Reforms and efficiency change in transition agriculture

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Abstract

Studies on efficiency changes in transition agriculture yield mixed results. This paper develops both a theoretical model of efficiency changes during transition and uses a unique set of representative farm survey data to assess efficiency changes during transition. We find that reforms have a positive impact on efficiency and that input and output market imperfections importantly affect efficiency growth.

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Introduction

Economic and institutional reforms have dramatically affected agricultural organization, output, and production efficiency in transition countries from Central Europe to East Asia. Following the introduction of the the household responsibility system (HRS) in China and the Doi Moi in Vietnam, productivity and incomes in both countries soared (Justin Lin, 1992; John McMillan et al, 1989; Prabhu Pingali and Vo-Tong Xuan, 1992).[1] As a consequence, expectations were high ten years later when leaders in many nations of Central and Eastern European (CEE) and the former Soviet Union began to dismantle Socialism and liberalize their agricultural economies. The reforms, however, disappointed many nations. Not only did farm output fall dramatically, in the transition countries of Europe and the former Soviet Union (FSU), some studies find that efficiency decreased as well during transition. In a review of the evidence, Rozelle and Swinnen (2004) conclude that productivity started increasing early on during transition in Central Europe and parts of the Balkans and the Baltic, but continued to decline much longer in parts of the FSU. Declines in productivity are associated with initial disruptions due to land reforms and farm restructuring in Eastern Europe (Macours and Swinnen, 2000) or with poor incentives and soft budget constraints in some of the countries of the former Soviet Union (Sedik et al, 1999; Lerman, Csaki and Feder, 2004) and disorganization in the supply chains (Gow and Swinnen, 1998).

[1] The reforms lifted hundreds of millions of rural households out of dire poverty (World Bank, 2000). Economists praise the Chinese reforms as the "biggest antipoverty program the world has ever seen" (John McMillan, 2002, p. 94) and have claimed that the reform policies have led to "the greatest increase in economic well-being within a 15-year period in all of history" (Stanley Fischer, 1994, p. 131).

However, there are several problems in comparing efficiency studies and drawing implications from them. First, a limitation is that those studies which include more countries and a longer time horizon use aggregate data, while studies using farm-level data are restricted to one country and short time periods, often even one year. Second, comparisons and cross-country conclusions are complicated by differences in data samples. Third, with few exceptions, the available studies focus solely on the empirical aspects without providing a conceptual approach of how efficiency would evolve during transition, or how various reforms would affect them differently. In other words, these studies pay little attention to the *process* of efficiency change and how reforms affect this. Linking efficiency changes to specific reforms is important to understand which factors have been crucial in constraining or stimulating efficiency growth. Such issues are particularly relevant in the debate on optimal sequencing and complementarities of policies.

This paper develops both a theoretical model of efficiency changes during transition and an empirical analysis of how efficiency has changed during various stages of transition. The empirical analysis uses a unique set of representative farm survey data from five East European countries, collected in the 1997-2001 period and based on a common set of survey instruments. The countries for which data are collected (Albania, Bulgaria, Czech Republic, Hungary, and Slovakia) are all in Eastern Europe and started reforms more or less simultaneously, but have done so at different speed and depth. As such the combined data allows for cross-country comparisons without the complexity of vastly different starting positions (as none of them was part of the former Soviet-Union, or in Central or East Asia). We calculate farm-level efficiency indicators using data envelopment analysis (DEA) and calculate kernel density estimates for each of the countries.

In the second part of the paper we compare the calculated efficiency distributions of the countries and we correlate these with various indicators of particular reforms. We discuss whether the efficiency has increased during transition and which aspects of the reforms are important in explaining differences in efficiency among the countries.

The last part of the paper uses these insights to develop a theoretical model on how reforms, which are implemented in the process of the transition of a communist system to a market economy, affect production efficiency. The model assumes that (potential) farm managers are heterogeneous in their managerial capacities but face similar market constraints. These heterogeneities and constraints affect farm efficiencies. We model how reforms change constraints in input and output markets, and thereby farm efficiencies, and we use the theoretical model to simulate how the distribution of farm efficiencies would change during transition. We show that the variations in a few reform parameters yield simulation outcomes consistent with the empirical results.

Data

We use a unique set of representative farm survey data from five East European countries, collected in the 1997-2001 period and based on a common set of survey instruments. The surveys in Hungary and Bulgaria were implemented in 1998 and have representative data for 1997. Data for Albania, Czech and Slovak Republic are for the production year 1999. To increase the accuracy of comparisons, we take only crop farms into consideration to enhance the homogeneity of the dataset. Cleaning resulted in a dataset of 178 Hungarian farms (63 cooperatives, 40 companies and 75 family farms), 93 Bulgarian farms (45 cooperatives, 9 companies and 39 family farms), 183 Czech farms (38 cooperatives, 14 companies and 131 family farms) and 210 Albanian family farms.

The Albanian, Hungarian and Bulgarian dataset is representative for the whole country, while in the Czech and Slovak Republics some regions were selected for surveying, but we selected regions with significant variations in the location of the farms (hills, low land and more urban areas).

All countries differ largely in terms of agricultural reform, land use and economic conditions. In Albania, the poorest country of Europe, almost half of the active population is still employed in agriculture, and virtually all agricultural land is cultivated by small individual farms. In Hungary and Bulgaria, land is used by a mixture of large-scale farming companies and small scale individual farms, with much regional variation. Share of agriculture in total employment is 23% in Bulgaria and 8% in Hungary. Slovakia and the Czech Republic are the opposite of Albania in most respects. They are much richer and only around 5% of employment is in agriculture. The vast majority of the land is used by large-scale farming companies, successor organizations of former collective and state farms.

All countries have a highly fragmented ownership structure of land due to land restitution or distribution processes implemented in early 1990s. However in all countries the land reform process was well advanced by the time of the survey. In terms of the land reforms progress indicator, as calculated by the World Bank, all have an indicator between 7 (Bulgaria) and 9 (Csaki et al.). The countries vary most strongly in terms of their income levels and broader institutional progress (see table 3).

