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Emerald Article: Investigating agricultural productivity improvements in transition economies

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Investigating agricultural productivity improvements in transition economies

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Abstract

Purpose – This paper aims to conduct inter-country analysis of agricultural productivity growth in transition countries in Asia and Europe. This paper pays particular attention to the magnitude and direction of productivity growth over different stages of their market reforms.

Design/methodology/approach – The paper adopts a nonparametric Malmquist index approach using an output distance function to measure productivity growth and decompose it into its associated components. The empirical analysis is performed using the most recent FAO data set of 35 transition countries in Asia and Europe over the period of 1979-2004.

Findings – The paper shows that decomposition analysis of productivity growth differs considerably at different stages of the transition period. This study presents supporting evidence that serious improvements in performance and efficiency, as well as continued technology transfer and adoption are required for transition economies to meet the demand for food and anticipated increases in world population.

Originality/value – A comprehensive picture about the agricultural performance of the transition countries has somehow been missing in the literature. This study fills this gap by analyzing the productivity in these transition countries.

Keywords Agriculture, Productivity growth, Technical change, Transition countries, Malmquist index, Productivity rate

Paper type Research paper

Introduction

The accession in 2004 of eight Central and Eastern Europe (CEE) countries to the European Union (EU) has triggered a new round of debate on agricultural performance in transition economies. Intense debate could date back to the later 1970s after China has embarked on an economic reform program and introduced the household responsibility system (HRS). Almost a decade later, countries with a heavily regulated Asian-style economy, e.g. Laos, Myanmar and Vietnam, attempting to change their basic constitutional elements towards market-style fundamentals began their market reforms in the late 1980s. The market-oriented reforms in Asia had aroused anxiety

JEL classification – D24, Q10

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of the communist bloc countries in Europe. As the consequence, the CEE countries and Newly Independent States (NIS) began the breakup of the former Soviet Union and undertook liberalization of their economy in the late 1980s and early 1990s.

Given anticipated increases in world population, there is growing concern regarding the availability of resources for agricultural production and sources of productivity improvements in different regions of the world. With nearly 40 percent of global agricultural outputs, transition countries have the potential to supply a substantial share of the expected growth in food demand forecast for the first half of this century. Enhancing the production capacity of agriculture in transition countries through productivity increases is an important policy goal because agriculture still represents an important sector in these transition economies (Swinnen and Rozelle, 2006). The agricultural sector provides livelihood directly and indirectly to a significant portion of the population of transition countries. Economic reform has transformed the structure and volume of these countries' agricultural production, consumption and trade and introduced important agricultural productivity changes. Whether the market reforms results in significant improvement of their agricultural TFP growth and to what extent the differences exist among the transition countries during the post-reform period in terms of the magnitude and direction of their agricultural performance receive more attention from researchers in recent years.

In this study we seek to build on the past literature about investigation of cross-country differences in agricultural productivity levels and growth rates. Over the past two decades, many studies employed different productivity measures covering different sets of countries to analyze differences in productivity for a large number of countries (Otsuka *et al.*, 1992; Young, 1995; Pingali *et al.*, 1997; Lusigi and Thirtle, 1997; Fulginiti and Perrin, 1997; Suhariyanto and Thirtle, 2001; Trueblood and Coggins, 2003; Coelli and Rao, 2005). However, because of data problems, i.e. absence of data and differences in the nature of data between socialist and non-socialist countries, a comprehensive picture about the agricultural performance of the transition countries has somehow been missing in the literature. Transition countries generally have a long history of technology R&D investments but they may be somewhat behind the rest of the world in terms of level of new technology adoption. As a result of this, it might be expected that some of the nations might achieve TFP growth in agriculture by improving the technological base and this in turn would suggest that there could be above average shifts in TFP. In addition, these countries are, by definition, in transition and there has not been an equilibrium attached. As a result it is possible that agricultural TFP growth in some of the nations has been pulled down due to a fall in technical efficiency because the set of institutions that are needed in agriculture to produce and extend new technologies are weak or deteriorating enough.

It has been recorded in the literature that only a few analyses in the past examined the effect of market-orient reforms on agricultural performance (Lerman, 2000; Macours and Swinnen, 2002). Even though these studies included a broad range of countries, the analyses were conducted using partial measures of productivity because of data availability. Indeed, a recent book by Swinnen and Rozelle (2006) examines intercountry and interregional comparisons of agricultural TFP and the impact of the economic reforms on agricultural production in transition countries. They found that the effect differed widely across countries and over time within countries. Although their analysis gave special attention to the transition economies, they used different measures of productivity in comparison and the analysis was conducted in the years soon after the beginning of the reforms which could not give a comprehensive picture of agricultural performance in these countries.

To fill these gaps, the main purpose of the paper is to understand the state of productivity performance in the transition countries. To meet this overall goal we have three specific objectives. First, we seek to measure TFP growth and conduct a cross-countries comparison of TFP growth in all of the transition countries in Asia and Europe for the years between 1979 and 2004. Because of increased availability of data on enough variables on enough countries for sufficient years, it is possible to rigorously analyze differences in productivity for a large number of transition countries over time and update the analysis to a more recent time period. In this paper, we focus on 35 transition economies in Asia and Europe where these countries account for 30 percent of world's population and nearly 40 percent of global agricultural outputs. Second, we utilize a nonparametric Malmquist index approach and the most recent Food and Agricultural Organisation (FAO) data to decompose TFP growth of these transition countries into two of the sources of productivity growth: technical change (TC) and changes in technical efficiency. These sources are important because they provide useful information to policy makers that want to design suitable policies to achieve greater rates of TFP growth. Finally, as it is recorded that the market reforms in transition countries taken place at different periods and these countries applied different strategic packages in agricultural sector, we are going to pay particular attention to the magnitude and direction of TFP growth over different stages of their market reforms.

