Productivity change in Slovenian agriculture during the transition: A comparison of production branches

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Abstract

In this paper we investigate how Total Factor Productivity (TFP) has developed in Slovenian agriculture during the ten years of the transition for the period 1994-2003, and which agricultural production specializations recorded the highest TFP growth. We use an output-oriented TFP model that includes three different outputs (crop, livestock, and other outputs) and four inputs (land, labor, capital, and intermediate consumption). Empirical results indicate that TFP, on average, progressed only slightly, by 1.2 percent, over the ten-year period. However, this relatively slow TFP growth hides a switchback evolution over the analyzed period. The decomposition of the TFP change indicates that its change is mostly due to a technological change, which increased by 3 percent. Technical efficiency has remained rather stable on average, suggesting that farmers were able to implement the new technologies on time. Dissimilar developments in TFP are shown according to the production specialization. Crop farms have performed the best, with a TFP progress on average by 9 percent solely due to technological progress. For all branches, technological change constitutes the sole part of TFP change, except for sheep farms, which recorded a high technical efficiency progress. As we used a common frontier, our result indicates that crop specialization is leading the country's agricultural technology.

JEL classification: D24, Q12
Keywords: Slovenia, Farms, Total Factor Productivity

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1. Introduction

The transition process from the previous socialist system to a market economy has brought significant changes in the economies and in the agricultural and food sectors of Central and Eastern European Countries (CEECs) (e.g. Barlow and Radulescu, 2005). Several CEECs are now members of the enlarged European Union (EU). While the performance of agriculture in CEECs has received substantial consideration from researchers (see Gorton and Davidova, 2004, for a review), the performance of the Slovenian agricultural sector has rarely been investigated. The only available study is Brümmer (2001), who calculates the technical efficiency for Slovenian farms, for the years 1995-1996. Gocht and Balcombe (2006) also used a Slovenian farm sample, for the year 1996, but in a methodological view only, applying the usefulness of bootstrapping and thus without discussing the implications for Slovenia.

Slovenia has attracted less research about performance in agriculture potentially because of its relatively small size (compared to Hungary, Poland or the Czech Republic, which have received considerable research interest), and because of its strong and quick economic development during the transition. However, there is still a considerable gap between the high level of overall economic development and the low productivity in agriculture, that indicates possible agricultural and farm restructuring problems. By the level of economic development measured by gross domestic product (GDP) per capita, Slovenia is approaching the EU average (Eurostat, 2006). Most of the Slovenian territory is classified as rural (European Commission, 2004) with a significant role of agriculture in employment. The noteworthy gap between the proportion of agricultural workers in total employment (10 percent) and the agricultural contribution to GDP (2 percent) indicates a lower productivity in agriculture vis-à-vis the other sectors in the economy. Therefore, investigating structures and patterns of the performance change in Slovenian agriculture in the past years is essential for understanding Slovenian agricultural development within the overall economic development, and is also crucial in the lights of Slovenian competitiveness in the enlarged EU markets, which Slovenia joined on 1st May 2004.

This paper focuses on the development of a quantitative component of performance, namely Total Factor Productivity (TFP), in Slovenian agriculture during the transition. It provides three contributions to the existing literature. Firstly, it contributes to the research on agricultural performance in Central and South-Eastern Europe. Secondly, it covers the long period 1994-2003, when the Slovenian economy and agriculture were adjusting to market conditions and finally were preparing for EU membership. Thirdly, it uses an original Farm Accountancy Data Network (FADN) dataset that includes representative farms by agricultural production branches (13 in total). This enables to discuss which type of farming has had the strongest TFP growth, and, in the light of EU agricultural policies and subsidies now granted to Slovenian farmers, if this performance is likely to remain after the EU accession.

The rest of the paper is organized in the following way. We start with a brief literature review on agricultural productivity and dynamics in pre- and post-reform Slovenia. Then, we present the methodology, the data used and the empirical results on technical efficiency change, technological change, pure technical efficiency change, scale efficiency change, total factor productivity, and comparison of the Malmquist productivity change indices. The final section concludes.

2. Brief literature review

The first studies on agriculture in CEECs were focusing on comparisons of performance of different production systems pre-transition. Slovenia at that time was a constituent part of the former Yugoslav economy and agricultural system. Boyd (1987) investigated the performance of private and cooperative socialist organization in postwar (1956-1979) Yugoslav agriculture. The sources of differences were examined with TFP estimates on regional aggregate data with separate Cobb-Douglas production functions for both types of organizations. The author found that socialist enterprises in Yugoslav agriculture experienced higher levels of productivity growth than private small-scale producers. Socialist enterprises were found to exhibit technology adoption behavior similar to enterprises in non-socialist agriculture, whereas technological change for private agriculture reflected the different institutional and organizational constraints they faced during the communist system. Piesse and Thirtle (1996) focused on the last years of communist regime (1974-1990) for Slovenia in particular when it was still part of Yugoslavia. The authors used both a Cobb-Douglas stochastic frontier and a non-parametric frontier, on a pooled sample of 4 public (called "social") enterprises and 12 large private, family producers in dairy farming. Their findings highlight that despite a technology policy discrimination in disfavor of the private sector, the latter one experienced more or less the same technological change as the public sector, and three times greater TFP growth than the public sector.

