Transition and Total Factor Productivity in Agriculture
1992 - 1999

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Abstract: This study measures multifactor agricultural productivity for 23 transition economies in Central and Eastern Europe (CEECs) and the Former Soviet Union (FSUs), studied over 1992 to1999. During the reform period, almost all countries in the CEEC have shown continuous productivity improvements compared to 1992, while in more than half of the FSUs productivity was still below its 1992 levels. On the average, aggregate productivity has increased by 20.9 percent in the CEECs and declined by 4.7 percent in the FSUs. These developments reflect changes in resource use and technical progress in 1999 compared to 1992. Technological change has been slow or declining in many of the former soviet republics while contributing positively to productivity changes in almost all CEECs.

Keywords: productivity, factor productivity, transition, technological change, FSU

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1.   Introduction

Studies on the agricultural economy during transition indicate large differences in performance (Macours and Swinnen, 2002). A weakness of many cross-country comparisons of productivity changes during transition is their reliance on partial productivity measures such as yields or labour productivity. The main exception is China, where reforms started at the end of the 1970s and where several studies have estimated the development of total factor productivity (TFP) for agriculture (McMillan, Whalley and Zhu, 1989; Lin, 1992; Wen, 1993; Huang and Rozelle, 1996; Fan, 1997; Jin *et al.,* 2002). All show that in the first years after reform (1978 to 1984) comprehensive measures of productivity (either TFP or a regression based equivalent) rose by 5 to 10 percent per year. Fan (1997) and Jin *et al.,* (2002) show that during the 1990s, TFP continues to rise at around 2 percent per year.

There is much less evidence on TFP developments in other transition countries. Pingali and Xuan (1992) estimate that also in Vietnam the agricultural output rose rapidly in the early years of transition: e.g., between 1980 and 1985, TFP in rice production, which makes up a large part of the agricultural economy, rose by 2 to 3 percent annually. Benjamin and Brandt (2001) estimate that TFPs for rice and total crop output continued to rise between 1992 and 1997 (though TFP of total crop output declined in the north).

Available studies suggest that in other transition regions TFPs developed very differently. Macours and Swinnen (2000) analyse output and productivity changes in Central and East European countries (CEECs) between 1989 and 1995. They find that TFP in Central Europe (Czech Republic,

Hungary, Poland, Slovakia) has declined in the first three years of transition, on average by –2.3% annually, but rebounded strongly afterwards: annual TFP growth from 1992-1995 was 4.5 % on average. The Balkan countries (Albania, Bulgaria, Romania, Slovenia) showed a similar, but more pronounced pattern: TFP fell by around 7% annually over the first three years, while increasing by more than 7% on average during the three years afterwards.

Studies of TFP developments in countries of the former Soviet Union (FSU) do not yield a consistent picture. The only comprehensive study on the FSU is by Lerman *et al.,* (2001) who estimate TFPs for all FSU countries between 1992 and 1997. Their analysis indicates strong average productivity growth in Baltic countries[1] and strong TFP declines in the Central Asian republics. Interestingly they find growth of total factor productivity, albeit relatively small (0.7% annually on average), in the European New Independent States (NIS), i.e., Belarus, Moldova, Russia and Ukraine. This contrasts with several more detailed studies on Russian agriculture. Sotnikov (1998) and Sedik *et al.,* (1999) found that efficiency of Russian farms had declined during the reform period up to 1995. A more recent study by Trueblood and Osborne (2001) estimating multifactor productivity for crops on corporate farms in Russia for 1993-1998 and using disaggregated data from 70 oblasts (equivalent to provinces), concludes that "their results support the conventional wisdom that overall productivity [in Russian agriculture] has declined in the reform period". They find that productivity declined by -2.1% annually after 1993 and continued to decline up to 1998 and that there was no indication of a productivity rebound.[2]

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[1] TFP increased strongly as well in Armenia and Georgia, two Caucasian countries that dramatically shifted to individual farming while recovering from natural disaster and war devastation. Both countries are special cases, characterised by a huge inflow of labour in agriculture due to a collapse of industry and war-related upheavals.

[2] Productivity declined by 2.1 percent *annually* over the 1993-1998 period, with losses in technical efficiency and inward shifting frontiers (losses of technical change) contributing in equal quantities to the productivity losses. Trueblood and Osborne (2001) also found that the latter factor contributed disproportionately to productivity losses in the regions with the greatest losses. The technological regression is likely due to input supply disruptions, lack of credit and spare parts, etc., which inhibits the use of previously, used inputs.

A major problem of the latter studies is their focus on corporate farms, ignoring private household farming. While household farming in 1998 only used 5.4% of total available agricultural land, it accounted for 57.3% of the value of total agricultural output in Russia. Starting from the hypothesis that productivity is higher on the household plots than it is on Russian corporate farms, this bias in the study coverage may account for the different findings compared to Lerman *et al.*, (2001) who do include all inputs and outputs in their analysis. There is some support for this hypothesis in the study by Murova *et al.*, (2001) on crop productivity in Ukraine. They also use oblast data, but include all farming production. They find that technical efficiency has improved slightly over the 1991-96 period, with inputs (particularly labour[3] and fertiliser) contracting faster than output.[4]

An important problem with the previous studies for country comparisons is that the studies differ in methodology (various estimation procedures), data (sources), commodity coverage (crops, total agriculture, ...), and time periods. All these differences are likely to affect the results and therefore seriously complicate a reliable comparison of TFP developments between the transition countries. For example the two most comprehensive studies on CEECS (Macours and Swinnen, 2000) and FSU (Lerman *et al.*, 2001) cover different commodities (crops versus total output) and different periods (1989-1995 versus 1992-1997).

The objective of this paper is to overcome these problems by using a single methodological framework to estimate TFP for all CEECs and FSU countries. The methodology is discussed in section 2 below. Section 3 describes the data and variables used. Section 4 presents the empirical specification of the model, and section 5 discusses the results.

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[3] The study indicates that labour measured in hours employed contracts significantly stronger than "agricultural employment", suggesting significant underemployment.

[4] Murova *et al.*, (2001) argue that positive incentive effects of privatisation and liberalisation offset disruptive effects on factor markets.

2.   Methodology

The methodology in this paper is based on the growth accounting approach as in Macours &

Swinnen (2000).

The growth accounting literature empirically accounts for growth in output by measuring

factor inputs and an unexplained residual, which is generally attributed to technological change. [5]

We assume a three-factor Cobb-Douglas production function for the representative economy

at time *t*:

$$Y(t) = A(t)\left(K(t)^a L(t)^b I(t)^g\right), \qquad 0 < a < 1, \quad 0 < b < 1, \quad 0 < g < 1 \tag{2.1}$$

where *Y(t)* is output, *K(t)* is the stock of physical capital, *L(t)* is raw labour, *I(t)* is land, *A(t)* is the

estimable exogenous technology, and α, β, γ are parameters of the production function to be

estimated. [6]

Assuming there are constant returns to scale in the reproducible factors and that factors are

paid their marginal products, the above function is more conveniently given as [7]:

$$\frac{\dot{Y}}{Y} = h_K \frac{\dot{K}}{K} + h_L \frac{\dot{L}}{L} + h_I \frac{\dot{I}}{I} + h_A \frac{\dot{A}}{A}, \tag{2.2}$$

with the dot indicating the derivative with respect to time. $\frac{\dot{Y}}{Y}$ is the growth rate of output (i.e., the

rate of change in *Y* expressed in relative terms as the ratio to the value of *Y* itself),

$h_K = a\frac{K}{Y}, \quad h_L = b\frac{L}{Y}, \quad h_I = g\frac{I}{Y}, \quad h_A = \frac{A}{Y}$ are output elasticities with respect to the arguments

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[5] See Madison (1987) for a survey of the growth accounting literature.

[6] Note that the above formulation can be augmented to account for additional inputs, as appropriate.

[7] Taking logarithms, differentiating with respect to time and rearranging.

K, L, I, A or the share of output that would accrue to each of the factors if they were to be rewarded by rates of payment equal to their marginal products. The term $\boldsymbol{h}_A \dfrac{\dot{A}}{A}$ is referred to as the productivity residual often associated with technological change. [8]

Clearly, the above approach allows us to disaggregate the change in output due to changes in inputs and technical changes represented by the unexplained heterogeneity in a classical framework.

Nelson has pointed out a potential critique to the above approach, which is common for growth accounting models. He argues that the experienced growth is unlikely to be the simple sum of the contributions of separate factors because of possible interactions between them (Nelson, 1992). In our study, however, the relationship in 2.2 holds by a reasonable approximation assuming that the degree of interaction between the factors is small given the relatively limited period under consideration (i.e., 8 years).