The remainder of the paper is organized as follows. The next section presents the underlying construction of the Malmquist TFP index decomposition. The following section discusses the data set and the definitions of the variables used in this study. The empirical results are presented and discussed in the next section and the final section concludes and summarizes.

The Malmquist TFP growth index decomposition

Let the input vector at period $t = 1, \ldots, T$ with $n = 1, \ldots, N$ inputs be denoted as $\mathbf{x}^t = \left(x_1^t, x_2^t, \ldots, x_N^t\right) \in \Re_+^N$ and the output vector at period t with $m = 1, \ldots, M$ outputs be denoted as $\mathbf{y}^t = \left(y_1^t, y_2^t, \ldots, y_M^t\right) \in \Re_+^M$. Färe *et al.* (1989, 1994) proposed a Malmquist TFP growth index to measure TFP change using a nonparametric technique or data envelopment analysis (DEA) approach. The output-oriented Malmquist TFP change (MTC) index between period t and $t+1$ consists of four output-oriented distance functions which is defined as:

$$M_o(\mathbf{x}^{t+1}, \mathbf{y}^{t+1}, \mathbf{x}^t, \mathbf{y}^t) = \left[\frac{D_o^t(\mathbf{x}^{t+1}, \mathbf{y}^{t+1})}{D_o^t(\mathbf{x}^t, \mathbf{y}^t)} \times \frac{D_o^{t+1}(\mathbf{x}^{t+1}, \mathbf{y}^{t+1})}{D_o^{t+1}(\mathbf{x}^t, \mathbf{y}^t)}\right]^{1/2}, \tag{1}$$

where $D_0^1(\mathbf{x}^t, \mathbf{y}^t)$ represents the output-oriented distance function evaluated using observed data at period t relative to the reference technology at period t and other three output-oriented distance functions can be interpreted by interchanging subscript t and $t+1$. Equation (1) is defined as the geometric mean of two Malmquist TFP indices between period t and $t+1$ where the first and second terms inside the blanket represents the output-oriented Malmquist TFP index in period t and t + 1, respectively.

The Malmquist TFP index can be decomposed in a way that highlights what sources are attributed to the TFP growth as:

$$M_o(\mathbf{x}^{t+1}, \mathbf{y}^{t+1}, \mathbf{x}^t, \mathbf{y}^t) = \frac{D_o^{t+1}(\mathbf{x}^{t+1}, \mathbf{y}^{t+1})}{D_o^t(\mathbf{x}^t, \mathbf{y}^t)} \cdot \left[\frac{D_o^t(\mathbf{x}^{t+1}, \mathbf{y}^{t+1})}{D_o^{t+1}(\mathbf{x}^{t+1}, \mathbf{y}^{t+1})} \times \frac{D_o^t(\mathbf{x}^t, \mathbf{y}^t)}{D_o^{t+1}(\mathbf{x}^t, \mathbf{y}^t)} \right]^{1/2}, \quad (2)$$

where the first ratio outside the square brackets is called "efficiency change" component which measures the change in the output-oriented measure of Farrell TE between periods t and $t+1$. The efficiency change component simply compares the distances of two observations, $(\mathbf{x}^t, \mathbf{y}^t)$ and $(\mathbf{x}^{t+1}, \mathbf{y}^{t+1})$, to the corresponding frontier technology at period t and $t+1$. It measures whether production is catching up with or falling behind the frontier technology. It is assumed that this component captures diffusion of technology related to differences in knowledge and institutional setting. The remaining part of the index is a measure of "TC". It is the geometric mean of the shift in technology in period t and $t+1$ using observed data at $(\mathbf{x}^t, \mathbf{y}^t)$ and $(\mathbf{x}^{t+1}, \mathbf{y}^{t+1})$. This term captures changes in technology at a national level. All three terms, i.e. the change in TFP, and its decomposition to the change in efficiency and the change in technology, are interpreted as progress, no change, and regress when their values are greater than 1, equal to 1, and less than 1, respectively. In order to calculate the MTC index and its components, it requires the solving of four LP problems for the output-oriented distance functions, i.e. $D_o^t(\mathbf{x}^t, \mathbf{y}^t)$, $D_o^{t+1}(\mathbf{x}^{t+1}, \mathbf{y}^{t+1})$, $D_o^t(\mathbf{x}^{t+1}, \mathbf{y}^{t+1})$ and $D_o^{t+1}(\mathbf{x}^t, \mathbf{y}^t)$ which can be done using the DEAP software (Coelli, 1996)[1].

Description of the data

The empirical analysis in this study focuses on agricultural production of transition countries where these countries cover a wide range of transition economies located both in Asia and Europe. Countries selected for analysis are categorized into three groups according to the starting point of the transition and the geographic location of the countries. The first group, or CEE, consists of transition countries located in CEE. Three Baltic countries (i.e. Estonia, Latvia, and Lithuania) and Turkey are also included into this group. The second group, or NIS, consists of NIS of the former Soviet Union. The last group, or ASIA, consists of transition countries located in East Asia and Southeast Asia. Because these transition countries began the market reforms at different periods of time, the year of their market reforms in these countries are listed in Table I.