After the collapse of the former Yugoslavia in 1991, following the transition to a market economy, Slovenia adopted a policy of land restitution to the former owners, which has further strengthened the role of the private agriculture (Bojnec and Swinnen, 1997). Institutional and organizational constraints on the size and behaviors of the private farms have been abolished, giving opportunities for market selection and concentration processes, which have been encouraged by the increased domestic and foreign competition arising from trade liberalization processes and the EU membership. Slovenian agriculture has remained dominated by private, on average small-scale, family farms, and performs well in comparison to other CEECs. According to Pouliquen (2001), in 1999 farm yields in Slovenia were on average up to 69 percent of the EU-15 average, while they were only up to 38.5 percent in the other CEECs. However, there is still some potential for productivity improvement in this country. This was for example underlined during the transition period by Brümmer (2001), whose analysis revealed significant inefficiency for Slovenian farms in 1995 and 1996. The author calculated technical efficiency for 185 farms with a stochastic translog frontier and a non-parametric approach. The more optimistic results (with the stochastic frontier) showed that farmers could have expanded their output by 25 percent without using additional inputs. As for differences between farms, the results indicated that part-time farmers and cattle farmers were the least efficient, while diversified farmers were the most efficient.

3. Methodology and data

3.1. Methodology

In our paper focusing on TFP change was assessed with Malmquist indices calculated with the non-parametric Data Envelopment Analysis (DEA). Based on the concept of distance functions from Farell (1957), the DEA method, developed by Charnes et al. (1978), uses linear programming to construct the efficient frontier, with the best performing observations of the sample. This avoids errors from misspecification of the functional form or of the distributions. Färe et al. (1992) adjusted the DEA method to the calculation of productivity change with Malmquist indices, given by equation (1). TFP indices can further be decomposed into technological change and technical efficiency change, as shown by equation (2). The method also enables to break down technical efficiency change into scale efficiency change (focusing on the optimal or sub-optimal farm sizes) and pure efficiency change (focusing on the management practices only).

$$M_{t,t+1} = \left[\frac{d^t\left(X_{t+1},Y_{t+1}\right)}{d^t\left(X_t,Y_t\right)} \frac{d^{t+1}\left(X_{t+1},Y_{t+1}\right)}{d^{t+1}\left(X_t,Y_t\right)} \right]^{\frac{1}{2}} \quad (1)$$

with $d^t\left(X_{t+1},Y_{t+1}\right)$ the distance from observations in the t+1 period to the frontier of the t-th period, $\left(X_t,Y_t\right)$ the input-output vector in the t-th period.

$$M_{t,t+1} = \frac{d^{t+1}\left(X_{t+1},Y_{t+1}\right)}{d^t\left(X_t,Y_t\right)} \left[\frac{d^t\left(X_{t+1},Y_{t+1}\right)}{d^{t+1}\left(X_{t+1},Y_{t+1}\right)} \frac{d^t\left(X_t,Y_t\right)}{d^{t+1}\left(X_t,Y_t\right)} \right]^{\frac{1}{2}} \quad (2)$$

where the left ratio gives the change in technical efficiency and the bracket measures technological change.

We used an output-oriented model that includes three different outputs (crop, livestock, and other outputs) in value, and four inputs (utilized land in hectares, labor use in Annual Working Units, capital as the value of depreciated assets, and the value of intermediate consumption).

3.2. Data

The data were obtained from the Slovenian Farm Accountancy Data Network (FADN) that was provided by the Ministry of Agriculture, Forestry and Food (MAFF) of Slovenia. The data set contains individual family farms, which represent the great majority of the Slovenian farming structures. The number of farms included in the FADN data varies by individual years between 226 farms in 2003 and 328 farms in 1996 with the annual mean value 271.4 farms in the FADN sample in the analyzed period 1994-2003. The farms have their own identification code and are classified according to socio-economic type into four groups (pure agricultural, mixed, supplementary, and farm with elderly members), by different types of areas according to factors of agricultural production into six groups (lowland areas, hilly areas, less favored areas with steeper terrain, mountainous areas, karsts areas, and non classified) and by production types into fifteen branches (crop; dairy using own feed; cattle using own feed; pigs using own feed; sheep using own feed; poultry using own feed; other livestock using own feed; livestock using purchased feed; fruit; grape and wine; mixed; vegetables; forestry; combined; non classified) according to the shares of revenue. The share of a specific production in the shares of farm revenues is greater than fifty percent for the first ten branches of farms (from crop to grape and wine). The revenue structure of the mixed farms consists of a combination of revenues from crop revenues, own feed, livestock, fruit, grapes and wine and hops, where a single product contribution in total revenue is less than 50 percent. In the case of vegetables and forestry, the single revenue criteria are set as greater than 75 percent. The combined farm in its revenue structure has incomes from crop and livestock using own feed (branches one-crop to seven-other livestock using own feed), where the single production contribution in total revenue is less than 75 percent (Pajntar, 1997).

