Externalities of Trade and Foreign Direct Investment for Production Efficiency in Laos*

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Abstract

Using an unbalanced panel dataset of 81 developing countries from 1995–2010, we assess the impacts of trade and inward FDI on national efficiency in Laos. We find that the Laos' production function is determined by physical capital, human capital, labor inputs, and foreign R&D. Our results show that trade and FDI can serve as carriers of knowledge accumulation from advanced countries to Laos and that the opening up of Lao economy through increased imports of capital goods contributes to national efficiency about 28%. However, the contribution of FDI inflows on national efficiency is only 0.23%, suggesting that there is still much progress to be made to enhance Laos' production efficiency via FDI.

Keywords: Trade, FDI, aggregate efficiency

1. Introduction

International trade and foreign direct investment (FDI) can serve as means for improving production efficiency. Trade affects efficiency through capital goods imports which are assumed to be carriers of international knowledge spillovers in open economy. FDI can potentially affect efficiency in a host country by bringing new technologies, providing technological assistance to local suppliers and customers, training workers, and increasing competition in the host country's market. In view of efficiency gains, many countries have allocated many expensive, publicly funded incentive schemes to promote trade and FDI. These FDI and trade promotion policies are particularly acute in Lao PDR (subsequently Laos), where trade and FDI barriers have been gradually removed. To further stimulate sustained economic growth, industrialization may be

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required. Policies to enhance international trade and promote FDI therefore seem a clear means to boost the domestic production and integrate the country into the regional and global economy, and thereby remove Laos from of the list of less developed country. The fact that greater trade openness and more FDI inflows benefit the host country is the theory, but does it actually work?

We begin with some background. At an aggregate level, the Lao economy has performed moderately well in recent years, with an annual average growth of real GDP of 7% since 2000, slightly above the average rate over the preceding decade. Trade openness increased from 51% in 1995 to 80% in 2010 (World Bank, 2011a), while FDI inflows rose sharply from $95 million in 1995 to $350 million in 2010 (UNCTAD, 2010). With exports as the leading engine of growth, real GDP per capita increased from $268 in 1995 to $560 in 2010. As in most developing countries, Laos' trade pattern is characterized by the exports of primary product (i.e., minerals, electricity, and garment) to the rest of the world in exchange for capital goods and consumer goods. Approved FDI in Laos is concentrated in the mining and electricity sectors, accounting for 16.3 and 48.3%, respectively, of total FDI stock as of 2009.

Economic reforms called the New Economic Mechanism (NEM), beginning in 1986, have seemingly contributed to these favourable outcomes by permitting greater participation in local, regional, and global markets through trade and FDI. However, it is recognized that removal of obstacles to the functioning of markets and investment may be further enhance by importing more capital goods and attracting more FDI. This is especially important in Laos where both (physical and human) capital and production know-how are lack. Removal of obstacles to the functioning of markets and investments may be of little or no assistance to Lao people if the production has been operated inefficiently which causes production costs to be so high as to prevent the investors in Laos from participating fully in these markets. The accumulation of capital and knowledge is essential and its inadequacy is a cause of underutilized production resources. Such accumulation can be conducted not only by private investors, but also by the collective action of the government. Although there is still much progress to be made, over the past decade action by the Lao Government has resulted in substantial increase in capital goods imports and FDI inflows. The present paper is an attempt to study the contribution that increased imports of capital goods and FDI inflows have made to improvement of national efficiency in Laos in the recent past through these means.

Several studies suggest that trade and FDI inflows enhance national efficiency. Iyer et al. (2008) apply a stochastic frontier approach using a panel data set of 20 OECD countries over the period 1982–2000. The results show that greater trade openness increases efficiency, and FDI inflows enhance efficiency in countries with a larger relative investment in R&D and more developed financial markets. Using a panel data set of 57 countries (both developed and developing countries) over the period 1988–2001, Ciruelos and Wang (2005) find that both FDI and trade can serve as important channels of international technology diffusion. Henry et al. (2009) analyze the production frontier for 57 developing countries over the period 1970–1998 applying the stochastic frontier approach. The result indicates that trade volume and trade policy play an important role in raising output both through technology improvements embodied in imported capital goods and by inducing efficiency improvements. Blomstrom and Sjoholm (1999) examine the effects on technology transfer and spillovers deriving from ownership sharing of foreign multinational affiliates using unpublished Indonesian micro data. Their results show that domestic establishments benefit from spillovers. Using panel data on Venezuelan plants, Aitken and Harrison (1999) investigate technology spillovers from foreign to domestic firms. They find that small plants (employing fewer than 50 workers) with higher foreign ownership tend to exhibit positive productivity gains, but foreign ownership has a negative effect on the productivity of domestic firms in the same industry.

It is recognized that having access to leading edge technologies through technology transfers may not of itself lead to productivity improvements if these technologies are not absorbed and utilized efficiently. In view of this, the absorptive capacity and technical efficiency of a country is a critical factor in its ability to catch up with countries at the technological frontier. For developing countries this is even more of vital importance. Consequently, this paper employs a stochastic frontier analysis (SFA) to consider the effects of both technology transfer and absorptive capacity on the output levels of Laos in a panel data framework. The production frontier refers to the maximum technically feasible output attainable from a given set of inputs. Countries (the producers of output for given inputs) then either operate on or within this frontier. The first outcome represents a technically efficient outcome while the latter admits to some level of technical inefficiency. In a panel data set of developing countries, Laos is viewed as one of the producers of output. It is this panel data that allows us to estimate the efficiency for each country over time.

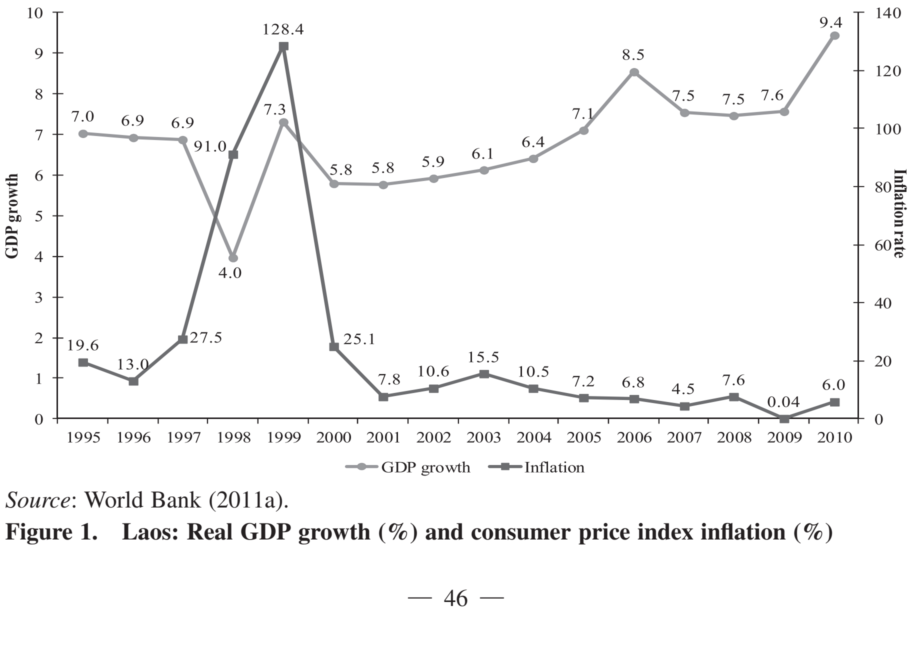
The structure of the present paper is as follows. Economic change in Laos since 1995 is reviewed in Section 2. This is important because this paper is concerned with analysing changes in production efficiency between 1995 and 2010. This requires an understanding of the economic background within which these changes occurred. Due to structural changes within the Lao economy, both domestic and foreign investors have been subjected to considerable economic pressure, which is important for an understanding of the changes in national efficiency level that have occurred. The results of the empirical analysis of the relationship between trade/FDI and efficiency improvement in Laos are then presented in Section 3, and conclusion is provided in Section 4.