Panel data on 35 transition countries covering the period 1979-2004 are used in the empirical analysis. These countries account for nearly 40 percent of global agricultural outputs and 30 percent of world's population. Due to the breakdown of the former Soviet Union, data on the NIS countries are only available since 1992. The primary source of data is obtained from the web site of the FAO of the United Nations (UN). Specifically, the agricultural statistics were acquired from the AGROSTAT system, which is supported by the Statistics Division of the FAO. In this study, the production technology is presented by two output variables (i.e. crop and livestock) and five input variables (i.e. land, machinery, labor, fertilizer and work animals). The output series are derived by aggregating detailed output quantity data on 127 agricultural commodities (115 crop commodities of average 1999-2001 and 12 livestock commodities). Construction of output data series uses the following steps. The first step is to calculate average aggregate for the base period 1999-2001. These aggregates are constructed using

Countries and year of reform					
CEE		NIS		ASIA	
Albania	1989	Armenia	1992	China	1979
Bulgaria	1989	Azerbaijan	1992	Mongolia	1991
Czech Republic	1989	Belarus	1992	Laos	1986
Hungary	1989	Georgia	1992	Myanmar	1989
Poland	1989	Moldova	1992	Vietnam	1986
Romania	1989	Russia	1992		
Slovenia	1989	Ukraine	1992		
Bosnia and Herzegovina	1992	Kazakhstan	1992		
Croatia	1992	Kyrgyzstan	1992		
Cyprus	1992	Tajikistan	1992		
Macedonia	1992	Turkmenistan	1992		
Malta	1992	Uzbekistan	1992		
Serbia-Montenegro	1992				
Slovakia	1992				
Estonia	1992				
Latvia	1992				
Lithuania	2001				
Turkey	2001				

Table I.
Classification of selected countries

output quantity data and international average prices (expressed in US dollars) derived using the Geary-Khamis method[2]. The next step is to extend the average base period output series 1999-2001 to cover the whole study period 1992-2002. This is achieved using the FAO production index number series for crops and livestock separately. Inputs are classified into traditional and modern inputs. Traditional inputs are land, labor, and work animals. Land input represents the arable land, land under permanent crops as well as the area under permanent pasture in hectares. Labor input refers to economically-active population in agriculture. Work animal input is the sheep-equivalent of the five categories of animals used in constructing this variable. The categories considered are: buffaloes, cattle, pigs, sheep and goats. Numbers of these animals are converted into sheep-equivalents using conversion factors: 8.0 for buffalos and cattle; and 1.00 for sheep, goats and pigs. Two modern inputs, i.e. fertilizer and machinery, are considered to embody technology. Fertilizer use data by grades were converted into actual nutrient sums of nitrogen, phosphorus, and potash ($[N + P_2O_3 + K_2O] \times 10^3$ metric tons per year). Machinery input represents the total number of wheel and crawler tractors, but excluding garden tractors, used in agriculture[3].

Descriptive statistics of the variables summarized by each region group is presented in Table II.

Results

Examining TFP growth and the forces that are driving overall TFP growth of transition economies is important because they provide useful information to policy makers that want to design suitable policies to maintain or achieve greater rates of TFP growth. In the past because of absence of data in transition economies, many analyses of the economy just ignored most of these countries. This paper sketches a picture agricultural TFP growth of all of transition countries in different regions. Following the previous studies

	Output variables		Input variables				
	Crops (10^6 \$)	Livestock (10^6 \$)	Land (10^3 ha)	Machinery (10^3)	Labor (10^3)	Fertilizer (10^6 ton^3)	Work animal (10^6)
CEE	2,376.2	798.9	6.5	195.8	1.4	3.8	22.7
	(3,919.6)	(1,025.3)	(9.4)	(347.0)	(3.2)	(5.8)	(33.4)
NIS	3,344.6	1,756.9	47.2	157.5	1.8	4.0	59.8
	(5,122.8)	(3,155.2)	(76.1)	(255.8)	(2.4)	(7.0)	(96.9)
ASIA	36,089.4	13,084.0	132.6	184.1	104.6	59.3	333.1
	(68,145.8)	(28,829.8)	(199.7)	(326.5)	(189.8)	(119.8)	(568.7)
All	10,612.5	3,978.3	48.2	181.8	25.9	16.9	106.8
	(36,115.2)	(14,968.0)	(116.6)	(317.6)	(101.8)	(62.8)	(308.5)

Notes: 1979-2004; means are calculated; standard deviations are presented in parentheses; the data on the NIS countries are only available during the period 1992-2004
Source: AGROSTAT system, FAO

Table II. Descriptive statistics of variables

on analyzing intercountry comparisons in agricultural TFP growth, this paper utilizes the DEA-based Malmquist index approach to analyze the intercountry differences in agricultural TFP growth in the transition economies[4]. Table III provides a summary of weighted growth rates of the MTC and its decomposition into technical efficiency change (TEC) and TC. The TEC component (when it is positive) explains the "catching-up" part of the TFP growth whereas the TC component (when it is positive) explains the "frontier-shift" part of the TFP growth. The record of TFP growth decomposition for all transition economies over the period 1979-2004 is reported in Section A.

Overall, the annual average growth rate across all transition countries over the entire time period of our analysis (1979-2004) was 3.65 percent (Table III, Section A).

Region	Period	TEC	TC	MTC
A) All	1979-1983	−1.17	1.37	0.20
	1984-1988	0.17	3.56	3.73
	1989-1993	0.48	4.98	5.46
	1994-1998	0.10	3.83	3.94
	1999-2004	0.24	4.52	4.75
	1979-2004	−0.03	3.68	3.65
B) CEE	1989-1993	0.67	3.14	3.80
	1994-1998	0.82	3.34	4.16
	1999-2004	−0.04	2.56	2.52
	1989-2004	0.45	2.98	3.43
C) NIS	1992-1996	−0.54	4.07	3.53
	1997-2001	3.30	1.83	5.13
	2002-2004	0.41	3.71	4.11
	1992-2004	1.14	3.12	4.26
D) ASIA	1979-1983	0.06	1.37	1.43
	1984-1988	0.19	3.32	3.51
	1989-1993	−0.40	8.40	8.00
	1994-1998	−2.06	5.67	3.61
	1999-2004	0.35	6.77	7.12
	1979-2004	−0.37	5.11	4.73

Table III. Weighted growth rates of the MTC decomposition for all transition countries over the period 1979-2004 and for each country group over the transition period in percentage

This finding paints a fairly optimistic picture that agriculture in these transition economies was healthy in terms of its improvement in productivity over the past two decades. Most developed countries that are considered to have well performing agricultural economies (e.g. the USA, Germany, Australia) have consistently posted TFP growth rate of more than 1.5 percent (Bureau *et al.*, 1995). The findings of the decomposition analysis demonstrated convincingly that the relatively high overall rate of TFP growth in these transition countries to a large extent has been driven by the increase of TC. In fact, through the entire period (except in 1979-1983), the rate of TC exceeds TFP growth. Between 1979 and 2004, the adoption of new varieties of crops, the extension of new breeds of livestock and other breakthroughs have pushed up the production frontier by 3.68 percent annually.

