Causes of Efficiency Change in Transition: Theory and Cross-Country Survey Evidence from Agriculture

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CAUSES OF EFFICIENCY CHANGE IN TRANSITION: THEORY AND CROSS-COUNTRY SURVEY EVIDENCE FROM AGRICULTURE

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Abstract

Studies on efficiency changes in transition agriculture yield mixed results. This paper develops both a theoretical model and an empirical analysis of how distribution of efficiency scores changes with the various stages of transition. We use a unique set of representative farm survey data to calculate farm level efficiency scores, compare the efficiency distributions of different transition countries and correlate these with various indicators of particular reforms. Our study indicates that, in particular, general institutional reforms and reforms focused on market institutions and on reducing market imperfections in input and output markets have an important positive impact on farm efficiency.

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1 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 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

[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).

Soviet Union (Sedik et al, 1999; Lerman, Csaki and Feder, 2004) and disorganization in the supply chains (Gow and Swinnen, 1998).

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 (Mathijs and Swinnen, 2001) while studies using farm-level data are restricted to one country and short time periods, often even one year (Mathijs and Vranken, 2001). 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 and an empirical analysis of how the distribution of efficiency scores changes with the various stages of transition. The empirical analysis uses a unique set of 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 they 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.

Next, we compare the efficiency distributions of the countries and we correlate these with various indicators of particular reforms. We discuss how the share of farmers producing efficiently changes during transition and which aspects of the reforms are important in explaining differences in the observed efficiency distributions.

The last section wants to explain what causes the shift in the distribution of efficiency scores during transition. Therefore, we 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 heterogeneity in production efficiency within a country. 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.

2 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. The format of the surveys is consistent among countries and this increases the comparability of the data.

To increase the accuracy of comparisons, we take only crop farms into consideration as technologies (land/labour ratio) differ with product specialisation (crops versus livestock). In this way, we enhance the homogeneity of the dataset. In all countries, crop production is almost equally important and its share in total agricultural output ranges from 42% to 52%. To be included in our analysis the value of grain production in the value of total production need to be more than 50%. Selection of farms out of the total sample occurred according to objective criteria and not randomly. Further, all five country data were checked for outliers[2] and observations with incomplete information were dropped. The cleaning of the data 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), 138 Slovak farms (63 cooperatives, 8 companies and 67 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

[2] To trace outliers we first plotted partial productivity measures versus the respective input factor (i.e. plotting for example land productivity versus land use) and identified which observations did absolutely not fit within the general observed pattern. This observation was then dropped if, in addition, its partial productivity measure or input factor was more than 2 standard deviations removed from the previous one.

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 and 9 at the time of the surveys (Csaki and Lerman, 1997). The countries vary most strongly in terms of their income levels and broader institutional progress (see table 3).

3 Methodology

To investigate how average efficiency and the distribution of efficiency scores have 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 is technically efficient - meaning that it produces on the boundary of the production possibility set or phrased differently, if it maximizes output with given inputs after having chosen technology[3] - and if it is at the same time scale efficient - meaning that the input-output combination corresponds to a situation following from a competitive long run competitive equilibrium situation. As such, deviations from the frontier, i.e., inefficiencies, are independent of output or input prices and the availability of inputs. Rather, they reflect the internal working of the producing unit such as the incentives for efficient operation, the ability to effectively organise, motivate and monitor workers and supervisors, and the ability to avoid mistakes and wasteful decisions (Brada and King, 1993).

Compared to a parametric technique, a non-parametric approach such as DEA has the advantage that we do not have to choose a priori functional forms for the estimation of the production function and that we hence do not need a priori information on the actual form. The latter is particularly interesting because such information is mostly absent. Moreover, parametric measures such as stochastic frontier analysis that decomposes the

[3] This should be distinguished from the economic efficiency of productive activities which implies producing any given level of output at the minimum opportunity cost of the inputs used in production. Economic efficiency depends on factor prices and on technical efficiency itself.

error term into two components, one to account for random effects and another to account for technical (in)efficiency, typically assume that the efficiency scores have a normal distribution and are independently and identically distributed. Consequently, we can only observe (half) normally distributed efficiency scores if we rely on stochastic frontier analysis and it confounds the effects of mis-specification of functional forms with inefficiency, while DEA is more flexible and allows observing both normally and non-normally distributed efficiency scores and it is less vulnerable to misspecifications.

The data used in the DEA calculations are similar for all countries and include gross output, expressed in local currency, and data on land, labour, capital and other variable inputs. Output is the value of physical production valued at fixed prices. These fixed prices are calculated based on the price information in the survey. Labour is expressed in annual working units which correspond to 2150 labour hours or the number of hours that a full-time worker can perform in one year. Land is the total amount of agricultural land cultivated. To take into account quality differences in land, the area cultivated is multiplied with a land quality indicator. The value of estimated farm buildings is used as a proxy for capital. Further, we also take into account the amount of money spent on the purchase of seeds, feed, grains, roughage, concentrated feed, fertilizers, energy and services. Five different frontiers are assumed, i.e. one for each country[4].

We encountered two problems when calculating the efficiency scores. First, efficiency scores are affected by the number of observations in a sample as well as by the number of inputs used to calculate the efficiency scores. The latter are identical for all countries, while the number of observations differs and this might bias our results. However, if we create for each country a new sample with an equal number of

[4] Pooling the data for all five countries was not possible because all countries in our sample have different land quality measures so that it was impossible to take this variable into account when assuming one frontier for the five countries, while land quality is a crucial factor for crop production.

observations by using bootstrapping techniques, the distributions are practically identical (see appendix).

Second, Slovak sample includes only registered farm households while data for other countries include both registered and unregistered farms. Consequently, the Slovak efficiency distribution will too positive compared to other countries. Based on the efficiency distribution for each country, we will estimate a kernel density function. This allows us to correct for the fact that the Slovakian data does not include unregistered farms and we will calculate the average total technical efficiency for each country using these density functions.

4 Results of efficiency calculations

The DEA calculations illustrate that there are large differences in efficiency distribution between the countries (figure 1). In Albania for example most farmers have an efficiency score lower than 30 and only a very small share (2%) of the farmers are efficient, i.e. they achieve an efficiency score close to 100. On the other hand, we observe that in Hungary most farmers have an efficiency score between 40 and 70 and 9 % have an efficiency score between 90 and 100.

