The Dynamics of Productivity Changes in Agricultural Sector of Transition Countries

by

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Paper prepared for presentation at the American Agricultural Economics Association Annual Meeting, Providence, Rhode Island, July 24-27, 2005

Abstract: Relying on frontier production approach (e.g., Luenberger's shortage function), we investigated the performance of agricultural sector in transition countries and its changes over time, especially focusing on the dynamics of productivity changes. We found that; (i) CEE countries have improved their performance during the sample period whereas CIS have not; (ii) productivity changes in the last decade was attributable to the technical progress; (iii) overall performance was decelerated for the second 5-year sub-period (1997-2001) in both regions; (iv) agricultural reform has positive effects on the productivity and its components especially in CEE countries.

Key words: transition countries, productivity, directional distance function, agricultural reform

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I. Introduction

The development and performance of transition economies such as the former socialist countries in Europe and Central Asia, many of which embarked on a transition from a centrally planned economy to a more market-oriented economy during the period of 1989-1991, have been of interest to many researchers. Especially, the development of agricultural sector is of interest, because agriculture was one of the basic industries in transition countries at the beginning of transition. For example, in the transition countries of Europe and Central Asia, nearly 45% of the total population lived in rural area and the share of agriculture in GDP and employment exceeded 20% on average, in the 1980s.

Many researchers have shown some evidences that the socialist economy system and particularly the agricultural sector in the centrally planned economy were notoriously inefficient (Mathijs et al. 1997; Lerman et al. 2002). In this situation, making transit to a market-oriented system or emulating the economic order of the more successful capitalist countries has been regarded as a strategy to cure the chronic inefficiency. If this had been true, transition countries would have been improving their economic performance during the first decade after transforming their economy. This study attempts to shed some lights on these issues by estimating technical inefficiency and identifying the main sources of productivity changes during the first decade of transition.

A number of studies have investigated the performance of agricultural reform in transition countries, particularly for CEE (Central and Eastern Europe) and CIS (Commonwealth of Independent States) countries. Mathijs et al. (1997) investigated the influence of relative productivity and factor intensity on the pattern of privatization and decollectivization in transition countries. Swinnen (1999) investigated the divergent land reform strategies in CEE countries and their influences on the distributional consequences. Macours et al. (1999) focused on the differences in agricultural output and productivity changes in three groups of transition countries, i.e. CEE, CIS, and Asian transition economies. Lerman et al. (2002) provided a comprehensive analysis of agricultural land reform for 22 CEE and CIS transition countries. Lee et al. (2004) investigated productivity evolution in transition countries in Eastern Europe and Central Asia (ECA) using labor and land productivities.

Most previous studies adopted partial productivity (i.e. labor productivity) as a performance measure for the agricultural sector of transition countries.[1] However, from the perspective of empirical context, the literature on the performance of transition economies remains sparse. In addition, relatively little attention has been paid to the sources and dynamic patterns of productivity changes in these countries; e.g. Lerman et al. (2002).

This paper examines the performance of the agricultural sector in transition countries in order to investigate the differences in efficiency and technical change across countries during the first decade of transition, 1992-2001. This paper also examines the sources of productivity change in order to explore how the agricultural reform affects the performance of their agricultural sector.

[1] One exception is Lerman et al. (2003) which measured total factor productivity in the former Soviet Republics by using production function approach. They showed that total factor productivity growth in the agricultural sector was much slower than labor productivity growth.

To estimate the performance and the productivity changes, we use a frontier approach. In the frontier literature, productivity differential is often termed "(technical) inefficiency"; the inability to produce maximum output given production resources and technology.[2] Specifically, we employ a nonparametric programming approach commonly referred to as data envelopment analysis (DEA). To represent the production technology, the directional distance function, a version of Luenberger shortage function, is employed.

Total 22 transition countries in Europe and Central Asia are grouped into two circles for comparison; eleven CEE (Central and Eastern Europe) and eleven CIS (Commonwealth of Independent States, former Soviet republics) transition countries. Although CEE and CIS countries have the common heritage, the common starting point, and the common aspirations, they adopted different implementation strategies for their land reform and farm restructuring programs (Swinnen, 1999; Lerman et al., 2002). Land reform in CEE countries took the course of more liberal land market which puts greater emphasis on privatization through granting secure land rights than that in CIS countries (Macours et al., 1999; Lerman et al., 2002).

Our analysis shows that the performance of CEE countries has been more prominent than that of CIS countries during the last decade and the productivity growth is mainly attributable to the technical progress. Moreover, the two country groups have experienced quite different dynamics of productivity changes over time, i.e. CEE countries have enjoyed both efficiency and technical improvement while CIS countries suffered from efficiency decline and sluggish productivity during

[2] Economic efficiency is often considered as the sum of technical efficiency and allocative efficiency. Due to the lack of information on prices, we only focus on technical efficiency in this paper. In the rest of this paper, therefore, we use technical efficiency and efficiency interchangeably.

the first half of the decade after transition. Our result also suggests that the status of agricultural reform has positive effects on the productivity growth.

We first examine data and empirical model employed in this study and present estimation results and their implications. Then we give conclusion and some suggestions for future research.

