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Productivity Spillovers from Foreign Direct Investment: What If Productivity is No Longer a Black Box?

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Editor's Note

Strengthening bilateral economic cooperation between two countries will provide significant benefits for them. For example, in the case of bilateral trade, the benefits enjoyed here are in accordance with the law of comparative advantage, which mentions that two countries will enjoy the benefits of trade between them if the relative costs of producing goods and/or services are different. In other words, since one country is more efficient in producing certain goods or services, the other country will be better off if it imports those goods and/or services from that country instead of producing them domestically.

In an effort to strengthen the bilateral economic cooperation between Indonesia and Turkey, Turkish President Abdullah Gul visited Indonesia on 4th-5th, April 2011. A year before, President Susilo Bambang Yudhoyono paid a visit to Turkey.

In welcoming the visit of President Gul, the Indonesian Chamber of Commerce and Industry held the Business Forum on 5th April, 2011 which invited Indonesian and Turkey's businessmen, experts and academics.

In his speech, President Gul said that there are some important economic cooperation between Turkey and Indonesia in terms of the bilateral trade and investment, as well as cooperation in education. Data shows that the bilateral trade value between Turkey and Indonesia increased USD1.7 billion in 2010, up from USD1.2 billion in 2009. Of the total USD1.7 billion, around USD1.4 billion was in favor of Indonesia. The two countries have set a target of bilateral trade value at around USD5 billion by 2014 and up to USD10 billion in the future, including by boosting investment cooperation. Turkey`s investment in Indonesia has reached USD70 million, while Indonesian investment in Turkey is only USD600,000.

Regarding the data, Indonesia has offered the special economic zone development project to Turkish businessmen. In terms of international trade and management, this special zone could create the advantages in trade and investment sector for the Indonesia-Turkey bilateral trade; so far it is also expected to also provide the countries in the ASEAN Community with the spillover of opportunity. However, Turkey could be the gate to the European Union markets, which means that this international cooperation will help Indonesia expand its export market in the European Union.

Gul revealed at a joint press conference with Yudhoyono that the two countries are expected to sign an agreement on free trade within the framework of comprehensive and strategic cooperation in the near future. Both Gul and Yudhoyono are optimistic that the bilateral trade value target could be achieved given the two countries` huge economic potential.

Rofikoh Rokhim

Vice Editor
The South East Asian Journal of Management

THE SOUTH EAST ASIAN JOURNAL OF MANAGEMENT

Productivity Spillovers from Foreign Direct Investment: What If Productivity is No Longer a Black Box?

Tran Toan Thang*

While the positive productivity spillover from Foreign Direct Investment (FDI) to domestic owned firms in host countries is unequivocally emphasized in theory, the empirical evidence is contradictory. This paper, based on firm level data in Vietnam (enterprise census, 2000-2005), provides more inside on that. Using time-varying stochastic frontier approach, the study decomposed the change of productivity into technical change, technical efficiency change and scale efficiency change. The evidence from estimating the spillovers in each corresponding components suggest that horizontal FDI bring negative spillovers, mainly to technical change but positive spillovers to technical efficiency. Vertical FDI also have mixed impacts to domestic owned firm's productivity.

Keywords: *Stochastic frontier model, foreign direct investment, productivity spillover, panel data*

Introduction

Theoretically, when multinational companies enter host countries, they bring with them advanced technologies or firms-specifics which may induce some positive spillovers to domestic owned firms. However, empirical evidence on the existence of that effect is unclear or mixed. The reasons may arise from the nature of spillover receivers and producers as well as the conditions for that process. More importantly, some studies conclude that when measuring spillovers, biasness could occur unless researchers have properly estimation strategies. Such a conclusion is one of the concerns to address in this paper (Gorg and Greenaway, 2004).

Conventionally, the estimation of productivity spillovers is conducted upon a classical assumption in which firms are operating efficiently. It means that the productivity change (if any) is entirely attributed by the technical change or technical progress - an exogenous term in the classical growth theory. Such approach is far from a completion. The shortcoming, *firstly*, is that the full-efficiency assumption is likely to contradict to the arguments in spillover theories proposing that domestic owned firms improve their efficiency as a result of foreign presence in the domestic

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market. *Secondly*, as stated in some studies, although firms tend to be efficient, in practice, they are not in certain to be successfully in doing so because of their incomplete knowledge of best technical technique, or regulatory or organizational factors (Kumbhakar and Lovell, 2000). *Thirdly*, when estimating the spillovers, researchers consider productivity change as a "black box" while it, in fact as showed by productivity theory, consists of various components including: (1) The change in technical efficiency or the approaching to frontier/full efficient level; (2) Technical change or the shift of frontier curve; the change in scale efficiency or the efficiency obtained by input expansion (see Section 3 for detailed discussion of those components). So, aggregating the productivity components into a single unit obviously limits a thorough investigation on the productivity impact of foreign investment.

This paper uses Stochastic Frontier Approach (SFA) to estimate productivity. On one side, this approach does not hold the full efficiency assumption, on the other side, it allows decomposing the productivity (total factor productivity/TFP) into different components. Although other methods e.g. Data Envelopment Approach (DEA) are also able to provide a similar decomposition, SFA is preferred in this paper due to its statistics inference[1] and the capability to cope with potential error caused by outliers in dataset[2].

To the best of author's knowledge, this paper is one of initial studies investigating the impact of foreign investment on individually TFP components. For academic interest, this approach is necessary because it provides an alternative explanation for the evidence of spillovers in empirical literature by looking further inside the productivity.

Another contribution of this paper is the computation of net effect. In contrary to conventional approach where only the marginal effects are estimated, in this study the net effect is also measured that can be considered as the aggregated outcome from foreign presence to the productivity of the firm for a specific period of time. It is also necessary for the case in which both horizontal and vertical spillovers are estimated in the same equation and the effects have contradictory signs.

The results obtained from this paper are analytical and informative. It finds that the productivity change of domestic owned firms during the research period (2001-2005) is largely contributed by the technical change and barely contributed by scale efficiency change. More importantly, it is found just a slight difference in the productivity change of the foreign firms and the domestic owned firms, implying a fact that the foreign firms in Vietnam are not substantially productive than the domestic counterpart.

Such findings are reinforced in the second stage of the analysis framework where the existence of productivity spillovers is investigated. This paper finds negative horizontal spillovers (or intra-industry spillovers) that is largely contributed by the impact to technical change while vertical spillovers (or inter-industry spillovers) have mixed signs.

