Inputs use in the agriculture of Emilia-Romagna: farm comparison through the Total Factor Productivity (TFP) index

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Abstract. *In order to measure agriculture sustainability, the efficient use of inputs becomes a crucial issue. In this perspective, the analysts concentrate their attention on the total factor productivity index (TFP). In this view, Lynam and Herdt (1989) proposed the TFP as a suitable assessment of the sustainability of single crops, of cropping systems or of farming systems. Even if the TFP does not take into account the non-market output (social and environmental aspects), it is possible to argue that a negative trend of TFP represents a resources' degradation if related to the generated outputs. On the other hand, the non-negative trend of TFP represents a fitting measure of a sustainable agricultural system and of an efficient use of the resources. The aim of the paper is to analyze the productivity in the use of external factors in different types of farming at the Emilia-Romagna Region level, i.e. specialist field crops, specialist permanent crops and specialist milk production farms. A significant number of indexing procedures is accessible to evaluate the efficiency in converting inputs into outputs. In this paper, the TFP is estimated through an indirect evaluation of quantity index of outputs and inputs of each farming system taken into account in the analysis. Purposely, the amount of the total sales is considered as a measure of the output, whereas labour, capital, external inputs and other intermediate consumption are considered as a measure of the inputs. Data, referred to the period 2000 – 2009, are collected from the farm accountancy data network of the Emilia Romagna Region DG Agriculture. The study highlights how the TFP is a convenient index to evaluate the efficiency in the use of resources. In a broader view, the TFP index trend allows an estimation of economical and social benefits or damages which in the end improves or worsens environmental quality.*

Keywords: *Total Factor Productivity (D24); Sustainability (Q56);*

1. Introduction

Sustainability is a multidimensional topic that for several years has occupied the minds and interests of many researchers. It is obvious that in literature it is possible to find a bountiful source of interpretative possibilities as regards sustainability (Herdt et al., 1992). However, even though it is widely recognised the importance attributed to the concept of sustainability, the term seems to be skimmed through with a certain level of uncertainty. This situation gives rise to the diverse interpretations of sustainability as well as different methods of measuring. Those who approach such studies within this area of research must obviously make references to a clear interpretation of such concepts to which they refer to in the research.

The term sustainability is often associated with the concept of sustainable development, sanctioned for more than twenty years by the United Nations (WCED, 1987). The Bruntland Commission defined sustainability as the development which is capable of satisfying the needs of the present generation without compromising the capabilities of the future generation as to satisfying their needs. Although it is widely shared, from this definition, no precise indications arise for the evaluation criteria on sustainability.

In this light, the definition proposed by Conway (1985; 1994) represents instead a useful starting point for whoever approaches the studies of sustainability. The author, in fact, interprets sustainability as the ability for whatever system to maintain within a certain time its own productivity. Related to this definition is the one proposed by Ikerd (1993), according to which sustainability of a system represents the capability to maintain within a certain time its own productivity and is equally useful within the society where it operates. Both definitions differentiate from the concept of sustainable development for the trait of dynamism and they combine for the interpretative criteria of the concept of sustainability.

Lyman et al. (1989) in an article of particular interest on the subject, define sustainability as the capability of a system to maintain its levels of output approximately at the same levels, or at a superior level, of that of the average of a fixed period. In this sense, a system is sustainable if the trend of the output is not negative. This affirmation, although clear within the general sense of the terms, is characterized for

certain key aspects which only become explicit by the authors after, like the output to be considered in the evaluation of the sustainability, the criteria of measurements of the same, and the noted period most suitable for the evaluation.

In the attempt to develop a criteria to evaluate the sustainability, the authors proposed the Total Factor Productivity (TFP) as one of the most appropriate measures of sustainability of single-crops or whole productive systems as well. Such measures represent the result of the comparison between the output coming from the system and all the inputs used to obtain it[1]. Positive values of the index represent a clear signal of how the output obtained from the system increases more quickly with respect to the input supplied. Non-negative results are therefore an expression of productivity and sustainability of the system. It is important to underline how the productivity, frequently confused with the concept of efficiency[2] and technical progress[3], represents a wider measure that includes the effects of the two aspects just cited.