The differences in efficiency distribution between countries are also reflected in the average efficiency scores. Albanian farmers reach for example an average efficiency score of 25, Bulgarian farms an average efficiency level of 37, Czech farms an average efficiency level of 43, Hungarian farms an average efficiency level of 47 and Slovakian farms an average efficiency level of 41[5].

Further, figure 1 illustrates that the distribution of farm efficiency scores differs from a normal distribution. Instead, one could argue that a two-peaked distribution is

[5] One should bear in mind that these indicators say something the distribution of efficiency scores, but they say nothing about farm efficiency comparisons across countries.

observed. One “high efficieny” peak can be found at the frontier and another “low efficiency’” peak can be found more to the left. The distance between both peaks differs with the country.

To see how farm efficiencies are distributed in a market economy, 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 CAP subsidies. The efficiency distribution of the UK potato farms, compared to the other distributions (see figure 1) 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.

In summary, our analysis shows that a country like Hungary, 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. In a country like Albania, which is less advanced in the transition stage, fewer farms can be found on the production frontier and the average efficiency score is lower. While one could assume that farms in Albania are less efficient than farms in Hungary (for a variety of reasons), it is remarkable that the distribution of efficiency scores differ so much <u>within</u> the countries.

5 Correlation between efficiency and reforms

There is a remarkable correlation between the average efficiency within countries and the stage of reform. To analyse this further, we first compare the average farm efficiency with reform indices as calculated by the World Band and EBRD[6] in figures 3

[6] The World Bank agricultural reform index is an aggregate index of progress in land reform, price and market liberalization, reforms in the agro-processing sector and rural finance and of the institutional

and 4. 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 relatively 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[7]. 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

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 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.

[7] The correlation between these factors and the average efficiency scores remains irrespective of whether we include or exclude the UK from our sample.

competition policy to reduce abuse market power is beneficial for the performance of an industry. However, in agriculture there is little 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 as agribusiness and food processors. Even when the market for agribusiness and food processors is rather concentrated, it is sufficient to have some large players in these markets who act competitively to achieve better system performance. To reach such beneficial outcome it is important that these large players up- and downstream coordinate with the agricultural producers by obtaining agreements and monitoring their enforcement (Poulton et al., 2004). Such agreements typically allow agribusiness and food processors to access sufficient agricultural output (often of a specific desired quality), while the producers get assistance in accessing credit and information and know how about new and better production technologies (Gow and Swinnen, 1998, 2001; Dries and Swinnen, 2004).

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. However, the efficiency effects of privatization in agriculture are conditional upon other reforms and changes such as in input, output, credit and technology markets. In the rest of the paper, I will develop a theoretical model to explain the observed differences in efficiency distribution among countries at different stages of reform.

6 Theory

Factors like out- and input prices and progress in land reform and privatization affect the efficiency distribution. However, at the time of the surveys, land reform and privatization were largely completed in all 5 countries. Furthermore, the technical efficiency scores which we calculated are independent of input or output prices or the availability of inputs (see previous sections). Previous studies show the great importance of labor markets (Swinnen et al., 2005; Dries and Swinnen, 2002; Macours and Swinnen, 2000, 2002, 2005; Rizov and Swinnen; 2004) and access to markets and technology (Gow and Swinnen, 2001; Dries and Swinnen, 2004; Swinnen, 2006) and hence we will also focus on these factors. The model illustrates that lowering transaction costs in accessing new technologies and reducing labour market imperfections, and in particular increasing the labour opportunity cost, are sufficient to explain the mechanism that drives the changes in the efficiency distribution.

Consider a production model as described in Mundlak (2001) where each producer i chooses the input x_i to maximize the expected profits $\pi^i = q^i - wx_i$ and where q^i is the value of output (whit the output price normalized at one), x_i the inputs used and w the (exogenous) input price. A single-input Cobb-Douglas function describes the production function:

$$q_i = Ax_i^{\beta}e^{m_i} \tag{1}$$

with m_i the firm effect, or management. The first order condition implies that at the optimum $\beta Ax*_i^{\beta-1} = we^{m_i}$ which determines the optimal input $x*^i$ and, given the Cobb-Douglas production function (1), also the optimum output $q*^i$.

In the DEA efficiency calculations, we calculated input-oriented efficiency scores. 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:

$$eff*^i = \frac{q*^i / wx*^i}{q\# / wx^\#} \text{ with } q*^i = q^\# \tag{2}$$

and $wx^\#$ the cost function of the “efficient” producer, i.e. the producer that can be found on the production possibility frontier. If we combine (1) and (2), we can write the efficiency scores as follows:

$$eff*^i = e^{(m_i - m_\#)/\beta} \tag{3}$$

This means that the efficiency level of producer *i* depends on its own firm effect and on the firm effect of the producer that can be found on the frontier and that produces the same output as household *i*, namely $q*^i$. Assume that the firm effect depends on the managerial capacities *h* and on access to certain production technologies δ. We define δ as a 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. We assume that the farmers that can be found on the frontier have all access to high productive technologies. This allows defining the efficiency measure as follows

$$eff*^i = eff*^i\,(h^i, \delta^i, h^\#, \delta^\# = H) \tag{4}$$

Suppose that there are two factors that determine access to technology, namely the managerial capacity *h* and the market imperfections or transaction costs in accessing new technology. These market imperfections or transaction costs are exogenous to each producer, but they can be more easily overcome with higher managerial capacities.

One way to think about this process is that innovative or entrepreneurial strategies are needed to overcome these transaction costs and that people with more managerial capacities are more likely to implement such strategies. Another way in which transaction costs can be overcome is through a process of vertical integration in agri-food supply chains as described by Gow and Swinnen (1998, 2001) and Dries and Swinnen (2004). In this process, technology is provided to the producer by other companies, such as processors or traders, which face less credit and technology market constraints. Studies show that such companies are more likely to provide new technologies to suppliers with high managerial capacities.

