Evaluating the Role of Migration on Technical Efficiency

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Introduction

Due to increased globalization and free market economy, last decade of twenty century and first decade of twenty first century saw an increase in brain drain due to migration of people across countries. Increased migration into the west coincided with the end of cold war and also breaking up of the former communist bloc countries. Even though the collapses of political systems lead to increased migration in the last century, the economic incentives and increased globalization has been the driving force to migration in the current century. This is evident from increased migration between European countries due the formation of European Union. However, in Southeast Asia, the issue of migration is due to rampant movement away from rural to urban cities. Migration between countries and away from rural areas has become a global trend rather than an exception. According to International Organization for Migration, migration is considered as one of the defining global issues of the twenty-first century. About 3% of the world's population, or 192 million people, live outside their place of birth.

Studies on the political dimensions of international migration has been the focus of numerous research based on neoclassical economic theory (Sjaastad 1962; Todaro 1969), segmented labor-market theory (Piore 1979), and world-systems theory (Sassen 1988). These theories suggest international migration depends on the global supply and demand for labor, intensive labor (farm labor), and natural product of world development respectively. Alternatively, studies have also examined the importance of migration on technical efficiency using stochastic frontier analysis and also two-step process linear programming-tobit model using survey data (Wouterse, 2008). In this paper, we digress to examine the importance of migration on technical efficiency at the aggregate level using 76 countries world-wide for the period, 1961-2007. Specifically, we examine the importance by treating migration as an undesirable output for the domestic country in a hyperbolic distance function following Shaik, 1999. Second, we evaluate the distance function under alternative returns to scale assumptions – constant returns to scale (CRS) and variable returns to scale (VRS). The following two propositions correspond to the two objectives of the paper:

Proposition 1: *Quantifying the importance of migration on technical efficiency using hyperbolic distance function under CRS and VRS.*

Even though there are variations in the global supply and demand for labor, the major reasons of migration include the search for better living conditions, escape from territories with active war operations and escape from justice. The first listed reason is the most popular: millions of people aspiring to improve their lives immigrate to more prosperous countries for a permanent residence. The largest influx of migrants falls on the USA and Western Europe. One of the explanations for incentives of these countries to accept the migrants is labor supply shortage for low-paid jobs, therefore foreign labor power industrial intake is the best solution for satisfying the cost minimization strategy. The other reason is the contrary: these countries attract highly qualified workforce (brain drain trend). So the question is does this brain drain increase, decrease or neutral to technical efficiency changes of domestic agriculture economy? The importance is evaluated by treating migration as an undesirable output and without migration in a hyperbolic distance function.

The technology that transforms input vector $x = (x_1, ..., x_n)$ into desirable outputs $y = (y_1, ..., y_m)$ and undesirable output (migration or brain drain) $R = (R_1, ..., R_o)$ can be represented by output set. With output set, technical efficiency is measured as the ability to increase output taking input quantities as given. Hence, an efficiency score above one indicate by how much the output (efficiency) can be increased (improved) given inputs. The output set is effectively utilized in the computation of the migration accounted technical efficiency measure using the primal approach. Migration or brain drain endogenized as an undesirable output with a weak disposability assumption is modeled to compute the technical efficiency measure. Under a weak disposability risk assumption, a reduction in risk requires a reduction in desirable output with a fixed input or requires an increase in input usage to maintain the same desirable output.

Weak disposal output reference set satisfying constant returns to scale, strong disposability of desirable outputs and inputs, and weak disposability of migration can be defined as:

$$(1) \qquad P_w^T(x) = \left\{ \begin{array}{l} y : x \, can \; produce \left(y_g, R\right) \text{in year} \, T; \\ 0 \le \theta \le 1 \;\; implies \;\; \theta\left(y_g, R\right) \in P_w^T(x) \quad R' < R \Rightarrow \theta\left(y_g, R'\right) \in P_w^T(x) \end{array} \right\}$$

where $P_w^T(x)$ is a weak disposable output set.