The remaining of this paper consists of four sections. Section 2 brie□y reviews the mixed evidence productivity spillovers. Section 3 describes stochastic frontier

[1]Very recent DEA version can provide statistics inference of total factor productivity(TFP) index based on bootstrap technique and asymptotic results. However, there is no evidence of this non-parametric approach provides better outcome, and in practice there is also no strictly preferential between SFA and DEA.

[2]Vietnam has some large SOEs that hold major share of total capital and employment compare to the rest which is believed small and very small companies. As it is discussed in Ruggiero (2007), DEA is rather sensitive with outlier in the dataset because it uses the best practice firm in the dataset as frontier, while SFA uses prior specified function form to represent for production frontier.

approach, the data and the specification of the empirical model for estimating spillovers. The results and discussion are presented in Section 4. The last section provides some remark conclusions.

Literature Review

Spillover evidence: how and why mixed?

As it is clearly stated in theoretical framework (Findlay, 1978; Cave, 1996; Markusen and Venables, 1999), the presence of FDI induces positive productivity spillovers. The term describes a phenomenon in which the presence or entry of foreign firms, those have assumedly some advanced technologies or know-how, have some external effects that benefit domestic owned firms in term of productivity improvement. Although there has been a little different definitions about this term, productivity spillovers clearly implies the positive externalities generated by the presence of foreign firms in local market that make domestic owned firms accumulatively better off.

Productivity spillovers take place under various forms, for example, domestic owned firms can imitate the superior technologies from foreign firms nearby (imitation effect), or can benefit from labor turnover from foreign firm to domestic owned firms. In addition, domestic owned firms can obtain positive effect from competition because competition itself can be considered as a motivation for reducing x-inefficiency and technology improvement. More importantly, they also benefit from production linkages (either forward or upward linkage) when they are input suppliers or customers of foreign firms. In this case the domestic owned firms may obtain the technical support/guidance from foreign firms or have better sources of inputs that result in the productivity improvement in domestic owned firms

Empirically, the reviews by Blomstrom and Kokko (1998), Lipsey (2002), Meyer and Sinani (2001), Javorcik (2002), Crespo and Fontoura (2007), all, however, showed that empirical evidence on positive spillovers are contradictory or mixed, particularly for horizontal spillovers. As such, some studies found positive spillovers, for example Globerman (1979), Blomstrom and Persson (1983), Kolasa (2007), many others discovered negative or negligible effects. For almost two decades, both empirical and theoretical studies have focused on explaining these mixed results. An important conclusion from such studies is that the signal and the magnitude of productivity spillovers depend on the nature and extent of each effect's channel as well as on the nature of firms and the conditions of host countries.

As an example, the imitation effect is not simply a duplication of technology but depends on the complexity of the technology imitated (Blomstrom and Kokko, 1998), furthermore it has never been an easy process because the optimal choice made by foreign firms is to minimize the probabilities of their technology to be imitated (Ethier, 1986). The skilled acquisition effect also is limited because foreign firms tend to pay higher than domestic firms to keep skilled labor (Haddad and Harrison, 1993; Lipsey and Sjoholm, 2001). The positive effect through vertical linkages seems to be obvious, however, depends upon the intensity of the input-output linkages. If buyer's power is significant, the gain from productivity growth in the upstream sectors are largely appropriated by downstream sectors (Driffield and Love, 2002; Graham et al., 1999).

The possibilities of spillovers also depend on the absorptive capability of domestic firms (Kinoshita, 2001; Girma 2005), productivity gap (Kokko 1994), the ownership heterogeneity nature of both foreign and domestic owned firms

(Blomstrom and Sjoholm, 1999, Li et al., 2001) and the negative market stealing effect as well (Aitken and Harrison, 1999).

In addition to the aforementioned factors, an arguable reason explaining the mixed results is the bias of estimation due to data source and estimation methods. Hale and Long (2007) suggested three sources of biasness for productivity spillover studies including the aggregation bias (for studies use aggregated data rather than firm level data), endogeneity bias (caused by the endogeneity of variable FDI), selection bias (caused by using only the sub-sample of domestic owned firms while there might be a non-random sample selection). They concluded that cross-section data and aggregated data potentially produce biased result (upward or downward) unless researchers have appropriate solutions. A meta-analysis study by Gorg and Strob (2000) also suggested the same conclusion. They emphasized that by using cross-section or sectoral data, researchers have faced with endogeneity problem that may cause biased estimation.

Does the productivity measurement matter?

In economic sense, the productivity term conventionally is understood as a ratio of output produced to input consumed. However, due to the complication in measuring inputs and outputs, defining a precise concept of productivity is a challenge. There are various definitions of this term such as: "*it is a quantitative relationship between output and input*"; "*productivity is nothing more than the arithmetic ratio between the amount produced and the amount of any resources used in the course of production*" (Oyerranti, 2000). There are also some other definitions of productivity by which the productivity is defined as the ratio of output per unit of a particular input, e.g. labor productivity, land productivity. Such kinds of productivity are understood as partial productivity and normally are believed not entirely reflecting the nature of productivity. A more general and perhaps more precise definition is that productivity is the relationship between output produced and the input index (composite from various types of input e.g. labor, capital, natural resources). This kind of productivity is conceptualized as total factor productivity (TFP) or multi-factor productivity (see Oyerranti, 2000).

It is also necessary to note that productivity should not be understood as efficiency, although some time it is used interchangeably and mistakenly. Efficiency is a narrower concept relating to the use of input factor efficiently or with a minimum of waste. So, efficiency enhancement should be considered as a source of productivity improvement but not entirely it is.

Recent studies on efficiency and productivity (Battese et al., 1998; Cornwell et al., 1990) pointed out that productivity change is not a single unit term but consists of some components including the technical change, technical efficiency change and the change in scale efficiency. In other words, the productivity change is contributed by (1) the change in environment and overall technical progress; (2) the change in efficiency of using input; (3) the change in efficiency due to the scale economies.

Because the foreign presence can lead to the change in not only efficiency but also the change in technology and production scale as it is mentioned in previous section, this paper uses a broad definition of productivity being defined as the residual of output after taken into account the contribution of production factors. Such definition, in fact, is the definition of TFP. Moreover, it needs to keep in mind that productivity is a relative concept, have much more meaning when a comparison is made either with other agent (e.g. firm) or with previous times. So the productivity change but not productivity in general is of the concern in this paper.