The consequence of the small number of farms in Slovenian FADN data is that there are only a few farms per production type. Therefore, for confidentiality reasons, only data averages per production types can be provided by the MAFF. Due to missing data for some years, we have omitted poultry using own feed and non classified farms. The data used in the empirical analysis were thus the averages for 13 production branches, for the 10-year period 1994-2003. The nominal output data were deflated by the agricultural producer price index and the nominal input data were deflated by the agricultural input price index, which were provided by the Statistical Office of the Republic of Slovenia (SORS).

Table 1 presents the summary statistics of the total output and of the four inputs for all branches in the each analyzed year in real terms (in 1994 prices). Slovenian farms are small on average, usually less than 20 ha. The sample’s real value of production has been tripled over the analyzed years, while the input uses have been doubled or less, therefore suggesting an increase in the farm productivity.

Table 1: Summary real output and input data statistics by years

	Total revenue (mio SIT 1994 prices)	Land (UAA ha)	Labor (AWU)	Capital (mio SIT 1994 prices)	Variable inputs (mio SIT 1994 prices)
1994	2.49	12.39	2.02	12.9	1.43
1995	2.99	12.59	2.05	15.2	1.65
1996	3.17	12.14	2.29	12.4	1.78
1997	3.32	11.14	2.08	12.6	1.92
1998	3.99	10.98	2.26	12.3	2.35
1999	4.36	12.15	2.01	14.7	2.70
2000	7.39	15.89	2.31	21.1	4.35
2001	7.72	16.40	2.09	22.4	5.29
2002	7.51	21.50	5.57	30.4	3.64
2003	7.27	18.49	5.39	29.4	3.52

4. Results

4.1. Summary statistics per year and per branch

Table 2 presents summary statistics of technical efficiency change, pure technical efficiency change, scale efficiency change, technological change, and total factor productivity by year. The first row shows the averages over the whole period. Between 1994 and 2003, the sample has experienced a TFP progress of 1.8 percent, due to technological progress (2.7 percent). Efficiency has approximately remained the same (average index about 1), with a slight worsening of the management practices (-1.1 percent of pure technical efficiency). Over the period studied, TFP change has fluctuated between -11.5 percent in 2001-2002 and 14.4 percent in 1997-1998. Those fluctuations are partly due to variations in technological change that are likely to be determined also by some influences of external factors such as weather conditions. It can however be noted that except in the initial years, in most of the other analyzed years there has been technological progress (index greater than one). Efficiency oscillations between -8.3 percent in 2000-2001 and 8.5 percent in 1999-2000 explain for the other part the fluctuations in TFP. In general, technical efficiency change and technological change have varied in opposite direction patterns, confirming other studies on TFP change (Brümmer et al., 2002; Balcombe et al., 2005). The explanation is that it is easier for farmers to catch up with the technology (and thus improve their efficiency) when there is technological regress, while when there is technological progress a large part of farmers cannot adopt the new technique quickly (which means lower efficiency).

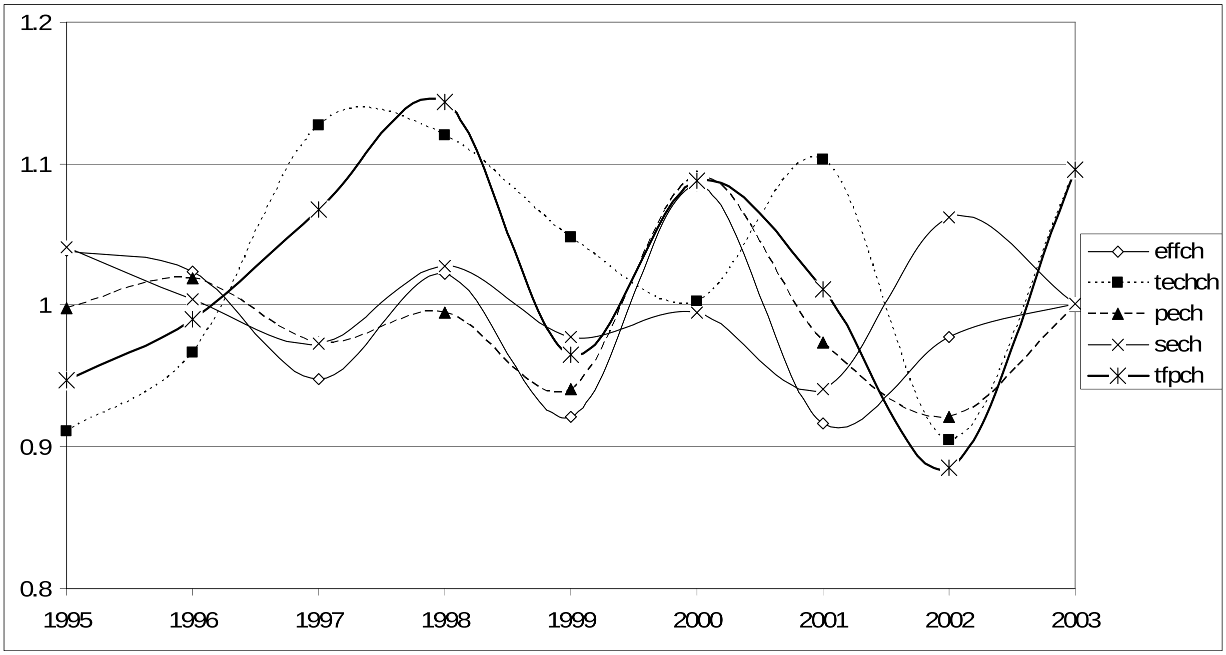
Table 2: Productivity changes by years (geometric means)