The weak disposable output set can be represented by the output distance function and the nonlinear programming problem used to calculate the output measure can be evaluated for each country in year *t* as:

$$D_o^T\left(x^t, y_g^t, R^t \mid crs\right)^{-1} = \max_{\theta,\text{z}} \left\{\theta : \left(x^t, \theta\, y_g^t, \theta^{-1} R^t\right) \in P_w^T\left(x^t\right)\right\}$$

or

$$\max_{\theta,\text{z}} \theta \quad s.t. \quad \theta\, y_g^t \le Y_g z \qquad \text{where} \quad Y_g = \left(y_g^1, y_g^2, ..., y_g^T\right) \tag{2}$$

$$\theta^{-1}\, n^t = R\, z \qquad R = \left(r^1, r^2, ..., r^T\right)$$

$$x^t \ge X\, z \qquad X = \left(x^1, x^2, ..., x^T\right)$$

$$z \ge 0$$

From (2), ***z*** is a {*Tx1*} vector of intensity variables with $z \ge 0 (z = 1)$ identifying the constant return to scale (variable return to scale) boundaries of the reference set, and the equal sign on the second constraint indicates the weak disposability assumption on migration with a less than (greater than) sign representing the strong disposability of desirable output (input).

To evaluate the importance of migration, the above weak disposable output set is compared to the strong disposable output set without migration. The strong disposal output reference set satisfying constant returns to scale can be represented by the output distance function and the linear programming problem as:

$$D_o^T\left(x^t, y_g^t \mid crs\right)^{-1} = \max_{\theta,\text{z}} \left\{\theta : \left(x^t, \theta\, y_g^t\right) \in P^T\left(x^t\right)\right\}$$

or

$$\max_{\theta,\text{z}} \theta \quad s.t. \quad \theta\, y_g^t \le Y_g z \qquad \text{where} \quad Y_g = \left(y_g^1, y_g^2, ..., y_g^T\right) \tag{3}$$

$$x^t \ge X\, z \qquad X = \left(x^1, x^2, ..., x^T\right)$$

$$z \ge 0$$

The difference between the equation (2) and (3) quantifies the importance of migration on technical efficiency by country.

Proposition 2: Differential impact of migration can be observed across geographical regions and income groups.

Migration decisions depend upon numerous factors: both economic and social, - and often may be based on a combination of these factors, which include education (Ma and Liaw, 1994; World Bank, 2008), age (Millington, 2000), family composition (Clark and Withers 1999), labor market conditions (Dustmann, et al., 2003), income (Graves, 1979), etc. The average levels of these factors may vary significantly from region to region even within the same country letting alone different countries. Consequently, the amount of migration we observe differs across countries (income groups) of the world. Further, if the effect of migration on technical efficiency can be found and quantified, it should not be identical for different regions and income groups. We show subsequently in this paper that differential impact of accounting for migration can be observed across geographical regions and income groups due to resource endowments , labor demand and supply, etc.

The purpose of this paper is to estimate migration adjusted technical efficiency measures for 76 countries agriculture sector using hyperbolic distance function framework under CRS and VRS assumptions. Specific objectives of the paper are to estimate the difference with and without accounting for migration across geographical regions and income groups of the world agriculture sector. The study uses 76 country level agricultural sector data for the period, 1961-2007.

3. Input, output and migration agriculture sector data

This study is based on Food and Agricultural Organization data available online. The study includes 76 countries worldwide for the period 1961 to 2007. For the output and the five inputs, a quantity index with 1999-2001 as the base year was constructed.

Due to the problems of estimating multiple outputs in primal production functions, an aggregate output variable published by FAO is used in the analysis. The FAO output concept is the output from the agriculture sector net of quantities of various commodities used as feed and seed, which is why feed and seed are not included in the input series. Details on the construction of aggregate output variable are available on FAO webpage, www.fao.org.

This analysis considers only five input variables following earlier studies estimating a production function. These variables include land, labor, capital, fertilizer and livestock. The land variable includes harvested acres of cereals, fibers, fruits, nuts, oil crops, pulses, roots and tubers, rubber, spices, stimulants, sugar crops, tobacco and vegetables unlike earlier studies. The capital variable covers the total number of agricultural tractors, and number of harvesters and threshers used in agriculture. With respect to tractors, no allowance was made to the quality (horsepower) of the tractors. The labor variable refers to the economically active population in agriculture. An economically active population is defined as all persons engaged or seeking employment in an economic activity, whether as employers, own-account workers, salaried employees, or unpaid workers assisting in the operation of a family farm or business. The economically active population in agriculture includes all economically active persons engaged in agriculture, forestry, hunting, or fishing. This variable obviously overstates the labor input used in agricultural production, but the extent of overstatement depends on the level of development of the country. Following other studies on inter-country comparisons of agricultural productivity, this analysis uses the sum of nitrogen, (N) potassium, (P_2O_2) and phosphate (K_2O) contained in the commercial fertilizers consumed. This variable is expressed in thousands of metric tons.