There has been yet a consensus on how measurement of productivity in spillover literature makes the general conclusion of productivity evidence less robust. While some studies use labor productivity that is a partial productivity measurement, some others use output growth or TFP – a more appropriate measurement for multi-input and output cases. Girma (2005) also noted that the evidence of productivity spillover is likely less pronounced for most recent studies which used TFP or output growth.

That notation raises a question of how productivity measurement can help to explain the mixed evidence of spillovers. It is noted that previous studies considered productivity as a "black box" that is absolutely a residual of output after extracting the contribution of input factors. It does not allow looking further into the simultaneous movement of the component of productivity change, i.e. technical change, efficiency improvement as well, that all help to foster the productivity.

Some very recent studies have tried to go deeper into investigation for the productivity measurement and evidence of spillovers. Kathuria (2000) for India, Olivera (2007) for Portugal, using stochastic frontier tries to examine the efficiency spillovers. They concluded that the presence of foreign investment has a positive impact on the efficiency growth of the same sector (a horizontal effect). Also to answer the same question, Hirschberg and Lloyd (2000) used DEA method to compute efficiency of domestic owned firms and estimate it against the presence of foreign investment for the case of China. They found positive spillovers for small firms while negative effect for larger domestic owned firms.

A notable point from such research is that although they are no longer stick to the assumption of a firm efficiency, they did not fully discuss on the productivity but limited in efficiency. Girma and Gorg (2006), Kravtsova (2006), Ghali and Rezgui (2006), for most of author's knowledge, are recent studies investigating productivity spillovers through the spillovers in each productivity component.

Girma and Gorg (2006) raised a question that whether are foreign firms more efficient than domestic owned firms, if so, does such a superior efficiency spillover to domestic owned firms? They used stochastic frontier approach to decompose TFP into technical change and scale efficiency and applied propensity score matching method to analyze the correlation of productivity growth and foreign acquisitions. They found positive effect of foreign acquisition to TFP of domestic owned firms; more importantly, they concluded that the TFP change, as the consequence of spillovers, is largely contributed by technical change rather than the change in scale efficiency. In their paper, the scale efficiency effect is found negative for a number of industrial sectors.

Using a non-parametric method (DEA), Kravtsova (2006) contributed to literature by decomposing productivity into technical efficiency and scale efficiency effect for firms in transition economies (in European continent). She came to a conclusion that the average efficiency of the foreign firms is not statistically larger than that of the local counterparts. It is even lower for four out of ten industrial sectors. However, the foreign firms obtain more scale efficiency than domestic firms. Similarly to Girma and Gorg (2006), she also found evidence of positive spillovers to the efficiency level of domestic owned firms. A shortcoming of this paper is that it does not take into account the technical change.

Ghalli and Rezgui (2006) is, perhaps, the most comprehensive paper used both SFA and DEA for productivity computation and conducting spillover testing. Similarly to the debate in almost productivity literature on the question of whether DEA or SFA is better to measure firm's efficiency, they found that it is sensitive to compare the efficiency computed by both methods. However, they found the consistent results when calculating TFP growth for the sample of domestic owned firms only. The most important result from their paper is that they did not find negative impacts of foreign investment in the sector.

As a summary, although few studies using stochastic frontier approach have been found, this review reveals an important point that positive productivity spillovers are likely confirmed under the efficiency perspective. It is not as contradictory as almost previous literature which used partial productivity measurement or "cover-all" TFP. This conclusion enhances the importance of productivity decomposition approach in spillover literature.

Methodology

Stochastic frontier and decomposition of productivity change

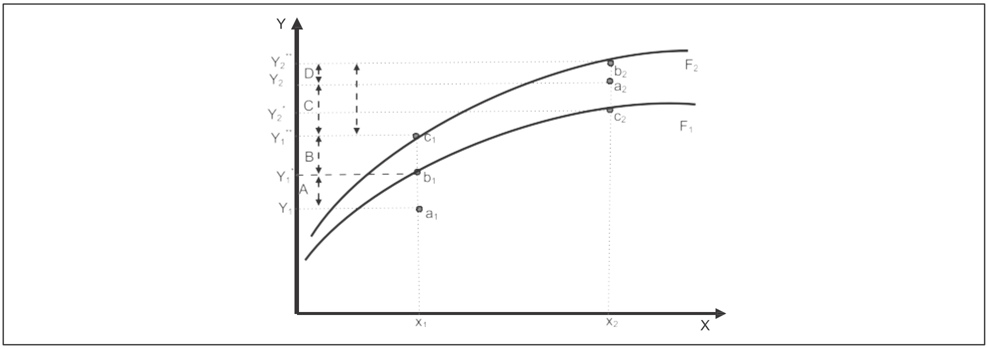
Recent studies on efficiency and productivity (Cornwell et al., 1990, Battese et al., 2005) pointed out that productivity change is not a single term but consists of some components including the technical change, technical efficiency change and the change in scale efficiency. In other words, the productivity change is contributed by (1) the change in environment and overall technical progress; (2) the change in efficiency of using a unit of inputs; (3) the change in efficiency due to the scale economies. A figurative conceptualization of those components can be seen from a simple case of single input and output in the figure below[3].

In this figure, firm faces with two production faces F_1 and F_2 at a different point of time t_1 and t_2 respectively. Technical change is defined as the shift of the frontier from F_1 to F_2: so it is the distance between two frontiers and equal to $B=(Y_1^{**}-Y_1^{*})$.

As a firm is assumed working inefficiently, it operates below the frontier, for example at point a_1 for time t_1. The technical inefficiency of the firm at this time is the distance from a_1 to the corresponding efficient point b_1 or $A=Y_1^{*}-Y_1$. Similarly, the distance $D=(Y_2^{**}-Y_2)$ for the time period t_2 measures the inefficiency of the firm at input level X_2. The firm is believed to have technical efficiency[4] improvement over two periods if:

$$[(Y_2^{**}-Y_2) – (Y_1^{*}-Y_1)]>0$$

Figure 1. Productivity change and its components



[3]Thorough discussions on those components for the case of multi-input and multi-output can be found in current theoretical work on productivity, including Balk (2001), Battese et al. (2005), Kumbhakar and Lovell (2000).
[4]In some papers, this concept is called technological efficiency.