Methodology

To investigate how average efficiency and the distribution of efficiency has changed during various stages of transition, we first calculate farm level total technical efficiency scores using Data Envelopment Analysis for each country. To measure technical efficiency requires the specification of a frontier production function, and the measurement of the deviation or distance of the farms from the frontier, which is then a measure of technical inefficiency. The technique of Data Envelopment Analysis (DEA) constructs a convex hull around the observed data (Charnes et al., 1978). As in Färe et al. (1985), we assume that production is characterized by a non-parametric piecewise-linear technology, so that simple linear programming techniques can be used to calculate efficiency. We further assume strong disposability of outputs and inputs and estimate the non-parametric deterministic frontier, expressed in terms of minimizing input requirements.

For each production unit we can obtain a measure of the ratio of all outputs over all inputs such as $u'y_i/v'x_i$ where u is a vector of output weights and v is a vector of input weights. To select the optimal output weights we formulate the following mathematical program: $\{\max_{u,v} u'y_i/v'x_i$ *subject to* $u'y_i/v'x_i \leq 1; u,v \geq 0\}$. By imposing the constraint that $v'x_i=1$ and using the duality in linear programming, one can derive an equivalent *envelopment* problem: $\{\min_{\lambda,z} \lambda$ *subject to* $z Y \geq Y_i; z X \leq \lambda X_i; z \geq 0\}$, where Y_i denotes the output of farm k, X_i is a vector of inputs employed by farm i, and z is a vector of intensities that characterizes each farm.

A farm displays total technical efficiency if it produces on the boundary of the production possibility set, i.e. it maximizes output with given inputs and after having chosen technology. This boundary or frontier is defined as the best practice observed.

Results of efficiency calculations

The DEA calculations yield a two peaked efficiency distribution in all countries. In Albania, a high share of farmers have an efficiency score lower than 30 and a only a very small share of the farmers are efficient, i.e. get an efficiency score close to 100. For Bulgaria, the lower peak shifted a bit to the right: the majority of farms reach an efficiency score between 10 and 40. 14% of the Bulgarian farms can be found on the frontier. In Slovakia, the majority of farms reach an efficiency level between 20 and 50 and a large share (22%) can be found close to or on the frontier. In the Czech Republic and Hungary, the lower peak shifts even more to the right. In the Czech Republic the majority of farms reach an efficiency level between 30 and 60 and 12% can be found in the highest efficiency category (90-100). In Hungary, most farmers have an efficiency score between 40 and 70 and 9 % have an efficiency score between 90 and 100. However, we have to take into account that the Slovak sample includes only registered farm households so that in figure 1 the Slovak efficiency distribution looks too positive compared to other countries.

The efficiency distribution illustrates that a country which is farther advanced in the transition stage has more farms that can be found on the boundary of the production possibility set and that the majority of farms reaches on average a higher efficiency level. Based on the efficiency distribution for each country, we estimate a kernel density function. This allows us to correct for the fact that the Slovakian data does not include non-registered farms and we can calculate the average total technical efficiency for each country assuming these density functions. Albanian farmers reach an average efficiency score of 25, Bulgarian farms an average efficiency level of 37, Czech farms an average efficiency level of 43 and Hungarian farms an average efficiency level of 47.

To illustrate the process of efficiency change, we present the estimated density function of the efficiency scores of 3 transition countries (Czech 1997, Bulgaria 1997, Albania 1999)[2] in figure 2. Figure 2 shows that Albania and Bulgaria have more observations with low total efficiency scores and "low efficiency" peaks. In the Czech Republic, a country more advanced in transition, there are more farms with higher efficiency scores. This suggests tat transition to markets induces a shift in the distribution of efficiency indicators.

To see how relative farm efficiencies are distributed in a market economy, i.e. in the final stage of the transition process, we use the results of a study by Wilson et al. (1998) on efficiency distribution among UK potato producers in 1992. The potato sector is good for comparison since it is one of the few EU crop sectors which are not distorted by large GDP subsidies. The efficiency distribution of the UK potato farms, compared to the other distributions (see figure 4) shows that in a market economy, most farms are close to the efficiency frontier. In fact there are few farms below 75% efficiency scores and the distribution is quasi-exponential towards the 90% efficiency.

Correlation between efficiency and reforms

The distributions in figure 1 and 2 suggest a particular relationship between farm efficiency and progress in some reform aspects. To analyse this further, we first compare the average farm efficiency with reform indices as calculated by the World Band and EBRD[3] in figures 3 and 4. As shown in figure 4 and 5 and table 3 and 4.

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[2] Replacing Czech Republic with Slovakia or Hungary would give similar results. Putting all in however complicates the picture without yielding more insights.

[3] The World Bank is an aggregate index of progress in land reform, price and market liberalisation, reforms in the agro-processing sector and rural finance and of the institutional reforms. A score of one means no reform, i.e. a situation comparable with a centrally planned economy. The maximum score that a country can reach is 10 which means the market reforms have been completed and the situation is a free market economy. The EBRD transition indicator gives a score from 1 to 4. It aggregates assessments of the privatisation of small- and large scale enterprises, enterprise restructuring, price

The graphs show that there is a clear positive relation between the stage of transition of a country and the average efficiency level reached by the agricultural producers. In countries which are less advanced in the transition process, there are much more inefficient production units. In countries more advanced in transition, there are less efficient farms. While the strong correlations between the aggregate reform indicators suggest an important causal affect,,, the indicators as such tell us little about the mechanism. For this reason we want to develop a theoretical model. However, before doing this, let us take a closer look at the correlations between efficiency scores and the reform indices. The first observation, which at first sight is somewhat remarkable, is that there is a closer correlation with the EBRD index (a non-agricultural index) than with the WB agricultural reform index. This suggests that the key factor may be not specific to agriculture. One important factor is that all surveys were done in countries, and at times, when farms used private land plots and faced hard budget constraints. Hence, in these situations, other factors, such as access to input and output markets become the prime determinants of efficiency.