The livestock input variable used in the study is the sheep-equivalent of five categories of animals. The categories considered are buffaloes, cattle, goats, pigs and sheep. The number of these animals is converted into sheep equivalents using conversion factors of 8.0 for buffalo and cattle and 1.00 for sheep, goats and pigs. Chicken numbers are not included in the livestock figures.

Variable accounting for migration represents the number of people born in a country other than that in which they live, including refugees, also called international migration stock .This data are extracted from the World Bank database, www.worldbank.org. For analysis, migration index with 1999-2001 as a base year was computed.

4. Empirical application and results

Proposition 1: *Quantifying the importance of migration on technical efficiency using hyperbolic distance function under CRS and VRS.*

To quantify the importance of migration equation (2) and (3) are estimated for each country under CRS and VRS assumptions. The difference suggests the importance of accounting for migration on technical efficiency measures. The results are presented under alternative groupings – by geographical regions and income groups. The classification of the geographical regions and income groups are presented in Table 1.

The analysis found evidence that migration has a significant and negative impact on efficiency measures regardless of returns to scale assumption. The magnitude of this impact, however, is influenced by the assumptions of returns to scale given the hyperbolic distance function with weak and strong disposability assumptions (based on 95% one-sided confidence intervals migration decreases technical efficiency by at least 0.0468 and 0.0806 for CRS and VRS assumptions, respectively). For VRS the effect of migration is statistically greater in size than for CRS, implying fewer negative consequences of migration when constant returns to scale are assumed. Specifically, efficiency measures for CRS are at least (on average) 0.0328 higher than those for VRS when migration factor is taken into account (based on 95% one-sided confidence interval), although they are identical in their values when migration is not accounted for.

Proposition 2: Differential impact of migration can be observed across geographical regions and income groups.

Empirical evidence shows that negative impact of migration is not consistent across different geographical geographical regions and income groups. Specifically, the least effect is observed for South Asia and East Asia & Pacific geographical regions for both CRS and VRS (the effects in these areas are not statistically different from one another). The greatest impact is produced in North America for CRS, and North America and Middle East & North Africa for VRS.

When breaking up the list of countries into five income groups and comparing efficiency measures peculiar to each group, it can be readily seen that income group is also a significant, hence important, factor influencing the migration effect. For constant returns to scale different effects are observed for two income blocks: the first block includes high income: OECD and upper middle income countries; the second includes high income: nonOECD, lower middle income and low income countries. For VRS three such blocks may be separated out: 1) upper middle income; 2) high income (both OECD and nonOECD) as well as lower middle income countries; 3) low income countries.

Note however that high income: nonOECD group includes only three countries and inference concerning this group should be taken with more caution.

5. Conclusions

Utilizing the non-parametric linear programming approach, theoretically and empirically we demonstrate -the inclusion of migration in the technical efficiency analyses would results in lower (higher) technical efficiency gains across geographical regions and income groups.

Where data is available the analysis completed here is useful technique in understanding gains from inclusion of migration. In integration traditional efficiency studies with migration, either aggregate or individual firm data can be employed. Bootstrapping techniques can also be employed in association with DEA analysis to provide still greater confidence regarding the conclusion of these analyses. In addition, the technical efficiency analysis could be extended to productivity and technical change to aid in deriving broad conclusions.

