Cross-border Activities, Human Capital and Efficiency: A Stochastic Frontier Analysis for OECD Countries

(JEL Category: F2, F43, O47)

(Keywords: immigration, foreign direct investment, international trade, human capital, stochastic frontier model)

Paper Submission
Fall 2009 MIEG Meetings
Pennsylvania State University

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Proposed Paper

As governments lowered their policy barriers to foreign countries in the 1980s and 1990s, the pace of globalization increased rapidly during this period. The World Bank (2008) defines economic globalization as the rapid rise in the sharing of economic activities in the world between people of different countries. This suggests that these cross-border economic activities can be placed into three broad groups: (i) the cross-border exchange of goods and services via international trade, (ii) the establishment and operation of a firm in the foreign country by residents of the host country via foreign direct investment (FDI), and (iii) labor services offered by residents of the host country to residents of the foreign country via labor migration. Evidence that goods, capital and labor services have become increasingly globalized is seen in the following facts: the value of trade (goods and services) as a percentage of world GDP has increased from 42.1 percent in 1980 to 62.1 percent in 2007, foreign direct investment has increased from 6.5 percent of world GDP in 1980 to 31.8 percent in 2006, and the number of foreign workers has increased from 78 million people (2.4 percent of the world population) in 1965 to 191 million people (3.0 percent of the world population) in 2005 (IMF, 2008).

This has led to a contentious debate on whether countries that are increasingly economically integrated with the rest of the world have seen an increase in economic growth. Consequently, there have been a vast number of empirical studies focusing on the impact that relatively more outward oriented economies have on economic growth and productivity. Studies of outward oriented activities include all three forms of cross-border activities; international trade (Frankel and Romer, 1999; Irwin and Terviö, 2002; Edwards, 1998 and Lee, Ricci and Rigobon, 2004); foreign direct investment (Borensztein et al, 1998; Alfaro et al, 2003; Balasubramanyam et al, 1996) and migration (Doledo et al, 1994; Lundborg and Sergestrom, 2002; Ortega and Peri, 2008; Morley, 2006).

When examining this issue most empirical studies use a cross-country regressions framework on a sample of developed and developing countries. Apart from the basic factors of production, growth accounting regressions look for additional determinants of growth which results in these regressions treating all determinants of output growth as inputs. Conceptually, this is incorrect since many included determinants may only indirectly affect output (Miller and Upadhaya, 2000). Economists typically explain output growth as the accumulation of factor inputs and the growth of total factor productivity. So these additional determinants of output growth may affect the efficiency of real inputs, physical capital and labor and, thus, directly affect factor productivity.

In general, productivity growth comprises of two mutually exclusive parts, technological change and efficiency change. While there are two distinct sources of productivity growth, the literature tends to focus almost entirely on technology change (e.g. Coe and Helpman, 1995) and its determinants rather than efficiency changes and its determinants (e.g. Boyle and McQuinn, 2004). However, an alternative empirical methodology, stochastic frontier analysis, which we use in this study, allows us to distinguish technology change from efficiency change in explaining productivity growth. Viewing output growth from the perspective of a production possibilities frontier, countries can be thought of as operating either on or within the frontier,
with the distance from the frontier reflecting inefficiency. Over time, a country’s frontier can shift, indicating technological change, or a country can move towards or away from the frontier, which represents efficiency changes. Moreover, a country can move along the frontier by changing inputs. So productivity growth can be seen as being made up of three components: efficiency change, technology change and input change with the first two components being the “productivity change” (Koop et al 2000).

In this paper, we reexamine the growth effects of outward oriented economies by using stochastic frontier analysis to measure the efficiency externalities of all three forms of cross-border activities – international trade, FDI and migration. We thus contribute to the existing literature in several important ways:

First, we adopt a comprehensive approach to outward orientation by including all three channels of cross-border activities. Earlier studies using stochastic frontier analysis have focused on either trade or foreign direct investment or both (e.g. Mastromarco and Ghosh, 2009; Kneller and Stevens, 2006; Iyer et al, 2008). Not including all channels of outward orientation can result in a bias in the estimation of the growth impact of others, or an underestimation of the growth effects of outward orientation in general (Hejazi and Safarian, 1999).

Second, our study, to the best of our knowledge, is the first to examine the efficiency impact of immigration on total factor productivity. In 2005, six of the top ten destination countries for immigrants in the world were OECD countries with 27.7 percent of immigration being in high-income OECD countries (World Bank, 2005). So immigration can potentially be an important source of productivity gains in OECD countries.

Third, we incorporate human capital into the stochastic frontier model and thus acknowledge the endogenous growth models of Lucas (1988) and Romer (1990) that use a theoretical framework where persistent economic growth is conditional on the accumulation of human capital. Incorporating human capital into the stochastic frontier model can reveal how human capital stock in host countries impacts the efficiency levels affected by each of the three cross-border activities. It is the level of human capital that determines how well the economy can absorb the transfer of knowledge and technology that occurs through international trade, FDI flows or migration. This has particular relevance for the immigration channel of outward orientation since immigrants can contribute to the host country’s human capital base by bringing their own skills to the host country and by influencing the natives’ knowledge accumulation; thus they can have an even further impact on total factor productivity via its impact on human capital. Also, by including human capital into the empirical framework we can ensure that efficiency changes due to human capital are not interpreted as changes arising from trade, FDI or immigration.