Therefore, define Θ as the extent of market imperfections or transaction costs in the technology market for the farms. In order to have access to high productive technologies a producer needs to overcome this hurdle and therefore s/he needs at least the threshold amount of management capacities $\bar{h}$ [8]. The magnitude of the threshold $\bar{h}$ is a positive function of Θ so that

$$\bar{h} = \bar{h}(\Theta) \ with \ \frac{\delta \bar{h}}{\delta \Theta} > 0 \tag{5}$$

$$\delta = \delta(h, \bar{h}(\Theta)) \tag{6}$$

We assume that the following conditions hold for the efficiency function defined in (4):

$$eff^{*i}(h^i, \delta = H, h^{\#}, \delta^{\#} = H) > eff^{*i}(h^i, \delta = L, h^{\#}, \delta^{\#} = H) \ and \ \frac{\partial eff^{*i}(.)}{\partial h} > 0 \tag{7}$$

Further, we assume that to continue farming a producer needs to reach a threshold income or amount of profits $\bar{\pi}$. Here, we assume that the threshold profit $\bar{\pi}$ that a producer needs to generate to continue farming is the opportunity cost of his labour which can be either off-farm wages, or retirement or unemployment benefits. If off farm wage employment opportunities are constrained, as it is often the case in transition countries, labour use in farming depends on the shadow cost of labour which is in turn affected by human capital characteristics and market imperfections (Rizov and Swinnen, 2004).

[8] One could argue that the magnitude of *h* is not exogenous to the above decision making process since each person takes into account that his/her managerial capacities affect access to production technologies when they decide how much to invest in acquiring these skills. Although, under communism several freedoms were limited as was the choice on how much to invest in development of certain skills.

Hence, a producer stays active in agriculture only if $\pi *^{i} > \bar{\pi}$ or, in words, if its human capital allows him to generate an income $\pi *^{i}$ which is larger than a threshold amount $\bar{\pi}$. The latter increases when a country is more advanced in the transition process, i.e. when the opportunity cost of labour increases because off-farm labour opportunities increase as well as retirement or unemployment benefits. Less productive producers cease their activities.

We now can formulate the effective efficiency function $eff^{\,effective}$ for each producer i as follows[9]:

$$eff^{\,effective} = eff^{\,H} \;\; if\; h > \bar{h}(\Theta)\; and\; \pi > \bar{\pi} \tag{8}$$

$$eff^{\,efeictive} = eff^{\,L} \;\; if\; h < \bar{h}(\Theta)\; and\; \pi > \bar{\pi} \tag{9}$$

Economic reforms are assumed to reduce market imperfections and therefore to lower transaction costs Θ, and also to increase the opportunity costs $\bar{\pi}$ because of improved labour mobility and more job alternatives. Consequently, more farmers will move from $eff^{\,L}$ to $eff^{\,H}$. In addition, the least productive farmers will leave agriculture so that the number of farmers with low productive technologies $eff^{\,L}$ decreases even more.

As a result, economic reforms will cause an increase in the share of high efficiency producers and a decline of low efficiency producers through this process of endogenous technology adoption with falling transaction costs and increasing opportunity costs. Other factors which affect opportunity costs will affect the number of inefficient producers, but not that of efficient producers.

[9] To simplify our notification we will use the notation $eff^{\,H}\; for\; eff *^{i}\,(h^{i}, \delta = H)$ and $eff^{\,L}\; for\; eff *^{i}\,(h^{i}, \delta = L)$.

7 Simulation Model

To see how these changes affect the distribution of production efficiencies in a heterogeneous population, we will use a simulation approach. By using specific parameters for the model described above, we can simulate how the efficiency of the producers and, the average efficiency of the agricultural sector changes with the state of reforms. Suppose equations (8) and (9) have the following functional form:

$$eff^{L} = h^{1.9}/100 \text{ with } h \in [1,100] \text{ and } e^{L} \in [0,63] \tag{10}$$

$$eff^{H} = h^{2}/100 \text{ with } h \in [1,100] \text{ and } e^{H} \in [0,100] \tag{11}$$

with h uniformly distributed over the interval [1,100] and different access to technologies incorporated in a different power of h. Given (5), a possible correlation between $\overline{h}$ and Θ is $\overline{h} = \alpha\Theta$ and to start, we assume that $\alpha = 1$. Since each producer maximizes its profits and given the production function defined in (1), $\overline{\pi}$ can be expressed as a linear combination of e^{m_i} and since the firm effect m_i depends on h_i, $\overline{\pi}$ is a function of h_i.

When h is large enough, i.e. larger than $\overline{h}$, the producer uses the best technology, as identified by condition (11) . Otherwise, the low efficiency technology in (10) is used.

We now stimulate the models with various parameters for $\overline{\pi}$ and Θ to reflect different stages in transition and reforms. We assume that initially (at t=0) $\overline{\pi}$ equals 30 because at the start of the reforms, off farm labour opportunities are limited and soft budget constraints apply so that $\overline{\pi}$ is small. $\overline{\pi}$ increases with time. Furthermore, in the beginning of the transition period, farmers experienced a large hurdle Θ, but this hurdle decreases over time. 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 (11)holds, i.e. the more producers reach the high efficiency function eff^H. The higher $\bar{\pi}$, the fewer “low efficient farms” stay in agriculture. At t=3 we find only producers for which equation (11) holds. Figure 4a illustrates how the efficiency distribution changes when a country moves from t=0 to t=3 under these simulation assumptions. This is comparable with the efficiency distribution we observe in transition countries (figure 1). To obtain the depicted shift in distribution, we require both an increase in $\bar{\pi}$ and a decrease in Θ. Figure 4b illustrates how the efficiency distribution shifts when the labour opportunity cost changes and transaction costs in accessing new technologies do not change. Figure 4c allows an increase in transaction costs in accessing new technologies, while the labour opportunity cost is unaltered. Clearly, it is necessary that both the labour opportunity cost and transaction costs in accessing new technology change to obtain a shift in the efficiency distribution comparable with the one that we observe in transition countries.

As explained in the theory section, reduced transaction costs through reforms will affect Θ. The increase in $\bar{\pi}$ may be caused both by reforms which increase the opportunity cost of agricultural production and, in a cross-country comparison, by higher social benefits or higher off-farm wages. If one considers the degree of unemployment and a country’s GDP per capita as a proxy for the opportunity cost of labour, the relationship between unemployment and efficiency, and GDP per capita and efficiency, as depicted in table 3, are then consistent with our hypothesis that one of the prime determinants of farm efficiency are a combination of general labour market imperfections and the relative size of social benefits.