2. Economic background

2.1 *Output development*

Despite its impressive growth performance, Laos remains a poor country, with GDP per capita in 2010 at $560, and total GDP of $3.5 billion. From 1995 to 2010 annual growth of GDP averaged 6.9% per annum, or around 5% per person (Figure 1). The agricultural sector dominates employment, with 75% of the workforce, and it contributes approximately 33% of GDP in 2010 declining from 56% in 1995. Laos remains dependent on external financial support. In 2009 net official development assistance accounted for 23% of gross capital formation, 62.5% of central government expense, and 7.1% of GDP.

There has been substantial structural change within the Lao economy. The agricultural sector contracted from 55% of GDP in 1995 to 31% of GDP in 2010, whereas the service sector increased from 26% of GDP in 1995 to 42% of GDP in 2010. The large share of services in GDP has been due largely to tourism. In 2003, for example, tourism accounted about 8% of GDP and generated direct and indirect employment about 22,000 workers. Tourists visited the



Source: World Bank (2011a).

Figure 1. Laos: Real GDP growth (%) and consumer price index inflation (%)

Lao PDR were mainly from Thailand (more than 70%) and from China, Japan, and Vietnam (ADB and WB, 2007). The industrial sector also grew significantly, rising from 19% of GDP in 1995 to 27.4% of GDP in 2010. The rapid expansion of the mining sector has been one of the major driving forces behind the contribution of the industrial sector to GDP, rising from 0.26% of GDP in 2002 to 7.1% of GDP in 2010. Large FDI inflows in mining sector since 2004 accounted for this change.

One feature of the contributions of the mining sector to GDP is worth considering. It directly contributes to the demand and supply-side GDP of Laos by raising investment and capital stock. As FDI inflows utilize domestic resources, it increases the demand-side GDP. At the same time, such inflows add new capital to the existing capital stock and thus contribute to the supply-side GDP. According to the World Bank (2011b), FDI in the resource sector, including mining and hydropower, was estimated to contribute 4.8 percentage points of economic growth rate (8.5%) in 2010, rising from 1.9 percentage points of economic growth rate (7.4%) in 2008. The mining sector became more attractive for both foreign and domestic investors. To some extent this was due to more favourable investment climate in Laos, but it was also due to the rising profitability of minerals itself. As this activity continues, more domestic resources will be transferred to the mining sector. This results in non-tradable goods more expensive, reflecting relative price movements within the country.

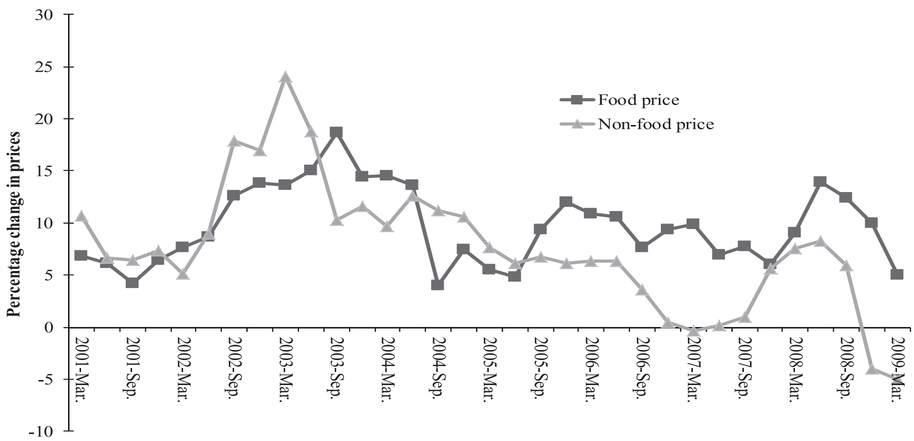
2.2 *Prices development*

Inflation was moderate prior to 1997, at single digit levels for this period, but accelerated from 1998 to 2000, peaking at 128% in 1999, as shown in Figure 1. This inflationary surge was affected by the Asian financial crisis exacerbated by inappropriate policy responses by the Lao government. Beginning in 1996–1997, a commitment on achieving food self-sufficiency led to large public expenditures through rapid monetary expansion, which further eroded investor confidence and resulted in the hyperinflation and sharp currency depreciation in the late 1990s. Since 2001 consumer price inflation has been under control, with an average annual rate around 8%.

The inflation in consumer prices in the late 1990s coincided with a substantial depreciation of Lao kip against the US dollar and Thai baht. Between 1997 and June 1999, the kip lost 464% of its value against the dollar. Given its close link to the Thai baht through international trade and foreign direct investment, the Lao kip was highly vulnerable to the exchange rate volatility that shocked the region. Between 1997 and June 1999, the kip lost 368% of its value against the Thai baht. These macroeconomic events resulted in significant relative price changes within

Laos, which are relevant to the central theme of this paper. Using consumer price data on the ratio of food to services prices as a proxy for the ratio of traded and non-traded goods prices, Warr (2010) showed that agricultural commodity prices fell dramatically relative to non-agricultural prices, especially those of services and construction between the late 1980s and the mid-1990s and between 2000 and 2004; but this real appreciation was reversed by the massive nominal depreciation between 1997 and 1999. Warr (2010) argued that an economic boom concentrated in the services and construction sectors of the Lao economy is the main force driving the ratio of traded and non-traded goods prices downward.

It is interesting to further examine the dynamics of relative prices because the industrialization process in the Lao economy has been more rapid since 2005. Similar to Warr (2010), traded goods price is represented by change in food price and non-traded goods price is represented by the weighted average of prices of services and housing. Figure 2 plots the changes in the traded goods price and non-traded goods prices from 2001 to 2009. As shown in Figure 2, prior to the beginning of 2003 economic reform in the Lao economy led to higher services and housing prices (non-food price). This implies lower relative price of traded to non-traded goods. In some cases, the program had indirect macroeconomic effects on agricultural and manufacturing output. The increased domestic expenditure backed by foreign aid and FDI in the resource sectors produces demand-side effects that imply contraction of agriculture and manufacturing. Increased demand produces increases in the domestic prices of those goods and services that cannot readily be imported. These include most services and construction and the expansion of these sectors



Source: Author's calculations using data from the IMF staff paper, various issues.