Second, if we disentangle the reform indices and correlate them with the observed efficiency scores (table 3), we see that there is significant correlation between efficiency and competition policy, enterprise reform, and institutional reforms. Again these correlations indicate the importance of general institutional reforms and reforms of the sectors "surrounding agriculture" as a source of efficiency growth. In general, good competition policy to reduce abuse market power is beneficial for the performance of an industry. However, in agriculture there is little

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liberalisation, trade and foreign exchange system liberalisation, competition policy, bank and non-bank financial sector reforms. A rate of 4+ is given when standards and performance are comparable with those of advanced industrial economies. The general EBRD indicator is the average of the score given to the reforms in each area. We can assign to the UK the highest EBRD reform and WB agricultural reform index as the country is not in transition.

market power. Therefore, maybe most important though is its indirect impact on agricultural producers. It may have an important impact on firms up- and downstream such qs agribusiness and food processors. Domination of large companies in the in- or output markets will strongly affect farms. Enterprise reforms which contributed to significant and sustained harden budget constraints and to promote corporate governance (e.g. through privatisation combined with tight credit and subsidy policies and/or enforcement of bankruptcy legislation), may also cause higher efficiency of the farms. In the next section, we will use these hypotheses that general (institutional) reforms have an important impact of farm efficiency to derive a theoretical model of efficiency change during transition.

Theory and Simulation Model

Producer *i* maximizes its profits $\pi^i = q^i - c^i(q^i)$ with q^i the value of output and c^i the cost function of the producer. The first order condition $c_q^i(q^{*i}) = 1$ determines the optimal output q^{*i}.

In the DEA efficiency calculations, we calculate input-oriented efficiency scores. The technical efficiency is the amount by which all inputs could be proportionally reduced without a reduction in output. To calculate efficiency measures, we compare therefore the output-input ratio of producer *i* with the output-input ratio of a producer that can be found on the frontier and that produces that same output as household *i,* namely q^{*i}. We define the efficiency score as follows:

$$e^{*i} = \frac{q^{*i} / c^i(q^{*i})}{q^{*i} / c^{\#}(q^{*i})} = \frac{c^{\#}(q^{*i})}{c^i(q^{*i})} \tag{1}$$

with $c^{\#}(q*^{i})$ the cost function of the "efficient" producer, i.e. on the production possibility frontier. Assume the efficiency level of producer *i* depends on managerial capacities *h* and on access to certain production technologies δ. We define δ as discontinuous variable equal to H when the firm has access to high productive technologies or equal to L when the firm uses low productive technologies. This allows defining the efficiency measure and costing function in equation (1) as follows

$$e*^{i} = e*^{i}\,(h^{i},\delta)\ and\ c^{i}=c^{i}(q;h^{i},\delta) \tag{2}$$

so that for all *q* holds that

$$c^{i}(q;h^{i};\delta=H)\prec c^{i}(q;h^{i};\delta=L)\ and\ \frac{\partial c^{i}(q)}{\partial h}\prec 0 \tag{3}$$

Under certain conditions, this implies that for a constant *h*

$$e(h,\delta=H)\succ e(h,\delta=L)\ and\ \frac{\partial e(\delta)}{\partial h}\succ 0 \tag{4}$$

Now we introduce two factors which affect the access to technology and the "environment" of the farms. First, assume that market imperfections or high transaction costs impose a "hurdle Θ on the farms. In order to have access to high productive technologies a producer need to overcome this hurdle Θ which we define in terms of efficiency units at different levels of h. We assume that institutional reforms lower this hurdle. Once farms overcome the hurdle – i.e. once they have access to technology, capital, in-and output markets– producers experience a jump in efficiency. Their possibilities rise enormously.

Second, we assume that a producer to continue farming s/he needs to reach a threshold income γ which we also define in terms of efficiency units[4]. Less

[4] In Swinnen and Vranken (2004) we have a more complicated model where Θ is defined in terms of costs and γ in terms of income.

productive producers (than γ producers) cease their activities and seek alternative income generating activities.

More specifically, if the gap between both functions increases whit *h*, the effective efficiency function $e^{effective}$ can be defined as follows[5]:

$$e^{effective} = e^H \text{ if } e^H - e^L \succ \Theta \text{ and } e^H - e^L > \gamma \tag{5}$$

$$e^{effective} = e^L \text{ if } e^H - e^L \prec \Theta \text{ and } e^H - e^L > \gamma \tag{6}$$

The average efficiency equals $\sum_{i=1}^{n} \frac{e_i^{effective}}{n}$ with n=number of producers.

Due to the reforms, the hurdle Θ decreases and the required minimum efficiency level γ will increase. Consequently, more farmers will move from e^L to e^H. Moreover, the least productive farmers are released due to higher labour mobility (more job alternatives) and higher competition so that the absolute number of producers decreases. Only the least efficient stop producing so that the share of farmers that reaches e^L decreases even more.

By estimating different parameters in the model described above, we can simulate how the efficiency of the agricultural sector depends on the state of reforms. Suppose equation (5) and (6) have the following functional form:

$$e^L = 0.01 * h^{1.9} \text{ with } h \in [0,100] \text{ and } e^L \in [0,64] \tag{7}$$

$$e^H = 0.01 * h^2 \text{ with } h \in [0,100] \text{ and } e^H \in [0,100] \tag{8}$$

The gap between e^L and e^H increases with *h*. When *h* is large enough, i.e. when the gap between e^L and e^H is larger than Θ, the producer reaches (7). Otherwise, the low efficiency function (8) is applicable.

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[5] To simplify or notification we will use the notation e^H *for* $e(h,H)$ and e^L *for e(h,L)*.

