The Dynamics of Agricultural Productivity and Industrial Transformation in Transition Countries

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ABSTRACT

Relying on the frontier production approach, we investigated the performance of the agricultural sector in 28 transition countries and its changes over time, especially focusing on the dynamics of productivity changes and the effects of reform policy. Our findings are: (i) Asian and CEE transition countries performed better than CIS countries, while the performance improvement of CEE countries seems to be more prominent compared to that of Asian and CIS countries; (ii) The productivity growth is mainly attributable to the technical progress, particularly in CEE countries; (iii) Reform policy and industrial transformation seems to have positive effects on the performance of agricultural sector and its changes; (iv) The initial conditions do matter.

KEYWORDS: transition countries, efficiency, productivity, directional distance function, agricultural reform, initial condition, industrial transformation

1. INTRODUCTION

With almost two decades having passed since dramatic institutional and economic reforms took place, the economic performances of transition countries have been of interest to many researchers. The performance of the agricultural sector and the structural transformation between agricultural and non-agricultural sectors during the transition period seem to be of particular interest because agriculture was a major industry at the beginning of transition in almost all transition countries. For example, in the Eastern and Central European transition countries, nearly 45% of the total population lived in rural areas while the share of agriculture in GDP and employment exceeded 20%, on average, until the late 1980s. In this study, we focus on the Eastern and Central European transition countries, many of which embarked on a transition from centrally planned to a more market-oriented economy during the period of 1989-1991.

Many researchers have shown evidence that the socialist economy system and particularly the agricultural sector in the centrally planned economy is notoriously inefficient (Mathijs and Swinnen, 1997; Lerman et al. 2002; Swinnen and Vranken, 2006). They suggested that the transition to a market-oriented system would be good strategy to cure these chronic

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inefficiencies. More recently, some argued that the performance of agricultural sector in transition countries largely depends on the combination of their initial conditions and reform policies (e.g. Swinnen, 2006). If this is true, transition countries have been improving their economic performance throughout the transition period. However, literature on the performance of transition economies remains sparse from the perspective of empirical context. In addition, relatively little attention has been paid to the sources and dynamic patterns of productivity changes in these countries. In this study, we attempt to shed some light on these issues by investigating factors influencing the performance and productivity changes of agricultural sector in transition countries.

A number of studies have investigated the characteristics and performance of agricultural reform in transition countries, particularly for CEE (Central and Eastern Europe) and CIS (Commonwealth of Independent States) countries. Mathijs and Swinnen (1997) investigated the influence of relative productivity and factor intensity on the pattern of privatization and decollectivization in transition countries. Macours and Swinnen (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. Swinnen (1999) investigated the divergent land reform strategies in CEE countries and their influences on the distributional consequences. 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. Recently in his analysis 'Policy Reform and Agricultural Adjustment in Transition Countries', Swinnen(2006) concluded that agricultural performance in input use, output, and productivity depend on a combination of initial conditions and reform policies.

This study examines the performance differentials of the agricultural sector in transition countries. We also investigate the sources affecting the performance and patterns of productivity change. In particular, we try to explore how the reform policies affect the performance of agricultural sectors. To estimate the performance and productivity change, we have used a frontier approach.[1] 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.

We first examine data and empirical models employed in this study, and present estimation results and their implications, followed by our conclusion and some suggestions for future

[1] Most of the previous studies adopted partial productivity (i.e. labor productivity) as a performance measure for the agricultural sector of transition countries. One exception is Lerman et al. (2003), which measured total factor productivity in the former Soviet Republics by using the production function approach. They showed that total factor productivity growth in the agricultural sector was much slower than labor productivity growth.

research.

2. DATA AND EMPIRICAL MODEL

2.1. Data

The data used for this study are obtained from the FAO and the UN, for the period of 1992-2003. We included 28 transition countries from Eastern, Central Europe and Asia to construct a complete balanced panel data set; hence, the total number of observations for this study is 218. As an output measure, we used gross domestic product in agricultural sector (agricultural GDP) 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, tractor equivalent total agricultural machinery is used as a proxy since it is the only available and consistent data set.

In this study, total 28 transition countries in Europe and Asia are grouped into three categories for comparison; eleven countries are categorized as CEE (Central and Eastern Europe), eleven countries are under CIS (Commonwealth of Independent States, former Soviet republics), and six countries fall under ASIA (Asian) transition countries. Although CEE and CIS countries have common heritage, a common starting point, and common aspirations, they have adopted different implementation strategies for their respective land reform and farm restructuring programs (Swinnen, 1999). Land reform in CEE countries took the course of a more liberal land market, which puts greater emphasis on privatization through granting secure land rights than that in CIS countries (Macours and Swinnen, 1999; Lerman et al., 2002). Table 1 provides summary statistics on input and output by country group over time.