	effch	pech	sech	techch	tfpch
All years	0.991	0.989	1.002	1.027	1.018
1994-1995	1.040	0.998	1.041	0.911	0.947
1995-1996	1.024	1.019	1.004	0.967	0.990
1996-1997	0.948	0.974	0.973	1.127	1.068
1997-1998	1.022	0.994	1.027	1.119	1.144
1998-1999	0.920	0.941	0.978	1.048	0.964
1999-2000	1.085	1.091	0.995	1.003	1.088
2000-2001	0.917	0.974	0.941	1.103	1.011
2001-2002	0.978	0.921	1.062	0.905	0.885
2002-2003	1.001	0.999	1.001	1.095	1.096

Note: technical efficiency change (effch), pure technical efficiency change (pech), scale efficiency change (sech), technological change (techch), and total factor productivity (tfpch).

Productivity results of Table 2 are illustrated by Figure 1. The figure clearly shows the cyclical developments in total factor productivity changes as well as oscillations in other change indices by the individual analyzed years. The peaks in the total factor productivity is found in 1998, and then in 2000 and 2003, whereas the deepest negative points in the total factor productivity are found for the initial analyzed year 1995, and then in 1999 and particularly in 2002. This indicates around three year long cycles in the total factor productivity change developments. There are some similarities between the patterns in development of the total factor productivity and technological change, the outlier being particularly the technological change in 2001. The other three analyzed productivity change indices (technical efficiency change, pure technical efficiency change, and scale efficiency change) have experienced lower degree of variations over time. Except in 1997, their development patterns over time are in similar directions as the patterns in developments in the total factor productivity, indicating an additional role they have played in the total factor productivity changes in the Slovenian farms. However, as stressed above, their development is usually in opposite direction of technological change.

Figure 1: Productivity changes by year (geometric means)



Note: technical efficiency change (effch), pure technical efficiency change (pech), scale efficiency change (sech), technological change (techch), and total factor productivity (tfpch).

Table 3 and Figure 2 present summary statistics of technical efficiency change, pure technical efficiency change, scale efficiency change, technological change, and total factor productivity for the 13 analyzed branches. The branches with the higher total factor productivity growth are the following: 1 – crop (+9.5 percent), 6 – other livestock on own feed (+8.9 percent), 5 – sheep (+7.8 percent), 8 – fruit (+6.4 percent), 10 – mixed (+5.7 percent), 9 – grape and wine (+5.6 percent), 11 – vegetables (+4.7 percent), and to a lesser extent 2 – dairy (+2.3 percent). The worst performer is branch 7 – other livestock on purchased feed (-15.6 percent) followed by 12 – forestry (-7.0 percent). For branches 3 – cattle, 4 – pigs and 13 – combined, TFP has rather stagnated (Malmquist index around 1). For most of the branches, the productivity change is solely due to technological change (progress or regress), as the efficiency change indices are around 1. Three branches only have seen their efficiency changed. Branch 7 – other livestock on purchased feed recorded a total technical efficiency decrease (-13.3 percent) and branch 3 – cattle a pure technical efficiency decrease (-4.7 percent), while branch 5 – sheep experienced a scale efficiency increase (+5.7 percent).