Even though the TFP is not free of critics[4], it was frequently used in the area of macroeconomics and microeconomics. With regards to the agricultural sector, for example, the TFP was proposed for the analysis of the sustainability of agricultural systems (Murgai, 1999; Ali et al., 2000) or of single-crops (Sidhu et al., 1992; Cassman et al., 1995). In this regard, there are no contraindications towards the level of aggregation in the systems considered. Lynam et al. (1989), with reference to this aspect, advise that the studies of the productivity and of the sustainability at macroeconomics level through the TFP had to be run with a certain level of homogeneity. In depth the authors referred to the homogeneity with regard to the productive resources which differentiate the system subject to the research, being a factor capable of influencing enterprises' choices. When it is possible, however, to have at disposal, information of enterprise-nature, it is plausible to evaluate the TFP of homogeneous groups of enterprises. Homogeneity, in this sense, may refer to the trend of the dominant production, or, as in the case of the study done by Cassane and Pingalli (1995), to a specific typology of productive systems.

Within the approaches of analysis of the TFP, the use of the index numbers of volume and the analysis of the frontiers of production are generally those which are adopted. With reference to the first, the index of volume of Fisher for the aggregates of the input and output, certainly represents an ideal choice from a theoretical point of view[5]. What is especially needed, is to consider how the adoption of a criteria of calculations of the index number of the volume within the research represents the benefits of a trade off between the optimal choice from a theoretical point of view, the expensiveness and availability of the information necessary in the calculations. By which way, a verification of the different formulas used for the calculations of the index of volume for the agricultural sector of the different member states of the European Union makes reference to the contribution of Boyle (1987), to which emerge the classical differences that mark the results obtained based on the choices made for the calculations of the index of volume[6].

Within the approaches of analysis based on the frontiers of production guided by the analysis of the productivity and the efficiency of the system, the Data Envelopment Analysis (DEA) and the Stochastic Frontier Analysis (SFA) are those most commonly used. In comparison to the TFP, the DEA and the SFA allow for the possibility of interference in the possible causes of the productivity, evaluating conjunctively the global efficiency, the technical efficiencies and the efficiency of the scales of the productive systems analyzed, thereby offering interpretative criteria of the observed phenomena. Like the TFP, the DEA and the SFA were also used in different productive sectors, investigating on different

[1] The acronym TFP refers to the global productivity in which the calculations what is considered are all the external resources used in the productive process, as opposed to the partial factor productivity (PFP), taken from a limited number of factors of the production.

[2] The efficiency of a decision making unit, be it a single farm or an aggregate of such, represents a measure which can be confronted in respect to an optimal capacity which may transform the resources into goods and services.

[3] With regards to the technical process and technology is intended the way the technical and technological capacity of the decision making unit to transform the resources into goods and services change during the time.

[4] The criticism regarding the dubious efficiency that the TFP had in evaluating the sustainability refer to the positive and negative externality which do not have a real and proper market and so are difficult to uphold their value and worth in the calculation of the index. In proposition to this, however, various studies have attempted to correct the index also including the evaluation of the external factors and calculating the Total Social Factor Productivity (TFSP).

[5] What also needs to be considered are other index numbers, such as those of Laspeyres and Paasche, which are the precursors of the ideal index of Fischer and the indices of Tornqvist and Divisia, may be used in the calculation of the index numbers of prices and of volume.

[6] From the contribution of Boyle (1987) one may deduce in particular the positive tendency of the index calculated by the formula of Laspeyres and on the contrary, the negative tendency of the index of volume of Paasche.

productive systems, at microeconomic levels as well as macroeconomic. With reference to the agricultural sector there are various studies. In some case studies the analysis is directed towards the analysis of the productivity of the agricultural sector in general (Bayarsaihan et al., 2003), or to evaluate the effects of the productivity following the introduction of new productive systems (Towsend et al., 1998). In other cases, the effect of the farm size on the productivity (Helfand et l., 2004), the productivity of single cultivation (Reig-Martinez et al., 2004) or the organized farm systems (Guzman et al., 2009) were investigated. Within this scenario it is possible to notice fruitful overlaps between the effort combined by the TFP and the DEA at the end to break down the index of volume used in the analysis, and to improve the study (Kuosman et al., 2004).

The aim of the paper is to analyze the productivity in the use of external factors in different types of farming at the Emilia-Romagna Region level, estimating the TFP through an indirect evaluation of quantity index of outputs and inputs of each farming system taken into account in the analysis (specialist field crops, specialist permanent crops and specialist milk production).

