of foreign firms in an estimation of FDI spillovers tends to understate the spillover effects that might exist. Considering the argument, this study estimates the samples of only domestic firms in order to examine further FDI spillovers. In this estimation, the foreign firms are excluded, but the spillover variables (*FDIHorizontal* and *FDIBackward*) are calculated from the original samples. The estimation results are presented in column (5) to (7) of Table 2. Similar to the results for all firms, the coefficients of labor and capital are positive and significant at the 1 percent level, indicating positive elasticity of labor and capital on output. For the inefficiency function, the coefficient of *FDIHorizontal* is positive, but it turns out to be significantly affects technical inefficiency. The exclusion of foreign firms in this estimation provides evidence of negative horizontal spillovers. As Aiken and Harrison (1999) argue, the competitive effects from a new foreign firm might overshadow the demonstration effects, so that the net spillover effects to domestic firms might be negative. For *FDIBackward*, the estimated parameter provides the same conclusion as in the sample of all firms. The negative sign and statistically significant *FDIBackward* estimate suggests positive spillovers from foreign firms to domestic suppliers. Excluding foreign firms in the estimation provides a negative and statistically significant coefficient of *AGE*, which indicates that older domestic firms have lower inefficiencies than younger ones. This finding supports the argument that firms accumulate their learning experience and might improve their efficiency through the learning process (Arrow, 1962; Malerba, 1992) and is consistent with findings in Hill and Kalirajan (1993) for the garment industry.

Table 2: Estimates of Stochastic Production Frontiers with Inefficiency Effect

	All Pharmaceutical Firms			**Domestic Pharmaceutical Firms**		
Variable (1)	**Coefficient (2)**	**Standard Error (3)**	**t-ratio (4)**	**Coefficient (5)**	**Standard Error (6)**	**t-ratio (7)**
Production Frontier (Dependent Variable: lnY)						
Constant	11.590***	0.573	20.24	10.088***	0.208	48.48
lnL	0.982***	0.044	22.12	0.950***	0.047	22.27
lnK	0.211***	0.016	13.03	0.219***	0.016	13.37
Inefficiency Effect (Dependent variable: u)						
Constant	1.093	0.699	1.56	-2.046**	0.952	2.15
FDI	-0.113***	0.032	-3.49	-	-	-

FDIHorizontal	0.139	0.101	1.36	0.218**	0.107	2.03
FDIBackward	-0.151*	0.087	-1.74	-0.167*	0.096	-1.73
AGE	-0.004	0.003	-1.21	-0.001**	0.0005	-2.36
Sigma-squared	1.230***	0.124	9.96	0.915***	0.311	2.94
Gamma	0.524***	0.128	4.08	0.918***	0.030	30.99
No. of Observation	1,001			791		

Note : Author's estimations on Equations (3) and (4) using FRONTIER4.1. ***, **, * denote significance at the level 1%, 5%, and 10% respectively.

As discussed in the literature review, though there have been a number of studies estimating FDI spillovers on technical efficiency level, they are not directly comparable as they differ not only in the data but also in the methodology. A study that is closer to the present research (Kathuria (2001) for India) also adopts a stochastic production frontier. However, the stochastic frontier used in testing the spillover hypothesis Kathuria's study is a two-stage approach, which has been widely known having limitations that may lead to bias in estimations (Kumbhakar *et al*, 1991; Wang and Schmidt, 2002). In this study, a one-stage approach, as discussed in the estimation methods, is adopted. The one-stage approach overcomes the possible limitations and provides estimates that are efficient and unbiased. Thus, our results differ than those of Kathuria (2001). Kathuria (2001) shows no evidence of horizontal spillovers for the whole manufacturing firms and positive horizontal spillovers for R&D firms, while this study finds negative horizontal spillovers. Another notable difference of this present study to that of Kathuria is that this study estimates backward spillovers, which enable estimating FDI spillover effects on domestic suppliers.

The Malmquist Productivity Indexes and Estimates for FDI Spillovers

The above estimations focus on FDI spillovers on technical efficiency levels. In this section, the spillover effects are evaluated in relation to changes in technical efficiency. Using the DEA based *Malmquist* productivity index, as discussed in Section B, the total factor productivity (TFP) growth is decomposed into technical efficiency change (TEC) and technological change (TC). The calculated TEC is then used as a dependent variable in the estimation of FDI spillovers. This study uses the DEAP2.1 computer software for running the *Malmquist* productivity index decomposition. This software requires balanced panel data for the decomposition. Therefore, the balanced panel set is constructed from the unbalanced panel used in the above estimation. The constructed balanced panel consists of 127 firms (with 762 observations). The average TFP growth and its components (TEC and TC) are given in Table 3 and the estimates of panel data for FDI spillovers are presented in Table 4.