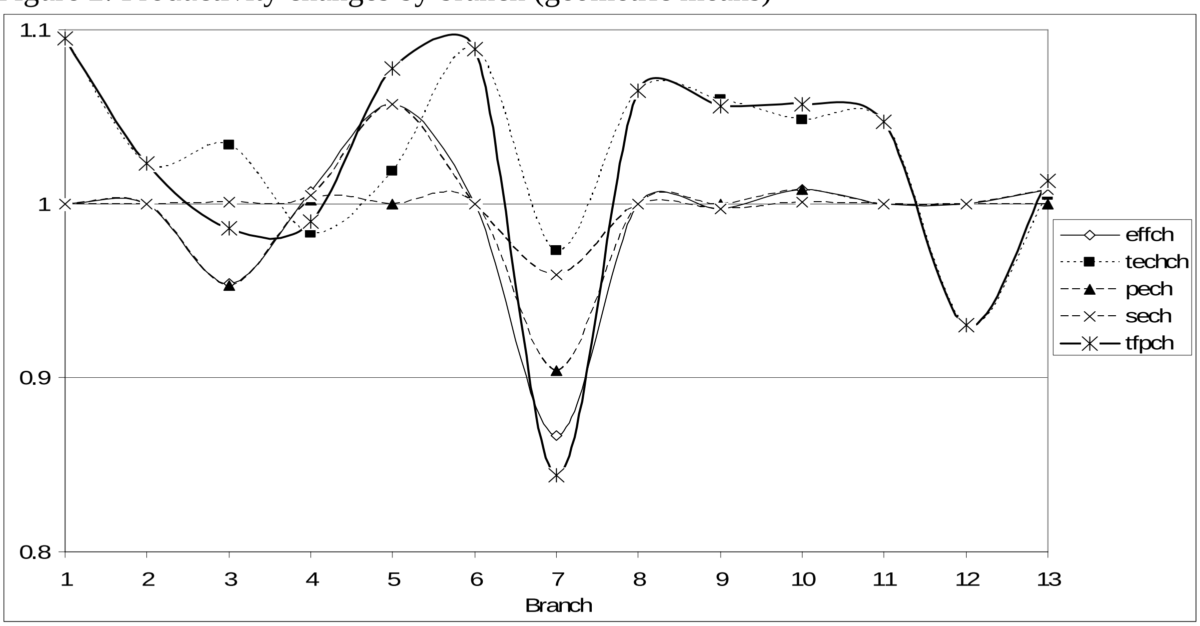
We have found that productivity changes are not necessary related to government policies. Branches 2 – dairy and 3 – cattle have received major attention by policy makers in terms of the absolute size of the government support (OECD, 2001). Whereas in the case of dairy there improvements in total factor productivity have been achieved, this is not the case of cattle where pure technical efficiency has deteriorated, and thus total factor productivity declined.

Table 3: Productivity changes by branch (geometric means)

	effch	pech	sech	techch	tfpch
All branches	0.991	0.989	1.002	1.027	1.018
1 – crop	0.999	1.000	0.999	1.095	1.095
2 – dairy	0.999	1.000	0.999	1.023	1.023
3 – cattle	0.954	0.953	1.001	1.034	0.986
4 – pigs	1.007	1.002	1.005	0.984	0.990
5 – sheep	1.057	0.999	1.057	1.019	1.078
6 – other livestock using own feed	1.000	1.000	0.999	1.089	1.089
7 – livestock using purchased feed	0.867	0.904	0.959	0.973	0.844
8 – fruit	1.000	0.999	1.000	1.065	1.064
9 – grape and wine	0.997	0.999	0.997	1.059	1.056
10 – mixed	1.008	1.007	1.001	1.048	1.057
11 – vegetables	0.999	1.000	0.999	1.047	1.047
12 – forestry	1.000	1.000	1.000	0.930	0.930
13 – combined	1.008	1.000	1.008	1.005	1.013

Note: technical efficiency change (effch), pure technical efficiency change (pech), scale efficiency change (sech), technological change (techch), and total factor productivity (tfpch).

Figure 2: Productivity changes by branch (geometric means)

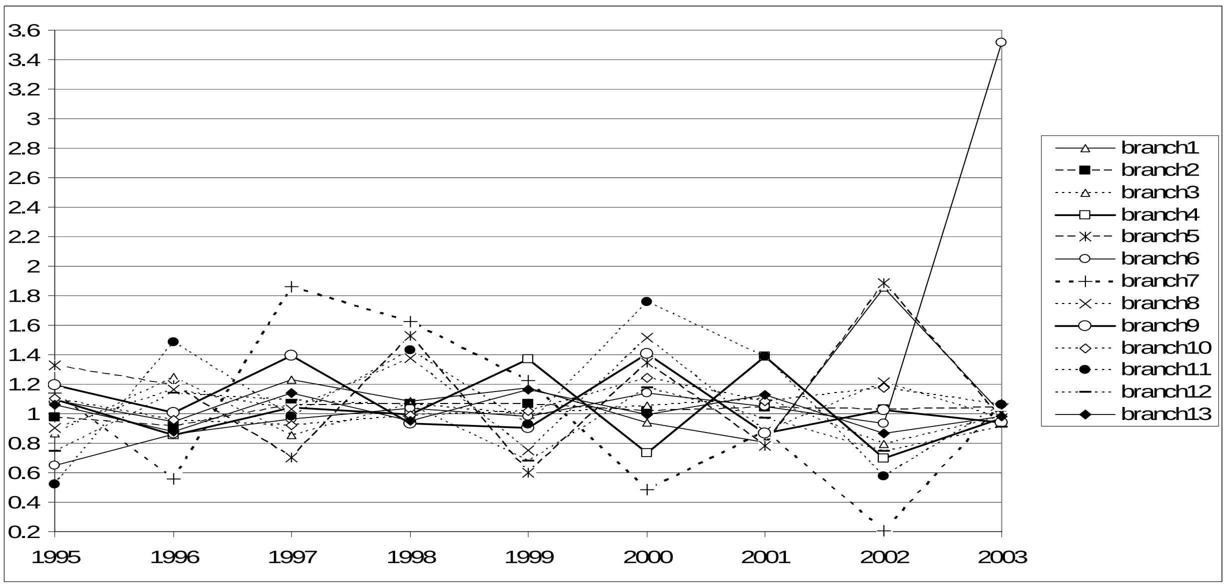


4.2. Evolutions of the branches over the period

Total factor productivity change

Total factor productivity change by individual production branches is shown for the period studied by Figure 3. The main outlier is a dramatic increase in total factor productivity for branch 6 – other livestock on own feed in the last year. In the beginning of the period branches are relatively close to each other in terms of productivity change, while differences between branches increase in the last years.