We assume that initially (t=0) γ equals 0 because at the start of the reforms, off farm labour opportunities are limited and soft budget constraints apply so that γ is small. γ increases to $\gamma = 2$ in t=1, $\gamma = 4$ in t=2 and $\gamma = 30$ in t=3. Furthermore, in the beginning of the transition period, farmers experienced a large hurdle Θ. We assume that $\Theta = 35$ at t=0 and decreases to $\Theta = 25$ at t=1, $\Theta = 20$ at t=2 and $\Theta = 5$ at t=3. As we move from t=0 to t=3, we move from a situation where more farms get access to better technologies due to lower constraints. The lower Θ, the more producers we find for which (5) holds i.e. the more producers reach the high efficiency function e^H. The higher γ, the less low efficient farms stay in agriculture. At t=3 we find only producers for which equation (5) holds. Figure 5 illustrates how the efficiency distribution changes when a country moves from t=0 to t=3 under these simulation assumptions. This is clearly with the efficiency distribution we observe in transition countries. To obtain the shift in distribution to both increase γ and decrease Θ as γ makes the first peak shift to the left and Θ increases the second peak at the expense of the first peak.

Conclusions

First, the empirical evidence provides strong support for a positive impact of reforms on productivity in agriculture. We find that average efficiency in agriculture is strongly positively correlated with reforms in the five countries in their stages of transition.

Second, the correlations suggest that, in particular, reforms focused on market institutions and on improving access to inputs and output markets have an important positive impact on farm efficiency for the countries included in the analysis.

Third, the empirically observed changes in efficiency distributions during transition are consistent with the simulations based on our theoretical model. They further lend support to the hypotheses that farm productivity increases are strongly constrained by factor market imperfections, including labor markets, and limited opportunities for off-farm employment.

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Table 1: Country characteristics

	Albania	Bulgaria	Czech	Hungary	Slovakia
Share of land cultivated by individual farms (%)	95 (2000)	52 (1997)	26 (2000)	54 (1997)	9 (2000)
Land reform	Distribution (physical)	Restitution	Restitution + sale (renting) [a]	Restitution + distribution (physical) + Sale for compensation bonds	Restitution + Sale (renting)[a]
Share of agriculture in total employment	53 (1994)	23 (1997)	5 (2000)	8 (1997)	7 (2000)
Unemployment	17	15 (1997?)	9 (2000)	9 (1997?)	19 (2000)

[a] Land is rented to individuals or entities pending sale

Table 2: Summary statistics

		Number of observations	Total cultivated land (ha)	Labour (AWU)
Albania	Individual farms	210	1.6	1.8
Bulgaria	Individual farms	39	6	1.2
	Enterprises	54	774	79
Czech Rep	Individual farms	131	54.4	2.1
	RIF	109	64.9	2.3
	NRIF	22	2.5	1
	Enterprises	52	1264	79.3
Hungary	Individual farms	75	26	1.2
	Enterprises	103	1504	46
Slovak Rep	Individual farms (RIF)	67	74	3
	Enterprises	71	2010	252

Table 3: Efficiency and reform indices of 5 transition countries and the UK

	Albania - 1999	Bulgaria - 1997	Slovakia -1999	Czech - 1999	Hungary -1997	UK-1992	Correlation coefficient with ToE exl UK	Correlation coefficient with ToE incl UK
Est average ToE	**24.7**	**37.1**	**41.1**	**43.0**	**47.2**	**90**	1.00	1.00
EBRD reform indices	**2.6**	**2.9**	**3.3**	**3.5**	**3.7**	**4.3**	0.95	0.92
Price liberalisation	3.0	3.0	3.0	3.3	3.0	4.3	0.29	0.94
Forex and trade liberalisation	4.0	4.3	4.3	4.3	4.3	4.3	0.91	0.49
Enterprise reform	2.0	2.3	3.0	3.3	3.0	4.3	0.87	0.93
Competition policy	1.7	2.3	3.0	3.0	3.0	4.3	0.95	0.95
Small scale privatisation	4.0	3.3	4.3	4.3	4.3	4.3	0.38	0.37
Large-scale privatisation	2.0	3.0	4.0	4.0	4.0	4.3	0.96	0.69
Banking sector reform	2.0	2.7	3.3	4.0	2.7	4.3	0.66	0.77
Reform non-banking financial institution	1.7	2.0	3.0	3.3	2.3	4.3	0.65	0.87
WB agr reform indices	**6.8**	**5.4**	**7.6**	**8.6**	**8.6**	**10**	0.59	0.77
Price&market	8.0	6.0	7.0	9.0	9.0	10	0.30	0.66
Land reform	8.0	7.0	8.0	8.0	9.0	10	0.42	0.83
Agro-processing	8.0	5.0	8.0	9.0	9.0	10	0.31	0.58
Rural finance	5.0	4.0	8.0	9.0	8.0	10	0.70	0.72
Institutional	5.0	5.0	7.0	8.0	8.0	10	0.84	0.87
GDP per capita (constant 1995 US$)	**960**	**1349**	**4180**	**5206**	**4662**	**17698**	0.85	0.94

Table 4: Regression of average total technical efficiency per transition country upon EBRD and WB agricultural reform indices.

Av. ToE	*Coefficient*	*t Stat*	*P-value*
Intercept	10.6	0.5	0.7
WB agr reform index	3.8	1.3	0.3
Adjusted R Square			0.14

Av. ToE	*Coefficient*	*t Stat*	*P-value*
Intercept	-17 .5	-1 .7	0 .18
EBRD index	17 .7	5 .6	0 .01
Adjusted R Square			0.89