In this section, two panel data models are estimated. These are fixed-effect (FE) and random-effect (RE) models. Estimates of these two models provide similar conclusions regarding the effects of FDI spillovers and age on technical efficiency change. There is a changing sign of the *FDI* estimate between FE and RE models. However, in both models, the estimate is statistically insignificant. In order to test which model appropriately represents the data set, a *Hausman* test is conducted. The results show that the null hypothesis (of difference in coefficients not systematic) can not be rejected. It suggests that the RE model appropriately represent the data. Hence, the analysis in this section is based on the RE model.

Table 3: Average Total Factor Productivity (TFP) Growth, Technical Efficiency Change (TEC), and Technological Change (TC) of Indonesian Pharmaceutical Firms.

Year	Average TFP Growth	Average TEC	Average TC
1990	1.000	1.000	1.000
1991	0.963	1.028	0.990
1992	0.951	1.057	1.005
1993	1.027	1.073	0.957
1994	0.916	1.037	0.885
1995	0.994	1.101	0.904
Average	0.970	1.059	0.948

Note: Author's calculation from the unbalance panel data set using DEAP2.1.

Table 4: Estimates of FDI Spillovers on the Change in Technical Efficiency
(Dependent Variable: $TEC_{t,t+1}$)

Variable (1)	Fixed-Effect Model: Coefficient (2)	Standard Error (3)	t-ratio (4)	Random-Effect Model: Coefficient (5)	Standard Error (6)	t-ratio (7)
Constant	1.1895***	0.080	14.80	1.2071***	0.072	16.65
FDI	-0.0016	0.022	-0.07	0.0080	0.010	0.78
$FDIHorizontal_t$	-0.4461**	0.189	-2.36	-0.4741***	0.172	-2.75
$FDIBackward_t$	3.6453***	1.064	3.43	2.7794***	0.751	3.70
Age	0.0006	0.005	1.22	0.0003	0.0003	0.97

Hausman test	Prob>chi2 = 0.6683 (Random-Effect)
No. of Observations	762

Note: Author's estimations on Equation (14) using STATA10. *** and ** denote significance at the level 1% and 5% respectively.

The results of FDI spillovers on technical efficiency change are consistent to those of FDI spillovers on technical efficiency levels, with a minor difference in the significance of FDI coefficient. The conclusions regarding spillover effects are similar. The positive and insignificant *FDI* coefficient indicates no difference in technical efficiency change between foreign and domestic firms. The coefficient of *FDIHorizontal* is negative, suggesting that the presence of foreign firms in year *t* generates positive spillovers on technical efficiency change (between year *t* and *t+1*) of firms in the same market. As noted in the previous section, the negative horizontal spillovers might be because the competitive effects of foreign firms are large enough to reduce the efficiency of domestic firms through the market stealing phenomenon (Aiken and Harrison, 1999). In other words, the presence of foreign firms in a domestic market reduces the market share of domestic firms, which in turn reduces their efficiency. This finding is in contrast with Ghali and Rezqui (2008) for Tunisia, though the method adopted is a same. A reason for the difference in findings could be a difference in data. As shown by Gorg and Strobl (2001), different data sets and different industrial focus can lead to mixed findings of FDI spillovers. The same argument also presented in Lipsey and Sjoholm (2005).

The positive and significant of the *FDIBackward* coefficient indicates spillover effects of foreign firms to the technical efficiency change of domestic suppliers, a finding in keeping with Javorcik (2006) and Blalock and Gertler (2008). This finding indicates the linkages of foreign firms to upstream industries. Thus, the presence of foreign firms in the Indonesian pharmaceutical industry generate higher technical efficiency change for domestic suppliers as these foreign firms tend to demand high quality inputs from and provide knowledge trainings to domestic suppliers.

The *AGE* variable proves to have a positive but insignificance coefficient, suggesting no significant difference in technical efficiency change between older and younger firms. Similar to the estimate on technical efficiency level, the insignificant estimate of age on technical efficiency change is unsurprising since the relationship between these two factors is still unsettled. Nevertheless, some previous studies that use different method of analysis has shown an insignificant effect of age on technical efficiency change (e.g. Berghall 2006).