II. Data and Empirical Model

1. Data

The Data used for this study are obtained from FAO (2004), United Nations (2004), ILO (2004), USDA (1998), and World Bank (1996) for the period of 1992-2001. For cross-country comparison, a consistent and well organized data set is essential. Since FAOSTAT (FAO, 2004) provides unified data set on agriculture for each country, we used FAOSTAT as a base data. However, we partially corrected the data set with ILO (2004) and USDA (1998) for the agricultural labor and land. We used UN database for Agricultural GDP data. We included 22 transition countries in Eastern Europe and central Asia to construct a complete balanced panel data set except for two countries in 1992; Czech Rep. and Slovakia[3], and hence the total number of observations for this study is 218.

As an output measure, we used gross domestic product in agricultural sector (agGDP) at 1990 constant prices. As input measure, we included labor, land and capital. Labor represents economically active population in agriculture and land covers total agricultural land including arable land, permanently cropped and permanent pasture. For the agricultural capital stock,

[3] These two countries were separated as independent states in 1993.

tractor equivalent total agricultural machinery is used as a proxy since it is the only available and consistent data set. Table 1 provides summary statistics on inputs and output by country group over time.

Table 1. Summary statistics of output and inputs

Year	ALL				CIS				CEE			
	AgGDP (mil. $)	Labor (1,000 persons)	Land (1,000ha)	Capital (1,000 unit)	AgGDP (mil. $)	Labor (1,000 persons)	Land (1,000ha)	Capital (1,000 unit)	AgGDP (mil. $)	Labor (1,000 persons)	Land (1,000ha)	Capital (1,000 unit)
1992	13,521	1738	31725	209	22225	2219	52513	229	2882	1149	6317	184
1993	12,366	1584	29009	190	21908	2177	52258	222	2823	991	5761	158
1994	11,007	1547	28978	191	19407	2134	52187	210	2608	961	5768	173
1995	10,187	1511	28582	185	17662	2090	51396	195	2712	933	5768	175
1996	9,695	1476	28477	178	16699	2046	51143	181	2690	906	5811	175
1997	9,849	1441	28485	171	16872	2002	51157	166	2826	880	5814	175
1998	8,628	1407	28320	166	14429	1958	50871	156	2826	855	5769	175
1999	9,372	1373	28182	160	15856	1914	50589	146	2888	831	5774	175
2000	10,050	1340	28271	158	17388	1872	50802	139	2712	808	5739	178
2001	10,974	1312	28222	160	19024	1839	50764	142	2924	784	5680	178
Average*	10,538 (22,694)	1470 (2,080)	28798 (60350)	177 (322)	18147 (30058)	2025 (2518)	28798 (60350)	179 (284)	2787 (1977)	905 (1295)	5811 (5488)	174 (358)

* Numbers in parenthesis are standard deviations.

2. Empirical Model

In order to measure the performance of agricultural sector in terms of technical efficiency in each country, we employ a non-parametric approach[5] commonly referred to as data envelopment analysis (DEA) developed by Charnes et al. (1978). The nonparametric approach has some empirical advantage over the parametric stochastic approach by Aigner et al. (1977) in that it does not require any assumption on the functional form of production technology and the distribution of error terms.[6]

Consider a production technology producing an M-vector of outputs, $y \in R_+^M$, by using a N-vector of inputs, $x \in R_+^N$. Let a closed set $T \subset R_-^N \times R_+^M$ represent a production possibility set. That is, $(x, y) \in T$ means that outputs y can be produced from inputs x.

Following Chambers et al. (1996a), the directional distance function as a variation of Luenberger's shortage function (1995) can be defined as

$$\vec{D}(x, y : g_x, g_y) = \sup\{\theta : (x - \theta g_x, y + \theta g_x) \in T\}. \tag{1}$$

Here, the non-zero vector $g_x \in R_+^N$ and $g_y \in R_+^M$ represent the directions in which the input vector x is contracted and the output vector y is expanded, respectively. This function measures the distance in a pre-assigned direction to the frontier technology. According to

[5] Although parametric and nonparametric approaches are based on similar theoretical foundations, they have own merits and shortcomings and often produce different empirical results.
[6] However, the nonparametric approach does not take into account random factors affecting inputs and outputs due to its deterministic characteristics.

Luenberger's shortage function, this distance can be interpreted as a shortage of (x, y) to reach the production frontier, while it can be interpreted as an efficiency measure using the directional distance function approach. That is, θ measures how far the point (x, y) is from the frontier technology, expressed in units of the reference input bundle g_x and output bundle g_y.

Following Chambers, et al. (1998), under freely disposability of inputs and outputs, the directional distance function in equation (1) can completely depict the production technology and is dual to the profit function. If and only if (x, y) is feasible, the directional distance function is nonnegative, i.e. $\vec{D}(x, y : g_x, g_y) \geq 0$. That is, $\vec{D}(x, y : g_x, g_y) < 0$ implies $(x, y) \notin T$. Therefore, the production possibility set T can be written as $T = \{(x, y) : \vec{D}(x, y : g_x, g_y) \geq 0\}$. Then, the frontier production technology can be represented by $\vec{D}(x, y : g_x, g_y) = 0$.