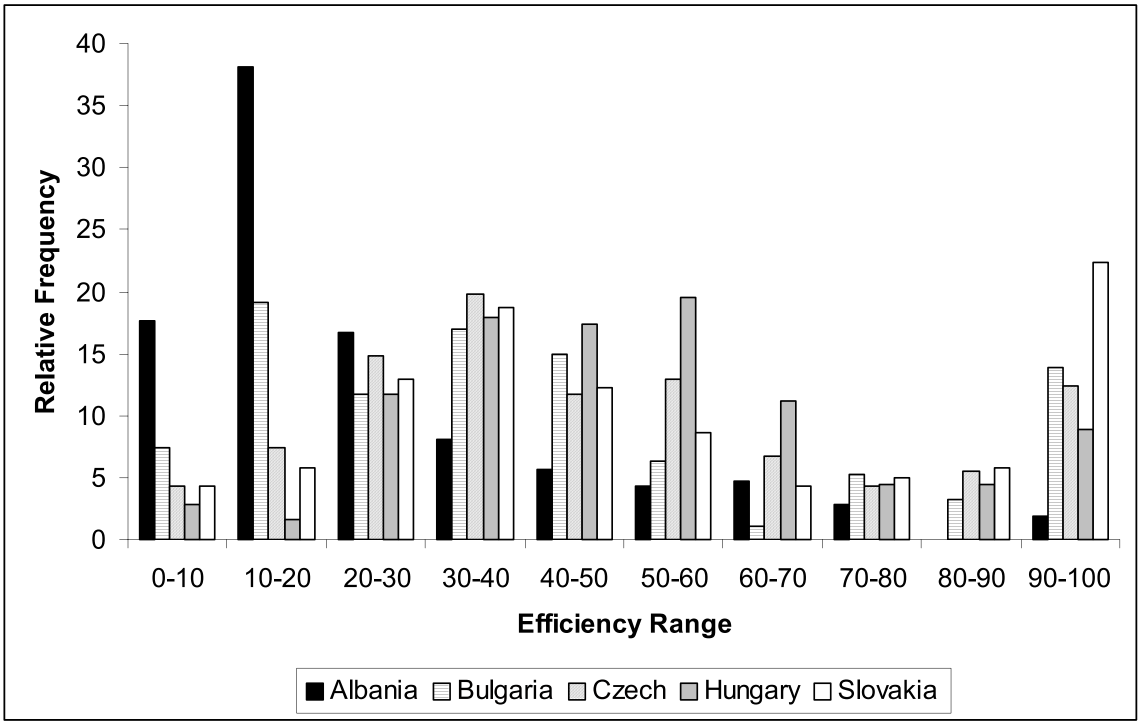

Figure 1a: Distribution of total technical efficiency.

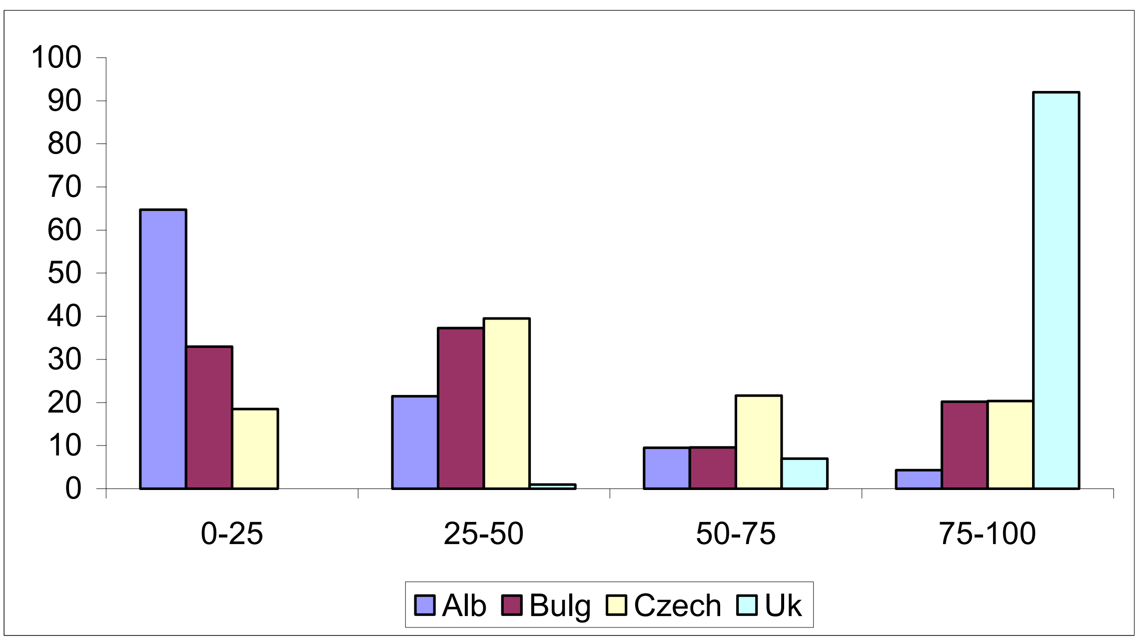

Figure 1b: Distribution of total technical efficiency.