2.2. Empirical Model

In order to measure the performance of the agricultural sector, we employ a non-parametric approach commonly referred to as data envelopment analysis (DEA) developed by Charnes et al. (1978). Specifically, this study uses directional distance function (Chambers et al, 1996a, 1998) as a variation of Luenberger's shortage function (Luenberger, 1995)

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 output y can be produced by using inputs x. The directional distance function can be estimated by solving the following linear programming problems.

Table 1: Output and input measures by country group

Year	Agricultural GDP (Million $)			Land (1,000ha)			Labor (1,000 persons)			Capital (tractor: 1,000 unit)		
	CEE	CIS	ASIA	CEE	CIS	ASIA	CEE	CIS	ASIA	CEE	CIS	ASIA
1992	1,659	6,662	1,826	5,813	52,533	31,004	1,025	2,219	8,470	168,135	229,121	9,933
1993	1,901	5,997	1,995	5,561	52,293	30,281	967	2,177	8,670	163,019	221,610	11,296
1994	1,976	4,375	2,174	5,529	52,209	30,178	937	2,134	8,862	177,709	209,921	18,656
1995	2,401	4,294	2,579	5,479	51,417	30,175	909	2,090	9,035	180,755	194,885	19,336
1996	2,416	4,039	2,829	5,587	51,161	30,286	882	2,046	9,187	180,924	180,251	21,271
1997	2,261	4,010	2,841	5,524	51,173	30,326	857	2,002	9,320	182,442	165,901	22,284
1998	2,193	2,858	2,450	5,483	50,892	30,365	832	1,958	9,443	182,719	155,868	23,669
1999	1,863	2,634	2,594	5,479	50,609	32,415	808	1,914	9,565	182,734	145,502	27,504
2000	1,696	2,769	2,667	5,442	50,817	32,547	785	1,872	9,694	185,845	138,056	30,355
2001	1,938	3,100	2,595	5,308	50,822	32,691	762	1,839	9,847	185,958	141,590	30,459
2002	1,920	3,314	3,057	5,194	50,791	32,697	740	1,807	10,007	191,399	135,573	30,303
2003	2,259	3,852	3,255	5,105	50,797	32,778	719	1,776	10,171	191,810	128,722	30,524
MEAN	2,040	3,992	2,572	5,459	51,293	31,312	852	1,986	9,356	181,121	170,583	22,966

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

Here, the value of θ is a measure of "(technical) inefficiency," which represents the inability to produce maximum output given production resources and technology; in other words it represents the performance (or productivity) gap compared with the most efficient production unit. 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. According to Luenberger's shortage function, this distance can be interpreted as a shortage of (x, y) to reach the production frontier, while it also 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 (1996) and Chambers et al. (1996b), we define Luenberger productivity indicator for *k-th* firm in equation (2) measuring productivity changes based on the directional distance function:

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

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

$$\text{EFFCH} = \vec{D}_t(x_t^k, y_t^k : g_x, g_y) - \vec{D}_{t+1}(x_{t+1}^k, y_{t+1}^k : g_x, g_y) \qquad (3\text{-}1)$$

$$\text{TECH} = \frac{1}{2}[\ \vec{D}_{t+1}(x_{t+1}^k, y_{t+1}^k : g_x, g_y) - \vec{D}_t(x_{t+1}^k, y_{t+1}^k : g_x, g_y) + \vec{D}_{t+1}(x_t^k, y_t^k : g_x, g_y) - \vec{D}_t(x_t^k, y_t^k : g_x, g_y)\ ] \qquad (3\text{-}2)$$

This decomposition provides an empirical framework to investigate the nature of productivity changes, as the technical change component (TECH) and efficiency change component (EFFCH) represent different sources of productivity changes, i.e., technology and efficiency.

3. Estimation Results

3.1. Changes in the Technical Efficiency

For solving the linear programming problems in equation (1), 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. Recall that the positive value of θ in equation (1) indicates the presence of technical inefficiency. The smaller the value of θ, the less inefficient, i.e., higher level of performance or productivity. Here, all transition countries are grouped into 3 groups for comparison purpose, CEE, CIS, and Asian countries.

The overall mean of technical efficiency estimate during the study period is 0.1827. This indicates that on average, the netput of the agricultural sector of transition countries could have been increased by 0.1827 times of observed netput level if frontier technology were available. Among the three country groups, the Asian country group recorded the smallest mean technical inefficiency, θ (0.0527). That is, the agricultural sector of Asian transition countries, on average, performed better than their CEE (0.0875) and CIS (0.3489) counterparts. CEE countries performed much better than CIS on average.

Table 2 also shows the existence of a significant performance gap across countries in their agricultural sector. During the study period, ten of the selected 28 transition countries are considered to be frontier countries. These countries include four CEE countries (Albania, Croatia, Estonia, Slovenia), two CIS countries (Armenia, Russian Federation), and four Asian transition countries (Afghanistan, Laos, Myanmar, Viet Nam). These are in high contrast compared to the four CIS countries with poor performance, i.e. Azerbaijan, Kyrgyzstan, Tajikistan, and Turkmenistan. In CEE and Asian countries, Lithuania, Latvia, Bulgaria and Mongolia did not perform well.