We estimate a panel of 23 transition countries in CEEC and FSU over 8 years starting in 1992 as, before this date, information for the individual FSUs is not available. TFP measures are then calculated as the ratio of output growth to the change in aggregate inputs, expressed as percentages. The aggregate measure for inputs is calculated as the weighted sum of individual inputs using the respective estimated coefficient as weights.

3.   Data and Variables

Most of the data used in this study, except for labour, come from the FAO on-line database. All input-output variables are expressed as the natural logarithm of the ratio with respect to year 1992 according to the following formula: $X_{it} = \ln\left(\frac{x_{it}}{x_{i92}}\right)$ where x_{it} denotes the variable for country i at time t and x_{i92} denotes the same indicator in 1992 taken as the base year.

OUTPUT is the Net Agricultural Production Index Number (PIN) reported by the FAO. The Net index equals total agricultural production excluding the amount of produce used as animal feed and seed. The index is calculated by the Laspeyres formula: $\frac{\sum q_t p_o}{\sum q_o p_o}$, where the net production quantity of each commodity produced in the current year (q_t) is weighted by the 1989-91 average per unit international commodity prices (p_o) and summed for each year. To obtain the index, the aggregate for a given year is divided by the average for the base period 1989-91 where q_o is the net production quantity in the base period (FAO, 1986). To ensure comparability, a single set of international commodity prices was used by the FAO for all countries and country groups. [9]

We have recalculated the PIN as reported by the FAO to show the index with respect to 1992, instead of the 1989-1991, as base period.

The variable for *LIVESTOCK* is also from the FAO database. We take account of cattle, chicken, horses, goats & sheep, and pigs indicated as the number of live animal heads in a country at the time of enumeration, except for chicken, which are reported in thousand units. We have then

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[8] See, Markiw, N.G., Romer, D. & Weil, D.N. (1982) for a discussion.

[9] For a description of the methodology and discussion of the rationale of this particular formula versus other possible methods, see FAO (1986), *Inter-country comparisons of agricultural production aggregates.* FAO Economic and Social Development Paper No. 61, Rome.

aggregated the physical units reported by the FAO into "standard heads" using the appropriate conversion factor originally adopted by Hayami and Ruttan (1985).[10]

CAPITAL is based on the physical number of tractors in use, as reported by the FAO. We do not have information on the power of those tractors for each country/year. Therefore, the assumption here is that, in each country, the type of tractors in terms of their horsepower stayed the same throughout 1992 to 1999. As such, the horsepower as a conversion factor drop out when the yearly to 1992 ratios are calculated.

Following the FAO definition, *LAND* includes arable land and land under permanent crop cultivation, excluding what left idle.[11] The area under permanent crops includes also land under flowering shrubs, fruit-trees, nut trees and vines, but excludes land under trees grown for wood.

LABOUR is the number of people who are economically active in agriculture including those that are either engaged or seeking employment in agriculture. For the Central Asian republics, the data comes from the Asian Development Bank. For the other countries in our sample, the information has been put together from a variety of sources including the International Labour Organisation (ILO), the Organisation for Economic Cooperation in Europe (OECD), the FAO, and individual country reports.[12]

FERTIL is the quantity of pure nutrient fertiliser in metric tonnes consumed in agriculture by a country, as reported by the FAO. Three types of fertilisers have been aggregated to produce this measure: nitrogenous, phosphate, and potash fertilisers.

4. Empirical Specification of the Model

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[10] We are very grateful to Zvi Lerman for providing the conversion factors.
[11] Land under permanent crops includes land cultivated with crops that occupy the land for long periods and need not be replanted after each harvest.

The model we estimate is of the following form:

$$\ln\left(\frac{OUTPUT_{it}}{OUTPUT_{i92}}\right) = b_1 \ln\left(\frac{CAPITAL_{it}}{CAPITAL_{i92}}\right) + b_2 \ln\left(\frac{LAND_{it}}{LAND_{i92}}\right) + b_3 \ln\left(\frac{LABOUR_{it}}{LABOUR_{i92}}\right) +$$

$$+ b_4 \ln\left(\frac{FERTIL_{it}}{FERTIL_{i92}}\right) + b_5 \ln\left(\frac{LIVESTOCK_{it}}{LIVESTOCK_{i92}}\right) + b_6 RD_i + b_7 SrD_i + \qquad (2.3)$$

$$+ b_8 T_{92-93} + b_9 T_{94-95} + b_{10} T_{96-97} + e_{it}$$

where i indicates the countries $i = 1,...,23$, t indicates time $t = 1,...,8$, and the error component is

independently and normally distributed $e_{it} \approx N(0, s^2)$.

A number of dummy variables have been added in the empirical specification of the model. Besides the conventional inputs, the base level of output growth might be expected to differ between different countries/regions due to a number of systematic factors including resource endowments, climate, institutions, etc.

The omission of these variables in a growth regression might lead to important biases in estimating the input coefficients. First, if an omitted variable is strongly correlated with any of the input(s) in the production function, the omitted effect is likely to be misallocated to the correlated input(s). Second, the effect of omitted variables might be absorbed by the error terms causing them to be autocorrelated following a pattern determined by characteristics such as regional similarities in climate, etc. Finally, in absence of explicitly controlling for these time invariant effects, some or all of the inputs might become endogenous to the output process. This is because, if the missing variables are correlated with the input(s) in the production function, their effect absorbed by the error terms will cause regressors (i.e., factor inputs) to be correlated with disturbances.

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[12] See Macours and Swinnen (2000) for full references to these country sources.

To address the above statistical problems, we have constructed a number of dummy variables capturing pure time invariant regional effects. First, *RD* was set to 1 if a country is in the CEE and 0 if it is in the FSU. Second, *SrD* was set to 1 for the Balkans (Albania, Romania and Bulgaria); 2 for Hungary and Slovenia; 3 for Czech, Slovak, and Poland; 4 for the Baltics (Estonia, Latvia, Lithuania); 5 for the European NIS (Belarus, Moldova, Russia, and Ukraine); 6 for the Caucasus (Armenia, Azerbaijan, and Georgia); and 7 for the Central Asian republics (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan).

Finally, three time dummies $T_{92-93}, T_{94-95,}$ and T_{96-97} were specified for 1992-1993, 1994-1995, and 1996-1997 respectively, to account for yearly shifts in the production function.

For reasons of cross-region comparability, panel regressions are run pooling all information for 23 countries together. As a result, any cross-country analyses, based on the above, have to rely on the assumption that the same production function applies to all countries investigated. The implication for the calculation of the TFPs is that this allows us to use the same input weights for all countries.

5.   Results

Model (2.3) is estimated with both OLS and an instrumental variables (IV) approach. The regression results are reported in tables 1 and 2.

OLS results for regression (1) show *LABOUR, FERTI, LIVESTOCK, and RD* to be positive and highly significant at 1 percent, while the dummy for 1994-95 is only significant at 10 percent and negative. Regression (2) uses instrumental variables allowing us to perform a Davidson-MacKinnon test for the exogeneity of the variables for factor inputs using once and twice lagged measures of these

inputs. The IV regression, instrumenting for inputs suspected of being endogenous, is the first stage in performing the test. The second stage involves an OLS regression of the original dependent variable on the original regressors, augmented by the residuals from each of the first stage instrumental variables regressions. This final regression gives rise to an *F*-test for the joint hypothesis that each of the coefficients on the residual series is zero.

The results obtained from the instrumental variables regression confirm those reported in regression (1). Moreover, the Davidson-MacKinnon exogeneity test cannot reject the null hypothesis that the OLS estimator of the same equation (see regression 1) would yield consistent estimates.

All results are derived using the Huber/White/sandwich estimator of variance instead of the usual OLS to correct for possible heteroskedasticity though a White-test after regression (1) reported no heteroskedasticity.

The error terms are normally distributed as suggested by the Jarque-Bera test.[13] Other normality tests including the Shapiro-Wilk and Shapiro-Francia test were also performed and all strongly accepted the hypothesis of error normality.

Finally, in both regressions, the hypothesis of constant returns to scale (CRS), i.e., the sum of the input coefficients equals to 1, cannot be rejected as shown by the results for the Wald test for coefficient restrictions[14]. Following these results, regression (3) imposes CRS on the input coefficients. The results for the conventional inputs are all positive and highly significant. As before,

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[13] The test statistic measures the difference of the skewness and kurtosis of the error series with those from the normal distribution. Under the null hypothesis of normal distribution the Jarque-Bera statistic is distributed as c^2 with 2 degrees of freedom. The reported probability is the probability that a Jarque-Bera statistic exceeds (in absolute value) the observed value under the null – a small probability value leads to the rejection of the null hypothesis of a normal distribution.

[14] The test reports a *F*-statistic and the associated *p*-value. In fact, under the null, the statistic has an asymptotic c^2 distribution depending on the number of restrictions under the null. For the case of linear regression models and linear restrictions, with the additional assumption that errors are independently normally distributed, the Wald test reduces to an

the *RD* is also strongly significant and positive whereas the T_{94-95} is negative and only significant at 10 percent.