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www.worldbank.org

Table 1. List of countries for analysis

Region	Income group				
	High income: nonOECD	**High income: OECD**	**Upper middle**	**Lower middle income**	**Low income**
East Asia & Pacific	-	Japan Korea, Rep.	Fiji	Indonesia Mongolia Philippines Thailand Vietnam China	Myanmar
Europe & Central Asia	Cyprus	Austria Denmark Finland France Greece Hungary Iceland Ireland Italy Netherlands Norway Poland Portugal Spain Sweden Switzerland	Albania Bulgaria Romania Turkey	-	-
Latin America & Caribbean	Trinidad and Tobago	-	Argentina Brazil Chile Cuba Mexico Panama Peru Suriname Uruguay	Bolivia Ecuador Honduras Paraguay	-
North America	-	Canada United States	-	-	-
Middle East & North Africa	Malta	Israel	Algeria Iran, Islamic Rep. Lebanon Libya	Egypt, Arab Rep. Jordan Morocco Syrian Arab Republic Tunisia Yemen, Rep.	-
Sub-Saharan Africa	-	-	South Africa	Côte d'Ivoire Nigeria Senegal Sudan	Ghana Guinea Kenya Madagascar Niger Tanzania Togo

too few countries in High income: non OECD group

The results averaged for each region and income group across years are presented in the tables below.

Table 2. Summary by region

Region	TE without migration		TE with migration		Impact of returns to scale		Effect of migration	
	CRS	VRS	CRS	VRS	without migration	with migration	CRS	VRS
(1)	(2)	(3)	(4)	(5)	(2) / (3)	(4) / (5)	(2) / (4)	(3) / (5)
South Asia	1.0375	1.0375	1.0236	1.0132	1	1.0102	1.0133	1.0237
East Asia & Pacific	1.0678	1.0678	1.0402	1.0171	1	1.0223	1.0255	1.0489
Europe & Central Asia	1.0934	1.0934	1.0373	1.0127	1	1.0243	1.0536	1.0796
Latin America & Caribbean	1.114	1.114	1.0778	1.0292	1	1.0468	1.0324	1.0812
North America	1.1474	1.1474	1.0256	1.0111	1	1.0143	1.1186	1.1342
Middle East & North Africa	1.1597	1.1597	1.0885	1.0187	1	1.0687	1.0636	1.138
Sub-Saharan Africa	1.1057	1.1057	1.0548	1.0299	1	1.0241	1.0462	1.0726

Table 3. Summary by income group

Income group	TE without migration		TE with migration		Impact of returns to scale		Effect of migration	
	CRS	VRS	CRS	VRS	without migration	with migration	CRS	VRS
(1)	(2)	(3)	(4)	(5)	(2) / (3)	(4) / (5)	(2) / (4)	(3) / (5)
High income: nonOECD	1.081	1.081	1.0454	1.0185	1	1.0261	1.0334	1.0609
High income: OECD	1.0937	1.0937	1.0306	1.0111	1	1.0192	1.0608	1.0815
Upper middle income	1.1376	1.1376	1.0769	1.0246	1	1.0509	1.055	1.1096
Lower middle income	1.1026	1.1026	1.0662	1.0228	1	1.0425	1.0323	1.0776
Low income	1.0746	1.0746	1.0425	1.0238	1	1.0179	1.0293	1.048