And the directional distance function completely generalizes Shephard's input or output distance function.[7] Recall that Shephard's input and output distance functions are defined as $D_i = \sup_\theta\{\theta > 0 : (x/\theta, y) \in T\}$ and $D_o = \inf_\theta\{\theta > 0 : (x, y/\theta) \in T\}$, respectively. If we take $g_y = 0$ and $g_x = x$ in equation (2), then the directional distance function can be represented by Shephard's input distance function, i.e., $\vec{D}(x, y : x, 0) = 1 - \dfrac{1}{D_i(x, y)}$. If we take $g_x = 0$ and $g_y = y$ in equation (2), then the directional distance function can be represented by Shephard's output distance function, i.e., $\vec{D}(x, y : 0, y) = \dfrac{1}{D_o(x, y)} - 1$. Shephard's input (output) distance function measures the largest 'radial contraction' of an input vector (the largest 'radial expansion'

[7] While Shephard's input and output distance functions are respectively dual to the cost function and the revenue function, while the directional distance function is dual to the profit function (Chambers et al., 1998).

of an output vector) with each remaining technically feasible (Chambers et al., 1998). That is, Shephard's distance function is defined by either contracting inputs or expanding outputs while satisfying feasibility conditions. However, the directional distance function is defined by simultaneously contracting inputs and expanding outputs. Therefore, the directional distance function is more general than Shephard's input or output distance function (Chambers et al., 1998).

The directional distance function defined above can be estimated econometrically. However, econometric estimation requires assumptions on the functional form and the distribution of error terms. On the contrary, a nonparametric programming approach, i.e. DEA technique can be used to estimate $\vec{D}(x, y : g_x, g_y)$ without such assumptions.

Consider a set of observations on K firms, (x^k, y^k), $\mathrm{k} = 1, \ldots, \mathrm{K}$. Assume that the set T is convex and that the technology exhibits free disposal. When there is no assumption on the return to scale of the technology (variable return to scale: VRS),[8] a nonparametric representation of the technology is

$$T_{VRS} = \{(-x, y) : \sum_{k=1}^{K} \lambda^k x^k \le x,\ \sum_{k=1}^{K} \lambda^k y^k \ge y,\ \sum_{k=1}^{K} \lambda^k = 1,\ \ \lambda^k \ge 0,\ k = 1,\ldots, K\}. \qquad (2)$$

Then, the directional distance function can be estimated by solving the following linear programming problems. Here, the value of θ is a measure of "(technical) inefficiency," which represents the inability to produce maximum output given production resources and technology and,

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[8] For the technology with the constant return to scale, the equation (2) can be modified by eliminating $\sum_{k=1}^{K} \lambda^k = 1$. That is, under constant return to scale (CRS), the nonparametric representation of the technology is $T_{CRS} = \{(-x, y) : \sum_{k=1}^{K} \lambda^k x^k \le x,\ \sum_{k=1}^{K} \lambda^k y^k \ge y,\ \lambda^k \ge 0,\ k = 1,\ldots, K\}$.

hence, the performance (or productivity) gap compared with the most efficient production unit.

$$
\begin{aligned}
\vec{D}(x^k, y^k : g_x^k, g_y^k) = \max_{\theta,\lambda} \theta \\
s.t. \quad & \sum_{k=1}^{K} \lambda^k x^k \leq x^k - \theta g_x^k, \\
& \sum_{k=1}^{K} \lambda^k y^k \geq y^k + \theta g_y^k, \\
& \sum_{k=1}^{K} \lambda^k = 1, \\
& \lambda^k \geq 0,\ k = 1,\dots,K
\end{aligned}
\tag{3}
$$

Following Chambers (1996) and Chambers et al. (1996b), we define Luenberger productivity indicator for *k-th* firm in equation (3) measuring productivity changes based on the directional distance function:

$$
\begin{aligned}
L(x_t^k, y_t^k, x_{t+1}^k, y_{t+1}^k) = \quad & \frac{1}{2}[\vec{D}_{t+1}(x_t^k, y_t^k : g_x, g_y) - \vec{D}_{t+1}(x_{t+1}^k, y_{t+1}^k : g_x, g_y) \\
& + \vec{D}_t(x_t^k, y_t^k : g_x, g_y) - \vec{D}_t(x_{t+1}^k, y_{t+1}^k : g_x, g_y)\ ],
\end{aligned}
\tag{4}
$$

where $\vec{D}_t(\cdot)$ and $\vec{D}_{t+1}(\cdot)$ represent the directional distance functions for the periods t and t+1, respectively. Note that for estimating productivity indicator, the input-output vector for the period *t* (x^t, y^t) and for the period *t+1* (x^{t+1}, y^{t+1}) should be evaluated using different reference technologies, i.e. $\vec{D}_{t+1}(x^t, y^t)$ and $\vec{D}_t(x^{t+1}, y^{t+1})$. This can be represented by the following linear programming problems.

$$\vec{D}_{t+1}(x_t^k, y_t^k : g_x^k, g_y^k) = \max_{\theta,\lambda} \theta$$

$$\begin{aligned} s.t. \quad & \textstyle\sum_{k=1}^{K} \lambda^k x_{t+1}^k \le x_t^k - \theta g_x^k, \\ & \textstyle\sum_{k=1}^{K} \lambda^k y_{t+1}^k \ge y_t^k + \theta g_y^k, \\ & \textstyle\sum_{k=1}^{K} \lambda^k = 1, \\ & \lambda^k \ge 0,\ k = 1,\dots,K \end{aligned} \tag{4-1}$$

$$\vec{D}_{t}(x_{t+1}^k, y_{t+1}^k : g_x^k, g_y^k) = \max_{\theta,\lambda} \theta$$

$$\begin{aligned} s.t. \quad & \textstyle\sum_{k=1}^{K} \lambda^k x_{t}^k \le x_{t+1}^k - \theta g_x^k, \\ & \textstyle\sum_{k=1}^{K} \lambda^k y_{t}^k \ge y_{t+1}^k + \theta g_y^k, \\ & \textstyle\sum_{k=1}^{K} \lambda^k = 1, \\ & \lambda^k \ge 0,\ k = 1,\dots,K \end{aligned} \tag{4-2}$$