Table 3 summarises the contribution of changes in each of the inputs to the change in output for the entire sample over the period 1992 to 1999 (detailed calculations for each country and region, are reported in appendix A). Table 3 shows how on average for all the countries combined, the 1999 output was almost 14% lower than the 1992 output. The main reason for this fall in output is the reduction in inputs, in particular livestock and fertiliser.[15] Livestock reductions alone make up almost three-quarters of the explained decline in output, and reduced fertiliser use another 14%. In combination, the total decline in inputs is 27% larger than the decline in output. This indicates that there has been a significant productivity increase over this period.

As such these aggregate numbers do not tell much, as there are major variations among countries. Table 4 disaggregates the reported input/output changes to a per country level. Column 1 reports total factor productivities calculated as the ratio of output to an index of weighted inputs used. In calculating the inputs' index, coefficients from regression (3) were used as weights. In addition, table 5 presents a summary of how total factor productivity has evolved during 1992-1999 using three-year moving averages of the TFPs calculated for each country and grouped by

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exact finite sample *F*-statistic.

[15] Note that the effect of a particular input on output change depends on the weighting coefficient as well as on the actual change in the use of that input itself. In terms of the change in input use, the largest absolute decline was for <u>fertiliser</u>. Compared to 1992, the average change in fertiliser use was –38 percent. Fertiliser use fell particularly sharply in the European NIS (-38.7 percent in Belarus, -95.6 percent in Moldova, -74.0 percent in Russia, -84.4 percent in Ukraine), the Caucasus region (-75.3 percent in Armenia, -81.3 percent in Azerbaijan, and –44.4 in Georgia) and the Central Asian republics (-93.1 percent in Kazakhstan, -68.7 percent in Tajikistan, and -61.0 percent in Turkmenistan). Among the CEECs, Albania, Bulgaria and Romania exhibited a decline of –52.7, -48.2, and –57.2 percent, respectively.

Compared to 1992 situation, the number of <u>livestock</u> had fallen by –30.5 percent compared to 1999, on average. The strongest decline was in the Baltic countries (-67.8, -57.8 and –53.9 percent in Latvia, Estonia, Lithuania respectively), in Kazakhstan (-61.34 percent) and Russia (-51.68 percent), while Azerbaijan and Turkmenistan experienced an increase of 7.82 and 6.91 percent respectively. Livestock also collapsed in almost all CEECs, except for Albania and Slovenia where the standard numbers increased by 10.51 and 1.29 percent (see annex).

geographical location. The 3-year averages help to separate out structural changes from ad hoc annual variations due to, for example, changes in weather conditions. Finally, figures 2-7 shows our calculations of changes in input use, output and total factor productivity disaggregated by year and country while figure 1 aggregates these results to a regional/subregional level for the Central European countries (Czech Republic, Hungary, Poland, Slovakia), the Balkans, (Albania, Bulgaria, Romania, Slovenia), the Baltics (Estonia, Latvia, Lithuania), the European NIS (Belarus, Moldova, Russia, Ukraine), the Caucasus (Armenia, Azerbaijan, Georgia), and the Central Asian republics (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan) regions, respectively.

Figure 2 illustrates how TFP has increased consistently since 1994 in Central Europe with output recovering while inputs continue to decline gradually. These results are generally consistent with the findings of Macours and Swinnen (2000) for crops that after the initial disruptions – which may well have lasted longer for agriculture as a whole than for crop production – there has been significant recovery in terms of productivity growth in Central European countries.

While TFP has increased consistently over the 1992-1999 period also in the Balkans, the pattern is quite different than in Central Europe. The most important increase in TFP took place during the 1992-1995 period, which was likely due to important structural changes in farm organisations and property rights reforms that occurred during this period, while TFP growth has slowed down considerably since 1995. The slow down is most markedly in Romania and Slovenia (see figure 3).

In contrast to the CEECs, virtually all FSU are characterised by TFP declines over the 1992-1999 period. This may reflect either significantly more complicated starting positions (initial distortions) or slower structural reforms, or both. A remarkable result from our calculations is the

strong decline in TFP in the Baltic countries, countries characterised by relatively strong reforms during the 1990s. All the Baltics were characterised by dramatic declines in livestock (around 60% on average), but huge falls in output (-40% on average) were also caused by declining productivity, especially in Latvia (see Annex A). Interestingly, the country with the most radical reform programme, Estonia, has suffered the smallest TFP decline; in fact TFP increased during the early periods of reforms (1991-1995), but declined afterwards (figure 4).

In the European NIS, output has fallen stronger than inputs over the 1992-99 period, resulting in a declining in TFP by more than 8% (table 4). Interestingly, our calculations suggest that this was caused especially be declines in Ukraine and Moldova and that TFP has actually increased by 5% in Russia. These results are consistent with the findings of Lerman *et al.,* (2001). Figure 5 shows how TFP growth in Russia appears especially after 1995, interrupted in 1998, possibly by the effects of the 1998 Russian financial crisis.

The Caucasian data should be interpreted with care as two countries (Georgia and Armenia) were heavily affected by natural disasters and war (figure 6).

The results of the Central Asian countries show a large variation in the region (figure 7). All countries, except Turkmenistan and Uzbekistan where few reforms were implemented, record significant declines in TFP during the first years of transition: TFP fell during 1992-1995 by -25% in Kazakhstan, -10% in Kyrgykstan and -20% in Tajikistan. While productivity in Tajikistan stabilised since 1996, our calculations indicate important TFP gains since 1995 for Kyrgykstan and Kazakhstan (see figure 7).

Finally, it should be emphasised that in comparing the TFP results for CEECs and FSU one should keep in mind that on average transition started 2 years earlier in CEECs, and that much of the disruptions, which occurred in CEECs in 1989-1991, are not captured by the TFP results presented

here.

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Table 1. The OLS estimation of the production function[a]

<u>Sample Size</u>: 23 countries; 8 years (184 observations)

Dependent:	Total Agricultural Output			
Regress. No	(1)		(2)[b]	
	Coeffic.	t-value	Coeffic.	t-value
Intercept	.009	.27	-.02	.44
Production Factors:				
Capital	.08	1.30	.10	1.49
Labour	.19	3.67***	.23	4.07***
Land	.13	.44	.07	.22
Fertiliser	.07	3.90***	.06	2.19**
Livestock	.42	7.86***	.37	6.46***
Shifters:				
Regional dummy	.15	6.22***	.20	5.98***
Subregional dummy	.0015	.26	-.0002	.03
Time dummies 92-93	-.045	1.55	---	---
Time dummies 94-95	-.04	1.61*	-.04	1.34
Time dummies 96-97	-.03	1.20	-.03	1.11
R- square	.72		.73	
Adjusted R- square	.71		.71	
Wald – test for Ho: $\sum_{j=1}^{5} b_j = 1$ (i.e.,CRS)	.14		.24	
Prob > F (.,.) for CRS	.71		.62	
Jarque-Bera statistic for Ho: normality	.54		.14	
Prob > $c^2(.)$ Jarque-Bera test	.76		.93	
Davidson-MacKinnon F-statistic	---		.69	
P-value for F(5.123)	---		.63	

[a]*** ,** and * denote significance at 1%, 5% and 10%, respectively.
[b] Regression (2) instruments for CAPITAL, LAND, LABOUR, FERTIL, LIVESTOCK using one- and two-year lagged values for each factor input. Note that $T_{92\text{-}93}$ is dropped due to the lags used in instrumenting.

Table 2. Calculation of input weights with constant returns to scale [a]

Sample Size: 23 countries; 6 years (184 observations)

Dependent:	*Total Agricultural Output*[b]	
Regress. No	(3)	
	Coefficients	*t-values*
Intercept	.009	.29
Production Factors:		
Capital	.09	1.99**
Labour	.19	4.79***
Land	.23	3.86***
Fertiliser	.07	3.69***
Livestock	.42	9.42***
Shifters:		
Regional dummy	.16	6.73***
Subregional dummy	.0015	.31
Time dummies 92-93	-.05	1.48
Time dummies 94-95	-.05	1.66*
Time dummies 96-97	-.03	1.30
R- square	.85	
Adjusted R- square	.84	
Jarque-Bera statistic for Ho: normality	2.95	
Prob > $c^2(2)$ Jarque-Bera test[d]	.23	

[a] *** ,** and * denote significance at 1%, 5% and 10%, respectively.
[b] Regression (3) imposes constant returns to scale, following results from the Wald test on coefficient restrictions in regressions (1) and (2).

Table 3. Explaining output changes for the entire sample, 1992-1999.