Table 2: Mean Technical Efficiency of Transition Countries

CEE		CIS		Asia	
Albania	0.0000	Armenia	0.0000	Afghanistan	0.0000
Bulgaria	0.1434	Azerbaijan	0.5052	Cambodia	0.0367
Croatia	0.0000	Belarus	0.3282	Laos	0.0000
Czech Republic	0.0437	Georgia	0.2671	Mongolia	0.2794
Estonia	0.0000	Kazakhstan	0.3113	Myanmar	0.0000
Hungary	0.0894	Kyrgyzstan	0.6212	Viet Nam	0.0000
Latvia	0.2544	Russian Federation	0.0000		
Lithuania	0.3583	Tajikistan	0.6087		
Poland	0.0514	Turkmenistan	0.6849		
Romania	0.0220	Ukraine	0.2297		
Slovenia	0.0000	Uzbekistan	0.2814		
MEAN	0.0875	MEAN	0.3489	MEAN	0.0527

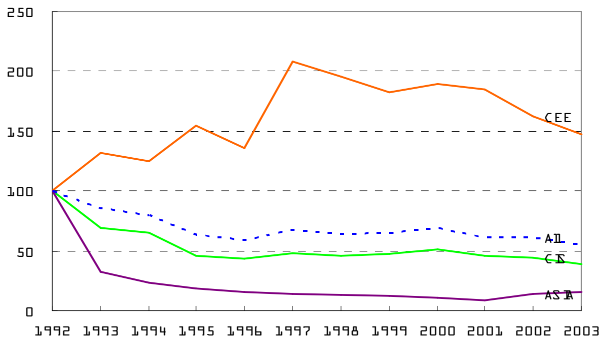
The dynamics of technical efficiency is of interest in many aspects, which, in particular, gives us some insights regarding the adjustment path taken by the agricultural sector in order to cope with the rapid changes in social and economic environments. With some fluctuations, the mean technical efficiency of all transition countries considered in this study seems to have a decreasing trend during the study period (Table 3, Figure 1). This suggests that the changes in social and economic environment in transition countries during the late 1980s and the early 1990s might not have significant positive impacts on the improvement of production efficiency.

However, Table 3 and Figure 1 indicate different evolutions of technical efficiency among country groups. That is, even though there are some fluctuations, CEE countries have experienced efficiency improvement during the study period. This means that the performance gap of agricultural sector between CEE and CIS countries has increased. This stark 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 a relatively progressive policy reform for transition, compared to the CIS countries (Lerman et al., 2002; Macours and Swinnen, 1999; Heath, 2003).[3]

Table 3: Technical Efficiency by Country Group over Time

year	CEE	CIS	Asia	All
1992	0.1340	0.1760	0.0081	0.1235
1993	0.1012	0.2535	0.0248	0.1447
1994	0.1070	0.2688	0.0347	0.1551
1995	0.0868	0.3859	0.0437	0.1951
1996	0.0988	0.4038	0.0513	0.2084
1997	0.0643	0.3684	0.0570	0.1822
1998	0.0683	0.3845	0.0619	0.1912
1999	0.0733	0.3695	0.0669	0.1883
2000	0.0706	0.3428	0.0752	0.1785
2001	0.0724	0.3845	0.0976	0.2004
2002	0.0827	0.3989	0.0579	0.2016
2003	0.0906	0.4500	0.0533	0.2238
Mean	0.0875	0.3489	0.0527	0.1827

Figure 1: Technical Efficiency Indices by Country Group



[3] Lerman et al. (2002) indicated four factors influencing labor productivity growth; a 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 and Swinnen (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.

3.2. The Patterns of Productivity Changes

Table 4 and Table 5 summarize the decomposition of productivity changes into efficiency and technical changes. The positive values of changes in productivity and its components imply improvements, whereas the negative values imply regress or deterioration. In spite of efficiency deterioration (-0.0091), transition countries in this study recorded productivity growth (0.0046), which is mainly attributable to technical progress (0.0137).

However, Table 4 shows that the patterns of productivity change are quite different among each country group. CEE countries recorded much higher productivity growth (0.0232) than CIS(-0.0173) and Asian(0.0105) transition countries. The higher productivity growth of CEE countries is mainly attributable to technical progress (0.0192). Although Asian transition countries suffered from efficiency deterioration (-0.0041), they recorded positive productivity growth (0.0105) due to technical progress (0.0146). However, agricultural sector in CIS countries experienced productivity decline (-0.0173) due to high efficiency deterioration (-0.0249).