Note that the positive sign of Luenberger productivity indicator means productivity improvement and negative values are consistent with productivity declines. Following Chambers et al. (1996b), the Luenberger productivity indicator can be decomposed into two components, i.e., efficiency change (EFFCH) and technical change (TECH).

$$\mathrm{EFFCH} = \vec{D}_t(x_t^k, y_t^k : g_x, g_y) - \vec{D}_{t+1}(x_{t+1}^k, y_{t+1}^k : g_x, g_y) \tag{5-1}$$

$$\begin{aligned} \mathrm{TECH} = \ & \frac{1}{2}[\,\vec{D}_{t+1}(x_{t+1}^k, y_{t+1}^k : g_x, g_y) - \vec{D}_t(x_{t+1}^k, y_{t+1}^k : g_x, g_y) \\ & + \vec{D}_{t+1}(x_t^k, y_t^k : g_x, g_y) - \vec{D}_t(x_t^k, y_t^k : g_x, g_y)\,] \end{aligned} \tag{5-2}$$

This decomposition provides an empirical framework to investigate the nature of productivity changes. This is because technical change component (TECH) and efficiency change component (EFFCH) represent different sources of productivity changes, i.e., technology and efficiency. We make use of this framework in our empirical analysis in the subsequent sections.

III. Estimation Results

1. Changes in the Technical Efficiency

The technical efficiency θ estimated from equation (3) represents the measure of the performance of agricultural sector in transition countries. For solving the linear programming problems in equation (3), we used each country's observed inputs and outputs in that period as the direction, i.e., $g_x = x$, $g_y = y$. Table 2 shows the estimation results of technical efficiency across countries over time. Recall that the positive value of θ indicates the presence of technical inefficiency. The smaller the value of θ, the less inefficient, i.e., higher level of performance or productivity. All observations are grouped into 2 categories for comparison purpose, CIS and CEE countries. The span of the study is also divided into two periods, the first half (1992~1996) and the second half (1997~2001) to see the dynamics of technical efficiency.

The overall mean of technical efficiency during the study period is 0.1999. This indicates that on average, the netput of the agricultural sector of transition countries could have been increased by 0.1999 times of observed netput level if frontier technology were available. Table 2 also shows the significant performance gap among countries in their agricultural sector. The estimates of good performed seven countries (Albania, Armenia, Belarus, Croatia, Estonia, Russian Federation, and Ukraine) are highly contrasted with those of poor performed four countries (Tajikistan, Turkmenistan, Hungary, and Poland). On average, CEE countries (0.1612) performed better than CIS countries (0.2392).

Table 2. Changes in the Technical efficiency

CIS				CEE			
Country	**1992~2001**	**1992~1996**	**1997~2001**	**Country**	**1992~2001**	**1992~1996**	**1997~2001**
Armenia	0.0000	0.0000	0.0000	Albania	0.0000	0.0000	0.0000
Azerbaijan	0.1907	0.2087	0.1726	Bulgaria	0.0714	0.1427	0.0000
Belarus	0.0000	0.0000	0.0000	Croatia	0.0000	0.0000	0.0000
Georgia	0.0867	0.0333	0.1401	Czech Rep.	0.1852	0.2310	0.1485
Kazakhstan	0.0255	0.0472	0.0037	Estonia	0.0000	0.0000	0.0000
Kyrgyzstan	0.1047	0.1408	0.0686	Hungary	0.6145	0.6097	0.6193
Russia	0.0000	0.0000	0.0000	Latvia	0.0341	0.0349	0.0332
Tajikistan	0.6029	0.6307	0.5752	Lithuania	0.3920	0.3852	0.3987
Turkmenistan	0.6051	0.5805	0.6296	Poland	0.6212	0.6524	0.5899
Ukraine	0.0000	0.0000	0.0000	Romania	0.4298	0.4197	0.4398
Uzbekistan	0.1582	0.1088	0.2075	Slovakia	0.2833	0.2874	0.2800
Mean	0.1612	0.1591	0.1634	**Mean**	0.2392	0.2512	0.2281

The dynamics of technical efficiency measure is of interest in many aspects, which, in particular, gives us some insights regarding the adjustment path taken by agricultural sector in order to cope with the rapid changes in social and economic environments. With some fluctuations, technical efficiency seems to have an increasing trend during the decade. The mean technical efficiency estimate (0.1958) for the second half (1997~2001) is lower than that (0.2041) for the first half. This suggests that on average, the changes in social and economic environment in transition countries during the late 1980s and the early 1990s might have positive impacts in improving production efficiency.

Table 2 also indicates different evolutions of technical efficiency between two country groups. CEE group experienced the improvement of their performance by 9.2% while CIS group the deterioration by 2.7% between the first and second half. This sharp difference in the dynamics of technical efficiency estimates might be partly explained by the different transition policies taken by the countries in two groups since the CEE countries are generally believed to have pursued relatively progressive policy reform for transition compared with the CIS countries (Lerman et al., 2002; Macours et al., 1999; Heath, 2003).[9]