Explanatory Variables	Estimated Coefficients	Change in variable	Contribution to output changes		
			Absolute	*% total*	*% explained*
Production factors[a]:			*-17.66*	*-127.02*	*-100.00*
Capital	.09	-11.65	-1.03	-7.38	-5.81
Labour	.19	-6.02	-1.17	-8.41	-6.62
Land	.23	-0.55	-.13	-.92	-.73
Fertiliser	.07	-37.78	-2.54	-18.24	-14.36
Livestock	.42	-30.55	-12.80	-92.07	-72.48
Shifters[b]:					
Regional dummy	.16	---	---	---	---
Sub-regional dummy	.002	---	---	---	---
Time 1992 – 1993	-.05	---	---	---	---
Time 1994 – 1995	-.05	---	---	---	---
Time 1996 – 1997	-.03	---	---	---	---
Residual			*3.76*	*27.02*	---
Total output change			**-13.90**	**-100.00**	**-100.00**

[a] Output and input changes are averages over the 23 countries.
[b] Note that the value of the regional shifters (*RD* and *SrD*) does not change over the period. As such, though affecting the year-to-year change in output due to the cross-sectional variation, those cannot affect the over time output change. On the other hand, the average change over the 1992 to 1999 period in the times dummies is also zero. Consequently, the effect of shifters is not reflected in the above calculations.

Table 4. Output and productivity changes per country (%), 1992-1999

Country	Change in TFP [a]	Change in total output[b]	Change in weighted inputs
	(1)	(2)	(3)

Albania	29,04	38,84	7,59
Bulgaria	-1,31	-24,37	-23,37
Romania	49,33	23,30	-17,43
Slovenia	32,46	23,54	-6,74
Balkans	**27,38**	*15,33*	*-9,99*
Czech Rep.	19,32	-8,32	-23,17
Hungary	6,06	-5,34	-10,75
Poland	7,11	1,41	-5,33
Slovakia	25,31	-9,85	-28,06
Central Eur.	*14,45*	*-5,53*	*-16,83*
Estonia	-6,66	-43,80	-39,79
Latvia	-31,24	-57,23	-37,80
Lithuania	-15,59	-33,41	-21,11
Baltics	*-17,83*	*-44,81*	*-32,90*
Belarus	-7,77	-28,69	-22,69
Moldova	-18,48	-41,04	-27,68
Russia	4,85	-30,74	-33,94
Ukraine	-12,19	-38,60	-30,08
Europe. NIS	*-8,40*	*-34,77*	*-28,60*
Armenia	-3,03	-15,81	-13,18
Azerbaijan	-19,68	-17,34	2,91
Georgia	6,33	6,26	-0,07
Caucasus	*-5,46*	*-8,96*	*-3,45*
Kazakhstan	33,35	-37,81	-53,36
Kyrgyzstan	18,89	5,96	-10,88
Tajikistan	-27,39	-37,29	-13,64
Turkmenistan	6,24	11,25	4,71
Uzbekistan	1,73	-0,72	-2,41
Central Asia	*6,56*	*-11,72*	*-15,12*
Total	***4.20***	***-13,90***	***-17.66***

[a] Note that, due to averaging and differencing processes, the change in the TFPs reported in here does not amount to the ratio (2)/(3)*100 (columns above) though the yearly TFPs equal the yearly (output/input index)*100. Complete spreadsheets with calculations can be provided by the authors.
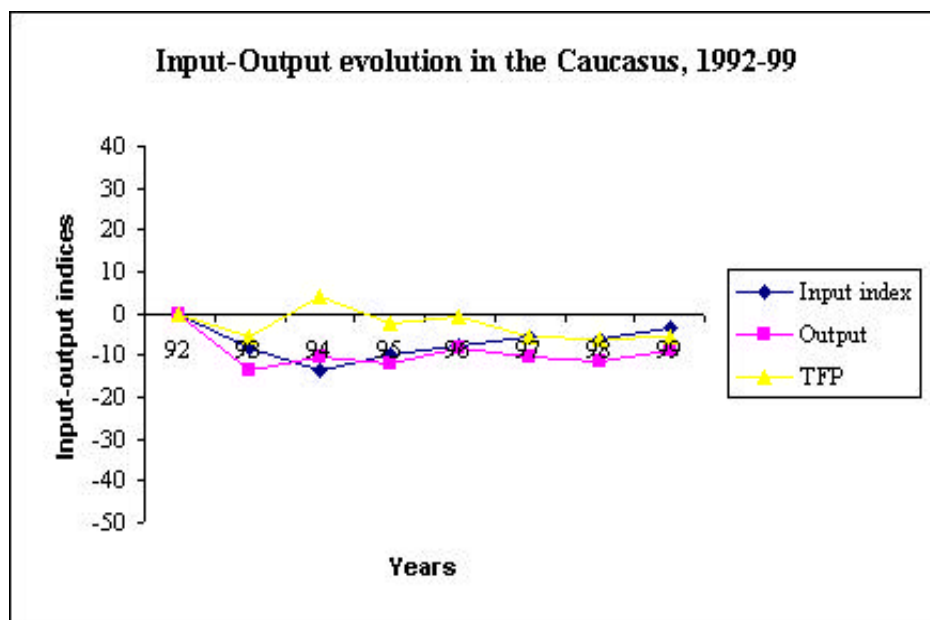
Table 5. Total factor productivity: three-year moving averages[a]

Country	Year			
	1992-94	*1995-97*	*1997-99*	*Chan. 92-99*
Czech	100,00	97,65	103,87	3,87
Hungary	100,00	106,47	110,28	10,28
Poland	100,00	101,95	104,66	4,66
Slovakia	100,00	106,27	114,83	14,83
Central Europe	*100,00*	*103,09*	*108,41*	*8,41*
Albania	100,00	113,22	119,12	19,12
Bulgaria	100,00	104,12	102,86	2,86
Romania	100,00	115,85	116,92	16,92
Slovenia	100,00	118,44	119,32	19,32
Balkans	*100,00*	*112,91*	*114,56*	*14,56*
Estonia	100,00	98,94	91,23	-8,77
Latvia	100,00	86,10	78,89	-21,11
Lithuania	100,00	97,64	95,04	-4,96
Baltics	*100,00*	*94,23*	*88,39*	*-11,61*
Belarus	100,00	93,68	96,70	-3,30
Moldova	100,00	96,81	88,85	-11,15
Russia	100,00	101,72	106,31	6,31
Ukraine	100,00	95,45	93,40	-6,60
European NIS	*100,00*	*96,92*	*96,32*	*-3,69*
Armenia	100,00	102,65	101,01	1,01
Azerbaijan	100,00	89,42	87,93	-12,07
Georgia	100,00	99,72	94,95	-5,05
Caucasus	*100,00*	*97,26*	*94,63*	*-5,37*
Kazakhstan	100,00	88,32	113,83	13,83
Kyrgyzstan	100,00	107,48	119,96	19,96
Tajikistan	100,00	83,85	79,45	-20,55
Turkmenistan	100,00	80,20	89,49	-10,51
Uzbekistan	100,00	98,55	99,19	-0,81
Central Asian rep.	*100,00*	*91,68*	*100,38*	*0,38*

[a] The results are calculated using data which have been averaged according to a three year moving average process with the 1992-1994 period taken as the base = 100. Note that the change in 1999 reported in here is different from the change for the same period using yearly data because of different base-periods, i.e., the base period here is the average of 1992-1994 as opposed to year 1992 in yearly data.

Figure 1: Productivity in transition agriculture after the initial disruptions

Input-output evolution in Central Europe, 1992-99

Input-Output evolution in the Balkans, 1992-99

Input-Output evolution in the Baltics, 1992-99

Input-Output evolution in European NIS, 1992-99

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Input-Output evolution in the Caucasus, 1992-99