Figure 2. Laos: Changes in prices of food to non-food, 2001–2010

attracts resources, including labour, away from agriculture and manufacturing. This phenomenon is known as the 'Dutch Disease'. It causes the prices of agricultural and other traded commodities to decline relative to other prices, with negative effects on agricultural and manufacturing production. To the extent that the NEM increased the exposure of agricultural and manufacturing commodities to international markets, this policy change indirectly increased the impact that these market phenomena had on agricultural and manufacturing production.

However, the non-food price has shown a declining trend since 2003. This implies higher relative price of traded to non-traded goods. As the service and housing sectors boomed for some time, entrepreneurs might be able to set high prices. Over time, markets for these businesses become more competitive and thus forcing entrepreneurs to lower their prices. This process will continue until these markets become fully efficient; that is, all entrepreneurs run their businesses with minimum costs.

The relevance of these events is that since around 1990, economic reforms within the Lao economy have supported the national plan for industrialization, but to some extent it has been biased toward the resource sectors. Since most businesses are concentrated in the main cities, the industrialization process has accelerated the rate of rural to urban migration that would otherwise have occurred. In short, these events have resulted in higher growth rates in the industrial and service sectors, and thereby higher its entire economy's efficiency level. This background is important for understanding national efficiency in Laos.

3. Trade, FDI, and production efficiency

Lack of physical capital and insufficient knowledge accumulation are apparent in the Lao economy. It seems obvious that increasing capital goods imports and attracting FDI could contribute to GDP growth by enhancing national production efficiency. However, by how much can production efficiency be increased in this way? The answer can be empirically investigated in a stochastic frontier model.

3.1 *Technical frontier*

The stochastic frontier approach constructs an efficient frontier by imposing a common production technology across all countries in the sample. Deviations from the frontier are decomposed into two components: inefficiency and noise. Representing noise by a disturbance term reduces the volatility in the temporal patterns of efficiency measures. In this study, it is assumed that output, Y, is a function of the production technology specified as

$$Y_{it} = f(K_{it}, L_{it}, HC_{it}, TRD_{it}, FRD_{it}, T)e^{\eta_{it}-u_{it}} \quad , i = 1, 2, \ldots N; t = 1, 2, \ldots T \tag{1}$$

where Y is output (GDP), $f(.)$ is a suitable functional form, K is the stock of physical capital, HC is a measure of the stock of human capital, L is the labor supply, TRD is the stock of foreign technical knowledge via capital goods imports, FRD is the stock of foreign technical knowledge via FDI inflows, T is a time trend and is included to capture technical progress over time, η_{it} is a symmetric random error component used to capture random variations in output level due to external shocks, and u_{it} represents the technical inefficiency used to capture technical inefficiency. Finally, i indexes country and t indexes time.

To allow for a flexible functional form, a translog production function is adopted to characterize the production frontier facing developing countries. Equation (1) can be expressed in log-linear form to give

$$\ln Y_{it} = \beta_0 + \sum_{j=1}^{4}\beta_j \ln X_{jit} + \beta_t T + \frac{1}{2}\sum_{j}^{4}\sum_{k=1}^{4}\beta_{jk} \ln X_{jit} \ln X_{kit} + \frac{1}{2}\beta_{tt}T^2 + \sum_{j}^{4}\beta_{jt} \ln X_{jit}T$$
$$+\sum_{r=1}^{3}\gamma_r D_r + \beta_t T + \varepsilon_{it} - v_{it} \tag{2}$$

where Y_{it} is the output of country i in time t, X_{jit} is the jth factor input used by the ith country in time t to produce Y. Five factors of production are included, namely physical capital, labor, human capital, trade-weighted stock of industrial R&D, and FDI-weighted stock of industrial R&D. Equation (2) also contains regional dummies (D_r) for Asia, America, and Africa. These capture differences in the initial level of technology for these regions and are preferred to country-specific fixed effects (Temple, 1999). The variable T proxies for technological progress and is used to capture elements of domestic technological progress not captured by foreign R&D. The β's are parameters to be estimated. Finally, $\varepsilon_{it} = \ln \eta_{it}$ and $v_{it} = \ln u_{it}$ [from equation (1)], with ε_{it}~iid N(0, σ_ε^2) being the random noise error component and $v_{it} \geq 0$, the technical inefficiency error component.

Regarding the inputs into the production function, there are contradicting views over the role of human capital in economic growth. Mankiw et al. (1992) advocate the inclusion of human capital as a separate term in the production function. In contrast, Islam (1995) and Pritchett (2001) argue that human capital influences growth indirectly through its effect on TFP. Our analysis in this paper chooses to follow Griliches (1969) and Mankiw et al. (1992) and allow for possible complementarity between human and physical capital by including the former as a separate input in the production function. Moreover, output is assumed to be a function of the total stock of knowledge in country i at time t. Following Grossman and Helpman (1991), it is assumed that this depends on the stock of R&D. Given that most developing countries undertake little domestic R&D, the stock of knowledge is assumed to depend on the stock of foreign R&D transferred into developing countries through trade and inward FDI. The measure of technology transfer used in this paper builds on that found from Lichtenberg and van Pottelsberghe de la Potterie (1998). They measure foreign R&D spillovers on the domestic economy as the sum of bilateral imports share in trade partners' GDP weighted by R&D capital stocks of trade partners. Following this literature, we measure the stock of frontier technology as the stock of industrial R&D in 21 OECD countries. To capture the spillover of foreign technology to developing countries, this stock of knowledge is weighted by the share of a developing country's capital goods imports in each OECD country's GDP and by the share of a developing country's FDI inflows in each OECD country's GDP. The stock of foreign industrial R&D spillovers (*TRD*) via imports by developing country i from the foreign OECD country j is therefore given by

$$TRD_i = \sum_{j \neq i} \frac{CGI_{ij}}{Y_j} RD_j \ . \tag{3}$$

Similarly, the stock of foreign industrial R&D spillovers (*FRD*) via FDI inflows to developing country i from the foreign OECD country j is therefore given by

$$FRD_i = \sum_{j \neq i} \frac{FDI_{ij}}{Y_j} RD_j \ , \tag{4}$$

where CGI_{ij} is capital goods imports of developing country i from developed country j, FDI_{ij} is FDI inflows to country i from country j, RD_j is real capital stock of industrial R&D, and Y is the GDP of the developed country.