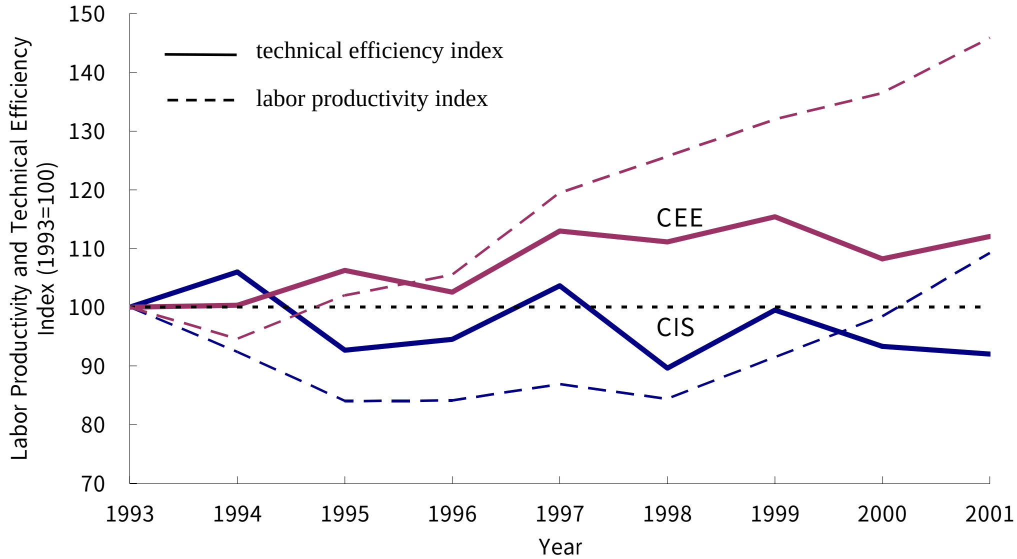
Figure 1 depicts the evolution of technical efficiency over time. Mean technical efficiency of CEE countries shows a gradual increasing trend while that of CIS countries a decreasing trend with some fluctuations. This implies that the CEE countries have improved their performance in agricultural sector and the performance gap between the CEE and CIS countries could have been reduced during the decade. Figure 1 also tells that the evolutions of technical efficiency are somewhat different from that of labor productivity in both two country groups[10], which means that firm correlation between technical efficiency and labor productivity does not seem to exist all over the period under analysis. For example, labor productivity of agricultural sector in CEE countries on average has increased very sharply since 1994 while technical efficiency shows slight increase up to 1999 and eventually shows decline. In sum, the growth rate of labor productivity seems to be much higher than that of technical efficiency in CEE group. On the other hand, the labor productivity of CIS countries shows a kind of U-shape with decline up to 1995, stagnancy between 1995 and 1998, and sharp recovery after 1998, which is considerably different from the shape of

[9] Lerman et al. (2002) indicated four factors influencing labor productivity growth; larger individual sector, greater liberalization, better performance of the overall economy and greater political commitment. They argued that the transition strategies of CEE countries are more preferable to have high productivity growth than those of CIS countries. Macours et al. (1999) also suggested that the path taken by CEE countries are more favorable than CIS countries, considering reform policy, initial conditions, disruption of exchange relationships, tensions and conflict problems.

[10] In early literature on the productivity, economists often utilized partial productivity to analyze cross country economic growth differentials due to data scarcity and easy computability. For example, Hayami et al. (1985) dealt with land and labor productivity as an evidence for their induced innovation hypothesis. However, in cross country comparison based on partial productivity, substitution possibility among inputs cannot be taken into account. And hence, our estimates of technical efficiency seem to be preferred as the performance measures. For the cross-country comparison of labor productivity in agricultural sector in transition countries, see also Macours et al. (1999) and Lerman et al. (2002).

technical efficiency evolution path.

Figure 1. Evolution of technical efficiency and labor productivity



The striking differences in the shapes of labor productivity and technical efficiency evolution curves convince us that the labor productivity index as a partial productivity measure might be misleading when investigating the economic performance of policy changes. This would be partly because the labor productivity cannot take into account input substitution as well as structural change effects.

Figure 2 depicts the changes in agricultural production and agricultural labor forces during the decade under analysis. The vertical axis represents changes in agricultural GDP and the horizontal axis, changes in agricultural labor forces. For example, the countries in the first quadrant experienced the increase in both agricultural GDP and labor while the countries in the second quadrant experienced the increase in agricultural GDP and decrease in agricultural labor, hence the increase in labor productivity. Thus, the countries above the 45-degree line (AB) represent the countries which experienced labor productivity growth.

Figure 2. The changes in agricultural GDP and labor force (1993=100)