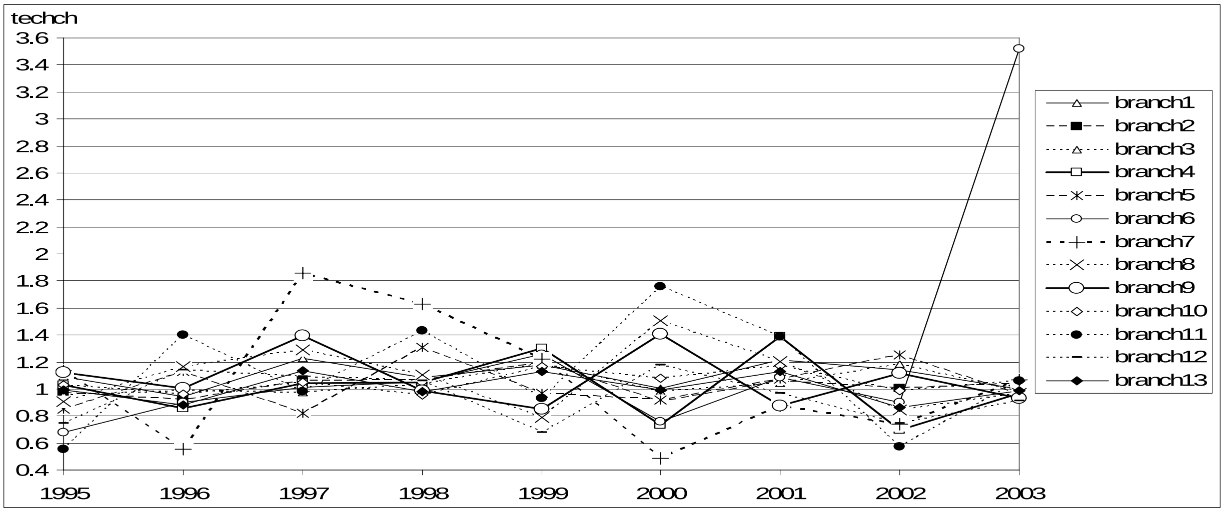
Figure 3: Total factor productivity change by branch and year



Technological change

Figure 4 pictures the evolution of technological change for each branch. Branches experienced relatively similar technological changes, with two exceptions. The first one is the very high technological progress for branch 6 – other livestock on own feed in the last year, which explains the TFP outlier for this branch as well (Figure 3). Such a sharp increase can be due to a significant improvement in external factors such as weather conditions that became favorable for crop feed. The second exception to smooth and similar evolutions of all branches is a high variation for branches 7 – other livestock on purchased feed and 11 – vegetables. This is not surprising for the latter production, as it is highly influenced by weather conditions. As for branch 7 – other livestock on purchased feed, it seems to be affected by the availability of good quality feed on the input market.

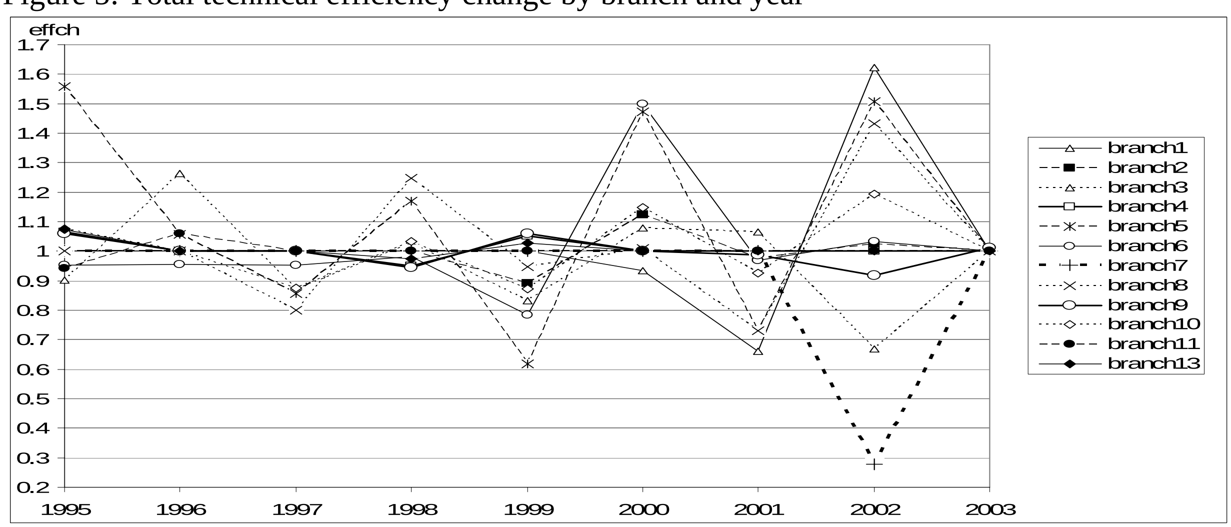
Figure 4: Technological change by branch and year