3.2 *Inefficiency effects*

Countries may differ in their level of productivity. This productivity difference is captured by the term η in equation (1). A country is fully efficient if the term η is equal to one. Otherwise, there are some impediments to absorption that will cause the country to produce below the frontier. Following Battese and Coelli (1995), the inefficiency effects are obtained as truncations at zero of the normal distribution $N(m_{it}, \sigma_v^2)$, where $v = -\eta$. Inefficiency is therefore specified as

$$m_{it} = z_{it}\theta \tag{5}$$

where m_{it} are technical inefficiency effects in the SFA framework and are assumed to be independently, but not identically distributed; z_{it} is a vector of variables which may influence the technical efficiency of a country, and θ is a vector of parameters to be estimated.

The mean level of inefficiency for our empirical analysis is specified as

$$m_{it} = \theta_0 + \theta_1 AY_{it} + \theta_2 CGI_{it} + \theta_3 FDI_{it} + \theta_4 FMD_{it} \qquad (6)$$

where *AY* refers to the share of agriculture in GDP, *CGI* is capital goods imports, *FDI* is FDI inflows, and *FMD* is financial market development.

The specification of equation (6) is based on previous literature. Geroski (1995) and Cameron et al. (2005) argue that investment in imitative or adaptive research activities plays a crucial role in adopting foreign technology. Using human capital and R&D to capture these effects, Griffith et al. (2004) find strong empirical support for this argument in the context of OECD countries. In our empirical study, human capital is already included in the technical frontier model [equation (2)].

Given a relatively low R&D capacity in developing countries, we capture their absorptive capacity for foreign R&D through their importation of capital goods and FDI inflows. Capital goods imports embody knowledge of foreign technology and production know-how; the greater these imports the greater the scope for direct absorption of foreign innovations by the importing firms and for spillover of this knowledge to other firms. With greater absorption of foreign technology through capital imports the nearer a country can be to the production frontier and the lower the measured inefficiency. FDI inflows can improve the productivity resulting from increased competition. The competition effects result from the increased numbers of firms (domestic and foreign) operating within the market and the resulting improvements in quality and incentives to reduce slack.

Following Henry et al. (2009, pp. 242), the share of agriculture in GDP is included in the inefficiency model. Other things being equal, higher agricultural intensity is expected to increase distance from the production frontier. Developing countries are characterized by lower average food output per unit input due to backward farming method. However, the wider domestic diffusion of existing know-how and by greater commercialization of agricultural activity can raise a country's output for given national resources. By raising efficiency and productivity in agriculture, the scope for an agricultural surplus and for releasing resources from agriculture to higher productivity activities increases.

Finally, the financial market can play a significant role in the channeling the contributions of FDI to economic growth. This argument is supported by Alfaro et al. (2004). Therefore, other things being equal more developed financial market increases production efficiency.

In conclusion, if capital goods imports, FDI inflows, and financial market development promote the absorption of technology, we would expect to find negative coefficients on θ_2, θ_3, and θ_4, respectively; that is they reduce the distance from the frontier. On the contrary, if a higher share of agriculture in GDP increases inefficiency (or the distance from the frontier) then θ_1 would be positive.

3.3 *Estimation method*

Since the pioneering work of Aigner et al. (1977) and Meeusen and van den Broeck (1977), over time a number of studies have produced many innovations in the specification and estimation of their model. Panel data applications have kept pace with other types of developments in the literature. Many of these estimators have been centered on familiar fixed and random effects formulations of the linear regression model.

Among several alternative approaches to estimating the stochastic frontier model in panel data framework, the Battese and Coelli (1995) method is preferred since it allows the estimation of efficiency and inefficiency determinants using a one-stage approach rather than the traditional two-stage approach.[1] Under the two-stage approach, efficiency scores are estimated in stage one, and the efficiency scores are then regressed on a set of variables in stage two. This approach suffers from two problems. Firstly, in stage on the efficiency scores are assumed to be normal, independent and identically distributed; however, in stage two the same efficiency scores are assumed to be not identically distributed. Secondly, the efficiency scores obtained from stage one suffer from under-dispersion due to the omission of the efficiency changing variables, and this results in the obtained estimates from the second stage regressions to be biased downwards (Wang and Schmidt, 2002).

Following Battese and Coelli (1995), the parameters of the models defined by equations (2) and (6) were estimated simultaneously by maximum likelihood. Moreover, to interpret the coefficients of the coefficients of the translog production function, the elasticities of output with respect to each of the inputs are calculated as follows:

$$E_m = \frac{\partial y}{\partial x_m} = \beta_m + \sum_n \beta_{mn} x_{nit}, \quad m = K, L, HC, TRD, FRD \tag{7}$$

1) The issue of the explanation of the inefficiency effects was raised in the early empirical papers, including Pitt and Lee (1981) and Kalirajan (1981).

Returns to scale (elasticity of scale) is calculated from the sum of the input elasticities as

$$RTS = \sum_m E_m \tag{8}$$

Following Coelli et al. (1999), the contribution of trade or FDI can be calculated as the difference between gross efficiency and efficiency net of the contribution of 'trade' or 'FDI', where gross efficiency is found using the conditional expectation of $\exp(-v_{it})$, given the random variable η_{it}

$$\begin{aligned} EE_{it} &= E[\exp(-v_{it})|\eta_{\text{it}}] \\ &= \left[\exp\left(-\omega_{it} + \frac{1}{2}\tilde{\sigma}^2\right)\right] \times \left[\Phi\left(\frac{\omega_{it}}{\tilde{\sigma}} - \tilde{\sigma}\right) \Big/ \Phi\left(\frac{\omega_{it}}{\tilde{\sigma}}\right)\right] \end{aligned} \tag{9}$$

where $\Phi(.)$ denotes the distribution function of the standard normal variable

$$\omega_{it} = (1-\gamma)\left[\theta_0 + \sum_{m=1}^{M} \theta_m z_{it}\right] - \gamma\eta_{it}, \quad \tilde{\sigma}^2 = \gamma(1-\gamma)\sigma^2, \text{ and } \gamma = \frac{\sigma_v^2}{\sigma_v^2 + \sigma_\varepsilon^2}$$

The operational predictor for the efficiency of country i at time t is calculated by replacing the unknown parameters in equation (9) with the maximum likelihood predictors. Net efficiency of trade or FDI (efficiency level excluding trade or FDI) is calculated by replacing $[\Sigma_{m=1}^{M} \theta_m z_{it}]$ with $[\Sigma_{m=1}^{M} \theta_m z_{it} - \theta_{trd} TRD]$ or $[\Sigma_{m=1}^{M} \theta_m z_{it} - \theta_{frd} FRD]$, respectively, and then re-calculating the efficiency predictions. Similar procedure is applied to calculate the net efficiency of the combination of trade and FDI.