Table 4. Summary by income group and region

Region	Income group	TE without migration		TE with migration		Impact of returns to scale		Effect of migration	
		CRS	VRS	CRS	VRS	without migration	with migration	CRS	VRS
(1.1)	(1.2)	(2)	(3)	(4)	(5)	(2) / (3)	(4) / (5)	(2) / (4)	(3) / (5)
South Asia	Lower middle income	1.0325	1.0325	1.0229	1.0112	1	1.0115	1.0092	1.021
	Low income	1.0408	1.0408	1.0241	1.0146	1	1.0093	1.016	1.0255
East Asia & Pacific	High income: OECD	1.0128	1.0128	1.0054	1.0019	1	1.0035	1.0074	1.0109
	Upper middle income	1.1079	1.1079	1.0509	1.0159	1	1.0348	1.0532	1.0896
	Lower middle income	1.0662	1.0662	1.0418	1.0198	1	1.0214	1.023	1.0452
Europe & Central Asia	High income: nonOECD	1.0606	1.0606	1.0371	1.0044	1	1.0324	1.0218	1.0555
	High income: OECD	1.0958	1.0958	1.0337	1.0125	1	1.0208	1.0597	1.0821
	Upper middle income	1.0921	1.0921	1.052	1.0155	1	1.0361	1.0369	1.0756
Latin America & Caribbean	High income: nonOECD	1.106	1.106	1.0801	1.0438	1	1.0343	1.0228	1.0587
	Upper middle income	1.1223	1.1223	1.0839	1.0239	1	1.0583	1.0344	1.0947
	Lower middle income	1.0974	1.0974	1.0634	1.0376	1	1.0242	1.0303	1.0564
North America	High income: OECD	1.1474	1.1474	1.0256	1.0111	1	1.0143	1.1186	1.1342
Middle East & North Africa	High income: nonOECD	1.0764	1.0764	1.0189	1.0072	1	1.0117	1.0557	1.0686
	High income: OECD	1.1145	1.1145	1.0421	1.0065	1	1.0354	1.0694	1.1071
	Upper middle income	1.1848	1.1848	1.0739	1.0312	1	1.0411	1.1022	1.149
	Lower middle income	1.1643	1.1643	1.1175	1.0143	1	1.1021	1.0382	1.1473
Sub-Saharan Africa	Upper middle income	1.2986	1.2986	1.1519	1.0504	1	1.0998	1.1252	1.2422
	Lower middle income	1.1048	1.1048	1.05	1.0307	1	1.0184	1.0509	1.0712
	Low income	1.0787	1.0787	1.0437	1.0265	1	1.0165	1.0322	1.0493

#Some statistics for interest sake:
To identify, whether the effect of migration is significant, paired t-test is performed. The null hypothesis: there is no difference in means (no effect of migration); alternative hypothesis: mean of TE without migration is greater than mean of TE with migration. The results are the following:

Table 5. Paired t-test

	95% CI	**t**	**p-value**	**Degrees of freedom**
CRS	(0.0468, Inf)	34.3526	< 2.2e-16	3571
VRS	(0.0806, Inf)	41.3121	< 2.2e-16	3571

Conclusion: the effect of migration is strongly statistically significant; moreover, migration has a negative impact on efficiency.
The effect of migration for VRS is typically greater in magnitude than for CRS. That is, efficiency measures for CRS are higher than for VRS when migration is taken into account. Test whether this difference is indeed positive:

Table 6. Paired t-test of CRS vs VRS (with migration)

	95% CI	t	p-value	Degrees of freedom
	(0.0328, Inf)	29.3526	< 2.2e-16	3571

Conclusion: the difference is significant and greater than zero; returns to scale do have an impact on efficiency measures when migration is taken into account.

Is the impact of migration consistent for all the geographical regions? F-values from one-way ANOVAs is 36.896 with p-value < 2.2e-16 (for CRS), and 43.035 with p-value < 2.2e-16 (for VRS), implying that there are differences in effect of migration for some geographical regions, i.e. migration effect is not the same for various geographical regions. Perform Tukey-Kramer test to find out between which geographical regions the difference exists.

Table 7. Tukey-Kramer test

Region	CRS	Grouping	Region	VRS	Grouping
South Asia	1.0133	A	South Asia	1.0237	A
East Asia & Pacific	1.0255	A B	East Asia & Pacific	1.0489	A
Latin America & Caribbean	1.0324	B	Sub-Saharan Africa	1.0726	B
Sub-Saharan Africa	1.0462	C	Europe & Central Asia	1.0796	B
Europe & Central Asia	1.0536	C D	Latin America & Caribbean	1.0812	B
Middle East & North Africa	1.0636	D	North America	1.1342	C
North America	1.1186	E	Middle East & North Africa	1.138	C

The same letter implies no significant difference.
#Strange results: effect of migration for Sub-Saharan Africa is the same as for Europe? Could it be explained?

Analogously, perform Tukey-Kramer test to find out between which income groups the difference exists (from ANOVA: F=26.812 (CRS), F= 24.868 (VRS)).

Table 8. Tukey-Kramer test

Region	CRS	Grouping	Region	VRS	Grouping
High income: OECD	1.0608	A	Upper middle income	1.1096	A
Upper middle income	1.055	A	High income: OECD	1.0815	B
High income: nonOECD	1.0334	B	Lower middle income	1.0776	B
Lower middle income	1.0323	B	High income: nonOECD	1.0609	B
Low income	1.0293	B	Low income	1.048	C

The same letter implies no significant difference.