Total technical efficiency change

The evolution of total technical efficiency change over the period for each branch is presented in Figure 5. Branch 12 – forestry had a perfect stagnation of average technical efficiency (index of technical efficiency change equal to 1 in each year), and other branches recorded also almost no change in their average technical efficiency (branch 2 – dairy, branch 4 – pigs, branch 6 – other livestock using own feed, 9 – grape and wine, 11 – vegetables, 13 – combined). By contracts, branch 5 – sheep has the most recurrent variations: the technical efficiency for the branch has on average increased or decreased each year. Other branches (1 – crop, 3 – cattle, and 8 – fruit) also recorded yearly fluctuations, with a period of efficiency decrease (respectively increase) being followed by a period of efficiency increase (respectively decrease). Only branch 7 – other livestock on purchased feed experienced a single drop (in 2001-2002), not followed by an increase back.

Figure 5: Total technical efficiency change by branch and year

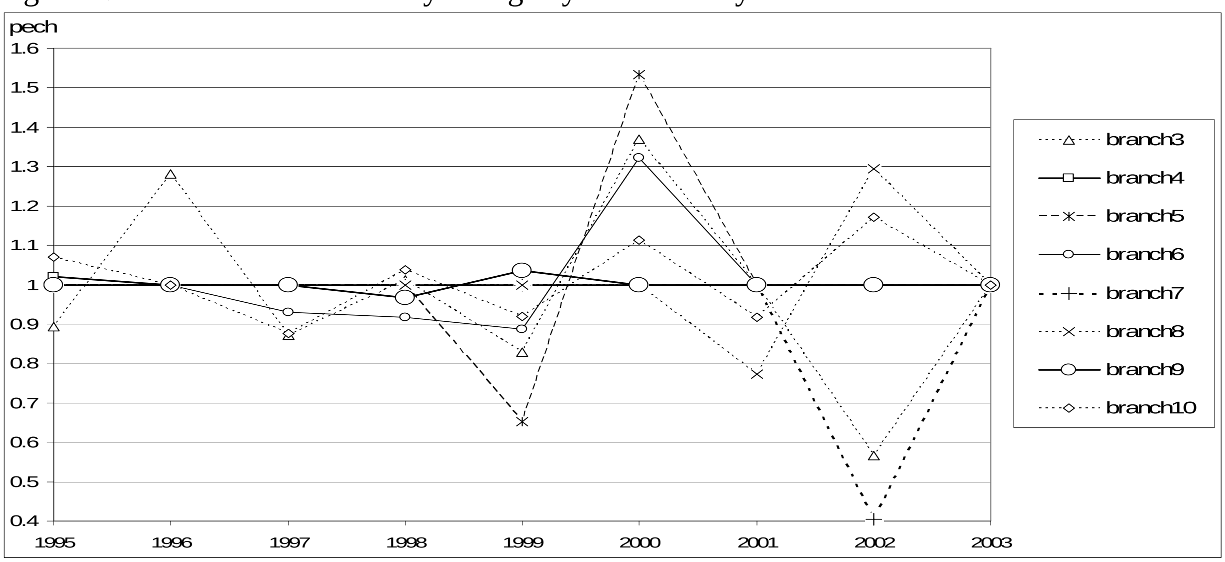


Note: Branch 12 – forestry have total technical efficiency change index equal to 1 in each year.

Pure technical efficiency change

Figure 6 shows the indices of pure technical efficiency change over the period per branch. Five out of thirteen production branches (1 – crop, 2 – dairy, 9 – grape and wine, 11 – vegetables, 12 – forestry and 13 – mixed) are found with constant pure technical efficiency (indices equal or almost equal to 1 in each year). This indicates that these branches have not modified (neither improved nor worsened) their farming practices over the period, and that any change in total technical efficiency identified on Figure 5 would be solely due to change scale efficiency. Branches 3 – cattle and 7 – other livestock on purchased feed are the only branches that have recorded deep decline in pure technical efficiency without recovery (the decline occurred in the period 2001-2002, and in the next period, the index was 1 meaning that there had been no change in pure technical efficiency between 2001-2002 and 2002-2003). This suggests that farming practices within these two branches have worsened at the end of the period studied. Those livestock farmers might not have been able to adapt their practices to the EU policy adaptation.