Input-Output evolution in Central Asia, 1992-99
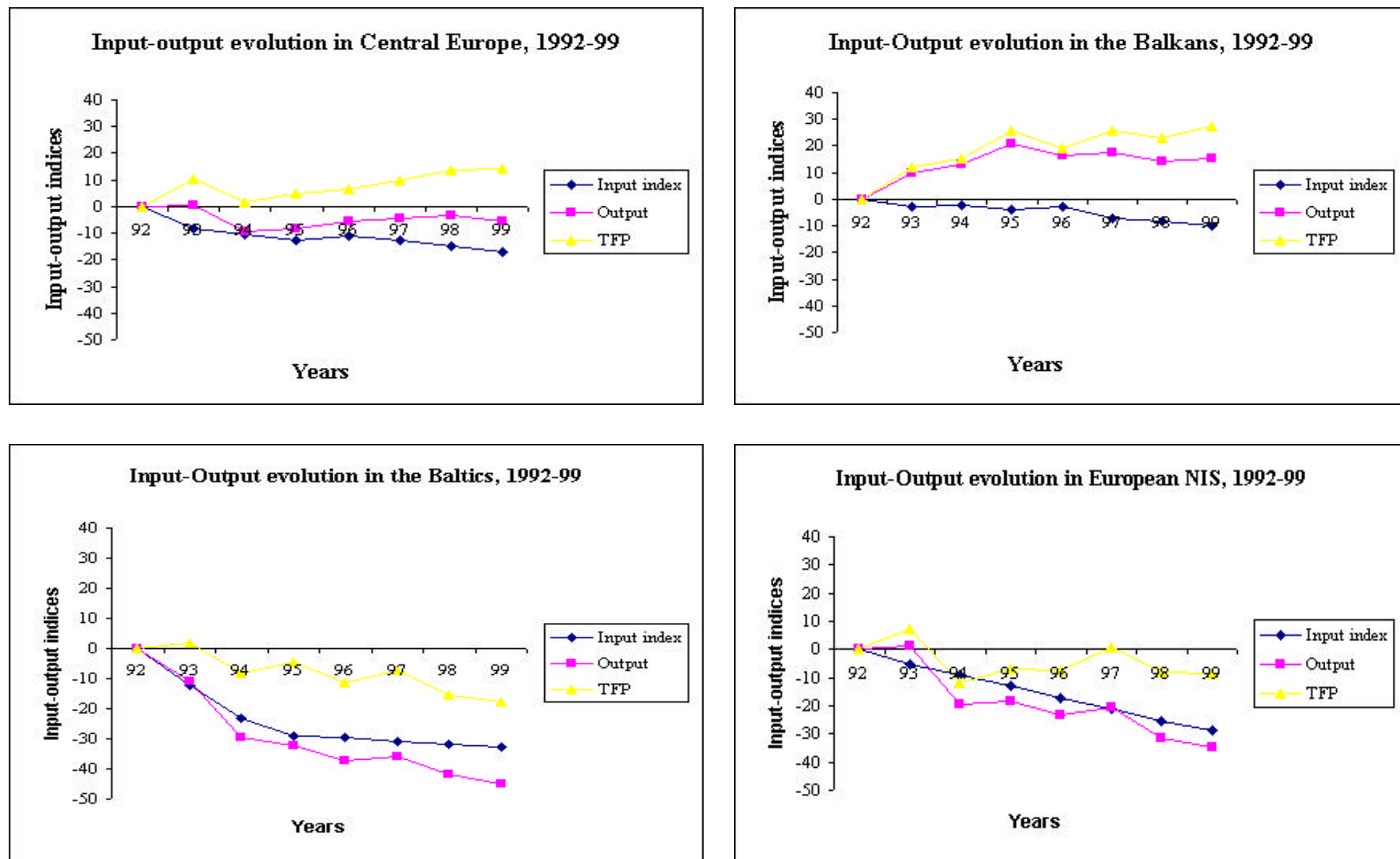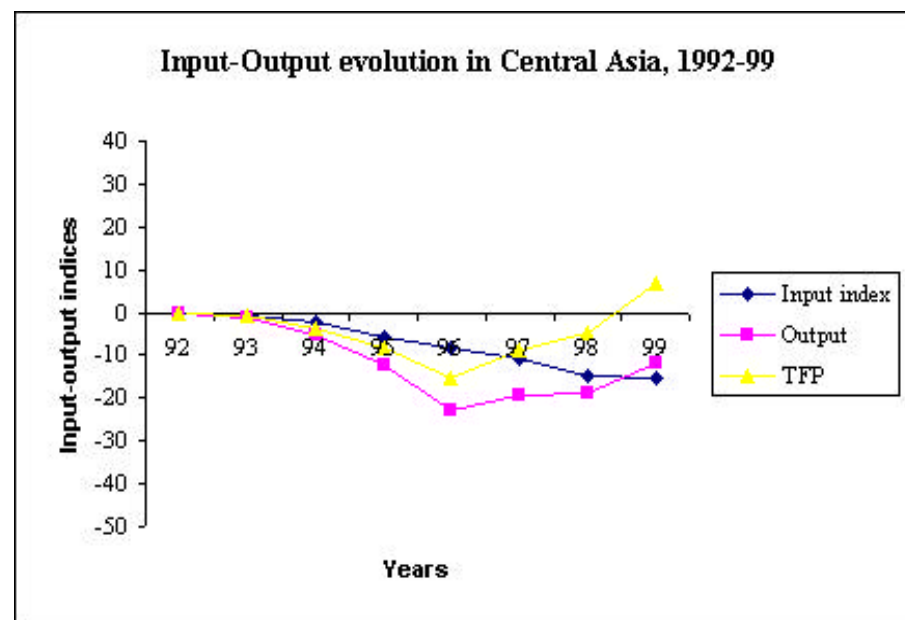
Note: The indices are averaged over the countries in each region and expressed in changes from year 1992.

Figure 2: Agricultural productivity evolution in Central Europe (in changes from 1992)