Scale efficiency is a more complicated term, it relates to another term named "optimum scale" implying the scale at which a firm works most efficiently. For example, if a firm has increasing return of scale, the scale efficiency increases until firm reach the constant return of scale. So, in that case constant return of scale is said to be the optimum scale. It means that scale efficiency can be obtained only for the case of variable return of scale.

The output growth due to the input expansion is measured along the frontier F^2 and can be presented as $= (Y_2** - Y_1**)$. It is noted that the observed output change between two periods is:

$Y_2 - Y_1 = A + B + C = (Y_1* - Y_1) + (Y_1** - Y_1*) + (Y_2 - Y_1**)$.

After adding and subjecting with the same term Y_2** into this equation and rearranging, the equation comes up with three components:

$$Y_2 - Y_1 = \underbrace{\{(Y_1* - Y_1) - (Y_2** - Y_2)\}}_{\text{Technical efficiency change}} + \underbrace{(Y_1** - Y_1*)}_{\text{Technical change}} + \underbrace{(Y_2** - Y_1**)}_{\text{Scale change}}$$

In practice, such three components are driven out, following Kumbhakar (2000), Battese et al. (1998). From the stochastic frontier model, *Y* is output of a firm *i* at time *t*; *X* is input vector, the stochastic production function can be formulated as follows:

$$y = f(x,t;\beta)TE_{it}\, exp\{v_{it}\} \quad (1)$$

of which $y = f(x,t;\beta)$. is deterministic component and $exp\{v_{it}\}$ is noise denoting for random shock that presumably has the following properties:

$E(v_{it}) = 0$; $E(v_{it}^2) = \sigma^2$; $E(v_{it} v_{jt}) = 0$ for all $i \neq j$; $E(v_{it} v_{is}) = 0$ for all $t \neq s$

Without the term TE_{it}, equation (1) is a classical production function where a firm is assumed to work efficiently. The term $TE_{it} = exp(-u_{it})$ denotes technical efficiency. With this specification, the translog form of the production function can be written as follow:

$$lnY_{it} = \beta_O + \sum \beta_j lnX_{jt} + ½ \sum \beta_k lnX_{jt} lnX_{kt} - u_{it} + \varepsilon_{it} \quad (2)$$

The presence of u_{it} that is assumed nonnegative means that firms operate below the technical efficiency or the output produced must be below the deterministic level. As u_{it} varies over time, this model is considered as time varying technical efficiency model.

The estimation of the above model is problematic because the intercept of the model is time varying and it is impossible to estimate all parameters $\gamma_{it} = \beta_0 - u_{it}$. Two approaches were introduced to deal with this problem by assuming the distribution of γ_{it}, including: (i) quadratic specification (Cornwell, 1990; Kumharkar, 2005) $\gamma_{it} = \Omega_{i1} + \Omega_{i2} t + \Omega_{i3} t^2$; and (ii) exponential distribution (Battese et al., 2005) $\gamma_{it} = \gamma_i \exp\{-\gamma(t-T)\}$ with $\gamma_{it} \approx iid\ N^+(\mu, \sigma_\gamma^2)$.[5]

Regarding the decomposing productivity, recall the general frontier production function (1) it is noted that technical change that is proxied by time trend and can be measured as $T\Delta = \frac{\partial \ln f(x,t;\beta)}{\partial t}$ and the technical efficiency can be measured as $T\Delta = \frac{\partial u}{\partial t}$.

From Divissia index of productivity change that is defined as the difference between the change of output and that of *n*

[5]In this paper we used the second approach because it is available in the STATA software. See Battese et al. (2005) for a discussion on the difference in those approach.

inputs quantity index: $T\dot{F}P = \dot{y} - \dot{X} = \dot{y} - \sum S_n \dot{x}_n$, in which $S_n = W_n X_n / \sum_{n=l,k} W_n X_n$ is the expenditure share of each input L and K, take derivative of the function (1) and replacing with the formula of technical change and technical efficiency change, one can come up with:

$$T\dot{F}P = \Delta T + \Sigma(\varepsilon_n - S_n \dot{x}_n)\dot{x}_n + TE\Delta$$
$$= \Delta T + (\varepsilon_n - 1)\sum(\frac{\varepsilon_n}{\varepsilon})\dot{x}_n + \sum(\frac{\varepsilon_n}{\varepsilon} - S_n)\dot{x}_n + TE\Delta$$

In case the price vector is not available, it is assumed that the share of input elasticity equal to the expenditure share ($\frac{\varepsilon_n}{\varepsilon} = S_n$), productivity change is, therefore, simplified to:

$$T\dot{F}P = \Delta T + (\varepsilon_n - 1)\sum(\frac{\varepsilon_n}{\varepsilon})\dot{x}_n + TE\Delta$$

The second component in this equation represents for scale efficiency.

Applying above approach, from value added production function (translog form) with two inputs L and K:

$$\ln y_{it} = \beta_0 + \beta_k \ln K_{it} + \beta_l \ln L_{it} + \beta_t t + ½(\beta_k (\ln K_{it})^2 + \beta_{lk} (\ln L_{it} \ln K_{it})) + ½\beta_{tt} t^2 + \beta_{lt} \ln L_{it} t + \beta_{kt} \ln K_{it} t + v_{it} - u_{it}$$

One can draw the productivity change components as below:

Technical change:

$$\hat{T}\Delta = \hat{\beta}_t + \hat{\beta}_{tt} + \hat{\beta}_{lt} \ln L_{it} + \hat{\beta}_{kt} \ln K_{it}$$

Technical efficiency change:

$$T\hat{E}\Delta = \hat{u}_i \hat{\eta} \exp(-\hat{\eta}(t-T))$$

Scale efficiency change:

$$T\hat{E}S\Delta = (\varepsilon - 1)\left[(\frac{\varepsilon_k}{\varepsilon})K + (\frac{\varepsilon_k}{\varepsilon})L\right]$$

where:

$\varepsilon_l = \hat{\beta}_l + \hat{\beta}_{lk} \ln K_{it} + \hat{\beta}_{lt} t$; $\varepsilon_k = \hat{\beta}k + \hat{\beta}_{lk} \ln L_{it} + \hat{\beta}_{kt} t$

$\varepsilon = \varepsilon_l + \varepsilon_k$; $\dot{K}$ and $\dot{L}$ are the rate of change in capital and labor respectively

Productivity spillovers

Reviewing theoretical and empirical literature show that productivity spillovers are conditional on the domestic firms themselves (e.g. absorptive capability, export-import incidence, size, age); the characteristics and degree of foreign investment (e.g. nationalities of foreign firms, entry mode, degree of presence in host countries, innovative level of technology); and the business environment factors (e.g. competition level in the sector, trade policy, linkages between different sectors, agglomeration, transportation cost[6]. Those determinants can be categorized into three groups, including: Foreign Direct Investment (FDI), firm characteristics (F) and sectoral characteristics (S):

$$T\dot{F}P = \Gamma(FDI, F, S) \qquad (3)$$

In this specification, a system of three equations is estimated against a similar set of explanatory variables (FDI, S, F).