Figure 6: Pure technical efficiency change by branch and year

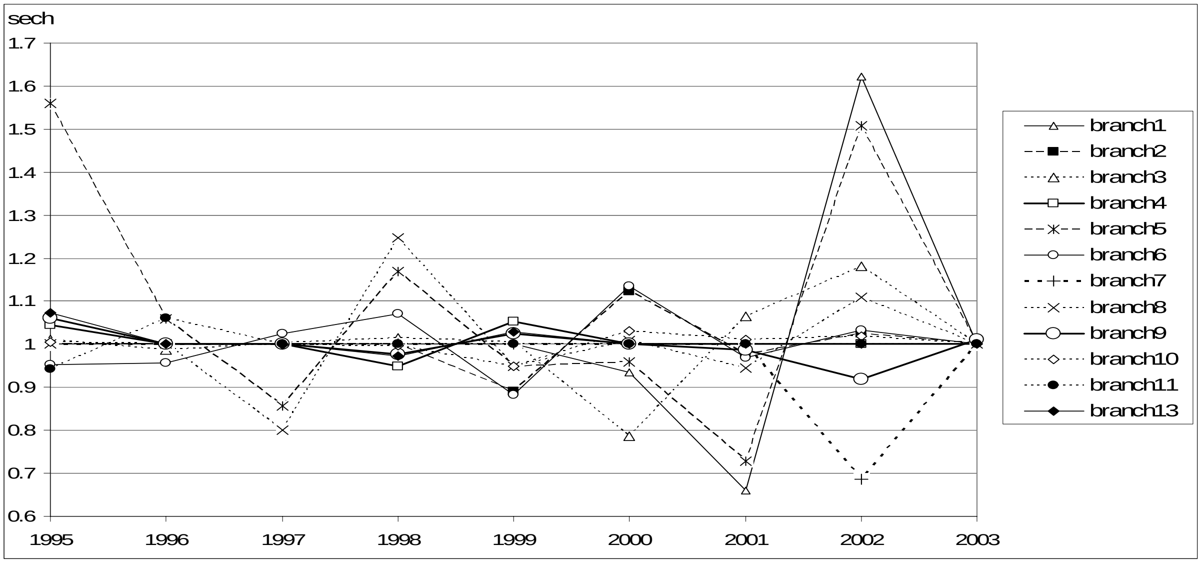


Note: Branches 1 – crop, 2 – dairy, 11 – vegetables, 12 – forestry and 13 – mixed have pure technical efficiency change index equal to 1 in each year.

Scale efficiency change

The evolution of scale efficiency per branch is illustrated on Figure 7. Scale efficiency seems to have fluctuated greatly for branches 1 – crop, 3 – cattle, 5 – sheep, 7 – other livestock on purchased feed, and 8 – fruit. Here again, branch 7 – other livestock on purchased feed has recorded a decrease in scale efficiency (i.e. farm size becoming sub-optimal) without any recovery.

Figure 7: Scale efficiency change by branch and year



Note: Branch 12 – forestry have scale efficiency change index equal to 1 in each year.

5. Conclusions

Empirical results indicate that TFP, on average, progressed only slightly, by 1.8 percent, over the ten-year period. However, this relatively slow TFP growth hides a switchback evolution over the analyzed period, with for example a peak of +14 percent in the years 1997-1998 and a drop of -12 percent in the years 2001-2002. As in any productivity calculations, such fluctuations in TFP can be attributed partly to short-term factors such as animal health diseases or pests, climatic or weather conditions, which vary greatly from year to year. But changing economic conditions during the transition and adjustment periods to trade liberalization and membership of Slovenia in the EU with price and policy transfers' shifts are likely to have plaid a role as well. The decomposition of the TFP change indicates that the driving force behind it is mostly technological progress, of about 3 percent. Technical efficiency has remained rather stable on average, suggesting that farmers were able to implement the new technologies on time.

Dissimilar developments in TFP are shown according to the production specialization. Crop farms have performed the best, with a TFP progress on average by 9 percent solely due to technological progress. Forestry farms were, by contrast, a very bad performer with a technological regress of -7 percent on average, suggesting that new technologies are less common in forestry than in crop or livestock production. For all branches, technological change constitutes the sole part of TFP change, except for sheep farms, which recorded a high technical efficiency progress and livestock on purchased feed which experienced a dramatic technical efficiency reduction. The latter production recorded the worst development of all branches over time, with a particular sharp decrease in efficiency, both pure technical and scale.

The fact that crop farming has had the strongest TFP development compared to livestock farming was also given evidence for example in France by Guyomard et al. (2006) for the period 1995-2002, although the authors used separate frontiers for production specializations. As we used a common frontier, our result indicates that crop specialization is leading the country's agricultural technology. So far greater policy focus in Slovenia has been directed towards livestock, dairy and beef, but our results suggest that this has not resulted in successful TFP progress. By contrast, conditions for productivity increase in Slovenia seem to be favorable for farms specialized in crop production. Slovenia needs to emphasize productivity progress in crop production to increase synergies within agricultural production structures, rationalize and increase agricultural productivity to compete on the enlarged EU agricultural markets.

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