The last column of Table 4 shows the cumulative indices of efficiency change, technical change, and productivity change. During the study period, CEE countries accomplished a productivity growth of 25.48 percent, from 21.15 percent technical progress and 4.33 percent efficiency improvement. However, CIS countries suffered a 19.0 percent productivity decline due to 27.41 percent efficiency deterioration, in spite of 8.4 percent technological progress.

Figure 2-a, b, c depicts the cumulative productivity change and its components. These also show that the growth pattern of productivity and its sources are quite different among the three country groups. In spite of higher technical change, CIS countries recently suffered from sluggish productivity growth due to rapid efficiency decline.

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. In Table 5 and Figure 3, which provide the yearly average changes in productivity and its components, significant differentials in the dynamics of productivity across countries are observed. During the study period, Bulgaria (0.0634) accomplished the highest productivity growth followed by Czech (0.0511), Viet Nam (0.0381), Slovenia (0.0370), and Romania (0.0335). Among CEE countries, Bulgaria recorded the highest productivity growth followed by Czech, Slovenia, Romania, and Croatia, whereas Latvia and Poland suffered from productivity decline. Most of the CIS countries experienced productivity decline except Armenia, Tajikistan, and Turkmenistan. Among CIS countries, Ukraine (-0.0626), Georgia (-0.0401), and Belarus (-0.0388) suffered from a deep productivity decline during the study period. In particular, Ukraine and Georgia suffered both efficiency and technical regress. Among Asian transition countries, Viet Nam (0.0381) and Myanmar (0.0295) recorded the highest productivity growth mainly due to technical change, whereas Afghanistan (-0.0011), Cambodia (-0.0105), and Laos (-0.0007) showed a slight productivity decline.

Figure 3 depicts the patterns of productivity change through decomposition in Table 5. Here, the horizontal axis represents efficiency change, and the vertical line represents technical change. 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. From Figure 3, the patterns of productivity change can be categorized into five groups; 1) countries with efficiency improvement and technological progress (Bulgaria, Czech, Romania), 2) frontier countries with technological progress(Albania, Croatia, Estonia, Slovenia, Armenia, Myanmar, Viet Nam), 3) frontier countries with technological regress (Russia, Afghanistan, Laos), 4) countries with technical progress and efficiency deterioration (Hungary, Latvia, Lithuania, Poland, Azerbaijan, Belarus, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan, Cambodia, Mongolia) , and 5) countries with technical regress and efficiency deterioration (Georgia, Ukraine).

Table 4: Decomposition of Productivity Changes by Country Group over Time

Period	CEE			CIS			ASIA			ALL		
	Efficiency Change (A)	Technical Change (B)	Productivity Change (A+B)	Efficiency Change (A)	Technical Change (B)	Productivity Change (A+B)	Efficiency Change (A)	Technical Change (B)	Productivity Change (A+B)	Efficiency Change (A)	Technical Change (B)	Productivity Change (A+B)
92/93	0.0327	0.0343	0.0671	-0.0776	0.0238	-0.0538	-0.0166	0.0420	0.0254	-0.0212	0.0319	0.0107
93/94	-0.0058	0.0253	0.0195	-0.0152	-0.0521	-0.0674	-0.0099	0.0312	0.0213	-0.0104	-0.0039	-0.0142
94/95	0.0202	0.0824	0.1025	-0.1171	0.0630	-0.0541	-0.0090	0.0947	0.0856	-0.0400	0.0774	0.0374
95/96	-0.0120	0.0155	0.0035	-0.0180	-0.0053	-0.0232	-0.0076	0.0245	0.0170	-0.0134	0.0093	-0.0041
96/97	0.0345	-0.0251	0.0094	0.0354	-0.0168	0.0186	-0.0058	0.0005	-0.0052	0.0262	-0.0164	0.0099
97/98	-0.0041	0.0067	0.0026	-0.0161	-0.0388	-0.0548	-0.0049	-0.0802	-0.0850	-0.0090	-0.0298	-0.0387
98/99	-0.0050	-0.0422	-0.0472	0.0150	-0.0483	-0.0333	-0.0050	0.0151	0.0101	0.0028	-0.0323	-0.0294
99/00	0.0027	-0.0369	-0.0341	0.0267	-0.0333	-0.0066	-0.0082	0.0001	-0.0081	0.0098	-0.0275	-0.0177
00/01	-0.0017	0.0568	0.0551	-0.0417	0.0759	0.0342	-0.0224	-0.0106	-0.0329	-0.0219	0.0499	0.0280
01/02	-0.0104	0.0117	0.0014	-0.0144	0.0307	0.0162	0.0397	0.0286	0.0682	-0.0012	0.0228	0.0215
02/03	-0.0079	0.0831	0.0752	-0.0511	0.0852	0.0341	0.0046	0.0143	0.0189	-0.0222	0.0692	0.0470
MEAN	0.0039	0.0192	0.0232	-0.0249	0.0076	-0.0173	-0.0041	0.0146	0.0105	-0.0091	0.0137	0.0046
Cummulative Indices	0.0443	0.2115	0.2548	-0.2741	0.0841	-0.1900	-0.0452	0.1603	0.1151	-0.1003	0.1505	0.0501