25
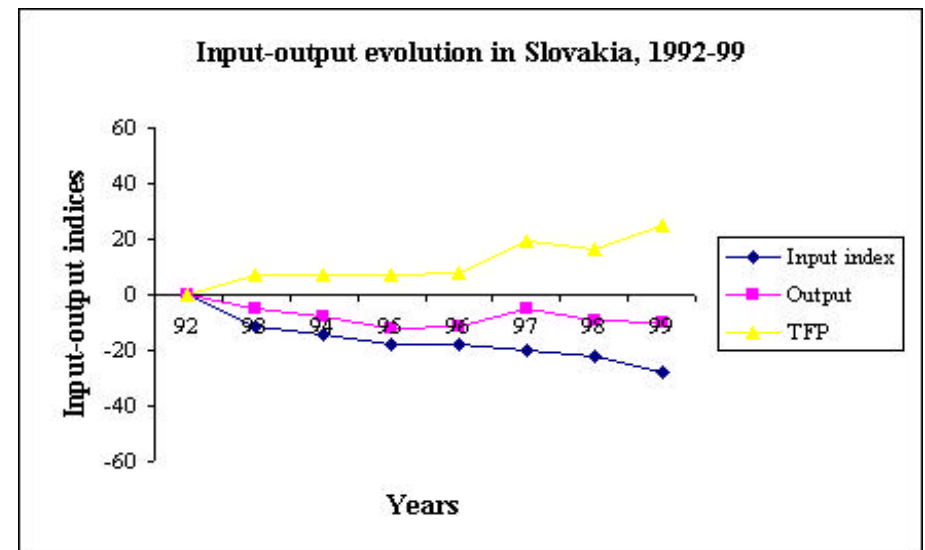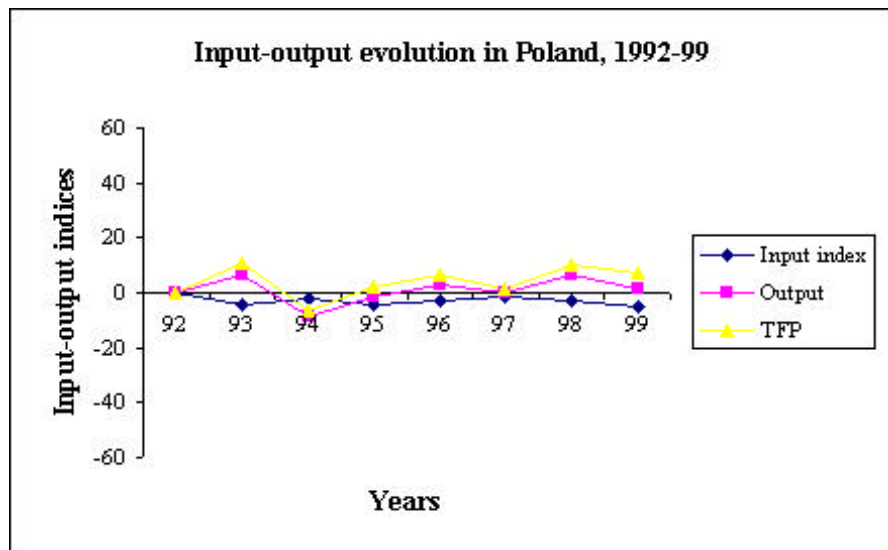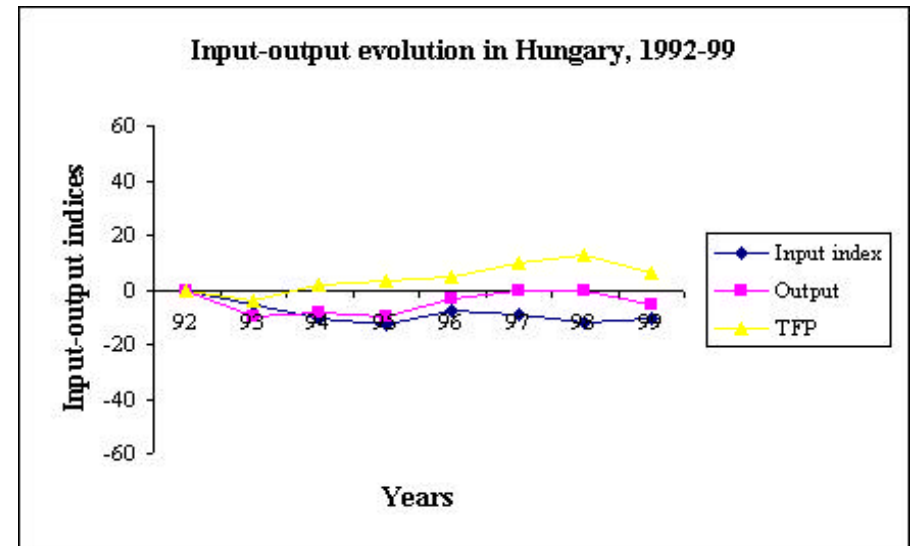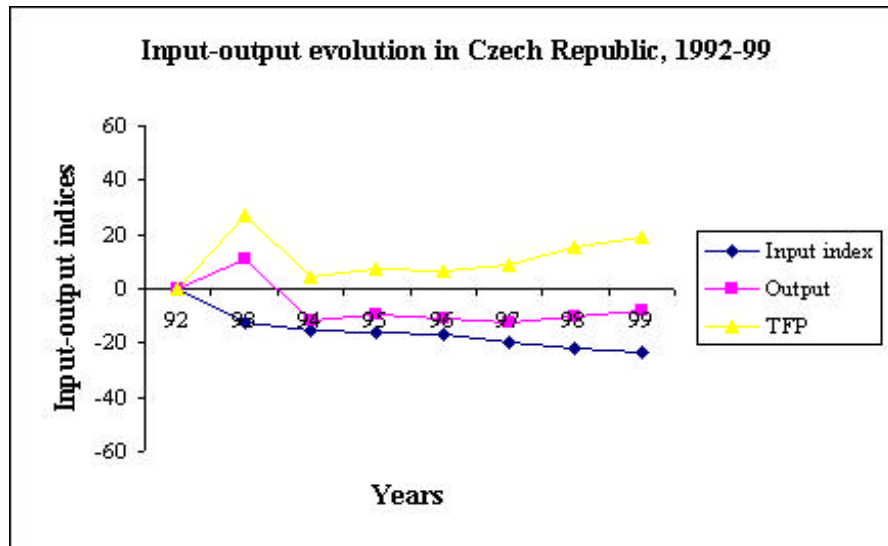
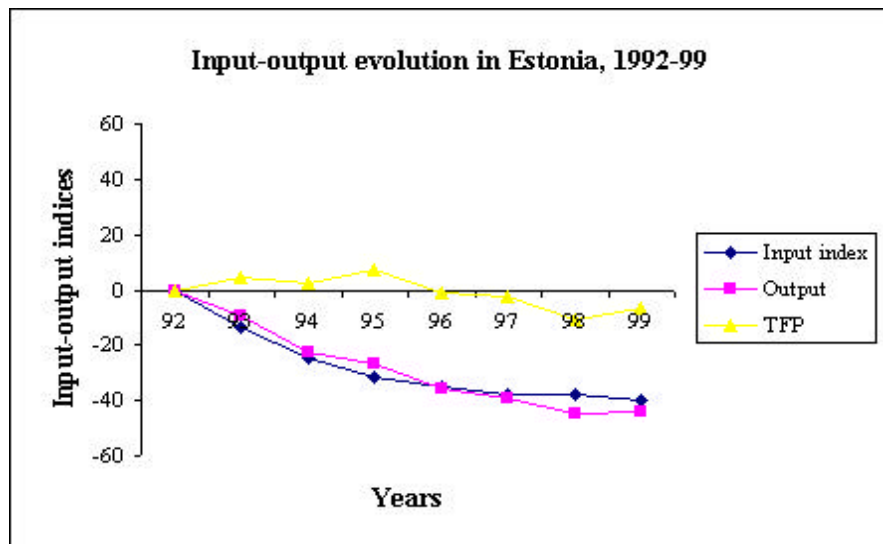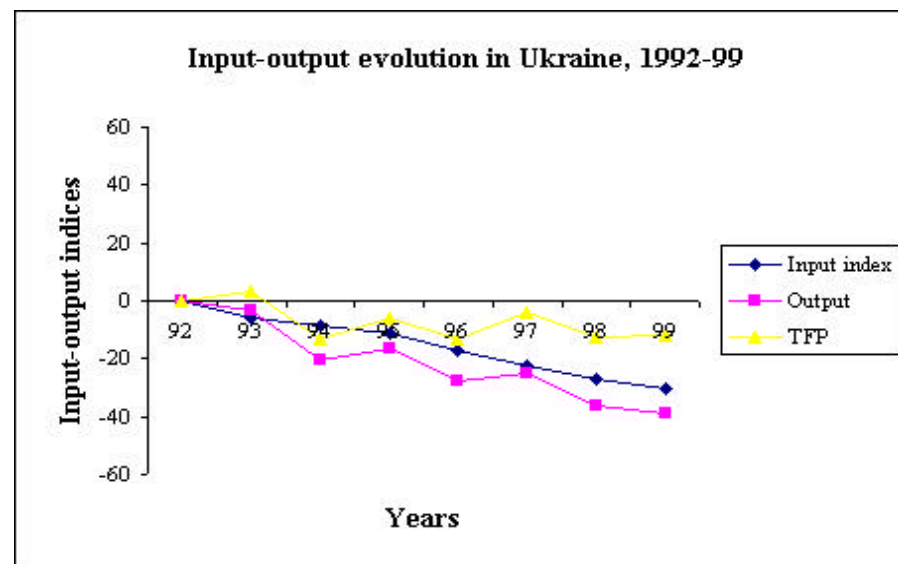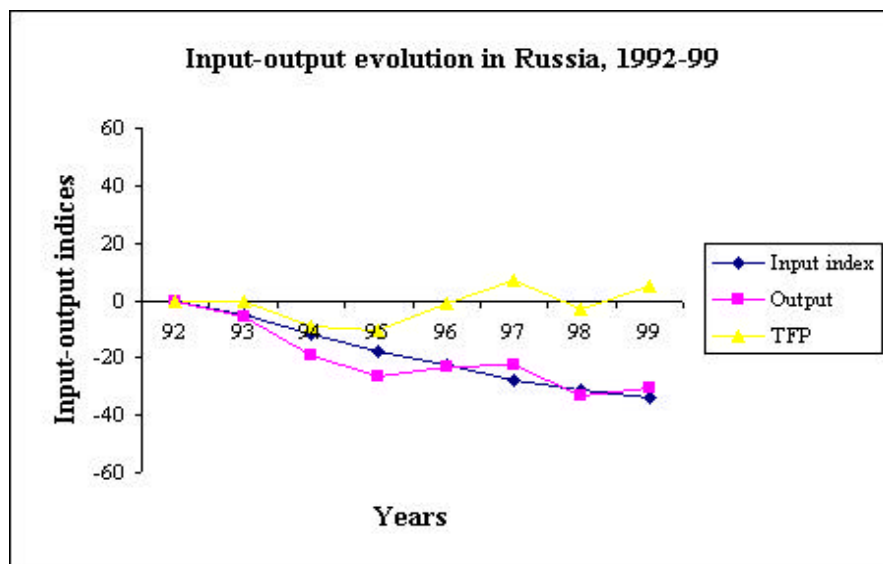**Figure 3: Agricultural productivity evolution in the Balkans** (in changes from 1992)