The agricultural sector of the region Emilia - Romagna, is made up of about 82,000 farms with an Utilised Agricultural Area (UAA) of about 1.1 million hectares. The average farm-size is almost 13 hectares of the UAA, in comparison to a national average of only 7.6 hectares. In this region there are significant amounts of national livestock. Emilia -Romagna, in particular, "is worth" on its own about 10% of the national bovine farms (which rises to 15% if you consider only dairy cows), 15.6% of swine and 19.3% of poultry farms. With regards to the management, direct management is now preponderant, in Emilia - Romagna as in the rest of Italy, since it characterises more than 93% of the farms. The agricultural sector of Emilia-Romagna employs 220,000 people, for a total of almost 18.7 million working-days. In the last ten years, the average annual value of the agricultural production of the region Emilia - Romagna was a little more than 5 billion euro, while the added value was close to 3 billion euro. The field crops represent more than 27% of the total production, permanent crops almost 19%, while milk, in large parts destined to the production of "Parmigiano Reggiano" cheese, is worth a little more than 12%.

The case study intends therefore to focus on the grounds of the productivity of three main type of farming in the Emilia-Romagna region in the period 2000-2009: specialist field crops, specialist permanent crops and specialist milk production.

2. Materials and methods

2.1. Materials

The analysis of the TFP and the partial factor productivity (PFP) is based on accounting information available by the Emilia-Romagna region farm accounting data network, collected through the methodology of the Farm Accountancy Data Network (FADN) of the European Commission. Data comes from samples annually gathered from farms selected according to European Union typology, making reference to economic size classes and the type of farming.

In the case study of the TFP of the productive systems, as in the agricultural one, a variable of particular relevance is the choice of time span considered as the most adapted to the analysis. Monteith (1990), in fact, highlights that one of the problems in this type of research is the choice of the most appropriate number of years to ensure reliability within the study. In this sense, Lynam and Herdt (1989) suggest a horizontal time span of no less than 3-5 years and definitely less than 20 years. In this light the research takes in consideration a period of 10 years, from 2000 to 2009. This time span is suitable to highlight the evolution of the observed phenomena. In the same time this choice seems to minimize possible distorted effects connected to the use of the volume index different from those ideals of Fisher.

The observations which are shown were aggregated in relation to the official classification proposed by the FADN at European level[7] based on the prevalent productive systems practised in agriculture. The research lingers over three types of farms, specialized respectively in growing field crops, in fruit and vineyard and in milk production. In the first group we refer to farms specialised in the production of cereals, oilseed and protein crops (COPs), as well as farms which produce all the other crops not associated with these. In the group of farms specialised in growing permanent crops, the ones considered

[7] The regulations regarding the type of farming adopted in this analysis are Reg. Ce 1999/725 and Reg. Ce 2003/369.

were those that prevailed in the production of grapes and fruit. In the third group, the ones with cows specialized in milk production. These three types of farms reflect the specific agriculture in the Emilia-Romagna region. In general, even if it is possible to find the three productive systems described, dairy farming is particularly developed in the furthermost western province of the region. Even though the field crops are spread throughout the region, they represent a particularly strong productive system in the central province and in the northern areas of the eastern province. Permanent cropping is particularly developed in the centre-east areas of the region.

For each of the three type of farming system were selected those farms of which accounting data were available in at least two consecutive years of the ten-year-period from 2000 to 2009. When the time span of analysis is so long, a common turnover occur. Some farms obviously get out and new ones enter in the fields of observation[8]. In this view, the shifting two years constant sample[9], mirror the ordinary turn over which characterizes the agricultural sector of Emilia – Romagna region. The decision obviously has had important reflections also within other aspects of the research. The volume index of the input and output used for the calculations of the TFP, in fact, was calculated in an indirect way through the chain base origin price index of the output sold and of the inputs bought by the farmers on the basis derived from the price index on a fixed base of 2000=100 made available by ISTAT (Italian National Statistics Office)[10].

To calculate the TFP, revenues from sales are generally considered as the output and intermediate consumptions as the input (Table 1). In a second phase, there were calculations of the PFP with regards to the chemicals used in growing field crops and permanent crops, whilst for the dairy farms, the PFP of fodder and supplements were analyzed.