Furthermore, Sections B-D in Table III report the results of TFP growth decomposition for each group of transition countries over the transition period. The CEE countries exhibited an impressive TFP growth after the start of the reform, the productivity increased quite strongly at the annual growth rate of nearly 3.5 percent (Table III, Section B). Similarly, the NIS countries posted TFP growth rate of more than 4.0 percent through the entire period (Table III, Section C). The annual TFP growth rate in the Asian countries was comparatively low at the start period of transition (Table III, Section D). TFP growth in ASIA, however, rebounded and kept rising afterwards at a rate more than 4.5 percent annually[5].

The annual growth rate of TFP across all CEE countries over the transition period was positive and nearly 3.5 percent (Table III, Section B). The findings of the decomposition analysis demonstrate that the relatively high overall rate of TFP growth has relied, in general, on TC. In fact, through the entire period, the rate of TC was higher than 2.5 percent. This finding shows that the adoption of new technology in this group occurred after the reform. TFP growth was above 3.5 percent at the start of the reform and posted TFP growth rate of more than 4.0 percent starting in 1994. Subsequently, TFP growth has been pulled down due to a decline in TEC during the 1999-2004 period. Although not reported in the table, the rate of decrease in TEC between 1999 and 2004 was due to a decline in TEC during the 1999-2002 period (3.61 percent annually). The CEE countries, however, posted impressive TEC at an annual rate above 5.0 percent between 2003 and 2004. This is consistent with abundant labor in family farm and "learning" at the early stages of transition as it was for Eastern Europe. In the Czech Republic, Hungary, Poland, Slovenia and Estonia, the growth in private ownership and investment in the sector, supported by a liberal policy framework and the prospect of EU accession, has led to significant improvements in the efficiency of agricultural production in recent years and explain both the positive TEC in recent years and the diffusion of new technology in the CEE countries. These countries have benefited from a substantial influx of capital, mainly from foreign sources, which has contributed to a renewal of the capacity and performance of the sector. As a result, their agricultural sectors are increasingly competitive in European and world markets.

When taking all countries in aggregate, it is clear that we cannot investigate the differences of their agricultural growth and what sources that force TFP growth for each transition economy. Table IV breaks down the aggregate results of transition countries in more details. Productivity profiles of the MTC decomposition for the transition countries can be mapped into four groups according to the forces that affect TFP growth. In the first group, both "catching-up" and "frontier-shift" effects drove overall TFP progress.

Region	Country	TEC	TC	MTC	Productivity profile[a]
A) CEE	Serbia-Montenegro	−7.17	3.90	−3.27	4
	Cyprus	0.89	−1.64	−0.75	3
	Latvia	−2.31	3.15	0.84	2
	Estonia	−3.88	4.92	1.04	2
	Slovakia	−0.55	1.64	1.09	2
	Bosnia and Herzegovina	−0.25	2.46	2.21	2
	Lithuania	0.26	0.28	0.54	1
	Turkey	0.47	1.54	2.01	1
	Macedonia	0.00	2.65	2.65	1
	Bulgaria	0.63	2.03	2.66	1
	Malta	0.00	2.77	2.77	1
	Poland	1.18	1.70	2.88	1
	Hungary	0.75	2.95	3.70	1
	Romania	0.57	3.17	3.74	1
	Czech Rep	1.11	3.28	4.39	1
	Albania	0.22	4.77	4.99	1
	Croatia	0.00	5.10	5.10	1
	Slovenia	4.58	2.54	7.12	1
B) NIS	Georgia	0.07	−0.85	−0.78	3
	Uzbekistan	−1.29	2.32	1.03	2
	Belarus	−0.42	3.83	3.41	2
	Armenia	1.80	0.54	2.34	1
	Turkmenistan	0.19	2.52	2.71	1
	Azerbaijan	1.41	1.56	2.97	1
	Kazakhstan	0.38	2.88	3.26	1
	Moldova	2.16	1.73	3.89	1
	Kyrgyzstan	1.41	2.77	4.18	1
	Tajikistan	2.62	1.65	4.27	1
	Russia	1.75	2.74	4.49	1
	Ukraine	0.79	4.50	5.29	1
C) ASIA	Laos	−2.20	1.38	−0.82	4
	Vietnam	−0.27	1.91	1.64	2
	Mongolia	−0.38	3.71	3.33	2
	Myanmar	−1.37	4.71	3.34	2
	China	−0.59	5.41	4.82	2

Notes: [a]1 – both "catching-up" and "frontier-shift" effects drove overall TFP progress; 2 – only the "frontier-shift" effect drove overall TFP progress; 3 – a decline in the "frontier-shift" effect led to overall TFP regress; 4 – a decline in the "catching-up" effect led to overall TFP regress

Table IV. Productivity profiles of the MTC decomposition for each transition country

In the second group, only the "frontier-shift" effect drove overall TFP progress. In the third group, a decline in the "frontier-shift" effect led to overall TFP regress. The last group covers that a decline in the "catching-up" effect led to overall TFP regress.