Input-output evolution in Albania, 1992-99

Input-output evolution in Bulgaria, 1992-99

Input-output evolution in Romania, 1992-99

Input-output evolution in Slovenia, 1992-99
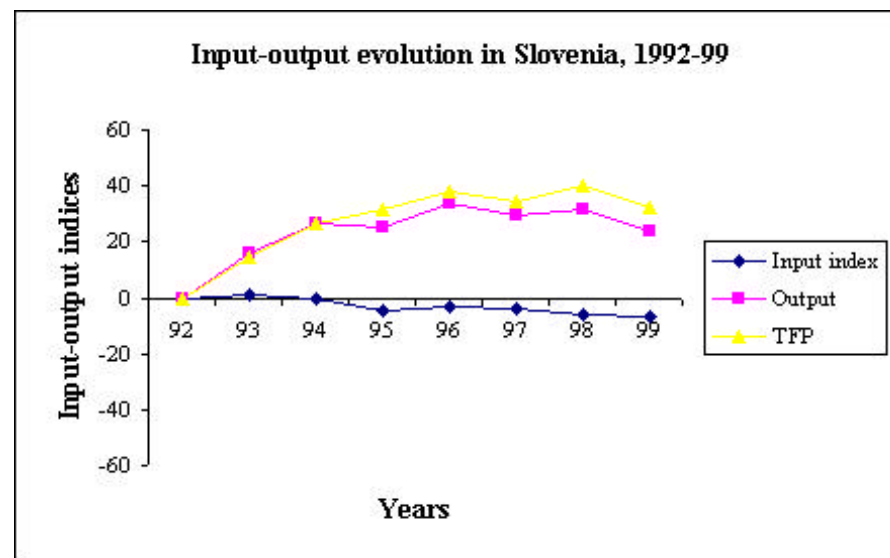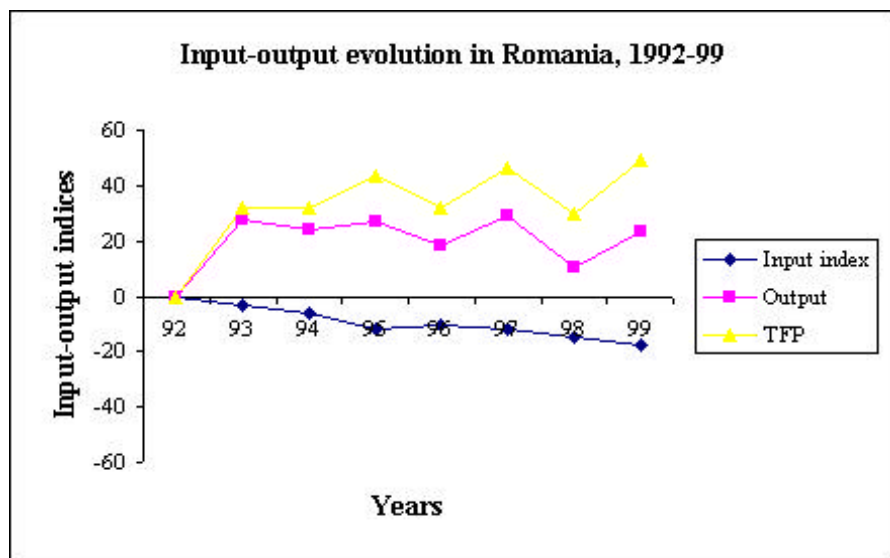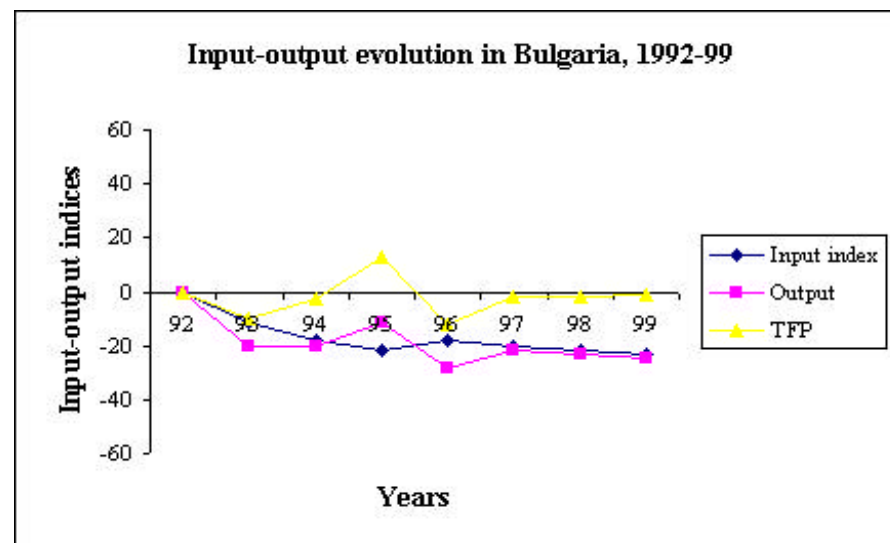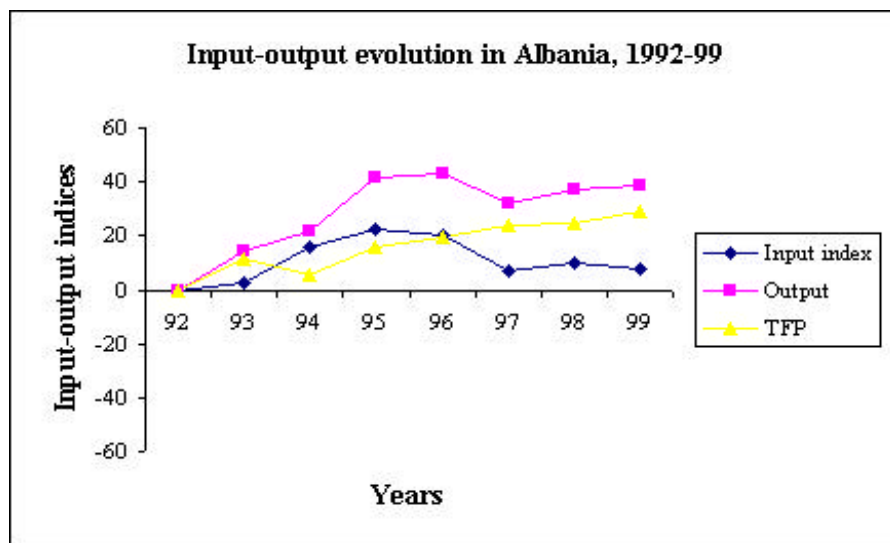
Figure 4: Agricultural productivity evolution in the Baltics (in changes from 1992)

Input-output evolution in Estonia, 1992-99

Input-output evolution in Latvia, 1992-99

Input-output evolution in Lithuania, 1992-99
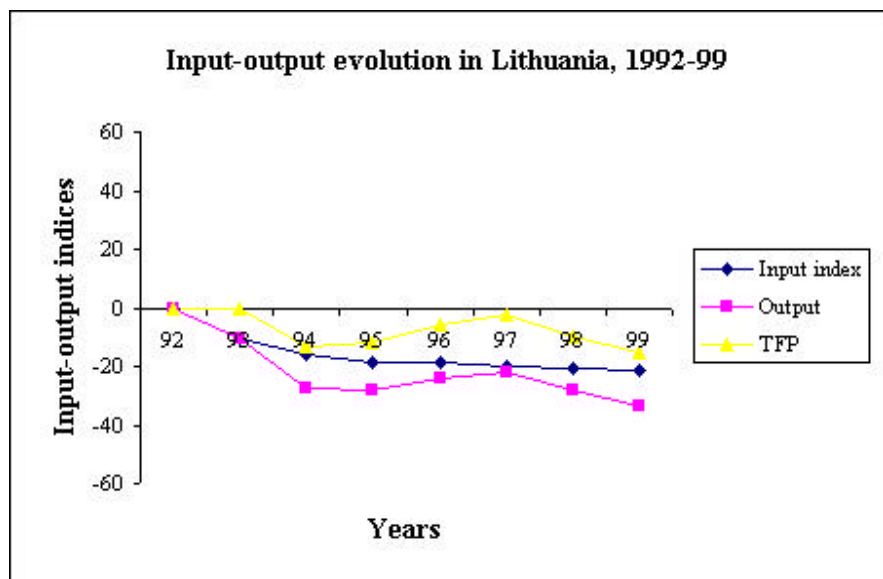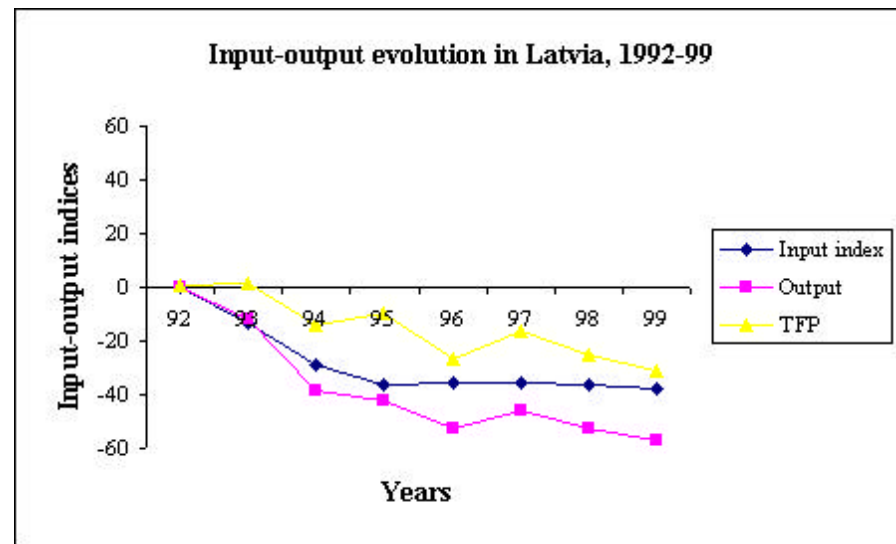
Figure 5: Agricultural productivity evolution in the European NIS (in changes from 1992)