3.4 *Panel data for the stochastic frontier analysis*

One of our goals is to estimate the technical efficiency which indicates how far a sample country lags behind the best practice as represented by the production frontier. A panel data set is needed. In our application, sample consists of 81 developing countries, including Algeria, Argentina, Bahrain, Bangladesh, Barbados, Belarus, Bolivia, Brazil, Bulgaria, Cameroon, Chile, China, Colombia, Republic of Congo, the Democratic Republic of the Congo, Costa Rica, Croatia, Cyprus, Dominican Republic, Ecuador, Egypt, El Salvador, Estonia, Gabon, Georgia, Ghana, Guatemala, Honduras, Hong Kong, India, Indonesia, Iran, Israel, Jamaica, Jordan, Kazakhstan, Kenya, Korea, Kuwait, Laos, Latvia, Lebanon, Libya, Lithuania, Malaysia, Mali, Malta, Mauritius, Mexico, Morocco, Mozambique, Nicaragua, Niger, Nigeria, Oman, Pakistan, Panama, Paraguay, Peru, Philippines, Qatar, Romania, Russia, Saudi Arabia, Senegal, Singapore, Slovenia, South Africa, Sri Lanka, Thailand, Togo, Trinidad and Tobago, Tunisia, Uganda, Ukraine, United Arab Emirates, Uruguay, Venezuela, Vietnam, Yemen, and Zambia.[2)] This study covers the period 1995–2010 and produces the unbalanced panel of 1041 observations. The unbalancedness of panel data is due largely to zero and missing data on FDI inflows. The Ahrens-Pincus statistic for unbalancedness is 0.92, indicating that the data set is slightly unbalanced in terms of observations for each year of data.

Data on GDP, FDI inflows, labor force, and physical capital investment were taken from UNCTAD for the period 1995–2010. Data on GDP and physical capital investment are in constant 2005 US$. The capital stock data were constructed using the perpetual inventory method. To avoid the problem of initial conditions, initial capital stocks were constructed for 1995. Data on human capital measured by mean years of schooling in the population aged 25 and over, the share of agriculture, and the indicator of financial market development measured by the ratio of M2 to GDP were obtained from the World Development Indicator (WDI).

Industrial R&D investment data for the 21 OECD countries were taken from the OECD's ANBERD Database. OECD countries include Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, and United States. Similar to the physical capital stock, the stock of R&D was computed using the perpetual inventory method. Data on capital goods imports for the sample of developing countries were extracted from the United Nations' COMTRADE Database. Following the United Nations (2003, pp. 6), classification of capital goods is based on the broad economic categories.

3.5 *Specification of stochastic frontier model*

The stochastic frontier model for 81 developing countries in equation (2) reduces to a traditional production function model if technical inefficiency effects are not present; that is, u_{it} do not exist in the model. It is possible to test for the absence of the technical inefficiency effects in the model. The test procedure employs a likelihood ratio (LR) statistic. The functional form of the stochastic frontier model can be of Cobb-Douglas or a more flexible translog form. This is also tested applying a LR test. Finally, LR tests are also employed to investigate the presence

2) Less developed or developing countries referred to in this study include 81 countries and OECD countries include 21 countries. These labels are somewhat misleading because some developing countries have similar or higher levels of GDP per capita or other indicators of development than some OECD countries.

and nature of technical change modeled through the incorporation of a time trend in the production function. Results of the hypotheses tests are reported in Table 1.

The rejection of the null of no inefficiency effects provides support for the specification of the stochastic frontier model. The translog production frontier is chosen based on the rejection of the Cobb-Douglas function as adequate. This implies that the input and substitution elasticities vary across countries. The hypotheses of no technical change and Hicks neutral technical change are also rejected. As a result, a time trend and its cross-products with conventional factor inputs in the production function are included.

Table 1. Likelihood-ratio tests of null hypotheses in the stochastic frontier production function

Null hypothesis (H_0)	LR-test statistic	Critical value (0.01)	Decision
No inefficiency effects	117.59	16.81	Reject H_0
A Cobb-Douglas function is adequate	288.10	38.93	Reject H_0
There is no technical change	258.75	18.48	Reject H_0
Technical change is Hicks neutral	235.09	16.81	Reject H_0

Note: Critical values for the hypotheses tests are obtained from the appropriate chi-square distribution.

3.6 *Stochastic frontier results: technical frontier*

The results of the translog stochastic frontier production function for 81 developing countries over the period 1995–2010 are reported in Table 2. A total of 19 out of the 30 coefficients (excluding the constant) included in the frontier function are significantly different from zero at the 5% level. Five of the six direct effects, two squared terms, 11 cross-products, and one region dummy have coefficients significantly different from zero. This further indicates the restrictiveness of the Cobb-Douglas specification in this case. Moreover, estimates from many nested models are reported. Whereas the results are quite robust across the alternative specifications, the nested models are rejected based on LR tests. The nested models are, however, useful as auxiliary models to show the robustness of the reported results and to shed light on whether the omission of specific variables is likely to cause bias in the coefficient of others.

The coefficient on the trend variable indicates that the technological progress in terms of non-R&D aspect is decreasing. The coefficient of time squared is positive but not statistically significant, indicating that there is no non-R&D aspect of technical change through time. The coefficient of time interacted with the physical capital stock (K) is positive and statistically significant, suggesting that the non-R&D aspect of technological progress has been physical-capital-saving over this period. In contrast, the coefficients of time interacted with the labor (L) and

Table 2. Maximum likelihood estimates for the stochastic frontier production function