1 Empirical studies by Benhabib and Spiegloal (1994), Dinopoulos and Thompson (2000) and Bils and Kelnow (2000), which factor in the suggestion of endogenous growth models that human capital is a factor influencing productivity growth, find its impact to be significant.
Thus, we estimate a stochastic production frontier for 24 OECD countries for the period 1993-2004 to determine how total factor productivity can increase through international trade, foreign direct investment, and immigration. While a lot of the earlier empirical work has been done on developing countries we limit our work to studying OECD countries. This is because the stochastic frontier model assumes a common production technology frontier for all countries in the sample, and pooling developed and non-developed countries together would be erroneous conceptually.

**Proposed Empirical Model**

We consider a standard growth model with externalities (Romer, 1986; Lucas, 1988). The product of a country $i$ at time $t$, $Y_{it}$, is determined by the levels of labour input and private capital, $L_{it}$ and $K_{it}$. The level of technology or multi-factor productivity is given by the parameter $A$. The production function is expressed as follows:

$$Y_{it} = F(A_{it}, L_{it}, K_{it})$$

(1)

The parameter $A_{it}$ describes the Hicks-neutral productivity and is assumed to be affected by a set of variables, $Z_{it}$, which are external to an individual country. Equation (1) can thus be rewritten as:

$$Y_{it} = A_{it}(Z_{it})F(L_{it}, K_{it})$$

(2)

Equation (2) indicates that the level of total factor productivity, $TFP_{it} = A_{it}(Z_{it})$, depends on the (embodied and disembodied) technological progress, $A_{it}$, and on external covariates such as a set of growth determinants, $Z_{it}$. Among these growth determinants we can consider, for instance, the contribution of human capital and the outward orientation measures such as international trade, migration, and FDI.

Following the efficient frontier literature (e.g., Färe et al., 1994), the $TFP_{it}$ component can be further decomposed into the level of technology, $A_{it}$, an efficiency measure, $\tau_{it}$, which depends on the covariates $Z_{it}$, and a measurement error, $w_{it}$, which captures the stochastic nature of the frontier,

$$TFP_{it} = A_{it}\tau_{it}(Z_{it})w_{it}$$

(3)

where $0 < \tau_{it} < 1$. $^2$ By writing equation (2) in translog form we thus have:

$$y_{it} = \beta_0 + \beta_1 k_{it} + \beta_2 l_{it} + \beta_3 \frac{1}{2} k_{it}^2 + \beta_4 \frac{1}{2} l_{it}^2 + \beta_5 k_{it} l_{it} + \beta_6 t + \beta_7 t^2 + \frac{1}{2} \beta_8 t k_{it} + \frac{1}{2} \beta_9 t l_{it} - u_{it} + v_{it}$$

(4)

where lower case letters indicate the previously defined variables in natural logs [i.e., $y_{it} = \ln Y_{it}$], $u_{it} = -\ln(\tau_{it})$ is a non-negative random variable and $v_{it} = \ln(w_{it})$. Non neutral technology is captured by a time trend, $t$, in translog form in order to take into account the possibility of non-neutral technological shocks. Expected inefficiency is specified as:

$^2$ When $\tau_{it} = 1$ there is full efficiency, in this case the firm $i$ produces on the efficient frontier.
$$E(u_{it}) = z_{it} \delta,$$

(5)

where $u_{it}$ are assumed to be independently but not identically distributed, $z_{it}$ is the $(1 \times K)$ vector of covariates which influence TFP via inefficiency, and $\delta$ is the $(K \times 1)$ vector of coefficients to be estimated.

We thus model the inefficiency of OECD countries as a function of:

\[
\begin{align*}
    u_{it} &= \delta_0 + \delta_1 FDI_{it} + \delta_2 \text{trade}_{it} + \delta_3 \text{impME}_{it} + \delta_4 \text{SEC}_{it} + \delta_5 \text{TER}_{it} + \delta_6 \text{Migr}_{it} + \delta_7 \text{SEC}^*\text{Migr}_{it} + \delta_8 \text{TER}^*\text{Migr}_{it} + \\
    &+ \delta_9 \text{SEC}^*\text{FDI}_{it} + \delta_{10} \text{TER}^*\text{FDI}_{it} + \delta_{11} \text{SEC}^*\text{trade}_{it} + \delta_{12} \text{TER}^*\text{trade}_{it} + \\
    &+ \delta_{13} \text{SEC}^*\text{impME}_{it} + \delta_{14} \text{TER}^*\text{impME}_{it} + \epsilon_{it}
\end{align*}
\]

(6)

where, FDI represents the foreign direct investments of country $i$ at time $t$; trade measures trade openness and is equal to the ratio of the sum of imports and exports of manufacturing goods to GDP; impME indicates imports of foreign physical capital; SEC and TER are two measures of human capital in the population of country $i$ at the end of year $t$; Migr is migration as inflows of foreign population; SEC*Migr, TER*Migr, SEC*FDI, TER*FDI, SEC*trade, TER*trade, SEC*impME, and TER*impME are the interaction terms of the openness indicators and human capital in the country. The hypothesis here is that the effect of all the cross-border activities on efficiency depends on the level of human capital. Finally, $\epsilon_{it}$ is a white noise.

In order to estimate the parameters of the production function in equation (4) together with the parameters in equation (6), we will use a single-stage Maximum Likelihood procedure proposed by Kumbhakar (1991) and Reifschneider and Stevenson (1991), in the modified form as suggested by Battese and Coelli (1995) for panel data with time-variant technical efficiency.
References