8 Conclusions

In this paper, we use farm survey data from 5 East European countries collected in 1997-1999 to calculate farm efficiencies using DEA, a non-parametric linear programming technique. In all 5 countries (Albania, Bulgaria, Czech Republic, Hungary, Slovak Republic) land reforms have been largely completed at the time of the survey and farms were largely private and working with hard budget constraints. However, they differ significantly in their role of agriculture, level of development, farm structure and progress in institutional reforms.

The DEA calculations yield a two peaked efficiency distribution in all countries and illustrate 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 firms reach on average a higher efficiency level. These results imply that the efficiency distributions are less heterogeneous when a country is more advanced in the transition process.

We find a positive empirical correlation between reforms on productivity in agriculture. We find that the share of efficient agricultural producers is strongly positively correlated with the stages of reforms in the five countries. The correlations suggest that, in particular, general institutional reforms and reforms focused on market institutions and on improving access to inputs and output markets may have an important positive impact on farm efficiency for the countries included in the analysis.

Next, we develop a theoretical model to provide a series of hypotheses on the mechanism that drives the shift in efficiency distribution when a country moves forward in its transition to a market economy. Key factors in our model are that labour opportunity costs increase with transition and transaction costs to access capital and technology decrease. Our model show that these two factors induce that more farmers become efficient and the least efficient stop producing, and that this, in turn, leads to a particular adjustment pattern in the distribution of farm efficiencies which is consistent with empirical observations.

The simulations based on our theoretical model are consistent with the empirically observed changes in efficiency distributions during transition. They support the hypotheses that farm productivity increases are strongly constrained by labour market imperfections, and in particular by limited opportunities for off-farm employment, as well as by market imperfections or transaction costs in accessing new technology.

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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	51 (2000)	23 (1997)	5 (2000)	8 (1997)	7 (2000)
Unemployment	18 (2000)	15 (1997)	9 (2000)	9 (1997)	19 (2000)

[a] Land is rented to individuals or entities pending sale
Source: National statistics

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

Source: Own calculations

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

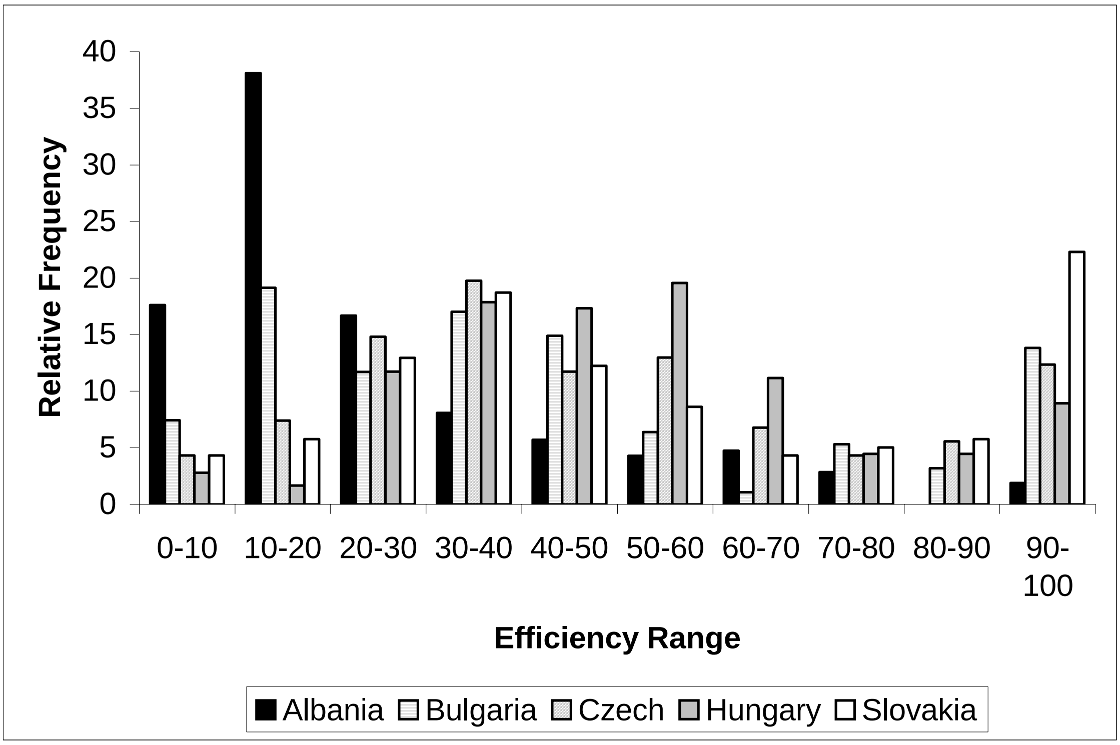


Figure 1a Distribution of total technical efficiency.