Table IV, Section A reports average country MTC decomposition into TEC and TC components for the CEE countries. There are 16 countries posting TFP progress over the transition period. Of these countries, 12 countries showed that both "catching-up" and "frontier-shift" effects drove overall TFP progress. These countries are Albania, Bulgaria, Croatia, Czech Republic, Hungary, Lithuania, Malta, Macedonia, Poland, Romania, Slovenia and Turkey. Among these countries, Slovenia was the top performer whereas Lithuania was the poorest performer. Slovenia, the richest republic of the former Yugoslavia with the highest per capita GDP among the East European countries, exhibited quite remarkable TFP growth (average of 7.11 percent annually). Its impressive growth was driven by TEC (rose by a rate of 4.58 percent annually) and TC (rose by a rate of 2.54 percent annually). On the other hand, Lithuania, a Baltic country with a small-scaled agricultural sector, showed a little TFP improvement (average of 0.54 percent annually). Its TFP growth was due to TEC (rose by a rate of 0.26 percent annually) and TC (rose by a rate of 0.28 percent annually). Other four CEE countries, i.e. Bosnia and Herzegovina, Estonia, Latvia and Slovakia, showed that only the "frontier-shift" effect drove overall TFP progress. Two Baltic countries, i.e. Estonia and Latvia, with small-scaled agricultural sectors posted a little TFP improvement over the transition period. Only two CEE countries, i.e. Cyprus and Serbia-Montenegro, exhibited overall TFP regress. Cyprus, a country with long traditions as market economies and dominated by small, largely part-time farmers, exhibited TFP regress (average of 0.75 percent annually). TFP regress in Cyprus was due to a decline in the "frontier-shift" effect. Serbia-Montenegro has proved that a decline in the "catching-up" effect led to overall TFP regress (average of 3.27 percent annually).

The pattern of TFP growth shows that the transition countries in the NIS countries exhibited quite healthy performance (Table III, Section C). The annual growth rate of TFP was 4.26 percent which was driven by TEC (rose by a rate of 1.14 percent annually) and TC (rose by a rate of 3.12 percent annually). A decline in TEC took place at the start of the reform but became positive starting in 1997, after five years on negative TEC. TC improvement took place at the start of the reform during 1992-1996 but was declining during the 1997-2001 period and then increasing between 2002 and 2004. As this result, TFP growth exhibited high at the start of the reform and remained high over the entire time period. This is consistent with a diffusion of new technologies coming from established market economies and with stabilization of agricultural output at a high level and exceeding the pre-reform 1989-91 levels (Csaki and Zuschlag, 2003), and also with a drastic reduction of the variable inputs use like fertilizers, machinery, and work animals.

Productivity profiles of the MTC decomposition into TEC and TC components for the NIS countries are reported in Table IV, Section B. Nine countries showed that both "catching-up" and "frontier-shift" effects drove overall TFP progress. These countries are Armenia, Azerbaijan, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Turkmenistan and Ukraine. Of these countries, Ukraine and Russia were among the top performers whereas Armenia and Turkmenistan were among the weakest performers. Other two NIS countries, i.e. Belarus and Uzbekistan, also exhibited overall TFP progress but only the "frontier-shift" effect drove overall TFP progress. Georgia was the only NIS country posting overall TFP regress (average of 0.78 percent annually). TFP regress in Georgia was mainly driven by a decline in the "frontier-shift" effect (average of 0.85 percent annually).

Turning to the agricultural performance in transition countries in Asia, the annual growth rate of TFP across the Asian countries over the transition period was 4.73 percent (Table III, Section D). TFP growth was driven by TC (rose by 5.11 percent annually). This was consistent with the findings shown in Jin *et al.* (2002), most of TFP growth can be accounted for by investments into R&D. The contribution of TEC to TFP growth was negative (at a rate of 0.37 percent annually). In other word, TFP growth would have been 0.37 percent high had efficiency levels not fallen. TEC fell over the entire period except a small increase during 1979-1988 and 1999-2004. Over time, growth rates of TEC in Asia vary significantly. This inconsistent growth is influenced by the performance of China and Vietnam which are the dominant players in this region. TEC was positive at the start of China's market reforms and fell significantly again during the Asian financial crisis of 1997-1999.

Many studies have reached the consistent conclusion that the positive TEC in Asia, especially China and Vietnam during the first stage of reform gained from the property rights reforms with better incentive, which make the farmers better incentive to manage the production and more efficient to apply physical inputs and allocate labor inputs (Fan, 1991; Swinnen and Rozelle, 2006; Jin *et al.*, 2007). Simultaneously, farm structure was comparatively simple that producers were more self-sufficient and produced staple commodities; technology is still labor-intensive. Moreover, a decline in TEC over the entire period was due to problems with the extension system, disequilibrium from rapid change and the relatively rigid tenure system which have kept farms relatively small and inefficient.

The pattern of TFP growth in Asia shows that TEC had fluctuated considerably over the transition period. The fluctuation of TEC in Asia could be explained by that more rural laborers with comparatively higher education or skills are moving out of agricultural production to take non-farm employment partly or fully. Unlike the CEE and NIS countries, shift in TC was fully responsible for TFP growth because TEC detracted from TFP growth of the Asian countries. TC improvement became large after five years of the reform, and posted impressive growth over the entire period. A record shows the healthy performance in Asia over the entire period except at the start of the reform. A low TFP growth at the start of the reform was due to a slow start of adopting new technology and a slow change of the system leading farms operating inefficiently. The performance of Asia's productivity growth, however, may be greatly enhanced by including China. Although not reported in the table, the annual growth rate of increase in TFP from other Asian countries excluding China over the transition period was only 1.71 percent. TFP growth has been pulled down due to declining TEC (at a rate of 0.59 percent annually) but was driven by TC (rose by a rate of 2.29 percent annually). These results suggest that the diffusion of technology related to differences in knowledge and institutional setting was a major source in slowing down agricultural growth of these transition economies.

Table IV, Section C reports productivity profiles of the MTC decomposition into TEC and TC components for the Asian countries. All transition countries in Asia except Laos showed that only the "frontier-shift" effect led to overall TFP progress. China was the top performers, followed by Mongolia and Myanmar. TC was a main force of driving overall TFP growth. TFP regress in Laos was due to a decline in the "catching-up" effect (average of 0.85 percent annually).