Figure 2-a: Cumulative Indices of Productivity Changes

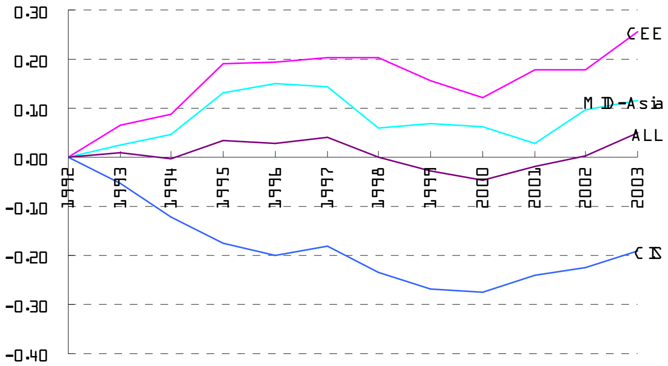


Figure 2-b: Cumulative Indices of Efficiency Change

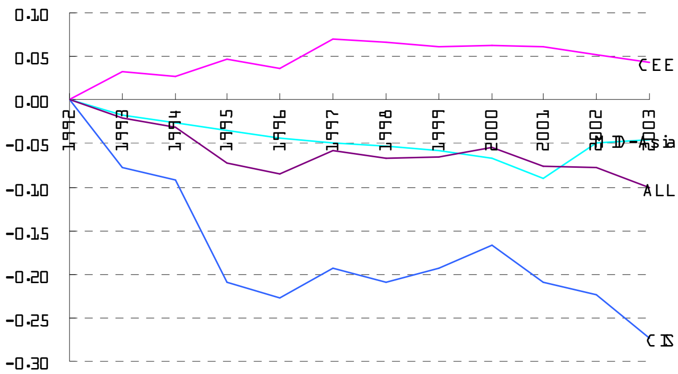


Figure 2-c: Cumulative Indices of Technical Change

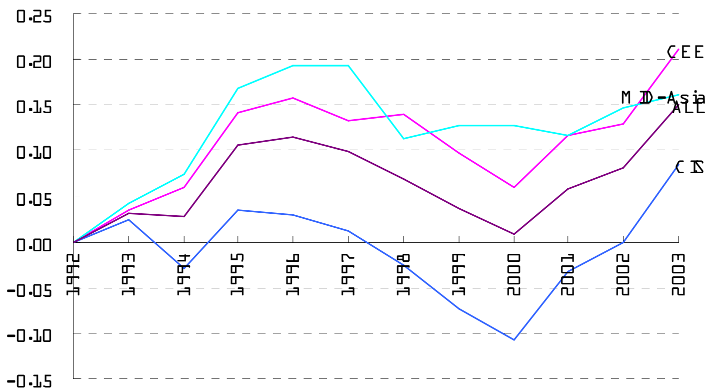
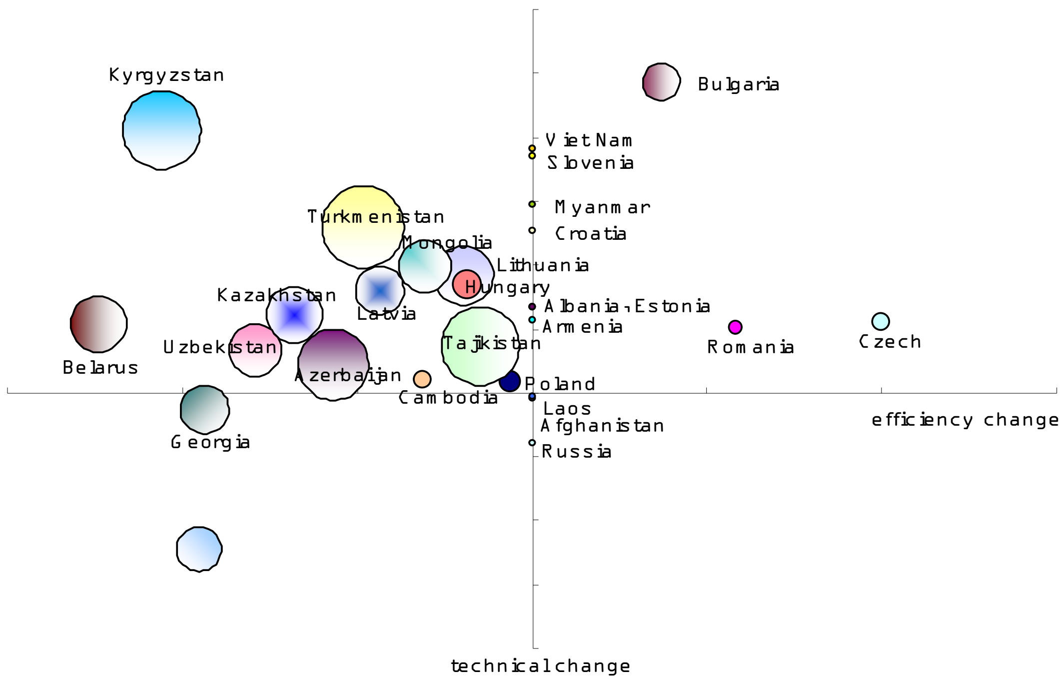