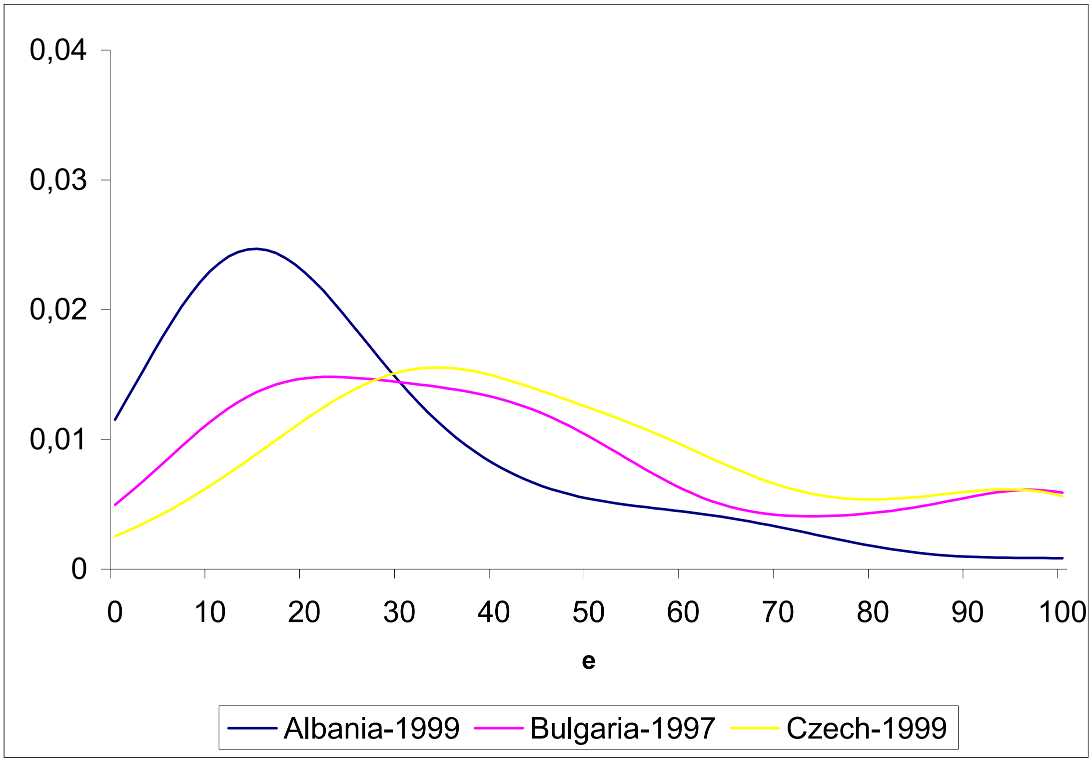

Figure 2a: Kernel densities for 3 transition countries

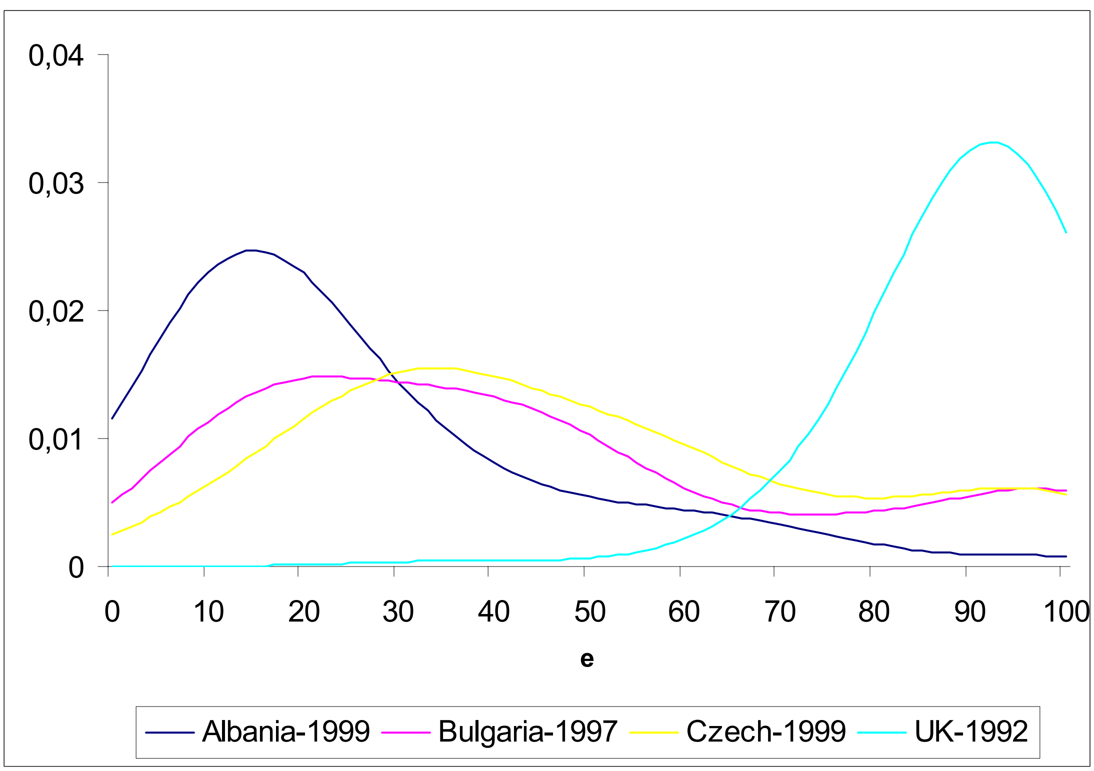

Figure 2b: Kernel densities for 3 transition countries and the UK

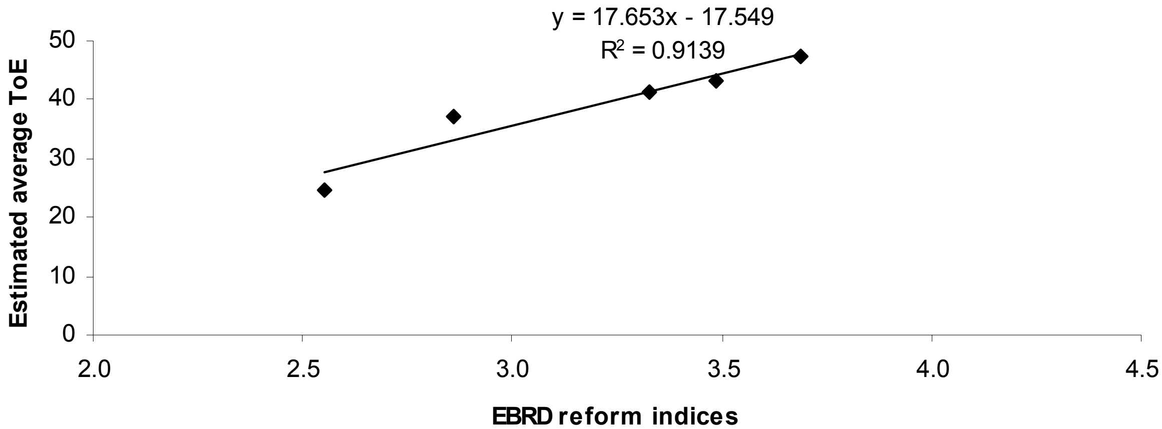

Figure 3a: Relation between efficiency of agricultural production in 5 transition countries and EBRD reform indices, and fitted trend line