By comparing agricultural TFP growth of transition economies presented in this study with non-transition economies, recent works by Lissitsa *et al.* (2008) and Rungsuriyawiboon and Wang (2009) used different measures of productivity in comparison the levels and trends in agricultural productivity on European and Asian countries[6]. They found that there were large differences in terms of the magnitude and direction of TFP growth among these countries during the past two decades. In their analysis, the findings of non-transition economies in Europe and Asia show that average TFP growth for the EU countries was 1.90 percent over the period 1992-2002.

Countries like Denmark, France and Germany exhibited TFP growth above 2.5 percent where both TC and TEC were major factors in contributing to their TFP progress. On the other hand, countries like Ireland, the UK and Portugal exhibited TFP growth below 1.0 percent where TEC was a major factor in dragging down TFP growth in these countries. Turning to agricultural performance in other Asian countries, they found that the annual growth rate of TFP across all of Asia was positive and nearly 2.0 percent over the past three decades. The East and South Asian countries such as China, Mongolia, India and Bangladesh exhibited impressive growth (above 2.5 percent) whereas the West and Southeast Asian countries such as Iraq, Israel, Saudi Arabia, Cambodia, Indonesia, Malaysia and Thailand exhibited TFP growth below 1.0 percent.

Examining agricultural performance of selected transition countries over the transition period

Because of the market reforms in transition countries taken place at different periods, the Asian countries experienced the changes in the structure and volume of agricultural production, consumption and trade since the late 1970s. The experiences that one observes from these countries could somehow provide insightful lessons for other transition economies to maintain or achieve higher growth in agriculture. In this section, we examine differences among the transition countries in terms of the magnitude and direction of their agricultural performance over the period after the start of their market reforms. In recognition of the volume of agricultural production and strategic importance, selected transition countries are served as the leading countries in agriculture in each group. The selected transition countries include five CEE countries (i.e. Bulgaria, Czech Republic, Hungary, Poland and Romania), five NIS countries (i.e. Belarus, Russia, Ukraine, Kazakhstan and Uzbekistan) and three Asian countries (i.e. China, Vietnam and Myanmar).

Table V tabulates the MTC decomposition into TEC and TC by the selected transition countries for each five-year period after the start of the market reforms. An important finding of our results shows that the trends in the MTC and its components across the selected transition countries follow a different set of contours. Interestingly, our findings show that during the first five years of the reforms, the transition countries posted remarkable differences in terms of the MTC decomposition. The pattern of MTC did not parallel thoroughly to that of TC. The performance of transition countries with a positive MTC was due to an impressive growth in TC. For other transition countries exhibiting a negative MTC, TFP growth has been pulled down due to declining TEC. At the first five years of the transition period, the NIS countries except Uzbekistan posted quite remarkable TC of more than 4.0 percent. During the same period, the CEE countries also exhibited high TC except in Bulgaria while the Asia countries posted a moderate growth rate of TC at the annual growth rate between 1.2 and 1.4 percent. Even though the institutional reform in these transition countries had been taken place at different points in time and their geographic location is different, our findings show that the adoption of new technology was a main source in driving agricultural performance in these transition countries at the early stage of the transition period.

Unlike the initial five years of transition, most of the CEE and NIS countries except Uzbekistan posted quite impressive MTC in the second five years of transition. Their impressive MTC was driven not only by the continuous growth rates in TC but also the rapid recovery of TEC. However, the pattern of the MTC decomposition

Table V. Annual growth rates of the MTC decomposition by selected transition countries for each five-year period over the transition period (%)

	TEC	TC	MTC	TEC	TC	MTC	TEC	TC	MTC	TEC	TC	MTC	TEC	TC	MTC	TEC	TC	MTC
CEE	*1989-1993*			*1994-1998*			*1999-2004*									*1989-2004*		
Bulgaria	−1.28	0.24	−1.04	2.71	1.15	3.85	0.52	4.29	4.81							0.63	2.03	2.66
Czech Rep	1.69	3.46	5.15	2.62	2.57	5.19	−0.60	3.72	3.12							1.11	3.28	4.39
Hungary	−1.65	1.58	−0.07	1.44	4.59	6.03	2.21	2.75	4.97							0.75	2.95	3.70
Poland	0.41	3.67	4.08	3.82	2.83	6.64	−0.34	−0.83	−1.18							1.18	1.70	2.87
Romania	0.77	2.29	3.07	−1.46	4.08	2.62	2.12	3.15	5.27							0.57	3.17	3.74
NIS	*1992-1996*			*1997-2001*			*2001-2004*									*1992-2004*		
Belarus	−4.34	4.15	−0.19	2.62	2.72	5.34	1.26	5.17	6.43							−0.42	3.83	3.41
Russia	0.56	4.08	4.64	3.15	0.95	4.10	1.43	3.53	4.95							1.75	2.74	4.49
Ukraine	−2.20	4.74	2.55	4.90	2.79	7.69	−0.85	6.98	6.14							0.79	4.50	5.29
Kazakhstan	−0.25	4.14	3.89	1.53	6.00	7.53	−0.47	−4.08	−4.55							0.38	2.88	3.26
Uzbekistan	−1.15	0.86	−0.29	−2.54	2.39	−0.15	0.57	4.70	5.28							−1.29	2.32	1.03
ASIA	*1979-1983*			*1984-1988*			*1989-1993*			*1994-1998*			*1999-2004*			*1979-2004*		
China	0.06	1.37	1.43	0.24	3.77	4.00	−0.52	8.86	8.33	−2.02	5.97	3.95	0.34	6.93	7.27	−0.60	5.41	4.81
	1986-1990			*1991-1995*			*1996-2000*			*2001-2004*						*1986-2004*		
Vietnam	−1.78	1.29	−0.49	0.39	2.33	2.73	2.16	1.52	3.68	−2.18	2.64	0.46				−0.27	1.91	1.64
	1989-1993			*1994-1998*			*1999-2004*									*1989-2004*		
Myanmar	2.93	1.28	4.21	−5.98	1.36	−4.63	1.75	7.82	9.57							−0.38	3.71	3.34

in the Asian countries was quite different. Although the annual growth rates of MTC in China and Vietnam were not far behind those of the CEE and NIS countries, TEC in China and Vietnam was nearly negligible (average of 0.4 percent annually) during the second five years of transition. In Myanmar, the growth rate of MTC was tied down by TEC, which declined sharply at an annual rate of nearly 6.0 percent during this period.