Table 5: Decomposition of Productivity Changes by Country

CEE				CIS				ASIA			
Country	Efficiency Change (A)	Technical Change (B)	Productivity Change (A+B)	Country	Efficiency Change (A)	Technical Change (B)	Productivity Change (A+B)	Country	Efficiency Change (A)	Technical Change (B)	Productivity Change (A+B)
Albania	0.0000	0.0133	0.0133	Armenia	0.0000	0.0112	0.0112	Afghanistan	0.0000	-0.0011	-0.0011
Bulgaria	0.0149	0.0485	0.0634	Azerbaijan	-0.0228	0.0044	-0.0184	Cambodia	-0.0125	0.0019	-0.0105
Croatia	0.0000	0.0253	0.0253	Belarus	-0.0495	0.0107	-0.0388	Laos	0.0000	-0.0007	-0.0007
Czech	0.0400	0.0111	0.0511	Georgia	-0.0375	-0.0026	-0.0401	Mongolia	-0.0122	0.0197	0.0076
Estonia	0.0000	0.0133	0.0133	Kazakhstan	-0.0271	0.0122	-0.0149	Myanmar	0.0000	0.0295	0.0295
Hungary	-0.0074	0.0167	0.0093	Kyrgyzstan	-0.0424	0.0409	-0.0015	Viet Nam	0.0000	0.0381	0.0381
Latvia	-0.0173	0.0161	-0.0012	Russia	0.0000	-0.0080	-0.0080				
Lithuania	-0.0077	0.0182	0.0105	Tajikistan	-0.0059	0.0073	0.0014				
Poland	-0.0024	0.0017	-0.0007	Turkmenistan	-0.0192	0.0260	0.0068				
Romania	0.0234	0.0102	0.0335	Ukraine	-0.0381	-0.0245	-0.0626				
Slovenia	0.0000	0.0370	0.0370	Uzbekistan	-0.0316	0.0065	-0.0251				
MEAN	0.0039	0.0192	0.0232	MEAN	-0.0249	0.0076	-0.0173	MEAN	-0.0041	0.0146	0.0105

Figure 3: The patterns of Productivity Change



3.3. Reform, Industrial Transformation, and Productivity

CEE countries, which are regarded, in general, to have adopted relatively progressive reform policies for transition compared to CIS countries, demonstrated 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' adjustments.

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 and Swinnen, 1999). Our analysis also adds some empirical evidence 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 investigated the relationship between agricultural reform level and productivity change. Agricultural reform index by the World Bank (Heath, 2003; Csaki et al., 2006) 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. 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 and Figure 5 provides scatter diagrams depicting the association between agricultural reform index in year 1997 (independent variable) and mean productivity and its changes during the study period for two country groups, CEE and CIS.[4] In general, the level of agricultural reform seems to have positive effects on the productivity (i.e. efficiency) and its changes. Only one exception is observed in the association between technical change and agricultural reform index. In Figure 4, both regression coefficients are statistically significant at 1%. The coefficients of independent variable (reform index) in Figure 5a and Figure 5c are also statistically significant at 5% and 10%, respectively.

We also estimate a regression model in order to characterize factors affecting the productivity of agricultural sector in transition countries. In particular, we focus on the effects of reform policy on the productivity. Table 6 provides the estimation results of two regression models in which the technical inefficiency measures are dependent variables; 1) including all countries, 2) including CEE and CIS countries only. To account for the truncated nature of the distribution of our productivity measures, we have used a panel Tobit approach. We regressed the productivity measure (technical inefficiency) on various explanatory variables,including the country group dummy (CEE, ASIA), time dummy (Time), farm size (Scale: farmland per worker in agricultural sector), capital-labor ratio (CapLab: the number of tractors per worker), and the level of industrial transformation (Agratio: the proportion of agricultural GDP to total GDP). We also include an explanatory variable measuring the level of reform in agricultural sector (Reform97) to test the hypothesis on the significance of reform policy in explaining productivity differentials across countries.

[4] Unfortunately, a reform index for Asian transition countries are not available.