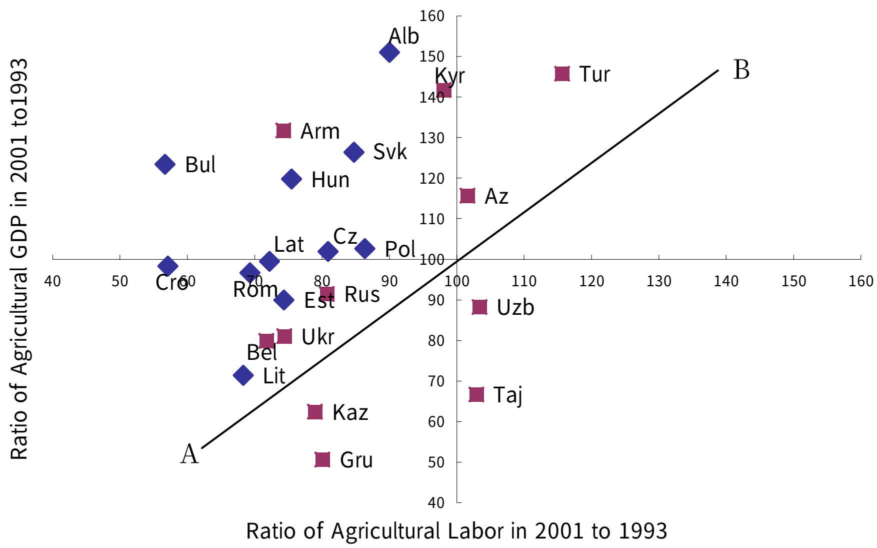


Figure 2 shows that the agricultural labor force significantly decreased with agricultural GDP increased or remained in many of CEE countries. We can also find that four of eleven CIS countries experienced sharp decline in labor productivity. Therefore, the current sharp recovery phase of labor productivity in both group countries seems to be largely explained by the rapid reduction of agricultural labor force rather than by the improvement of overall performance represented by technical efficiency. Here, the reduction of agricultural labor force might be partly resulted from the structural adjustment due to the relatively higher growth in industrial sector.

2. Dynamics of the Productivity Change Components

Table 3 summarizes the decomposition of productivity changes into efficiency and technical changes. The values are average changes of each component for every adjacent pair of years between 1992~2001. The positive values of changes in productivity and its components imply improvements, whereas the negative values, regress or deterioration. On average, CEE countries recorded higher productivity growth than CIS countries, and the main source of productivity growth is technical change in both group countries.

Table 3. Decomposition of productivity changes by country

CIS				CEE			
Country	Efficiency Change (A)	Technical Change (B)	Productivity Change (A+B)	Country	Efficiency Change (A)	Technical Change (B)	Productivity Change (A+B)
Armenia	0.0000	0.0068	0.0068	Albania	0.0000	0.0103	0.0103
Azerbaijan	0.0086	-0.0158	-0.0072	Bulgaria	0.0226	0.0219	0.0444
Belarus	0.0000	0.0053	0.0053	Croatia	0.0000	0.0326	0.0326
Georgia	-0.0211	-0.0194	-0.0405	Czech Rep.	0.0052	-0.0013	0.0040
Kazakhstan	0.0000	0.0334	0.0334	Estonia	0.0000	0.0483	0.0483
Kyrgyzstan	0.0042	0.0163	0.0205	Hungary	0.0009	0.0110	0.0119
Russia	0.0000	0.0014	0.0014	Latvia	0.0000	0.0112	0.0112
Tajikistan	0.0088	-0.0018	0.0070	Lithuania	-0.0116	0.0087	-0.0030
Turkmenistan	0.0010	0.0156	0.0165	Poland	0.0096	-0.0057	0.0039
Ukraine	0.0000	-0.0024	-0.0024	Romania	0.0059	-0.0043	0.0016
Uzbekistan	-0.0131	0.0090	-0.0041	Slovakia	-0.0004	0.0141	0.0136
Average	**-0.0011**	**0.0044**	**0.0033**	**Average**	**0.0029**	**0.0133**	**0.0163**

Agricultural sector in CIS countries experienced a sluggish productivity growth of an annual average rate of 0.33 percent over the decade. Among CIS countries, Kazakhstan accomplished the highest annual productivity growth rate of 3.34 percent followed by Kyrgyzstan(2.05%), and Turkmenistan (1.65%), whereas Georgia (-4.05%), Azerbaijan (-0.72%), Uzbekistan (-0.41%) and Ukraine (-0.24%) suffered from productivity decline. The productivity growth in CIS countries are largely attributed to technical progress (0.44%) even with the efficiency deterioration (-0.11%) during the period.

CEE countries experienced much higher productivity growth with an annual average rate of 1.63 percent during the period with the positive contributions of both technical (1.33%) and efficiency improvements (0.29%). Among CEE countries, Estonia accomplished the highest productivity growth rate (4.83%) followed by Bulgaria (4.44%), and Croatia (3.26%), whereas Lithuania (-0.3%) suffered from productivity decline.

Next we will see the dynamics of productivity and its components between CIS and CEE countries. In Table 4 which provides the yearly as well as first and second half average changes in productivity and its components, observed are significant differentials in the dynamics of productivity and its components between two groups of transition countries.

CIS countries suffered from productivity decline by -1.23 % annually due to technological regress (-1.42%) during the first half (1992~1997), whereas they experienced high productivity growth (2.29%) mainly due to high technical progress (2.77%) during the second half (1997~2001). The productivity growth of CEE countries is estimated to be positive in both periods and the growth rate in the second half is two times as high as that of the first half. Technical progress (2.26%) was identified as a major source of productivity growth in the second half, whereas the contribution of efficiency improvements is as much as that of technical progress in the first half.

Table 4. Dynamics of the productivity change decomposition

Year	CIS			CEE		
	Efficiency Change	Technical Change	Productivity Change	Efficiency Change	Technical Change	Productivity Change
1992/1993	0.0040	-0.0094	-0.0055	-0.0020	0.0065	0.0037
1993/1994	0.0088	-0.0443	-0.0355	0.0009	-0.0178	-0.0169
1994/1995	-0.0211	-0.0308	-0.0520	0.0141	0.0161	0.0303
1995/1996	0.0033	0.0027	0.0060	-0.0086	0.0162	0.0076
1996/1997	0.0145	0.0106	0.0251	0.0229	0.0088	0.0317
1997/1998	-0.0236	0.0024	-0.0212	-0.0038	0.0170	0.0132
1998/1999	0.0173	0.0270	0.0444	0.0086	0.0101	0.0187
1999/2000	-0.0104	0.0406	0.0302	-0.0146	0.0176	0.0030
2000/2001	-0.0024	0.0408	0.0384	0.0080	0.0455	0.0535
1992~1997	**0.0019**	**-0.0142**	**-0.0123**	**0.0055**	**0.0060**	**0.0113**
1997~2001	**-0.0047**	**0.0277**	**0.0229**	**-0.0005**	**0.0226**	**0.0221**
1992~2001	**-0.0011**	**0.0044**	**0.0033**	**0.0029**	**0.0133**	**0.0163**