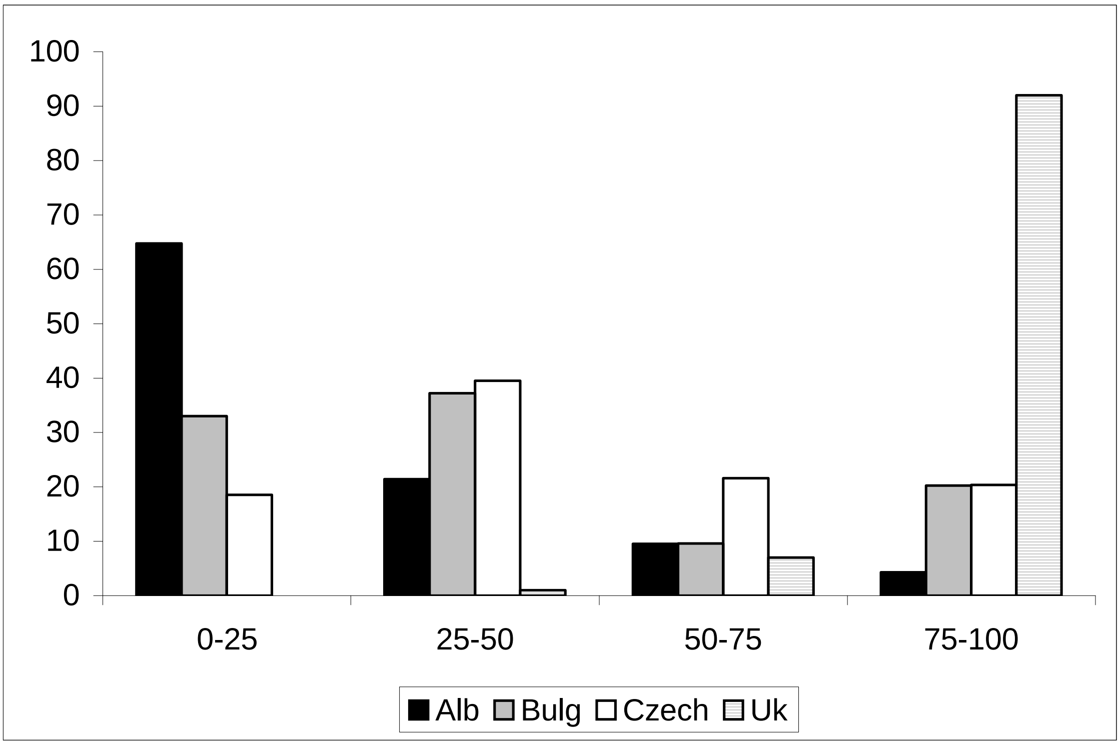


Figure 1b Distribution of total technical efficiency.

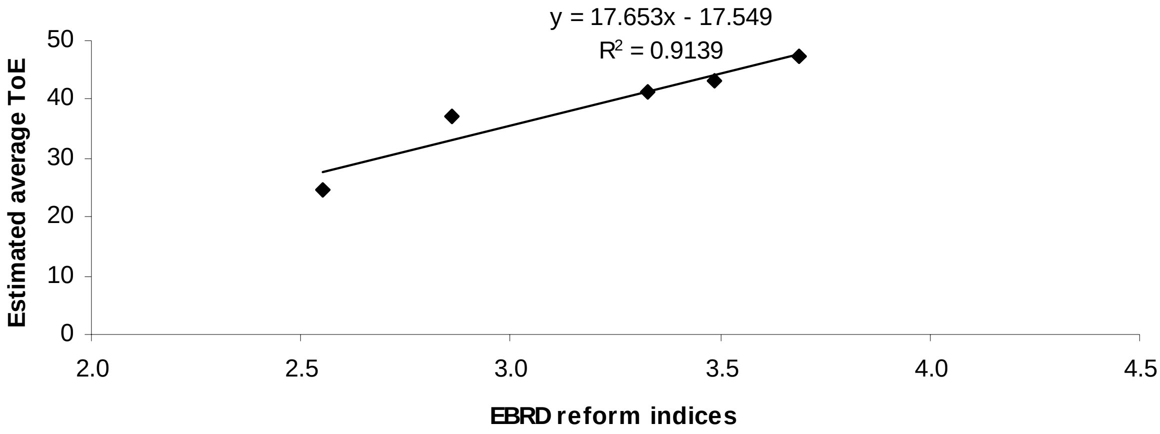


Figure 2a Relation between efficiency of agricultural production in 5 transition countries and EBRD reform indices, and fitted trend line

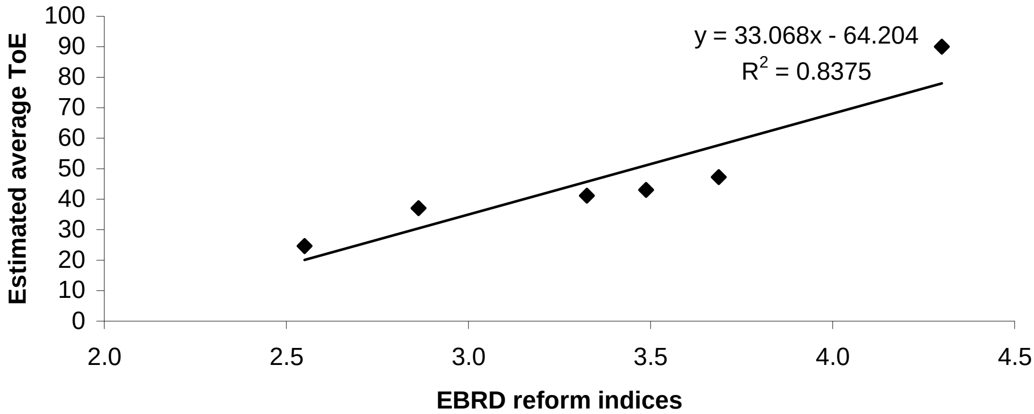


Figure 2b Relation between efficiency of agricultural production in 5 transition countries plus UK and EBRD reform indices, and fitted trend line

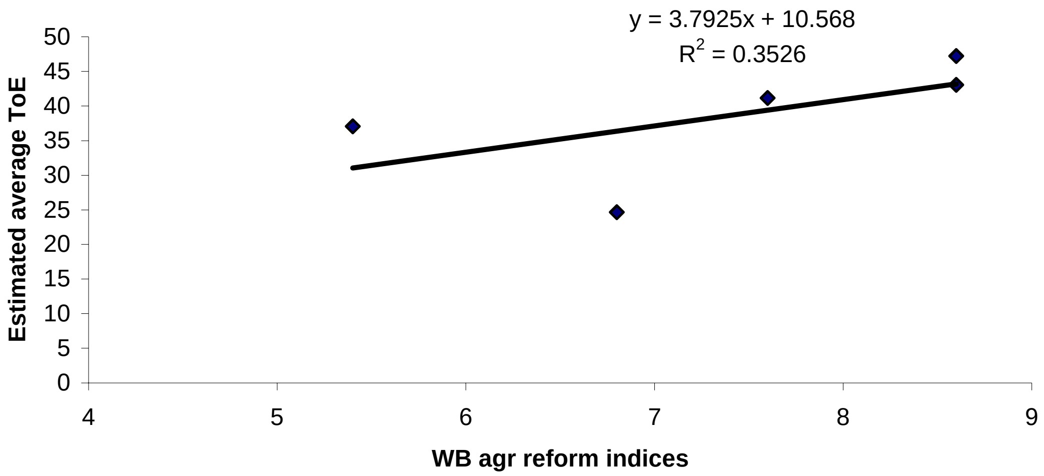


Figure 3a Relation between efficiency of the agricultural sector in 5 transition countries and WB agr. reform indices, and fitted trend line