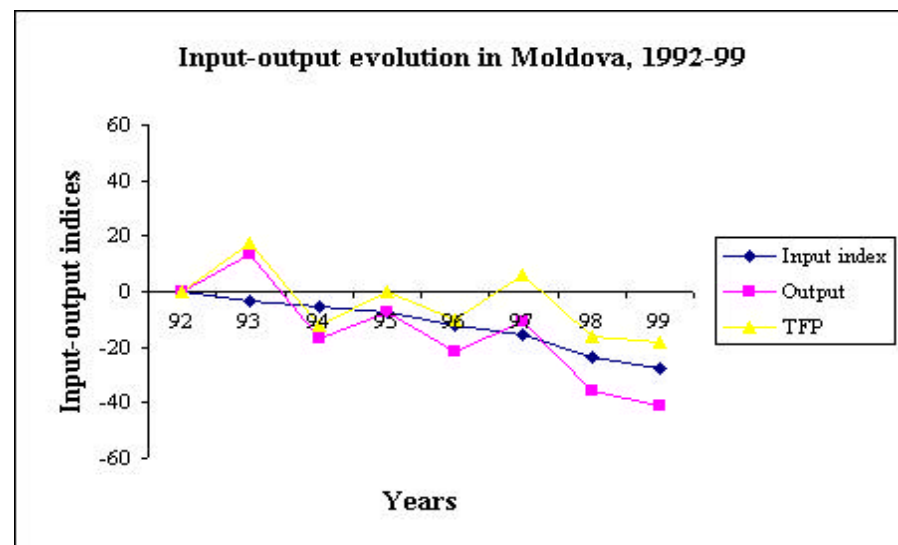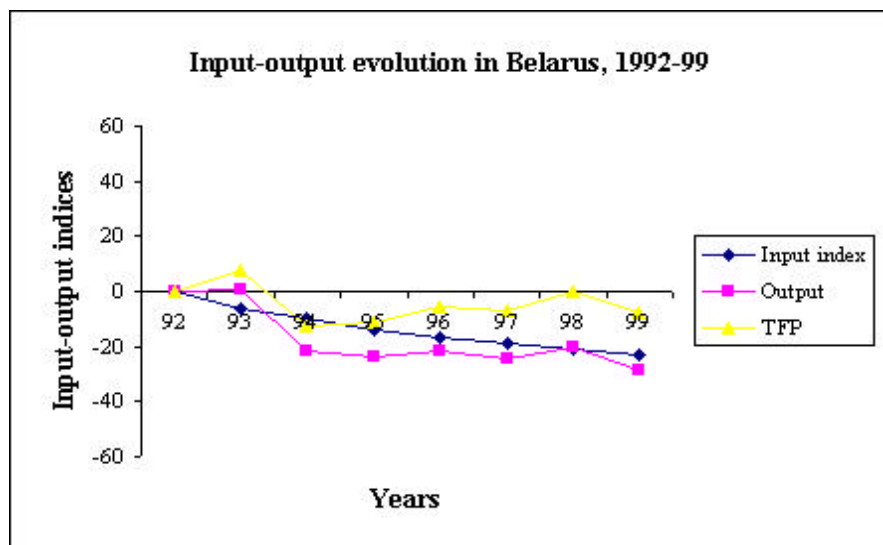Input-output evolution in Belarus, 1992-99

Input-output evolution in Moldova, 1992-99

Input-output evolution in Russia, 1992-99

Input-output evolution in Ukraine, 1992-99

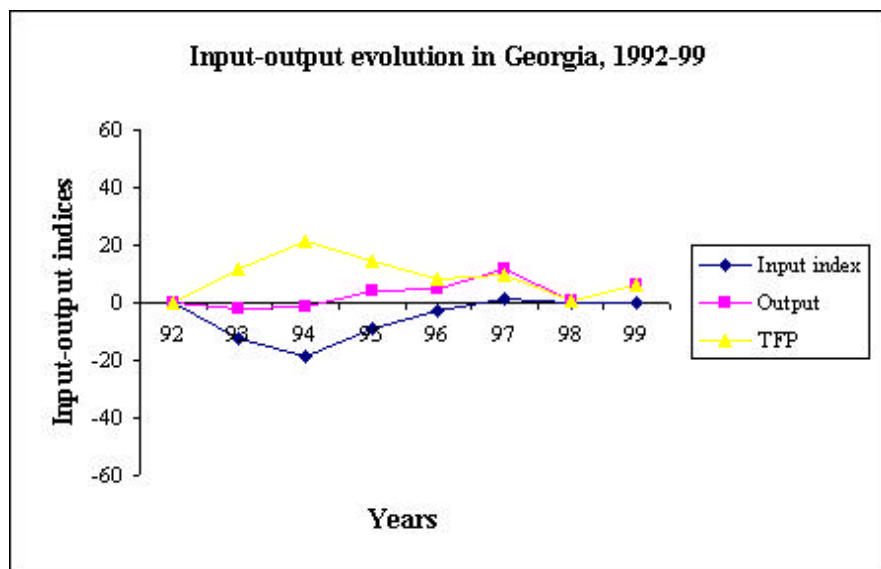**Figure 6: Agricultural productivity evolution in the Caucasus** (in changes from 1992)
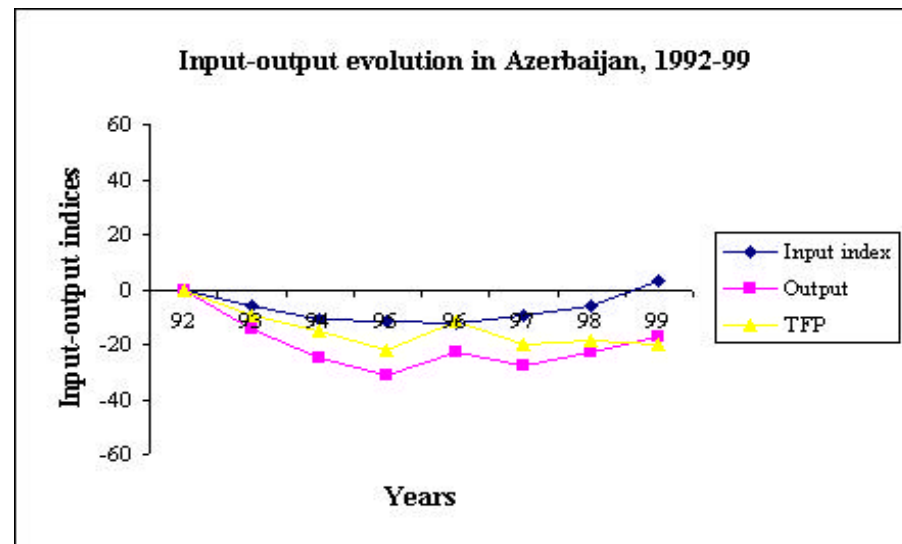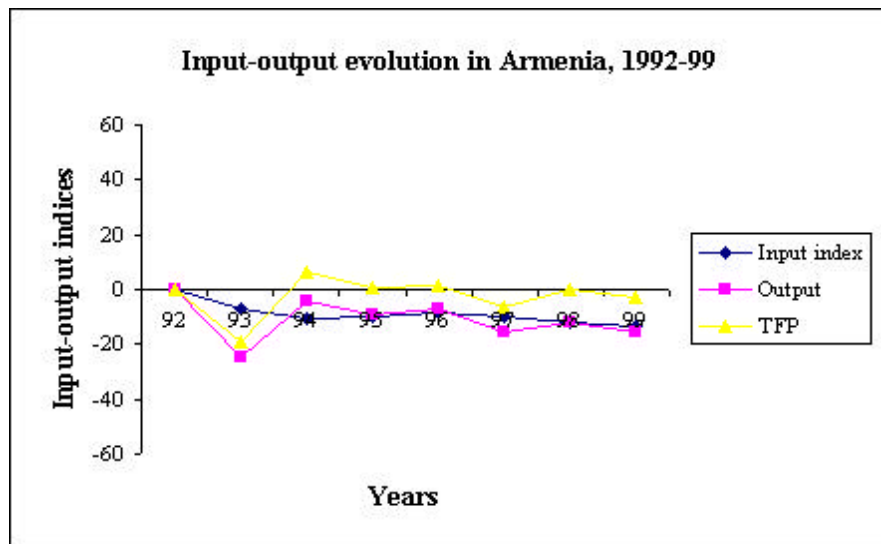
Figure 7: Agricultural productivity evolution in Central Asia (in changes from 1992)

Input-output evolution in Uzbekistan, 1992-99