CEE countries which are in general regarded as having adopted relatively progressive reform policies for transition compared to CIS countries demonstrated the higher efficiency improvements. The contribution of the efficiency change to productivity growth is as much as that of technical progress during the first half, which is quite different from the results of CIS group countries. Based on these results, a careful argument could be drawn that the policies for transition such as land or institutional reform policies matter to the productivity achievements by affecting the way of farmers' adjustment.

Although the influence of agricultural policy reform on the agricultural productivity in transition countries are still controversial in the literature (Heath, 2003), many empirical studies suggest positive associations between agricultural policy reform and productivity growth (e.g. Lerman et al., 2002; Macours et al., 1999). Our analysis also adds some empirical evidences to the arguments on the relationship between policy reform taken by transition countries and their productivity performances by implying that CEE countries generally regarded as having taken more market-oriented transition strategies have achieved better performances than CIS countries.

We also compared the dynamics of productivity change and its components for each individual country. There exist significant differentials in the dynamics of the changes in two productivity components across countries even in the same country group. Figure 3 reveals the dynamics of productivity changes between two periods, first and second half, especially focusing on the relative changes in the two components.

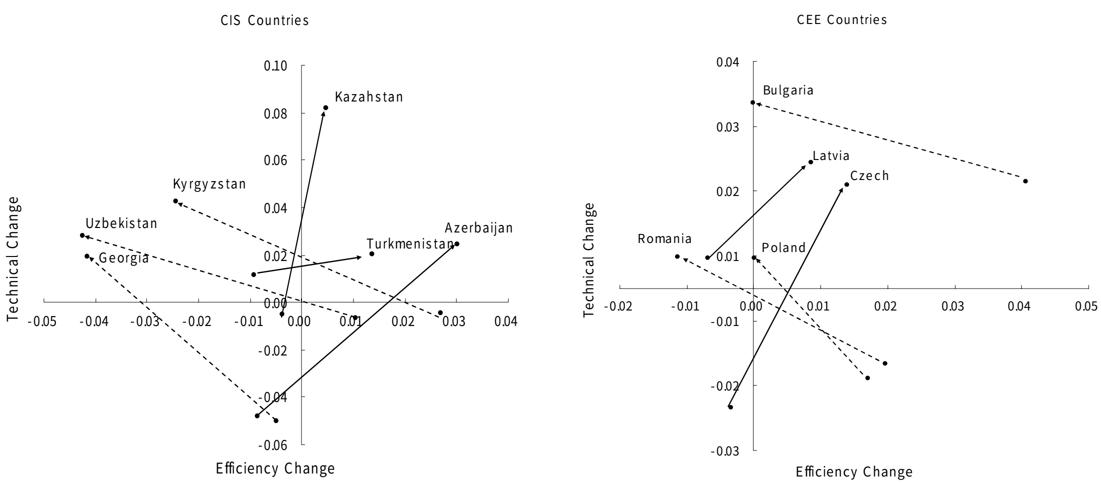
In figure 3, the vertical and horizontal axes represent technical and efficiency changes respectively. For example, the countries in the first quadrant represent those in the position of improvements in both technical and efficiency changes while those in the second quadrant, in the position of improvements in technical change and deterioration in efficiency change. Each arrow in figure 3 runs from the position of first half to that of second half.

The slope of the arrow connecting two positions indicates the ratio of technical change to efficiency change, measuring the dynamics of relative changes in two productivity components. Note that a country represented by a steep (flat) and upward negative slope can be seen as one experiencing small (large) "trade-offs" between technical and efficiency change. In other words, when the slope of an arrow is upward, negative and steep, it can be interpreted as achieving relatively high technical progress with a small cost of efficiency deterioration. On the contrary, a country represented by an upward positive sloped arrow can be seen as one experiencing increase in both productivity components, i.e., technical progress and efficiency improvement.

Figure 3 depicting the dynamics of two components for eleven representative countries, six for

CIS and five for CEE shows two different patterns of productivity dynamics in both country groups. First, three CIS (Georgia, Kyrgyzstan, and Uzbekistan) and two CEE countries (Poland, Romania) achieved productivity growth via technical progress at the cost of efficiency deterioration between two periods. The slope tells that Poland and Georgia paid relatively small efficiency deterioration to achieve given technical progress. Second, three CIS (Azerbaijan, Kazakhstan, and Turkmenistan) and two CEE countries (Latvia, Czech Republic) experienced both technical progress and efficiency improvement. Kazakhstan and Czech Republic experienced relatively technical-progress-oriented productivity growth.