Technical change:

$$\hat{T}\Delta_{it} = \Gamma(FDI, F, S) \qquad (4)$$

Technical efficiency change:

$$T\hat{E}\Delta = \Gamma(FDI, F, S) \qquad (5)$$

Scale efficiency change:

$$T\hat{E}S\Delta = \Gamma(FDI, F, S) \qquad (6)$$

The equation (4) relates to the nature of technical change that, in the classical growth theory, is regarded as exogenous rather than endogenous. Morrison (1999, p.46), however, criticized that such perception on technical change is based only on the notion of disembodied technical

[6]see Crespo and Fortuna (2007) for a detailed discussion on those determinants.

change, not in connection to specific input used or to specific firm behavior (e.g. R&D or investment in high tech). He argued that many aspects of technical change have an input-specific nature relating to capital, for example the vintage or the proportion of high tech in the capita, implying that the change is input-embodied technical change and being well consistent with translog production function form. In the sense of productivity spillovers from FDI, since technical change relates to the shift of production frontier it directly correlates to the general improvement of technology in the industrial sectors or the improvement of environments etc that can be relate to imitation effect proposed in spillover theory.

Equation (5) relates to efficiency improvement. Productivity spillover theory proposes the correlation between the foreign presence and the x-inefficiency of domestic owned firms, being realized through the pressure of competition, or any improvement in management skill, or mechanism encouraging workers to work harder or to exploit the current technology more efficiently.

In equation (6), the relation of scale efficiency and foreign investment is hypothesized largely through the production linkages that in turn relates to the expansion of production. The demand for inputs by foreign firms in downstream sectors leads to the expansion of the production of domestic owned firms in upstream sectors. Given assumption that domestic owned firms are non-constant return of scale, the expansion of input use results in the scale efficiency.

There are three variables involved the foreign presence in this model including *horizontal*, *forward* and *backward*. For the first one, a composed indicator developed by Aitken and Harrison (1999) that is the combination of capital stock and employment is used as follows:

$$Horizontal_{jt} = \frac{\sum_i S\_capital_{ijt} {}^{*} Employment_{ijt}}{\sum_i Employment_{ijt}}$$

in which *S_capital* is share of foreign capital averaged over all firms in sector *j*, *Employment* is labor of foreign firm *i* in sector *j* at the time *t*.

Vertical foreign presence is computed based on the IO table (IO 2000) and the method discussed in Driffield and Love (2002). In sort, they are the weighted sum of horizontal foreign presence from backward or forward sectors respectively as follows:

$$Backward_{jt} = \sum_{s=1}^{j} \alpha_{st} Horizontal_{st},\ s \neq j$$

$$Forward_{jt} = \sum_{s=1}^{j} \sigma_{st} Horizontal_{st},\ s \neq j$$

of which α_{st} and σ_{st} respectively are the coefficients of the IO table and its transpose matrix

Four variables related to firm's specifics are incorporated in the model, including (1) *Export:* a binomial dummy, taking value "1" if the domestic firms have trade internationally and 0 otherwise; (2) *labquality:* labor quality, representing for the absorptive capacity of the firms, in this paper ratio of wage payment to worker is proxied this variable, given an assumption that payment is closely related to labor quality; (3) *RD:* the investment by firms into R&D activities; and (4) *Age*: firm's age, computed as number of years since establishment

Characteristics of sectors are also expected to determine the productivity change of the firm in that sector. In this paper, the concentration ratio of the market is proxied by Herfindahl index. The indicator is constructed as the sum of square of employment share in the industry and presented as the following (see Tirole, 1988):

$$HEF_{jt} = \sum_i \left(\frac{x_{ijt}}{X_{jt}} \right)^2$$

in which x_{ijt} is the output of firm i in sector j at the time t. X_j is total output of sector j. In addition, the model also includes regional dummies and sectoral dummies to control for the heterogeneity over regions and sectors.

Data

The data for this analysis is drawn from Vietnamese Enterprise Census provided by the General Statistics of Vietnam (GSO). It contains a panel of 27,206 cross-section units (firms) and five years, from 2001 to 2005. In this dataset, the domestic owned firms occupy approximately 95% total number of the firms (85% are domestic private owned firms and 10% are State Owned Enterprises (SOEs), and the rests are foreign firms that include joint-ventures and wholly foreign owned firms). By sector, 27% of firms operate in manufacturing, 69% in service, the rest (4%) are in agriculture and mining sectors.

It is noted that this paper uses the whole sample for the analysis, not only manufacturing as conventional in many studies in this field. The reason is that FDI inflow to Vietnam is not only concentrated in manufacturing but also increasingly flowing into services and other non-manufacture sectors. Moreover, to investigate both horizontal and vertical spillovers, it is necessary to cover the foreign investment from all other sectors. In addition, the question of productivity spillovers in services and other sectors has not been well addressed in recent literature.

To estimate the production function (value added function) capital is calculated as fixed asset value (book value, in million VND), it, then, is adjusted by GDP deflator. Similarly, labor input is calculated as an average value of total employment of the firm.