Table 1. Data sources and variables

Variables	Descriptions	UM	Source
Output			
- Turnover	Sales of products	Euro	R-ER
Inputs			
- Total Intermediate consumptions	Value of the goods and services consumed as inputs by a process of production, excluding fixed assets	Euro	R-ER
- Chemicals	Fertilizers and pesticides	Euro	R-ER
- Fodder and supplements	Feeds and supplements	Euro	R-ER
Price index	Price index of agricultural outputs and inputs	-	ISTAT

R-ER = Regione Emilia Romagna

2.2. Method

Even though the calculation of the TFP may look simple, one needs to consider that for the direct calculation of the volume index, information on price and quantity of inputs utilized into the system are needed. The price and the quantity of the outputs are needed as well. The TFP is then computed as following:

$$TFP = \frac{I_V^O}{I_V^I} \qquad (1)$$

where:

I_V^O = Volume index of output;

[8] The motivations may be referable, for example, when the productive activity of the farm cease to operate, or because of the changing of the productive type of farming..

[9] Considering the micro-economic levels of the analysis, raising the number of years analyzed, the probability to work with a reasonably constant sample fall.

[10] ISTAT supplies the index numbers of the prices of Laspeyres for aggregates of sold products (vegetables, vegetables excluding fruits, animals and products of animals), for single category of sold products of the farmer (e.g. cereals, fruits, vegetables, dairy cows, pigs). Conjunctively with the index of prices for the sold products, ISTAT supplies also those of the products bought. Also in this case we take an index of the prices of Laspeyres for economic aggregates (intermediate consumption and investment) for single components.(e.g. fertilizers, seeds, pesticides, fuel)

I_V^I = Volume index of input;

In many cases, however, only the amount of the output and input considered in the analysis are available. To avoid such complications, a way to calculate the volume index is by deflating such costs through the use of the prices index. This approach is based on the hypothesis that the values variation within time is a result of the simultaneous changes to the prices and the quantity of the goods and the services used. The elimination of the effects of the inflation is therefore allowed to obtain the indirect index[11] of the quantity, the approximation of those measured directly.

In the examined cases, having at disposal only the current value of the inputs and outputs, and laying out the prices index of the sold goods and the materials purchased by the farmer[12], the volume index of the input and the output was calculated in an indirect way according to the following equation:

$$ {}_{t-1}I_{V,t} = \frac{X_t \Big/ {}_{t-1}I_{p,t}}{X_{t-1}} \qquad (2) $$

where:

${}_{t-1}I_{V,t}$ = volume chain base index;

$X_t = \sum_{i=1}^{n} p_{i,t} \times q_{i,t}$ = aggregate value of "*i*" referred to year "*t*";

$X_{t-1} = \sum_{i=1}^{n} p_{i,t-1} \times q_{i,t-1}$ = aggregate value of "*i*" referred to year "*t-1*";

${}_{t-1}I_{p,t}$ = price chain base index[13];

$p_{i,t}$ = current price of "*i*" referred to the "*t*";

$q_{i,t}$ = quantity of "*i*" referred to year "*t*";

$p_{i,t-1}$ = price of "*i*" referred to year "*t-1*";

$q_{i,t-1}$ = quantity of "*i*" referred to year "*t-1*".

Value of TFP and PFP was referred to the equation (3):

$$ {}_{t-1}TFP_t = \frac{{}_{t-1}I_{V,t}^O}{{}_{t-1}I_{V,t}^I} \qquad (3) $$

where:

${}_{t-1}I_{V,t}^O$ = volume chain base index of output;

${}_{t-1}I_{V,t}$ = volume chain base index of input;

[11] The indirect indices of quantity which are defined are in contrast to the direct indices deduced through the direct data of the quantity and the prices.

[12] Considering the criteria adopted in establishing the sample of farms it was decided to adopt the mobile price index of both the products sold and bought by the farmers, obtained by the fixed base price index (2000=100) supplied by ISTAT.

[13] ISTAT supplies the index numbers of Laspeyres of both the prices of the products bought and sold by the farmers for the homogenous category corresponding to a set year 1995=100, 2000=100 and 2005=100. With specific reference to the index prices of the sold agricultural products, elevated seasonal data which characterizes it, the index were calculated using a weighting system which was fixed for the aggregates "fruit" and "vegetables", but with monthly-baskets that were variable. The mobile price index considered in the study ${}_{t-1}I_{p,t}$ was calculated as the relationship between the current price index $I_{p,t}$ and the price index of the previous year ${}_{t-1}I_p$.