	Main model	Nested models		
		A	B	C
Frontier function[a]				
Constant	2.760 (0.764)	28.218 (6.517)	–2.551 (7.091)	–9.460 (3.997)
K	–2.389 (0.384)	–2.817 (0.429)	–2.230 (0.418)	–2.457 (0.444)
L	2.210 (0.253)	2.477 (0.251)	2.309 (0.252)	2.512 (0.252)
HC	0.963 (0.940)	1.631 (0.931)	1.599 (0.846)	1.692 (0.877)
TRD	1.170 (0.236)	0.012 (0.505)	1.033 (0.638)	1.555 (0.453)
FRD	0.558 (0.152)	0.841 (0.176)	0.744 (0.209)	0.828 (0.201)
T	–0.291 (0.060)	–0.305 (0.061)	–0.334 (0.061)	–0.342 (0.062)
Cross-product terms				
0.5 K × K	–0.021 (0.043)	–0.015 (0.043)	–0.061 (0.042)	–0.016 (0.043)
0.5 L × L	0.140 (0.017)	0.135 (0.018)	0.126 (0.017)	0.133 (0.017)
0.5 HC × HC	0.104 (0.101)	0.105 (0.107)	0.269 (0.097)	0.278 (0.100)
0.5 TRD × TRD	–0.106 (0.019)	–0.076 (0.025)	–0.089 (0.031)	–0.092 (0.028)
0.5 FRD × FRD	0.0023 (0.0064)	0.0048 (0.0068)	0.0094 (0.0069)	0.022 (0.0081)
0.5 T × T	0.0009 (0.0009)	–0.0007 (0.001)	0.0017 (0.001)	0.0012 (0.0009
K × L	–0.092 (0.024)	–0.090 (0.024)	–0.058 (0.023)	–0.074 (0.024)
K × HC	–0.160 (0.055)	–0.172 (0.056)	–0.168 (0.054)	–0.177 (0.055)
K × TRD	0.169 (0.027)	0.179 (0.028)	0.182 (0.028)	0.170 (0.029)
K × FRD	–0.020 (0.013)	–0.025 (0.013)	–0.027 (0.013)	–0.037 (0.014)
K × T	0.014 (0.0039)	0.012 (0.0042)	0.019 (0.0042)	0.017 (0.0042)
L × HC	0.194 (0.034)	0.239 (0.035)	0.208 (0.034)	0.243 (0.034)
L × TRD	–0.087 (0.019)	–0.098 (0.019)	–0.115 (0.018)	–0.119 (0.019)
L × FRD	0.037 (0.0065)	0.039 (0.0065)	0.041 (0.0065)	0.052 (0.0069)
L × T	–0.011 (0.0022)	–0.0087 (0.0022)	–0.013 (0.0022)	–0.011 (0.0022)
HC × TRD	–0.040 (0.059)	–0.083 (0.059)	–0.065 (0.053)	–0.081 (0.056)
HC × FRD	0.078 (0.020)	0.091 (0.021)	0.073 (0.020)	0.077 (0.021)
HC × T	–0.026 (0.0057)	–0.021 (0.0058)	–0.027 (0.0057)	–0.027 (0.0057)
TRD × FRD	–0.024 (0.010)	–0.033 (0.010)	–0.030 (0.011)	–0.038 (0.012)
TRD × T	0.0048 (0.0038)	0.0061 (0.0039)	0.0029 (0.004)	0.004 (0.004)
FRD × T	–0.00037 (0.0018)	–0.00074 (0.0017)	–0.0007 (0.0018)	–0.00024 (0.001
Asia	0.020 (0.035)	–0.081 (0.034)	0.017 (0.035)	–0.096 (0.034)
America	0.050 (0.035)	0.076 (0.036)	0.053 (0.036)	0.048 (0.034)
Africa	0.127 (0.040)	0.037 (0.043)	0.179 (0.042)	0.109 (0.041)
Inefficiency model[b]				
Constant	1.689 (0.662)	9.677 (1.316)	–2.022 (1.178)	–4.709 (3.134)
CGI	–0.077 (0.028)	–0.402 (0.058)	0.109 (0.060)	0.245 (0.144)
FDI	–0.0025 (0.024)	–0.015 (0.015)	–0.038 (0.022)	–0.379 (0.208)
FMD	0.228 (0.024)	—	0.243 (0.030)	—
AY	1.256 (0.090)	1.416 (0.185)	—	—
Log likelihood	–26.59	–36.84	–49.12	–73.97
LR test[c]	—	20.49***	45.06***	94.75***

Notes: Standard errors are in parentheses. [a] All continuous variables in the frontier function are in natural logarithms, except the time trend. [b] A negative sign on the coefficient of a z_{it} vector variable represents a reduction in inefficiencies. [c] Compares the log-likelihood of the nested model with that of the main model.
Source: Authors' estimation.

human capital (*HC*) are negative and statistically significant, suggesting that the non-R&D aspect of technological progress has been labor-using and human-capital-using over this period. Visually, this indicates that the isoquant shifting inwards at a faster rate over time in the labor-intensive and human-capital-intensive parts of the input space. This is most likely a consequence of the increasing relative cost of employing skilled labor as the process of development continues in developing countries. The coefficient of time at the sample mean for all developing countries and at the sample mean for Laos is −0.01 and −0.05, respectively, indicating that the decline of non-R&D aspect of technical progress over the sample period is 1% per year for the developing countries and 5% per year for Laos.

In contrast, the coefficients on the trade and FDI weighted R&D indicate that the R&D aspect of technological progress is rapid. The coefficient of *TRD* at the sample mean for all developing countries and at the sample mean for Laos is 0.10 and 0.11, respectively, indicating that the rise of R&D aspect of technical progress with respect to trade over the sample period is 10% per year for the developing countries and 11% per year for Laos. Similarly, the coefficient of *FRD* at the sample mean and at the sample mean for Laos is 0.03 and 0.10, respectively, indicating that the rise of R&D aspect of technical progress with respect to FDI inflows over the sample period is 3% per year for the developing countries and 10% per year for Laos. Taken together the impact of trade and FDI, R&D aspect of technological progress is 13% per year for the developing countries and 21% per year for Laos.

Since the overall technological progress is equal to the sum of non-R&D and R&D aspects, there is rapid technical change. More precisely, the annual average of technological progress is 12% for the developing countries and 16% per year for Laos. Interestingly, it is the contribution of the stock of foreign technical knowledge that explains this positive technological progress.

There is only the coefficient on the region dummy of Africa that is statistically significant. Since the region dummy of Europe was left out of the model, the estimated region dummies are interpreted relative to the developing countries in Europe. The coefficient on the Africa dummy is 0.127, indicating that the developing countries in Africa have higher initial level of technology than those in Europe by about 13%.

It is convenient to interpret the estimated coefficients of the technical frontier in terms of the input elasticities, and these and returns to scale calculated for all countries and for Laos are present in Table 3. Row 1 of Table 3 reports the elasticities evaluated at the mean of the data for the entire period and all countries, while rows 2-5 report them for Laos. The results appear plausible and compare well with those from the previous literature. At the mean for the entire

Table 3. Input elasticities of output and elasticity of scale

	K	L	HC	TRD	FRD	RTS
All countries (1995–2010)	0.630 (0.052)	0.152 (0.034)	0.027 (0.100)	0.100 (0.043)	0.025 (0.019)	0.934
Laos (1995–2010)	0.292 (0.037)	0.444 (0.029)	0.242 (0.080)	0.110 (0.028)	0.103 (0.018)	1.191
Laos (1995–2000)	0.261 (0.063)	0.538 (0.038)	0.442 (0.097)	–0.023 (0.033)	0.112 (0.025)	1.330
Laos (2001–2005)	0.248 (0.036)	0.452 (0.031)	0.223 (0.093)	0.169 (0.033)	0.106 (0.019)	1.198
Laos (2006–2010)	0.394 (0.039)	0.295 (0.030)	–0.035 (0.083)	0.235 (0.043)	0.085 (0.019)	0.974

Note: standard errors are in parentheses.
Source: Authors' estimation.

sample the elasticity of output with respect to physical capital is 0.63, for labor 0.15, and for human capital 0.03. The estimated capital elasticity is within the range estimated for developing countries by Koop et al. (1999) and Henry et al. (2009). However, the estimated labor elasticity and returns to scale are lower than that found by Henry et al. (2009). But this difference may result from different group countries and period under examination.