Our findings also show that over the first decade of the transition period, most transition countries except Uzbekistan and Myanmar experienced impressive MTC at an annual rate above 2.0 percent. It took almost a decade before Uzbekistan experienced impressive MTC. After the first decade of the transition, most transition countries still experienced impressive MTC. China and Myanmar posted MTC of more than 8.0 percent during the first half of the second decade of the transition period. Other transition countries experienced positive MTC at an annual rate above 3.0 percent during this period. However, the records by Poland and Kazakhstan were quite different. These countries experienced negative MTC which was driven by both TEC and TC. The negative MTC in these countries could be explained by stagnation in the crop production and by an increase of their uses of fertilizers and plant-protection agents.

Two transition countries, i.e. China and Vietnam, have undergone a transformation from CPE to a free market economy for more than two decades. Other transition economies are still in the late of the second decade of their transition period. Evidence that one could learn from the transition experiences in China and Vietnam are important because they provide valuable lessons for policy makers to design suitable policy to maintain or achieve higher MTC in the CEE, NIS and other Asia countries. Our findings show that during the second half of the second decade of their transition period the success of agricultural production in China and Vietnam mainly relied on an impressive growth in TC. However, TEC declined sharply at an annual rate of more than 2.0 percent during this period. Possible reasons in declining TEC could be explained by that more well-educated, young and male rural laborers in these countries had moved out of agricultural production and thus only aging and female workers remained in the agricultural production. Furthermore, agricultural production in China and Vietnam still beset at the small scale household level with comparatively low land labor ratio. Moving toward the second half of the second decade of the transition period, the CEE and NIS countries are also facing the problem of the rural labor migration due to the prospect of EU accession. A possible solution to guarantee the healthy development of agriculture in these countries is to keep TE improvement in the production.

The results in Table V also support the conclusion that the magnitude and speed of the MTC and its components are considerably different for the selected countries over the entire transition period. The leading CEE countries posted healthy MTC with an annual rate above 2.5 percent. Both TEC and TC were important forces that drove overall TFP progress in Czech Republic and Poland while TEC slightly contributed to overall TFP progress in Bulgaria, Hungary and Romania. During the early 1990s, the large socialist-era farms in Czech Republic, Romania and Hungary had turned into private, large-scale corporate enterprises. Our findings show that these countries posted impressive MTC among the CEE countries. Average MTC over the entire transition period grew at an annual rate of 4.39 percent by Czech Republic, 3.74 percent by Romania and 3.70 percent by Hungary. Poland is one of the largest agricultural producers in the CEE group and dominated by small-scale farming. The findings show that Poland posted MTC progress at an annual rate of 2.87 percent.

Bulgaria is dominated by large-scale farming and has a diversified agriculture, with fertile soils and favorable climatic conditions. Our findings show that Bulgaria experienced TFP progress at an annual rate of 2.66 percent.

Generally, the leading NIS countries except Uzbekistan MTC posted impressive MTC with an annual rate above 3.0 percent. Overall, Russia and Ukraine were the top performers among the transition countries. TC was a main force that drove overall TFP progress in these NIS countries. TEC was another important force of driving overall TFP growth in Ukraine whereas TEC was negligible in Russia and Kazakhstan. On the other hand, TEC has pulled down TFP growth in Belarus and Uzbekistan. Average MTC over the entire transition period grew at an annual rate of 5.29 percent by Russia and 4.49 percent by Ukraine. Russia and Ukraine posted significant TFP progress on the movement toward a more liberal agricultural policy. Their agricultural outputs have increased and they started to play more important role on the agricultural world market. The performance of agriculture in Russia and Ukraine has been impressive because they have improved agricultural system to increase productivity. For example, new large, vertically integrated producers could bring more efficient management to the sector than the former state and collective farms that currently dominate agriculture. Our results also show that TC was the only force of driving overall TFP growth in the Asian countries while TEC has pulled down TFP growth in these countries. China was one of the top performers among the transition countries. China's TFP growth rate over the transition period was quite remarkable and nearly 5.0 percent. Annual growth rates of MTC in China vary significantly over the period. Between 1984 and 2004, TFP growth averaged above 5 percent (increasing from 4.00 percent in the 1984-1988 period to 7.27 percent during the 1999-2004 period). However, the growth rates decreased to 3.95 percent annually during the 1994-1998 period. In the agricultural sector, in the long run, the lessens and experiences from developed economies strongly suggest that technology is the most effective factor that can ensure the sustainable growth of productivity. The variation of MTC is correlated with the application of new technology and use of inputs, like machine and labor as well as price reforms on input and output, etc. In the later 1980s, the input prices and distribution, especially that of fertilizer, are not controlled by the state's monopoly agricultural inputs supply corporations (Pingali and Khiem, 1995; Ye and Rozelle, 1994). The supply of important physical inputs such as fertilizer, pesticides and electricity could meet the needs of most farmers. However, in the early of 1990s, agricultural production in China is still labor-intensive, only about 20 percent of the rural laborers worked off the farm, by 2000, more than 80 percent of households had at least one laborers employed off the farm (Xiaobing *et al.*, 2011). Since the late 1990s, Chinese farmers have successfully access to new technologies, including the biotechnology of Bt cotton with the huge investment on R&D of new technology (Huang *et al.*, 2002; Rozelle *et al.*, 2005). The extremely high rate of TFP growth in China over the period was most consistent with those estimated by Jin *et al.* (2007). They show that TFP rates of cropping and livestock are high by international standards and growing over time. The results of TFP decomposition show that the performance of China's productivity was mainly driven by TC – and TEC dragged down TFP growth. TEC was low at the start of China's market reforms and fell sharply during the Asian financial crisis of 1997-1999. However, TEC has improved agricultural growth in recent years. These findings were consistent with those estimated by Huang *et al.* (2007). They explained why TEC falls in China's agricultural economy over the entire reform period. Furthermore, annual growth rates of the MTC in Vietnam also vary significantly after the market reform. The findings of the decomposition analysis demonstrate that the overall rate of TFP growth has relied, in general, on TC. According to this study's results, the adoption of new technology in Vietnam is the main factor that has driven TFP growth over the study period. At the beginning of the transition period, Vietnam experienced agricultural TFP regress, due to inefficient use of inputs in agricultural production and poor machinery used in farms. TFP growth, however, has improved significantly since 1991. Both adoption of innovations in agriculture and more efficient use of inputs on farms are the major factors driving TFP growth in Vietnam after its market reforms taken place a couple of years. The performance of Vietnam's productivity, however, was hurt by TEC after the Asian financial crisis. Over the past decade, government policies in Vietnam that have encouraged farmers to invest in agricultural production have succeeded, resulting in sustained agricultural growth.