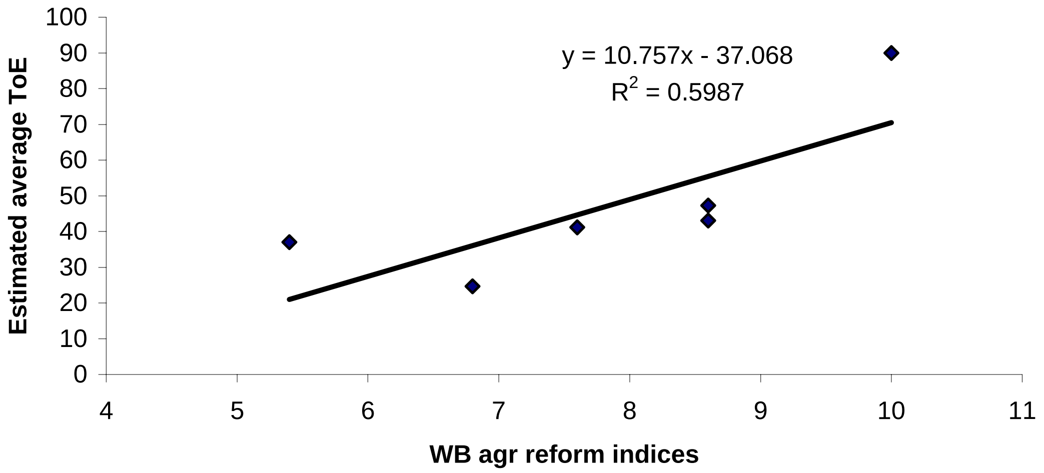


Figure 3b Relation between efficiency of agricultural production in 5 transition countries plus the UK and WB agr. reform indices, and fitted trend line

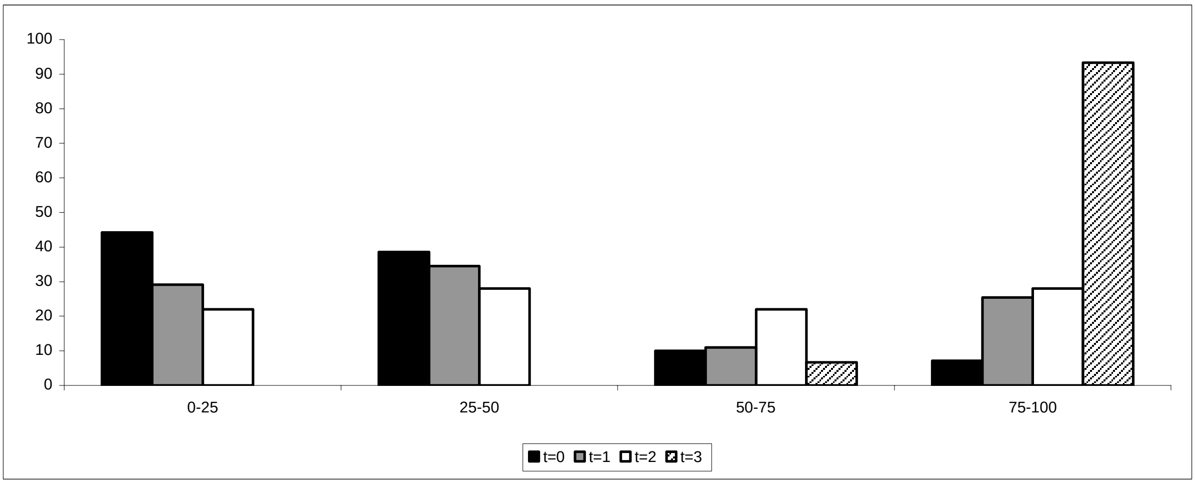


Figure 4a Simulated impact of reforms on the distribution of total technical efficiency when labour opportunity cost increases and transaction costs in accessing new technologies decrease.

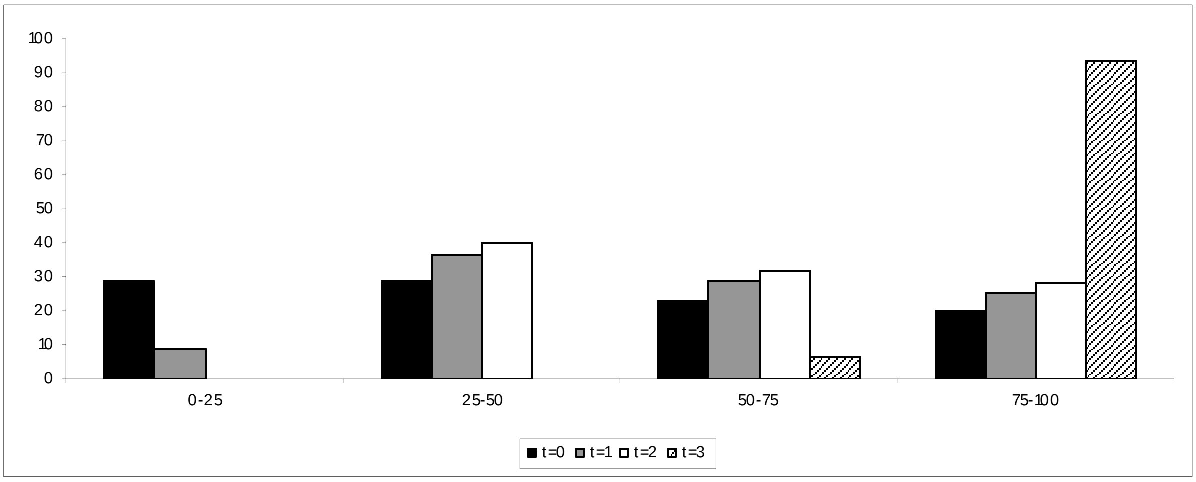


Figure 4b Simulated impact of reforms on the distribution of total technical efficiency when labour opportunity cost.