Figure 4. Agricultural Reform and Efficiency

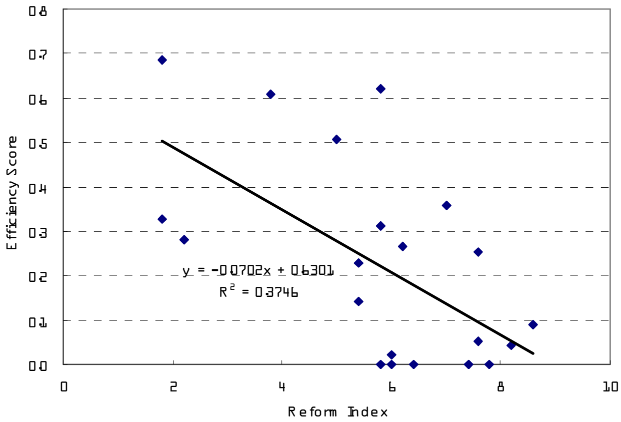
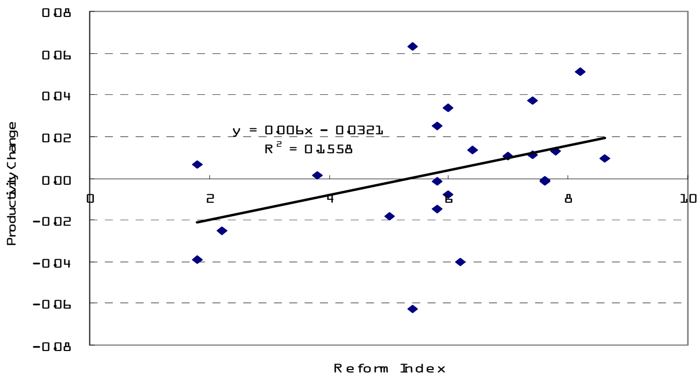
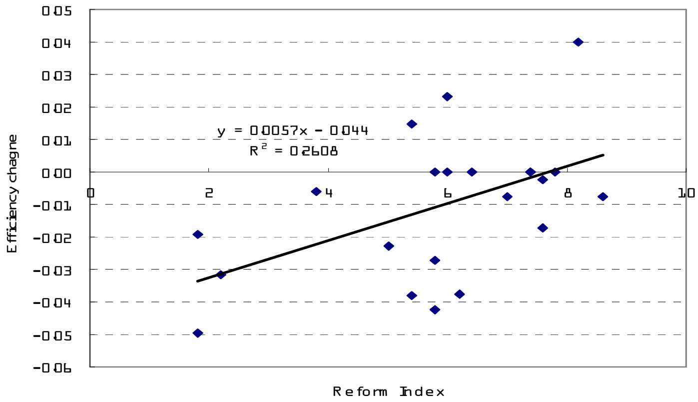


Figure 5: Agricultural Reform and Productivity Change

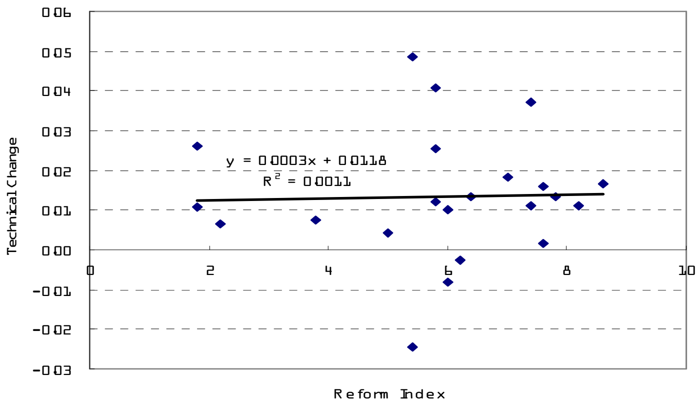
(a) Productivity Change



(b) Efficiency Change



(c) Technical Change



All coefficient estimates have the expected signs in both models, except for farm size (Scale). Recall that the dependent variable is inefficiency, and hence, a negative (positive) sign of a coefficient represents the positive (negative) effect of that variable on the performance of agricultural sector. First, in the regression model including Asian countries, all coefficient estimates are statistically significant. The estimation results show the presence of significant productivity differentials among country groups. As shown in Table 2, Table 3 and Figure 1, transition countries suffer efficiency deterioration during the study period since the coefficient of time dummy is estimated as positive and significant. We also found evidence that countries with higher capital-labor ratio perform better. Significant negative coefficients of the agricultural GDP proportion (Agratio) imply that the level of industrial transformation plays an important role in improving the productivity of agricultural sector. However, farm size turned out to be negatively related with productivity in transition countries.

Second, we estimated a regression model including CEE and CIS countries only. This provides a framework to test whether reform policy affects productivity or not. In CEE and CIS transition countries, farm size and capital-labor ratio may not be important factors for the performance of agricultural sector. Estimation results for time dummy and industrial transformation variables are same as the all-country model. The reform policy is found to be positively related to the performance of agricultural sector in transition countries, as shown by previous studies such as Swinnen (2006).