Conclusions

With growing concerns about world food crisis and surging food prices, economic stability and food security are now back on policy agendas. It is clear from a global perspective that each world region must have a sufficient supply in agricultural products in order to meet the growing demand for food and anticipated increases in world population for the first half of this century. Over the past three decades, many countries have undergone a transformation from a CPE to a free market economy. These transition economies undergo economic liberalization, macroeconomic stabilization, restructuring and privatization in order to create a financial sector, and move from public to private ownership of resources. Institutional reforms have helped transform the structure and volume of their agricultural production.

It is important to sketch a picture agricultural efficiency and TFP of all of transition countries because these countries account for almost half of the regions population and more than half of the land area in Europe and Asia. Because of data problems both absence of data and differences in the nature of data between transition countries, previous studies on analyzing intercountry comparisons in agricultural TFP growth just ignored most of these countries (Young, 1995; Otsuka *et al.*, 1992; Pingali *et al.*, 1997; Coelli and Rao, 2005). To fill this gap in the literature, the main purpose of the study is to understand the state of productivity improvements in these transition countries. This study conducts intercountry analysis in terms of the magnitude and direction of agricultural growth at the different stages of their transition process. Utilizing the DEA-based Malmquist index approach, TFP growth of transition countries is decomposed into TEC and TC components. The empirical analysis is performed using the most recent FAO data set of 35 transition countries in Asia and Europe. These countries account for 30 percent of world's population and nearly 40 percent of global agricultural outputs. The findings of the decomposition analysis demonstrate convincingly that majority of the transition economies experienced the comparatively high TFP growth over the transition period. TC was a major force of driving TFP growth in these transition countries. The pattern of TFP growth shows that TEC had fluctuated considerably over the transition period. Our findings also show that TFP growth and its associated components differ considerably at different stages of the transition period. In the initial five years of transition, the annual TFP growth rose quite strongly in some countries like Czech Republic, Poland, Russia and Myanmar, but it fell in other countries like Belarus, Bulgaria, Hungary, Uzbekistan and Vietnam due to declining TEC. During the second five years of transition, TFP growth rose considerably in most countries except Myanmar and Uzbekistan due to the improvement of TE and TC. In the beginning of the twenty-first century, the annual growth of TFP rose optimistically above 5 percent in many transition countries. Our empirical findings present supporting evidence that serious improvements in performance and efficiency, as well as continued technology transfer and adoption are required for transition economies to meet the demand for food and anticipated increases in world population for the first half of this century.

Notes

1. Details on how to set up the LP problems for solving these output-oriented distance functions can be seen in Färe *et al.* (1994).
2. Detailed information on how international average prices are constructed can be found in Rao (1993).
3. The definitions of some input and output variables used in this study may lead to the problem of measurement errors. For instance, the crop variable output is not final products (i.e. livestock can consume crops) or the land input cannot reflect different cropping seasons. In this study, the definition of the variables as well as the adjustment of final output variable follows the previous works by Suhariyanto and Thirtle (2001) and Coelli and Rao (2005) which they also used FAO database and adopted a nonparametric DEA approach to analyze the intercountry differences in agricultural TFP growth. To deal with cropping seasons, a proxy variable of latitude degree could be helpful especially when analyzed using the micro-level data. Considering the territory of nations, like China and Russia, the cropping seasons also vary within countries and there is not a single latitude representing the whole country. Since the data used in this study is aggregated at the national level, we omit this proxy to represent cropping seasons.
4. The nonparametric DEA approach adopted in this study may be sensitive to measurement errors leading to biased and incorrect results in productivity analysis. However, this approach does not require an explicit specification of the functional form of the output-oriented distance function. This advantage may offset the errors from the measurement problems. In the literature, another approach widely used to analyze TFP growth is known as a parametric stochastic frontier analysis (SFA). The SFA can provide a nice structural form and will likely reduce some measurement error. However, the SFA requires an *ex ante* specification of the functional form. Which approach can provide better analysis has been widely criticized in the literature. Therefore, further study will need to examine the impact of measurement error from different methodology in productivity analysis.
5. In the past a number of papers have reported agricultural performance of some transition economies in Asia and Europe using the parametric SFA approach (Lissitsa *et al.*, 2007; Rungsuriyawiboon and Wang, 2009). Their findings show that transition countries in Asia and Europe were considered to have well performing agricultural economies that had consistently posted TFP growth rates of more than 4 percent annually over the past two decades. Even using different productivity measure, the findings reported in this study are consistent with their studies.
6. Further, we also compare the results.

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