Table 3 also shows that Laos receives the large technological contribution to output from foreign R&D through trade and FDI. The contribution of trade is estimated to be 10 percentage points higher than the size of that received for the entire sample of countries as a whole, whereas the contribution of inward FDI is estimated to be substantially higher than that of the entire sample. To gain better understanding on the contribution of foreign R&D to Laos' output, the input elasticities are evaluated at the actual observations for Laos over sub-sample periods. It is found that foreign R&D embodied in capital goods imports contributes to Laos' output the most in the period 2006–2010, whereas that embodied in FDI inflows is quite stable. Indicated by the elasticity of scale, the Laos' production function is characterized by increasing returns to scale. This means that accessing to larger market can bring greater benefit to its entire economy.

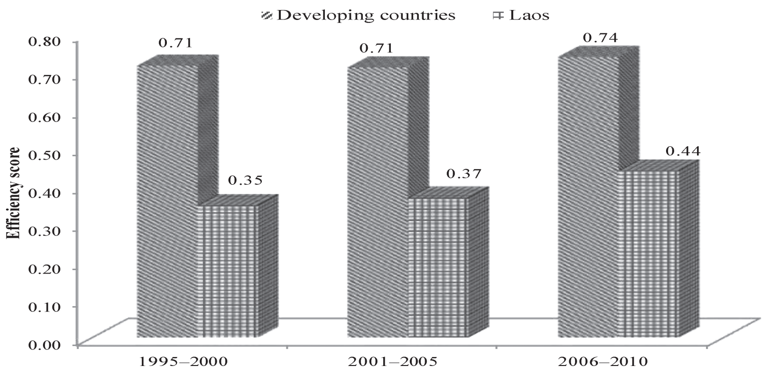
3.7 *Stochastic frontier results: inefficiency model*

To gain better understanding of the efficiency determinants for developing countries, it is important to investigate the inefficiency model. The results are shown in Table 2. Because the explained variable in the model is inefficiency, a negative sign on the coefficient of an explanatory variable represents an increase in efficiency. It is found that all variables have the expected sign, the exception being the variable *FMD* (financial market development). The coefficient on *CGI* is − 0.077, indicating that other things being equal, a 10% increase in capital goods imports decreases the inefficiency by 7%. This result points to an influence of international trade on the absorption of and efficiency with which foreign technology is utilized. In particular, an increase in actual levels of machinery imports is shown to raise national efficiency scores. The result is consistent with those of Griffith et al. (2004), Kneller (2005) and Kneller and Stevens (2006) for OECD countries and Henry et al. (2009) for developing countries. The coefficient on *FDI* is not statistically significant but shows a sign of reducing inefficiency. In the case of *AY*, a 10% increase in the share of agriculture in GDP raises the inefficiency score by 12.6%. This confirms the argument that other things being equal, higher agricultural intensity increases distance from the production frontier.

The estimated coefficient on *FMD* is positive. The negative effect of financial development on growth is also found in Akinlo (2004) who applies an error-correction model to investigate the causality between financial development and growth in Nigeria. This implies that countries with a larger financial market will be less efficient than those that have a smaller financial market, possibly resulting from high capital flight that the financial market generates. This result suggests that steps to equalize the legal and administrative playing field for domestic investors and to promote a stable macroeconomic environment could contribute to stemming capital flight.

3.8 *Stochastic frontier results: efficiency level*

Efficiency levels for all developing countries and for Laos can be estimated using equation (9) and are illustrated in Figure 3. As shown in Figure 3, the Laos' efficiency score increases from 0.35 for the period 1995–2000 to 0.44 for the period 2006–2010, whereas the efficiency score for all developing countries rises from 0.71 to 0.74 over the same period. It is noticeable that a positive change in production efficiency is rapid since 2000. Based on our estimated



Source: Authors' estimation.

Figure 3. Comparison of average efficiency score between Laos and developing countries

efficiency, the technical efficiency change for Laos is about 1.96% per year over the sample period. Among neighboring countries, this performance compares favourably with Thailand (0.83% decline per year), Vietnam (0.2% decline per year), and China (0.17% increase per year). The Lao rate of technical efficiency improvement is clearly encouraging. Sustaining it over an extended period will also sustain economic growth.

3.9 *Contribution of trade and FDI to production efficiency in Laos*

Since trade and inward FDI can contribute to efficiency, their contributions are worth considering. Trade in this context is defined to include the influences of trade via changes in the volumes of capital goods imports on efficiency. Similarly, FDI is defined to include the influences of inward FDI on efficiency.

Table 4 reports the contribution of trade and inward FDI to Laos' production efficiency. Over the period 1995–2010, efficiency score is estimated to be 0.38 and largely contributed by trade (25.6%) relative to the contribution of FDI inflows (0.2%). That is for Laos with a gross efficiency score of 38% over the period 1995–2010, efficiency would be 27.4% were it not for the positive effect that trade has on efficiency levels. Table 4 also identifies the average contribution of trade and FDI for sub-sample periods. There is a suggestion from Table 4 that the effect of trade on efficiency has increased with the general tendency for Laos to have become more open to international trade over time. The effect of international trade on Laos' efficiency rose from 25.6% during 1995–2000 to 26.8% during 2001–2005 and to 32.5% during 2006–2010. Consequently, the influence of trade on efficiency and technology transfer is non-negligible, and indicates the important role of trade in enhancing productivity growth in Laos.

However, the effect of inward FDI on Laos' production efficiency is small, estimated to be 0.23% over the sample period. The combined effect of trade and inward FDI on national efficiency in Laos is also small relative to the individual effect of trade. This suggests that the

Table 4. Contribution of trade and FDI to Laos' production efficiency (%)

Contribution channel	Estimated contribution to efficiency (%)			
	1995–2000	2001–2005	2006–2010	1995–2010
Trade	25.57 (0.87)	26.75 (2.86)	32.46 (2.33)	27.80 (3.54)
FDI inflows	0.20 (0.04)	0.27 (0.11)	0.22 (0.07)	0.23 (0.08)
Trade and FDI inflows	25.62 (0.85)	26.82 (2.88)	32.52 (2.31)	27.86 (3.54)

Note: Standard deviations are in parentheses.
Source: Authors' estimation.

urgent reform is needed to improve the country's absorptive capacity and to attract more FDI inflows.

4. Conclusion

Between 1995 and 2010, production efficiency in Laos increased by 31.3% from 0.35 in 1995 to 0.46 in 2010. This occurred even though some of the macroeconomic conditions in Laos worked against the interests of Lao people. The analysis of the relationship between the combined effect of trade and FDI and production efficiency provided in this paper suggests that approximately 28% of the average efficiency over the period 1995–2010 can be attributed to opening up a country for international trade and FDI.

Imports of capital goods and FDI inflows grew significantly over the period 1995–2010, but trade balance has been in deficit and most FDI inflows have concentrated on the hydropower and mining sectors. The analysis provided in this paper suggests that this strategy had a high pay-off in terms of improved efficiency and that additional FDI inflows offer the opportunity for further enhancing production efficiency. Furthermore, there is now a high return to allowing capital goods imports for domestic production.