6. Conclusions and Policy Implications

This article aims to estimate FDI spillovers on technical efficiency levels and technical efficiency changes of the Indonesian pharmaceutical sector. The stochastic production frontier and the DEA based a *Malmquist* productivity index are used to the plant-level survey data over the period 1990-1995. The empirical results from the stochastic frontier method show that foreign firms are less inefficient than domestic firms and there are positive spillover effects of FDI on technical efficiencies of domestic suppliers. Therefore, these results support the conventional wisdom of the advanced knowledge of foreign firms. Similarly, the results from the *Malmquist* productivity index show that FDI generates negative spillovers to domestic competitors, but provides positive spillovers to domestic suppliers.

The policy implications of these findings might not provide straightforward support for policies promoting FDI in the Indonesian pharmaceutical sector. From the outcomes obtained in the estimations, policy makers might at least need to consider whether the incoming FDI is intended to serve the domestic demands or to benefit from being near to local suppliers. In cases where there is potential for multinationals to 'steal' market from domestic firms, policy makers should at least, at the minimum, to ensure that the negative FDI spillovers on domestic firms do not overweight the overall benefits of the FDI. In contrast, when there is potential for multinational companies to source inputs from local suppliers, policy makers should provide incentives to encourage FDI. Furthermore, institutional reforms including political system, economic management and government administration and trade policies are needed in order to develop a more competitive environment in the whole manufacturing sector.

APPENDIX A

Back-casting the Missing Values of Capital

Following Vial (2006) and Ikhsan (2007), the missing values of establishment capital are back-casting using the following regression for the observed period of 1988-1995:

$$\ln k_{it} = \gamma_0 + \gamma_1 \ln y_{it-1} + \mu_{it} + \varepsilon_{it} \qquad \text{(A1)}$$

where k_{it} represents the fixed assets of establishment i at time t, y_{it-1} represents the gross-output of establishments *i* at time *t-1*, γ_0 and γ_1 denote parameters to be estimated, μ_{it} is the establishment-specific effect, and ε_{it} is the remainder disturbance. The reason for choosing a one-year lag of gross-output as an independent variable is to control for a potential endogeneity problems that could arise if using the gross-output at time *t*. In other words, as the predicted fixed assets from Equation (A1) will be used as the capital variable in the stochastic production frontiers, the use of gross-output at time *t* as an independent variable may cause an endogeneity bias in estimations.

The Equation (A1) is estimated using random effect Generalized Least Squared (GLS). There are two basic reasons for choosing random effect instead of fixed effect. First, a random effect model avoids an enormous loss in degree of freedom, as would have happened under the fixed effect model (Greene, 2008). Second, as indicated by Baltagi (2008), a random effect is to be preferred for a panel set with a larger number of establishments if compared to the time period, because the prediction in a random effect is unconditional of the number of establishments. The random effect GLS estimation is carried out under STATA10 computer software, and the estimates are then used to calculate the missing value of capital. By doing so, all missing values of capital are filled and the consistent panel set is constructed.

References

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

Arrow, K. J. 1962. The Economic Implications of Learning by Doing, ***The Review of Economic Studies***, 29 (3): 155-173.

Balcombe, K., I. Fraser, L. Latruffe, M. Rahman, and L. Smith 2008. An Application of the DEA Double Bootstrap to Examine Sources of Efficiency in Bangladesh Rice Farming, ***Applied Economics***, 40(15): 1919-1925.

Bartelsman, E. J., and M. Doms. 2000. Understanding productivity: Lessons from Longitudinal Microdata, ***Journal of Economic Literature***, 38 (3): 569-594.

Battese, G. E., and T. J. Coelli. 1993. A Stochastic Frontier Production Function Incorporating a Model for Technical Inefficiency Effects, *Working Paper in Econometrics and Applied Statistics, Department of Economics University of New England*.

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.

Berghall, E. 2006. Technical Change, Efficiency, Firm Size and Age in R&D Intensive Sector, *GIER Working Paper no. 390*. Government Institute for Economic Research.

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., and A. Kokko. 1998. Multinational Corporation and Spillovers, ***Journal of Economic Surveys***, 12(2): 247-277.

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

Chen, T. J., and D. P. Tang. 1987. Comparing Technical Efficiency between Import-Substitution-Oriented and Export-Oriented Foreign Firms in a Developing Economy. ***Journal of Development Economics*** 26(2): 277-289.

Chuang, Y. C. and P. F. Hsu. 2004. FDI, Trade, and Spillover Efficiency: Evidence from China's Manufacturing Sector, ***Applied Economics*** 36(10): 1103-1115.

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.

Coelli, T. J., D. S. P. Rao, C. J. O'Donnell, and G. E. Battese. 2005. *An Introduction to Efficiency and Productivity Analysis*, 2nd ed: Springer.