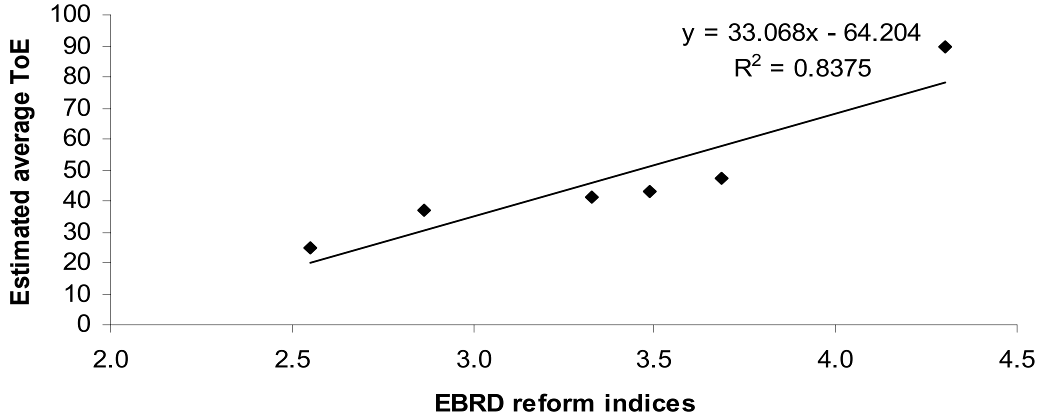

Figure 3b: Relation between efficiency of agricultural production in 5 transition countries plus UK and EBRD reform indices, and fitted trend line

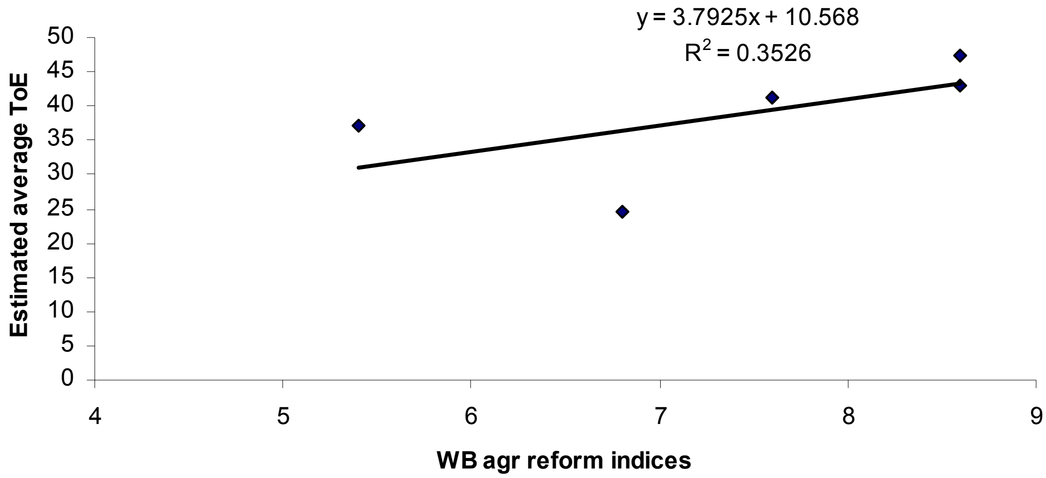

Figure 4a: Relation between efficiency of the agricultural sector in 5 transition countries and WB agr. reform indices, and fitted trend line

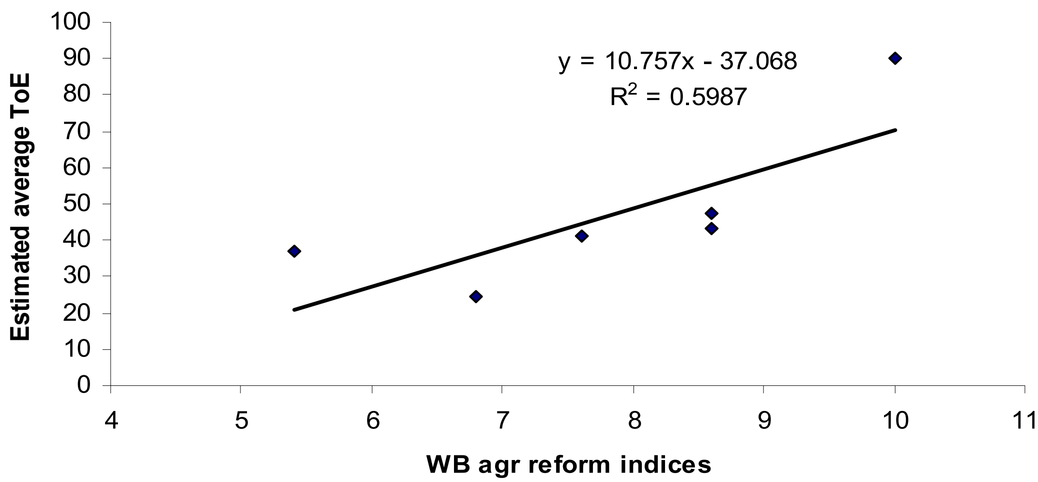

Figure 4b: Relation between efficiency of agricultural production in 5 transition countries plus the UK and WB agr. reform indices, and fitted trend line