The benefits of increases in capital goods and in inward FDI, measured in terms of efficiency improvement, must of course be compared with its costs. Nevertheless, the results of this study confirm that in a country like Laos, where physical and knowledge capital are primitive, either expanding international trade or attracting FDI or some combination of the two alternatives are effective ways of improving production efficiency.

To some extent, the short-term nature of the analysis of this paper produces estimates of the efficiency-increasing effects of trade and FDI that should be regarded as lower bounds. The longer-term dynamic effects of allowing international trade expansion and attracting FDI would include impacts not fully captured by the analysis of this paper. Large production efficiency at the national level would be affected. The effects would include the access of a larger variety of intermediate products and capital equipment by many rural people, which enhances the productivity of their own resources. The structure of domestic production would be affected as trade and FDI provide channels of communication that stimulate cross-border learning of production methods, product design, organization methods, and market conditions. The flow of market-related information would be greatly facilitated and economic efficiency would improve. The existence of technological and knowledge externalities embodied in capital goods imports and inward FDI can counterbalance the effects of diminishing returns to capital accumulation and lead to sustained economic growth. Finally, trade and FDI can raise the productivity in the development of new technologies or the imitation of foreign technologies, thereby indirectly affecting the productivity level of the entire economy.

Unfortunately, not all of the effects of increases in trade and FDI would necessarily be positive. In Laos, many infant industries in the manufacturing sector are being set up and can be weakened or forced to go out of the market as FDI increases domestic competition. Furthermore, since most FDI inflows concentrate on the mining and hydropower, they can lead to the scarcity of water resources for rural people through increased use for mining activities and hydropower development. Finally, importing more capital goods can lead to more severe trade deficit which could result in more macroeconomic fluctuation. The expansion of trade and FDI in Laos has the potential to raise production efficiency, but also the potential to cause some forms of macroeconomic instability and environmental deterioration if more prudent macroeconomic policies are not designed and standards of governance are not raised simultaneously.

References

ADB (Asian Development Bank) and the WB (World Bank). (2007). *Reducing investment climate constraints to higher growth.* Mandaluyong (Philippines): ADB and the WB.

Aigner, D., Lovell, C., and Schmidt, P. (1977). Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics, 6*, 21–37.

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

Akinlo, A. E. (2004). Foreign direct investment and growth in Nigeria: An empirical investigation. *Journal of Policy Modeling, 26*, 627–639.

Alfaro, L., Chanda, A., Kalemli-Ozcan, S., and Sayek, S. (2004). FDI and economic growth: The role of local financial markets. *Journal of International Economics, 64*, 113–134.

Battese, G. E., and Coelli, T. J. (1995). A model for technical inefficiency effects in a stochastic frontier production function for panel data. *Empirical Economics, 20*, 325–332.

Blomstrom, M., and Sjoholm, F. (1999). Technology transfer and spillovers: Does local participation with multinationals matter? *European Economic Review, 43*, 915–923.

Cameron, G., Proudman, J., and Redding, S. (2005). Technological convergence, RandD, trade and productivity growth. *European Economic Review, 49*, 775–807.

Ciruelos, A., and Wang, M. (2005). International technology diffusion: Effects of trade and FDI. *Atlantic Economic Journal, 33*, 437–449.

Coelli, T., Perelman, S., and Romano, E. (1999). Accounting for environmental influences in stochastic frontier models: With application to international airlines. *Journal of Productivity Analysis, 11*, 251–273.

Geroski, P. A. (1995). Innovation and competitive advantage. *Economic Department Working Papers, No.*

159. Paris: OECD.

Griffith, R., Redding, S., and Van Reenen, J. (2004). Mapping the two faces of RandD: Productivity growth in a panel of OECD industries. *Review of Economics and Statistics, 86*, 883–895.

Griliches, Z. (1969). Capital-skill complementarity. *Review of Economics and Statistics, 51*, 465–467.

Grossman, G., and Helpman, E. (1991). *Innovation and growth and growth in the global economy.* Cambridge, MA: MIT Press.

Henry, M., Kneller, R., and Milner, C. (2009). Trade, technology transfer and national effciency in developing countries. *European Economic Review, 53*, 237–254.

Islam, N. (1995). Growth empirics: A panel data approach. *Quarterly Journal of Economics, 114*(4), 1127–1170.

Iyer, K. G., Rambaldi, A. N., and Tang, K. K. (2008). Efficiency externalities of trade and alternative forms of foreign investment in OECD countries. *Journal of Applied Econometrics, 23*, 749–766.

Kalirajan, K. (1981). An econometric analysis of yield variability in paddy production. *Canadian Journal of Agricultural Economics, 29*, 283–294.

Kneller, R. (2005). Frontier technology, absorptive capacity and distance. *Oxford Bulletin of Economics and Statistics, 67*, 1–24.

Kneller, R., and Stevens, P. (2006). Frontier technology and absorptive capacity: Evidence from OECD manufacturing industries. *Oxford Bulletin of Economics and Statistics, 68*, 1–21.

Koop, G., Osiewalski, J., and Steel, M. (1999). The components of output growth: A stochastic frontier analysis. *Oxford Bulletin of Economics and Statistics, 61*, 455–487.

Lichtenberg, F. R., and van Pottelsberghe de la Potterie, B. (1998). International RandD spillovers: A comment. *European Economic Review, 42*, 1483–1491.

Mankiw, N. G., Romer, D., and Weil, D. N. (1992). A contribution to the empirics of economic growth. *Quarterly Journal of Economics, 107*, 407–437.

Meeusen, W., and van den Broeck, J. (1977). Efficiency estimation from Cobb-Douglas production function with composed error. *International Economic Review, 18*, 435–444.

Pitt, M., and Lee, M.-F. (1981). The measurement and sources of technical inefficiency in the Indonesian weaving industry. *Journal of Development Economics, 9*, 43–64.

Pritchett, L. (2001). Where has all the education gone? *World Bank Economic Review, 15*, 367–391.

UNCTAD (United Nations Conference on Trade and Development). (2010, September 17). *UNCTADstat*. Retrieved May 27, 2011, from UNCTAD Web site: http://unctadstat.unctad.org/ReportFolders/reportFolders.aspx

United Nations. (2003). Statistical Papers. *Classification by Broad Economic Categories*. New York: United Nations.

Wang, H.-J., and Schmidt, P. (2002). One-step and two-step estimation of the effects of exogenous variables on technical efficiency levels. *Journal of Productivity Analysis, 18*(2), 129–144.

Warr, P. (2010). Roads and Poverty in Rural Laos: An Econometric Analysis. *Pacific Economic Review, 15*(1), 152–169.

World Bank. (2011a, July 28). *World Development Indicators and Global Development Finance*. Retrieved September 9, 2011, from The World Bank Web site: http://databank.worldbank.org/ddp/home.do?Step=1andid=4

World Bank. (2011b). Sustaining growth, coping with rising uncertainty. *Lao PDR Economic Monitor 2011*. World Bank.