Figure 3. The dynamics of productivity change and its components by country

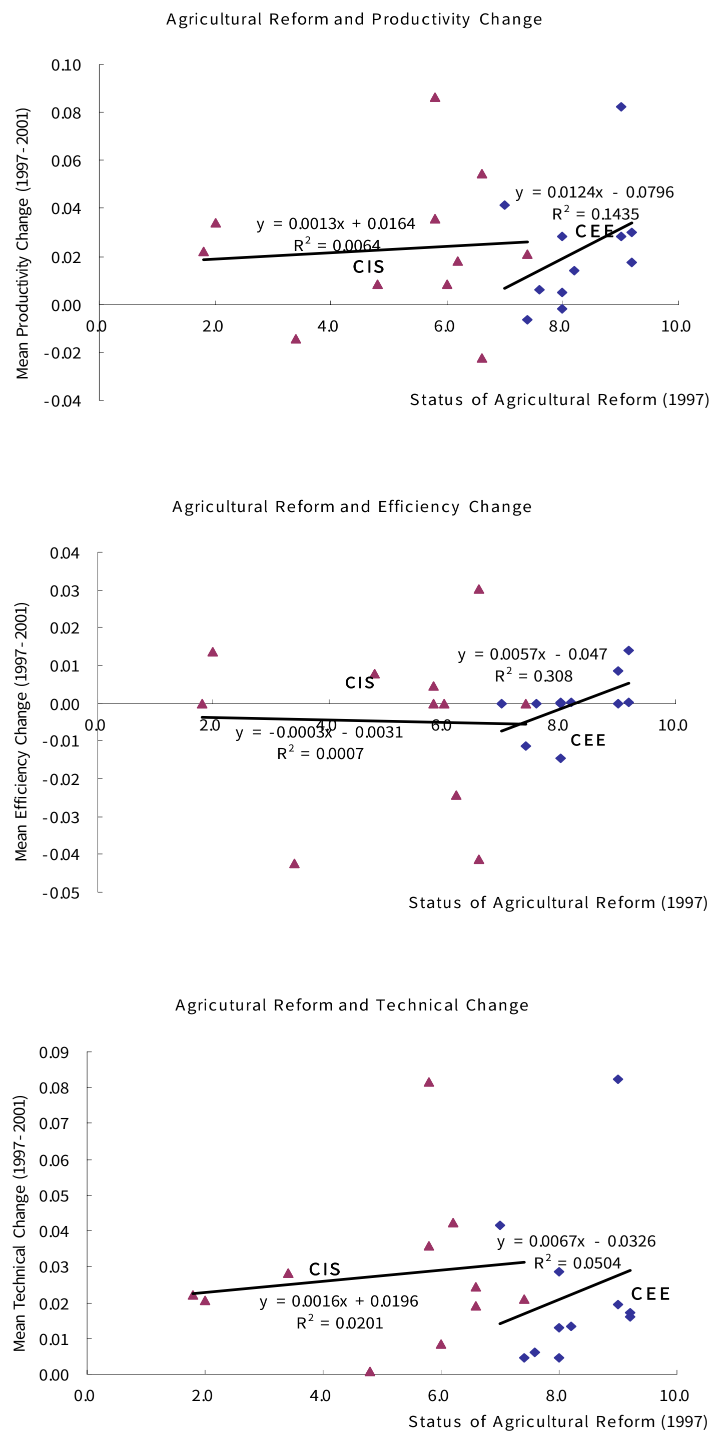


Finally, we investigated the relationship between agricultural reform level and productivity change. Agricultural reform index by Heath (2003) is employed here to measure the agricultural reform level of each country. The index represents the ratings ranging from 1 to 10 for five reform factors for each country (Heath, p. 33). The five factors representing agricultural policy reform in each transition country include: i) trade liberalization and market development, ii) land administration and reform, iii) privatization of agro-processing and input supply, iv) rural finance, and v) institutional reform.

Figure 4 provides scatter diagrams depicting the association between 1997 agricultural reform index and mean productivity and its components changes during the second half (1997~2001) for two country groups.[11] The agricultural reform indices of CIS countries are generally lower than those of CEE countries. In general, the level of agricultural reform seems to have positive effects on the productivity and its two components changes. Only one exception is observed in the association between efficiency change and agricultural reform index in CIS countries. In particular, agricultural reform indices look like being more closely associated with productivity and its components changes in CEE countries than in CIS countries. This might be partly because that the CIS countries have relatively low agricultural reform indices compared to CEE countries, which would imply that there is a kind of threshold level of agricultural reform to start influencing the productivity and its components change. That is, it is not until certain threshold level of agricultural reform is achieved that the agricultural sectors of transition countries start to enjoy productivity growth from transition to market economy.

[11] Heath (2003) provided the agricultural reform index for 1997~2001.

Figure 4. Agricultural reform level and productivity change



IV. Summary and Conclusion

The performance of agricultural sector in transition economies has been of interest to many researchers. This paper examined the performance of the agricultural sector in 22 CEE and CIS transition countries focusing on the dynamics of productivity and its components changes during the first decade of transition, 1992-2001. A frontier approach (data envelopment analysis: DEA) combining the directional distance function is employed in this paper.

The performance improvement of CEE countries seems to be more prominent compared to that of CIS countries. The productivity growth in the last decade is mainly attributable to the technical progress, particularly for the second half (1997~2001). CEE countries achieved both efficiency and technical improvement while CIS countries suffered from efficiency decline and sluggish productivity during the first half.

For the CEE countries, agricultural reform level has positive effects on the productivity and its two components changes, which would imply that there is a kind of threshold level of agricultural reform to start influencing the productivity and its components change. That is, it is not until certain threshold level of agricultural reform is achieved that the agricultural sectors of transition countries start enjoying productivity growth from transition to market economy.

This study has potential extensions. Above all, identifying the factors influencing the productivity change and its components such as several policy reform elements would be of interest in the sense that we could obtain some insights on the priority of several policy reform options.

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