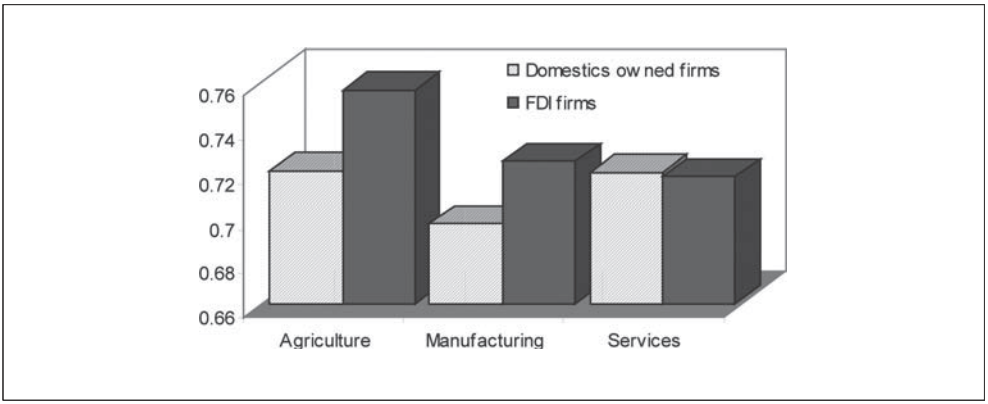
Ideally, foreign capital in joint-venture should have been counted based on the capital share of each partner. Unfortunately, this information is not available in the dataset. Therefore, the foreign capital in the joint-ventures is constructed by deducting the fixed asset by 30%. This ratio is a common ratio of capital contribution of Vietnamese partner in joint-venture (see Tue Anh et al., 2006).

Result and Discussion

Firms efficiency and TFP decomposition

Firstly, the stochastic frontier model is estimated. The technical inefficiency of the firms, then, is predicted from the model. The efficient score can be interpreted

Figure 2. Efficiency score



as the relative ratio between the actual performance and the full efficient level of the firms and ranging from 0 to 1 of which 1 is full-efficiency.

As it is showed in the graph, the difference in the efficiency score between foreign firms and domestics owned firms is profound in agriculture and manufacturing sector. The foreign firms show significantly more efficient. However, such a difference is not found in the services sector.

The technical efficiency is only a part of the story on productivity. A more concern is the productivity change of the firms. The productivity change is computed by employing differentiate procedure described in the previous section. TFP change is the summation of the change of three components (see Table 1).

In this table, three components of TFP change are presented. It shows that, on average, a large proportion of TFP change is accounted for technical change or by the shift upward of the frontier curve. In manufacturing technical change contributes 2.6 percentage points, accounting for 72%. This figure is 92% for agriculture and 48% for service sector. Scale efficiency change explains very little for the productivity change (2.41% for the foreign firms and 3.9% for the domestic owned firms). Furthermore, technical efficiency is improved substantially for services only. The fact suggests that the productivity change for the years 2001-2005 is considerably contributed by the application of new technology rather than the efficiency improvement or scale effects. This finding is important for the hypothesis testing in the next section that examines spillovers.

Productivity spillovers

Dynamic panel data model is used to estimate productivity spillovers. In this model, endogeneity is one of the concerns. Foreign presence possibly is endogenous because foreign firms are likely investing into sectors those have already-higher productivity. Furthermore by construction, the lag of dependant variable is endogenous since it correlates with the error term in the model. GMM procedure attached in Arrelano-Bond model for panel data is used. The advantage of that is it helps to solve out endogeneity problem of the

Table 1. Decomposition of productivity changes

		FDI Firms				*Domestic owned Firms*			
		2002	*2003*	*2004*	*2005*	*2002*	*2003*	*2004*	*2005*
Agriculture	TC	2.97	1.97	0.96	0.38	2.48	1.52	0.58	0.60
	TE	0.68	0.67	0.40	1.03	-0.64	-1.63	-0.94	-1.15
	SE	0.15	0.47	1.87	0.40	-0.54	0.29	0.60	0.48
	TFPc	3.79	3.11	3.23	1.80	1.27	0.19	0.21	-0.06
Manufacturing	TC	4.76	3.17	1.57	1.54	4.22	2.78	1.38	1.51
	TE	0.33	0.39	0.41	0.31	1.02	0.97	0.88	0.87
	SE	0.20	0.30	0.00	0.14	0.03	0.11	-0.12	0.15
	TFPc	5.30	3.86	1.98	1.99	5.26	3.86	2.14	2.53
Services	TC	3.24	1.58	-0.07	2.42	3.84	2.12	0.39	1.95
	TE	4.00	4.22	4.43	3.56	2.78	2.16	2.14	1.32
	SE	-0.35	-1.04	-0.94	-0.09	-0.03	0.09	0.06	0.11
	TFPc	6.89	4.76	3.43	5.89	6.59	4.37	2.59	3.38
Average	TC	3.66	2.24	0.82	1.44	3.51	2.14	0.78	1.35
	TE	1.67	1.76	1.75	1.63	1.05	0.50	0.69	0.35
	SE	0.00	-0.09	0.31	0.15	-0.18	0.17	0.18	0.25
	TFPc	5.33	3.91	2.88	3.23	4.37	2.81	1.64	1.95

Note: TC: Technical Change; TE: Technical Efficiency Change; SE: Scale Efficiency Change ; TFPc: TFP change regressor in the model, by using instruments which is the lags of level and differential of explanatory variables. GMM is also a relevant method for the panel data with short time period and long cross-sectional unit that is the case of the dataset (Arellano and Bond, 1991)[7].

Before going to discuss the estimation results of spillovers, robustness check is carried out using different productivity measurements, including labor productivity, TFP-Solow residual and TFP-Levinson and Petrin. Labor productivity is a partial measurement of productivity, may not well represent productivity especially for multi-input and multi-output case, however, it is a conventional measurement in spillover studies and presented here for the sake of comparison. Meanwhile, TFP-Solow that is simply calculated as Solow residual and being predicted from production function also contains a risk for bias due to not taking into account endogeneity of capital utilization. Levinson and Pentrin TFP that is developed further from Park-Olley TFP[8] is a more appropriate proxy for productivity since it desirably captures the endogeneity problem of capital utilization. It is noted that all of those measurements assume the full-efficiency of firms and constant return of scale production function.

The estimation results using those productivity measurements are presented in the first three columns of Table 2.

The table shows that, in principle, the estimated coefficients are robust in term of sign, but not the magnitude. The difference can be interpreted from the underlying assumptions (capital endogeneity, full efficient, return of scale) and the possible bias that non-stochastic frontier approach can bring about. The results used for our interpretation on productivity spillovers are presented in last four columns of Table 2; among which the first one is the model estimated for TFP change; the next three columns are the model with each TFP change components.

The first point to note is that most of the independent variables have expected signs. HEF that re□ects competition effects in the sector has negative sign and is consistent in all four equations. The variable *Export* is positive, indicating that there is a systematic difference in productivity of firms with and without export activities. Similarly, labor quality shows positive sign implying that better labor quality will bring better productivity.