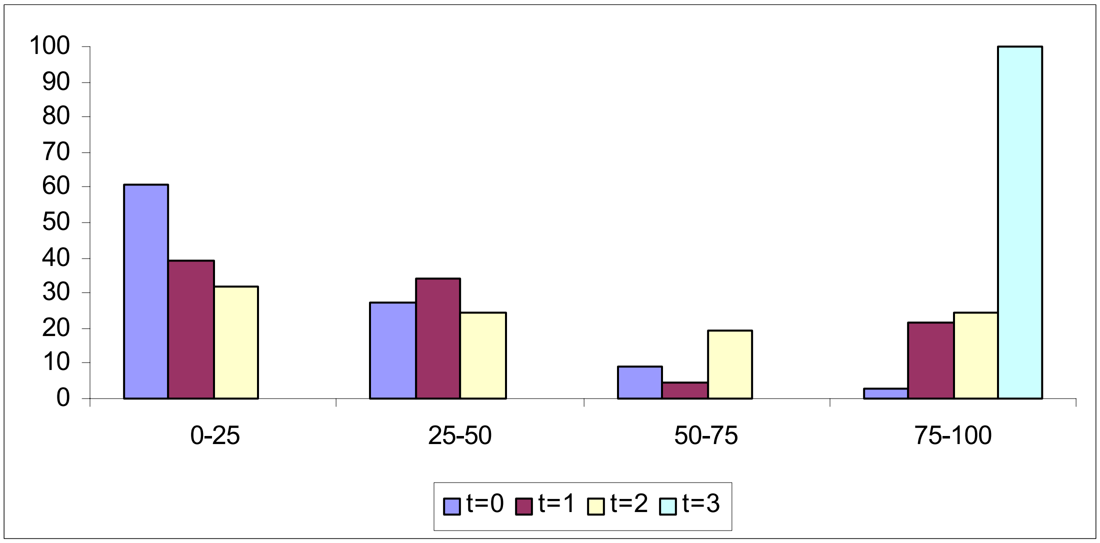

Figure 5a: Simulated impact of reforms on the distribution of total technical efficiency for four transition stages

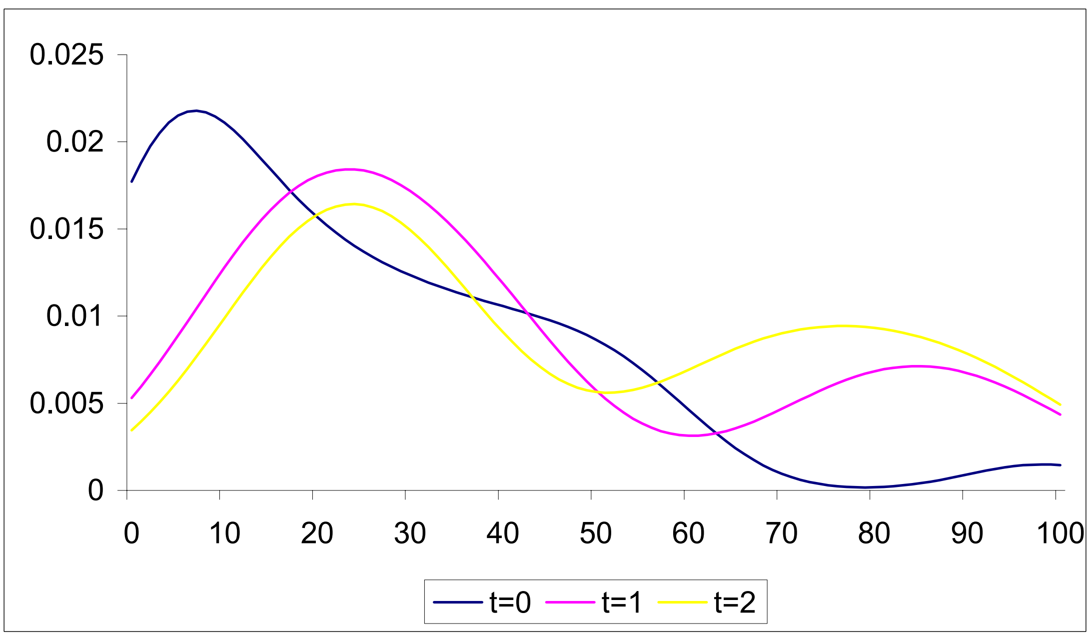

Figure 5b: Simulated impact of reforms on kernel density of total technical efficiency for three transition stages

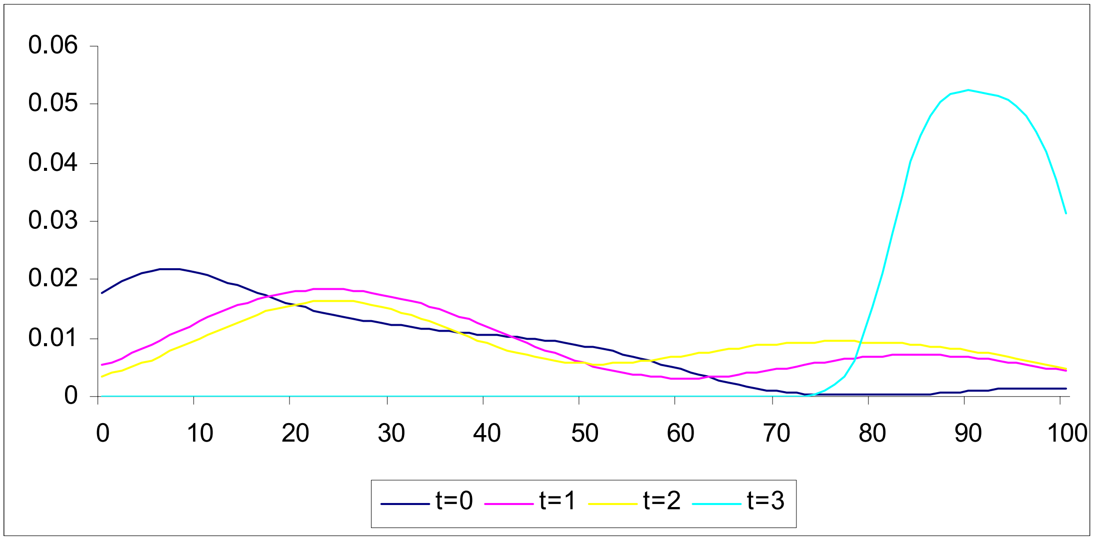

Figure 5c: Simulated impact of reforms on kernel density of total technical efficiency for four transition stages