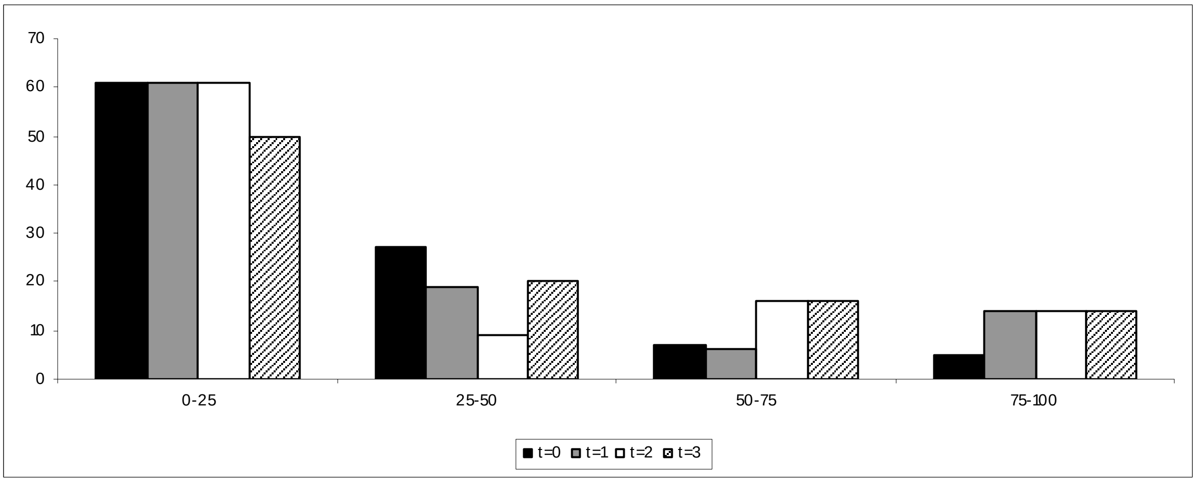
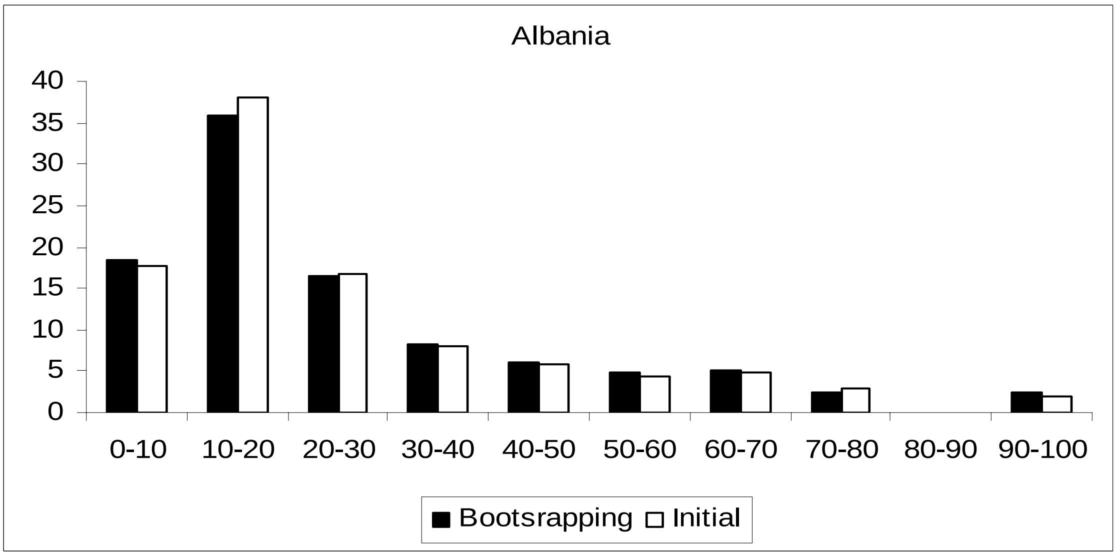
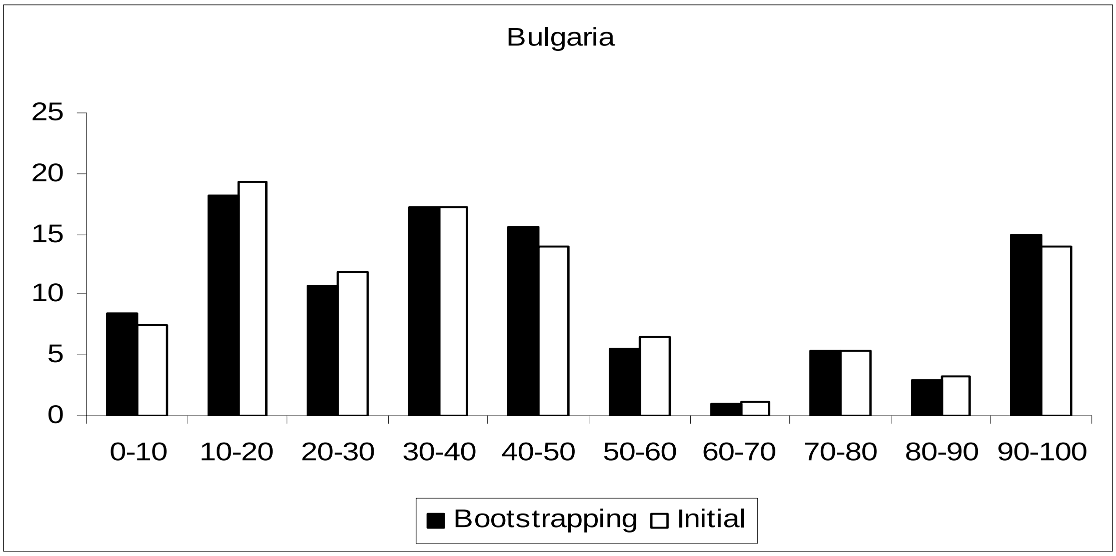
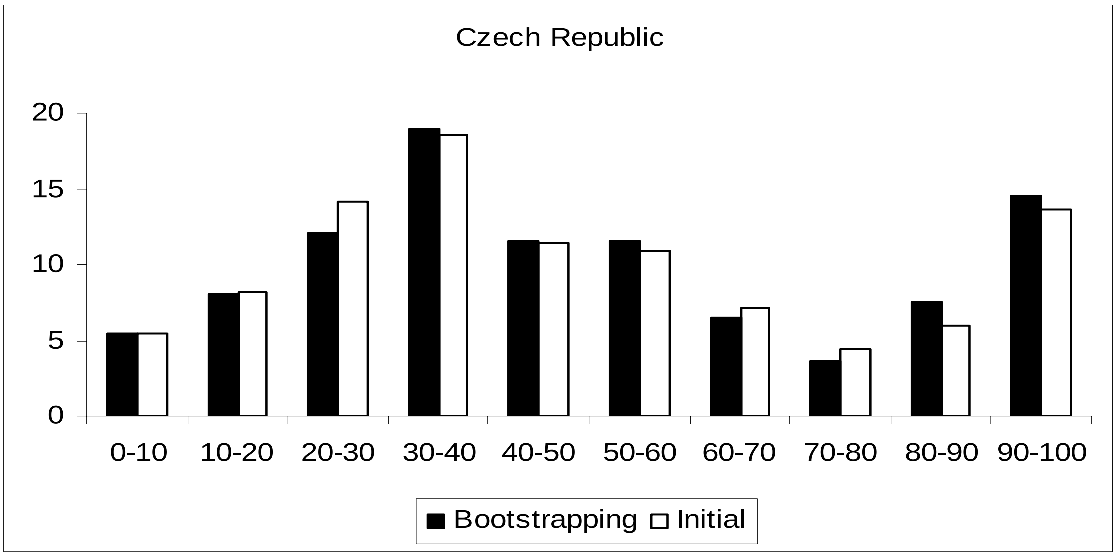