The second point is that the coefficient of the variable *Horizontal* is negative and statistically significant in equation of TFP change, suggesting an evidence for negative intra- industry productivity spillovers. However, a more important result is that such negative spillovers largely explained in the equation of technical change. This result is consistent with many empirical research which based on the assumption that the productivity change is equivalent to technical change or all firms are efficient.

Aitken and Harrison (1999) explain this negative effect as a consequence of competition effect in short run while firms can still benefit positive effects from other channels e.g. skill acquisition or imitation. As such, due to the market penetration of foreign firms, the domestic owned firms have to cut down their

[7]We tried both difference-GMM and system-GMM. Although system-GMM is said more efficient, we found that it is substantially unstable and sensitive to number of instruments introduced in the model, for some cases it even make estimated coefficients change the signs. Secondly, with system-GMM, many of our estimation were not able to pass the specification tests (Hansen ans Sargan test), whereas we cannot reject the hypothesis of the model which is valid specification for difference-GMM. We, therefore, use difference-GMM results for our interpretation. However, it is noted that even with this simpler specification, for some cases in our analysis, Hansen test is not passed. We keep the results for purpose of consistent reporting; therefore, the reader should interpret our result with caution.
[8]See Levinson and Petrin (2001); Olley and Pakes (1996) for insight discussion on those measurements.

output and reduce their profit. Such movement leads to less investment on R&D or imitation and adaptation of new technology, causing the negative technical change in the industry. This may become true for Vietnam because one can see the positive effect for technical efficiency and negative effect for scale effect (however, it is not statistical significant). The result suggests that domestic owned firms still benefit from foreign firm presence, in other words, they acquired positive effect from superior knowledge, working skill, etc, that lead to the reduction in the x-inefficiency. The positive coefficients of the lag of this variable support for the argument that in long-time firms can obtain positive spillover as the imitation effect takes time while the competition effect is more instant.

Table 2. Estimation results for domestic owned firms

	Labor productivity	Solow TFP	Levin & Patrin TFP	Stochastic Frontier			
				TFP	TC	TEC	SEc
Horizontal	-0.636***	-0.512***	-0.617**	-0.460***	-0.603***	0.100*	-0.009
	(0.031)	(0.053)	(0.067)	(0.107)	(0.035)	(0.042)	(0.06)
Lag1.Horizontal	0.066***	0.023	0.113***	0.130***	0.630**	-0.197***	-0.005
	(0.013)	(0.018)	(0.03)	(0.032)	(0.021)	(0.018)	(0.033)
Forward	0.097***	-0.074***	-0.051***	-0.326***	-0.041***	-0.028**	0.023*
	(0.008)	(0.01)	(0.015)	(0.023)	(0.01)	(0.01)	(0.011)
Lag1.Forward	0.139***	-0.104***	-0.049**	-0.217***	-0.132***	0.013	-0.029
	(0.008)	(0.012)	(0.018)	(0.027)	(0.011)	(0.011)	(0.018)
Backward	0.035***	0.036***	-0.008	0.614***	0.042***	0.145***	0.008
	(0.007)	(0.007)	(0.011)	(0.021)	(0.008)	(0.009)	(0.013)
Lag1.Backward	0.116***	0.079***	0.079***	-0.029	-0.025*	-0.002	-0.081***
	(0.009)	(0.012)	(0.017)	(0.027)	(0.01)	(0.011)	(0.017)
Labour quality	0.052***	0.033***	-0.001	0.400***	-0.017*	0.352***	0.029*
	(0.008)	(0.008)	(0.012)	(0.024)	(0.009)	(0.011)	(0.014)
HFF	-0.088***	0.098***	-0.047**	-0.260***	-0.112***	0.434***	-0.013
	(0.012)	(0.013)	(0.018)	(0.037)	(0.013)	(0.016)	(0.02)
Age	0.173	0.332*	0.661*	-0.21	0.907***	0.012	0.033
	(0.156)	(0.141)	(0.263)	(0.394)	(0.163)	(0.201)	(0.272)
Age_Squared	0.017	0.099	0.573***	0.188	0.483***	0.115	0.243
	(0.091)	(0.083)	(0.146)	(0.233)	(0.095)	(0.118)	(0.155)
R&D	0.019***	0.016***	-0.004	0.039**	-0.006	-0.009	0.045***
	(0.004)	(0.004)	(0.006)	(0.013)	(0.005)	(0.006)	(0.007)
Export	0.134***	0.204***	-0.178***	3.218***	0.012	2.529***	0.443***
	(0.016)	(0.017)	(0.025)	(0.045)	(0.018)	(0.02)	(0.028)
Lag1 labor prod.	0.170***						
	(0.027)						
Lag1Solow prod.		0.459***					
		(0.016)					
Lag1 LP TFP			0.022***				
			(0.006)				
Lag1 TFP				0.304***			
				(0.014)			
Lag1 Technical					0.186***		
					(0.01)		
Lag1 Tech Eff.						0.015**	
						(0.006)	
Lag1 Scale Eff.							0.084***
							(0.006)
Constant	-10.051***	17.395***	10.300***	-56.408***	-9.418***	19.169***	-0.868
	(1.932)	(2.579)	(0.885)	(3.898)	(0.581)	(2.94)	(1.756)
Obs number	*81563*	*81563*	*81563*	*81563*	*81563*	*81563*	*81563*
AR1 (P-value)	*0.236*	*0.389*	*0.521*	*0.462*	*0.112*	*0.442*	*0.0474*
AR2 (P-Value)	*0.157*	*0.044*	*0.083*	*0.077*	*0.036*	*0.055*	*0.012*
Sargan(P-value)	*0.013*	*0.21*	*0.092*	*0.121*	*0.461*	*0.111*	*0.09*

Regarding to the vertical spillovers, it is found the evidence of positive backward and negative forward spillover. While the positive backward can be normally explained by scale efficiency, learning-by-doing or the tougher standard requirement etc from the foreign firms to their local suppliers, the negative forward spillover is tricky to interpret because it seems to be contradictory to the theory on production linkages stating that the domestic owned firms who buy inputs from foreign firms benefit from better quality or from better technical guide for the input used as well as more in-time delivery etc. A possible explanation for this result is that such intermediate inputs produced by foreign firms are, in association with better quality, more expensive or there might be some less adaptive inputs that makes domestic owned firms in downstream industries do not immediately harmonize, hence, getting harm. By this sense, the results support the theoretical argument by Rodriguez-Clare (1996) about the linkage effect of FDI. The results also support the hypothesis on the positive impact of backward linkages, proposed in Markusen and Venables (1999) which states that the effect would be through the expansion of demand for intermediate goods.