Das, S. 1987. Externalities and Technology Transfer through Multinational Corporations. ***Journal of International Economics*** 22 (1-2): 171-182.

Dimelis, S., and H. Lauri. 2002. Foreign Direct Investment and Efficiency Benefits: A Conditional Quartile Analysis, ***Oxford Economic Papers***, 54(3): 449-469.

Dimelis, S., and H. Lauri. 2004. Foreign direct investment and technology spillovers: Which firms really benefit?, ***Review of World Economics***, 140(2): 230-253.

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, ***The Manchester School***, 69(1): 103-119.

Dunning, J. 1988. ***Multinational, Technology and Competitiveness***. London: Allen & Unwin.

Färe, R., S. Grosskopf, M. Norris, and Z. Zhang. 1994. Productivity Growth, Technical Progress, and Efficiency Change in Industrialized Countries, ***American Economic Review***, 84(1): 66-83.

Farrell, M. J. 1957. The Measurement of Productive Efficiency, ***Journal of the Royal Statistical Society***, 120(3): 253-290.

Ghali, S., and S. Rezgui. 2008. FDI Contribution to Technical Efficiency in the Tunisian Manufacturing Sector, *ERF Working Paper Series No. 421*:

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 E. Strobl. 2001. Multinational Companies and Productivity Spillovers: A Meta-Analysis, ***Economic Journal***, 111 (475): F723-F739.

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.

Harding, T., and B. S. Javorcik. 2007. *Developing Economies and International Investors: Do Investment Promotion Agencies Bring Them Together?*, Policy Research Working Paper 4339, Washington, D.C., World Bank.

Hill, H. and K. Kalirajan 1993. Small Enterprises and Firm-Level Technical Efficiency in the Indonesian Garment Industry, ***Applied Economics***, 25(9): 1137-1144.

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.

Jacob, J. 2006. *International Technology Spillovers and Manufacturing Performance in Indonesia*, *PhD Dissertation*. Technische Universiteit Eindhoven. www.alexandria.tue.nl/extra2/200610843.pdf (accessed September 6, 2007).

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

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.

Kumbhakar, S. C., and C. A. K. Lovell. 2000. ***Stochastic Frontier Analysis***, Cambridge University Press.

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).

Lipsey, R. E., and F. Sjoholm. 2005. The Impact of Inward FDI on Host Countries: Why Such Different Answers? In ***Does Foreign Direct Investment Promote Development?***, ed. T. H. Moran, E. Graham and M. Blomstrom, 23-43. Washington D. C.: Institute for International Economics and Center for Global Development.

Malerba, F. 1992. Learning by Firms and Incremental Technical Change, ***Economic Journal***, 102(413): 845-859.

Narjoko, D. A., and H. Hill 2007. Winners and Losers during a Deep Economic Crisis: Firm Level Evidence for Indonesian Manufacturing, ***Asian Economic Journal***, 21(4): 343-368.

Pitt, M. M., and L.-F. Lee. 1981. The Measurement and Sources of Technical Inefficiency in the Indonesian Weaving Industry. ***Journal of Development Economics*** 9 (1): 43-64

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

Salim, R. A. 2009. Differentials at Firm Level Productive Capacity Realization in Bangladesh Food Manufacturing: An Empirical Analysis, ***Applied Economics***, 40(24): 3111-3126.

Shepard, R. W. 1970. *Theory of Cost and Production Function*. New Jersey: Princeton University Press.

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): 1861-1876.

Teece, D. J. 1977. Technology Transfer by Multinational Firms the Resource Cost of Transferring Technological Know-How, ***Economic Journal***, 87(346): 242-261.

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 (March 2006)

Vial, V. 2006. New Estimates of Total Factor Productivity Growth in Indonesian Manufacturing, ***Bulletin of Indonesian Economic Studies***, 42(3): 357-369.

Wang, M. (2010), Foreign Direct Investment and Domestic Investment in the Host Country: Evidence from Panel Study, ***Applied Economics***, 42(29): pp 3711-3721.

Wang, J. W., 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.

Wang, C. and L. Yu. 2007. Do Spillover Benefits Grow with Rising Foreign Direct Investment? An Empirical Examination of the Case of China, ***Applied Economics***, 39(3): 397-405.

Winter, S. 1987. Knowledge and Competence as Strategic Assets. In ***The Competitive Challange***, ed. D. Teece, Cambridge: Ballinger.

Zofio, J. L. 2007. Malmquist Productivity Index Decompositions: A Unifying Framework. ***Applied Economics*** 39(18): 2371-2387.