Table 6. Estimation Results of Tobit Model

All Countries (N[1)]=336)			CEE and CIS Countries (N[1)]=154)		
Variables	Estimates	(t-value)	Variables	Estimates	(t-value)
CEE	-0.24154	(-2.47)**	CEE	-0.30724	(-2.58)***
ASIA	-0.33003	(-4.12)***	Time	0.00971	(2.35)**
Time	0.00584	(2.25)**	Reform97	-0.05420	(-1.85)*
Scale	0.00060	(2.39)**	Scale	-0.00136	(-0.85)
CapLab	-0.00061	(-2.79)***	CapLab	-0.00009	(-0.98)
Agratio	-0.76579	(-4.98)***	Agratio	-0.59995	(-1.85)*
Constant	0.47881	(6.00)***	Cons	0.69570	(3.16)***
σ_u	0.28799	(6.45)***	σ_u	0.27533	(5.75)***
σ_u	0.11269	(17.72)***	σ_e	0.07140	(12.59)***
$\rho = \sigma^2_u / (\sigma^2_u + \sigma^2_u)$	0.86722[2)]		$\rho = \sigma^2_u / (\sigma^2_u + \sigma^2_u)$	0.9370[2)]	
Loglikelihood	52.77		Loglikelihood	62.74	

***: significant at 1%, **: significant at 5%, *: significant at 10%

Note: 1) N = the number of observations used for regression

2) The hypothesis that ρ=0 is rejected at significance level of 0.1%.

3.4. Initial Condition and Productivity

Many studies emphasized the importance of the inherited economic conditions, natural resources, histories, and institutions of transition countries.[5] And they pointed out that transition countries have had different transition paths, due to different initial conditions and the economic policies implemented. We investigated the impact of initial conditions on performance of agricultural sector. Following De Melo et al. (1997), we include 11 initial condition variables, which can be categorized into two groups; 1) indicators for initial levels of development, resources, and growth (income, urbanization, industrialization, natural resources, geographical proximity to thriving market economies, prior economic growth); 2) initial macroeconomic distortions and institutional characteristics of the transition economies (repressed inflation, trade shares in GDP, the black market exchange rate premium, initial institutional characteristics of the transition economies, market memory). We also rely on the method of principal components to reduce the dimensionality of these variables for our regression. The result of principal component analysis indicates that the first two principal components account for most of the variation (65.4%). Like De Melo (1997), the first principal component (COM1) has high positive correlations for economic distortions such as the black market exchange rate premium, market memory, repressed inflation, and trade shares in GDP. Hence, the values in the eigenvector for these variables may represent the degree of macroeconomic distortions at the beginning of transition, and a measure of unfamiliarity with the market economy. The second principal component (COM2) has high positive correlation for income and urbanization, and hence COM2 might be interpreted an index of the overall level of development. Table 7 provides the estimation results of our regression model. Here, the dependent variable is also the technical inefficiency measure. Country group dummy (CEE) and reform variable (Reform97) are excluded due to high correlation with initial condition variables (COM1, COM2). All variables have the expected sign. Estimation results show that the degree of macroeconomic distortions at the beginning of transition (COM1) has significant negative impact on the performance of agricultural sector. The overall level of development (COM2) has positive impact on the performance of this sector, but the coefficient is statistically insignificant.

Table 7. The Impact of Initial Condition on the Performance

Variables	Estimates (t-value)

[5] De Melo et al. (1997)

Time	0.0042	(1.56)
Scale	-0.0015	(-1.67)*
CapLab	-0.0006	(-2.85)***
Agratio	-1.0195	(-5.99)***
COM1	0.1141	(6.64)*
COM2	-0.0392	(-1.31)
Constant	0.4289	(6.17)*
σ_u	0.2310	(5.65)*
σ_u	0.1099	(16.75)*
$\rho = \sigma^2_u / (\sigma^2_u + \sigma^2_u)$	0.8154	
Loglikelihood	60.54	

Note: 1) ***: significant at 1%, **: significant at 5%, *: significant at 10%, 2) the number of observations used for regression = 264, 3) The hypothesis that $\rho=0$ is rejected at significance level of 0.1%.

4. 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 28 CEE, CIS, and Asian transition countries focusing on the dynamics of productivity changes and the effects of reform policy. A frontier approach (data envelopment analysis: DEA) combining the directional distance function, is employed in this paper.

First, Asian and CEE transition countries performed better than CIS countries. However, the performance improvement of CEE countries seems to be more prominent compared to that of Asian and CIS countries. Second, the productivity growth is mainly attributable to the technical progress, particularly in CEE countries. CEE countries achieved both efficiency and technical improvement while CIS countries suffered from productivity decline due to efficiency decline and sluggish technical progress. Third, reform policy and industrial transformation seems to have positive effects on the performance of agricultural sector and its changes. Finally, the initial conditions do matter. The degree of macroeconomic distortions at the beginning of transition has significant negative impact on the performance of agricultural sector, while the overall level of development has positive impact on the performance of this sector.

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