The lag of backward spillover that has a negative sign in the equations for technical efficiency, technical change and positive sign in the equation for scale efficiency is of interesting point to note here. Intuitively, it means that the positive effect to technical change and scale efficiency change of contemporaneous backward spillovers is gradually deteriorated. The answer possibly relates to the relationship between vertical technology transfer and so-called exclusivity in intermediate market modeled in Lin and Sagi (2005) and the theoretical argument on the relationship between negotiating power and welfare stated in Driffield and Love (2002). In their models, not all local suppliers can obtain technological benefit from foreign entries, but only those who accept exclusivity contractual relationship with foreign firms. On one hand, besides the fact that only a limited number of upstream domestic owned firms get benefit, the benefited firms themselves, under the exclusivity contractual arrangement, also have to follow strict regulations on the ratio of output being able to sold out to domestic owned firms so that to ensure the low possibility of technology leakage. On the other hand, foreign entries harm local rivals by the competition effect.

Such a negative horizontal spillover in downstream may induce negative effect to the local suppliers in upstream who are providing intermediate goods for affected domestic owned firms. So in fact, domestic owned firms in upstream may not be absolutely benefited. In addition, the local suppliers also suffered from a so-called week negotiating power than foreign firms in downstream. This situation will leads to the fact that the benefit (if any) occurring to local suppliers will be reaped by foreign firms in downstream.

Net effect

Above estimation coefficients reflect the marginal effects, implying the amount of change to productivity by one unit of exogenous variable, given all others fixed. It does not allow one to conclude about the positive or negative spillovers for a period of time. In this paper, the net effect is computed based on the estimated coefficients and the value of the variable. Table 3 presents the net effect for an average firm in 22 aggregated industries[9].

[9]We also computed the nest effect for SOEs and domestic private owned firms. The results are provided on request.

Table 3. Net productivity spillover by type of effect

Sector	Vertical	Horizontal	Net	Sector	Vertical	Horizontal	Net
1. Agriculture	-0.003	0.064	0.061	13. Electric&water	-0.002	-1.049	-1.051
2. Food processing	0.000	0.106	0.106	14. Trade	0.001	0.316	0.317
3. Textile	0.013	-1.237	-1.224	15. Hotel&Rest.	0.038	0.223	0.261
4. Wooden&Furnature	-0.005	0.191	0.186	16. Transportation	0.000	-0.002	-0.002
5. Publishing&media	0.005	-0.005	0.000	17. Telecom	0.000	-1.261	-1.260
6. Petroleum	-0.011	0.000	-0.011	18. Finance	-0.001	0.180	0.179
7. Chemical product	-0.042	0.027	-0.015	19. Other services	-0.004	0.117	0.113
8. Plastic&ruber	-0.003	-0.518	-0.521				
9. Metal products	-0.003	0.186	0.184	General			
10.Machinary	-0.005	0.733	0.728	1. Agriculture	-0.003	0.064	0.061
11.Electronics	-0.008	-0.288	-0.295	2. Manufacturing	-0.007	-0.015	-0.022
12.Construction	0.008	0.000	0.008	3. Services	0.002	-0.050	-0.048

The results show that for the period 2001-2005, on average, Vietnamese firms suffered negative productivity spillovers at -2.1% of which vertical spillovers contributes -0.4% and -1.7% for horizontal spillovers. So, in fact, the net productivity spillover extensively depends on the horizontal effects. The low contribution of vertical spillovers confirms the conclusion on the poor linkages among foreign firms and domestic owned firms in some studies in Vietnam (Ruffing 2006; Thoburn et al., 2007)

In addition, the net effect also shows a mixed evidence of productivity spillover among different industries. Many major sectors in manufacturing namely chemical products, plastic and rubber, electronics suffer negative spillovers while service sectors obtain positive net effect, except telecommunication and transportation.

Conclusion

This empirical paper focuses on examining the productivity spillover effect of FDI inflow in Vietnam during 2001-2005. It contributes to literature in different faces. *Firstly*, it attempts to connect productivity theory with productivity spillover of FDI by employing the stochastic frontier model to measure productivity of the firms. This application helps to release the assumption that firms are working efficiently which is extensively criticized in productivity studies but very common in spillover studies. *Secondly*, the paper tries to examine how the presence of foreign firm contributes to the change of three TFP components. In addition, it goes further from current literature by computing the net effect of spillover by using the estimated coefficients and the degree of foreign presence.

The estimation in the first stage shows informative results such as a substantial difference in the efficiency level of foreign and domestic owned firms; technical change shares a large proportion of TFP change, particularly in manufacturing sector; scale efficiency change, in contrast, has very small contribution.

The estimation results in the second stage of the model show pessimistic picture on productivity spillovers from FDI to Vietnamese firms. Negative horizontal spillovers are found, furthermore, such negative effect is largely accounted by effect to technical change. However, domestic owned firms still enjoys positive efficiency spillovers.

The paper also finds that domestic owned firms are positively get benefit from the backward linkages but not from the forward linkages. The negative effect of forward spillover is explained by the lower negotiating capability of domestic owned firms and/or the higher price of output from upstream foreign firms due to better quality and time delivery for example. Although positive backward spillover is found, the dynamics of it shows that the value is undermined over time. The results for the vertical spillovers also point out that spillovers is slightly contributed by the spillover in scale efficiency, implying that in fact the productivity improvement of domestic owned firms is actually by the technical change and technical efficiency change. Going further by calculating the net effect it is found that although we find positive backward spillover in overall, many sectors suffer the negative net spillover effect.

The findings from this paper suggest some policy implications. Negative horizontal spillovers raise a critical demand for enhancing the competitive capacity of Vietnamese firms. Vertical effect as it is found negative for many sectors also suggest a weak position of domestic firms. More importantly, the small proportion of vertical effect in total net effect suggests policy makers to quickly enhance and encourage the linkages between the foreign firms and local firms such as to develop outsourcing industries for foreign investment, or to improve the infrastructure to enhance the production linkages.

Although more informative and analytical findings are found, this paper remains some unsolved issues: Firstly, stochastic frontier production function is criticized for the prior assumption on the production function form as well as the function form for the inefficiency term. In some cases, it may be substantially strong. It is needed to check this results by a counterfactual method i.e. Data Envelopment Approach (DEA).

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