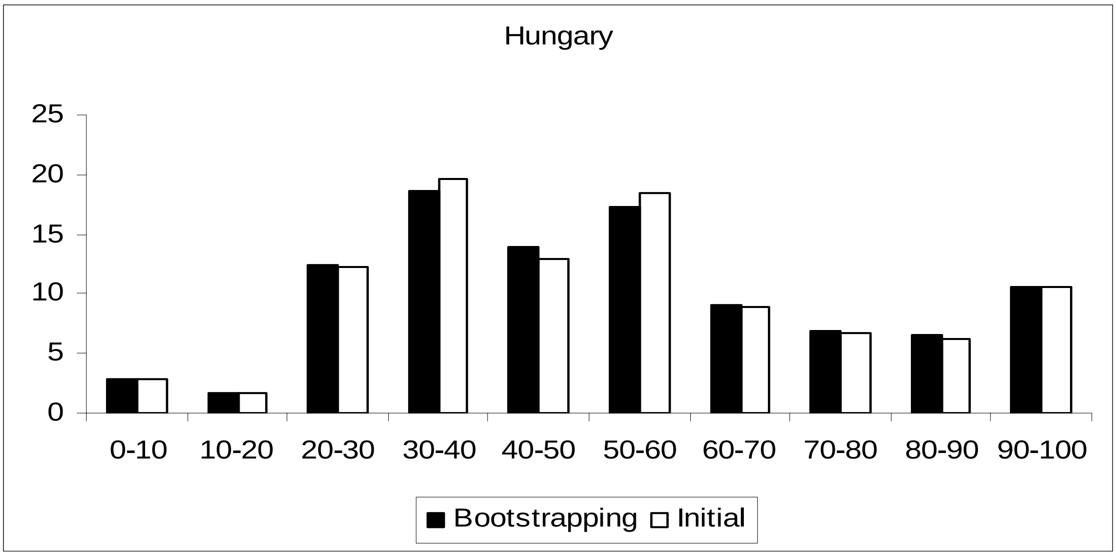
Figure 4c Simulated impact of reforms on the distribution of total technical efficiency when transaction costs in accessing new technologies decrease.

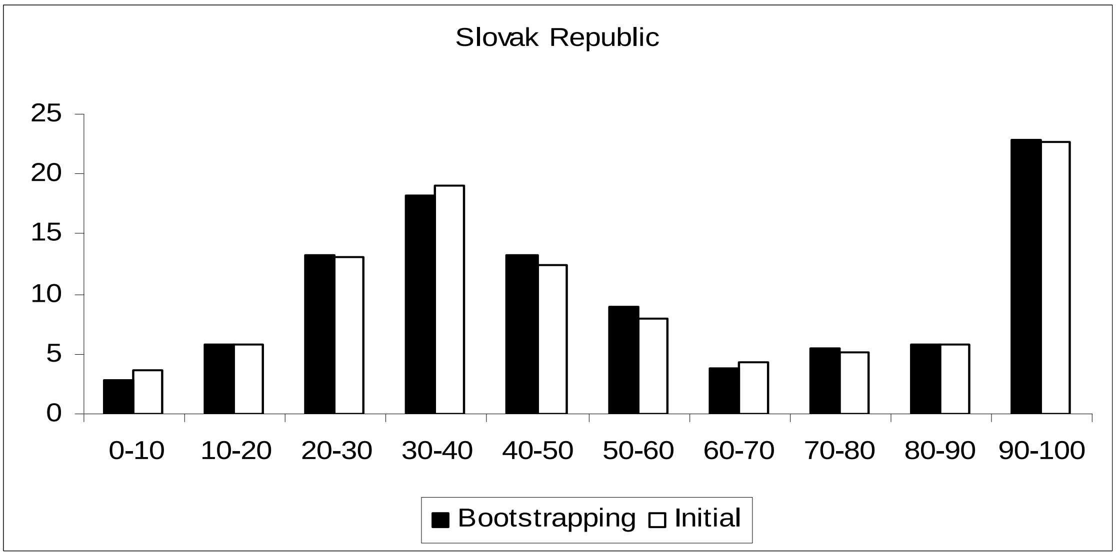
Appendix : Initial and Bootstrapped Distributions








Hungary
25
20
15
10
5
0
0-10
10-20
20-30
30-40
40-50
50-60
60-70
70-80
80-90
90-100
Bootstrapping
Initial


Slovak Republic
25
20
15
10
5
0
0-10
10-20
20-30
30-40
40-50
50-60
60-70
70-80
80-90
90-100
Bootstrapping
Initial