Considering that the index volume has a chain base, the results obtained by the TFP and the PFP is referred to the period "*t*" "*t-1*". In the light of the fact that the sample is not constant during the period, but considering it is homogeneous enough within the regional agriculture, the TFP and the PFP based on 2000=100 is computed linking the mobile volume index of one year with the corresponding index of the previous year. In such way it was possible to define the trend of the TFP and PFP index ($_{2000}TFP_c$ and $_{2000}PFP_c$).

3. Results

3.1. Sample description

The sample profile is displayed in Table 2. With reference to the economic size (Economic Size Unit - ESU), all the analyzed systems are characterized by a substantial homogeneity in the period. The farms have a standard gross margin between 40 and 100 ESU. The specialized field crops is made up of a group of farms in which the size is greater than that of the national average (7 hectares), and than that of the region Emilia-Romagna (15 hectares). Excluding the last two years, the revenues per hectare of these groups is chartered a little more than 2,000 euro. Also the specialized permanent crops are greater in size with respect to those in the national data (2 hectares) and the regional ones (5 hectares). In the period considered, the revenues fluctuate from 3,600 euro per hectare in the first two-year-period to 5,200 per hectare in the last one. In the group of farms specialised in the milk-production from bovines, the farm sizes are very close to those with dairy farming in Emilia-Romagna region, where the average is 70 livestock per farm.

The intermediate consumes represent a variable quota between 31% and 53% of the outputs (Table 3). In the field crops and the permanent crops, the chemical inputs in this time period alternates between 31% and 46% of the total inputs. In the specialist milk productions the amount spent on feeds and supplements goes from a minimum of 49.4% until finally reaching 65.8% of total inputs.

Table 2. Sample description (average value)

Period	Spec. field crops			Spec. permanent crops			Spec. milk production		
	UAA (ha)	Revenue (,000€/ha)	ESU[14]	UAA (ha)	Revenue (,000€/ha)	ESU	Livestock units (n.)	Revenue (,000€/ha)	ESU
'00-'01	53.7	2.1	8	21.6	3.6	8	71	2.4	8
'01-'02	44.1	2.4	8	16.7	4.8	8	72	2.6	8
'02-'03	37.6	2.3	8	13.1	4.9	8	61	2.4	8
'03-'04	40.9	2.1	8	13.5	4.4	8	61	2.3	8
'04-'05	50.2	2.0	8	16.0	4.1	8	76	2.2	9
'05-'06	39.5	2.1	8	15.5	4.7	8	66	2.2	8
'06-'07	35.3	2.1	8	13.5	5.9	8	67	2.3	8
'07-'08	33.7	2.1	8	13.6	5.4	8	69	2.4	8
'08-'09	34.0	1.7	8	13.5	5.2	7	63	2.3	9

Legenda:
UAA = Utilized Agricultural Area.
ESU= European Size Units (1 ESU=1,200 euro of Farm Gross Margin).

[14] The UE through the Reg. 2003/369 update the previous regulation and the classification of the enterprises in the followings ten classes of European Size Units (ESU): <2; 2 - <4; 4 - <6; 6 - <8; 8 - <12; 12 - <16; 16 - <40; 40 - <100; 100 - <250; >=250.

Table 3. Quota of inputs

	Specialist field crops		Specialist permanent crops		Specialist milk production	
Period	**TIC [(a)]**	**Chemicals [(b)]**	**TIC [(a)]**	**Chemicals[(b)]**	**TIC [(a)]**	**Feed & Suppl.[(b)]**
'00-'01	40.2	31.5	33.7	39.1	39.7	49.4
'01-'02	38.9	32.6	31.8	40.7	39.8	65.8
'02-'03	40.8	32.1	33.3	44.0	40.6	58.7
'03-'04	42.5	31.9	35.9	38.4	43.3	60.7
'04-'05	46.0	32.0	35.4	33.4	46.3	56.3
'05-'06	44.8	33.3	32.6	37.7	50.7	55.2
'06-'07	45.3	33.1	33.6	41.2	52.8	57.6
'07-'08	48.3	32.1	34.7	44.4	52.0	61.0
'08-'09	50.2	31.4	38.4	46.2	50.1	57.6

Legenda:
TIC = Total Intermediate Consumption
[(a)] % of revenues;
[(b)] % of TIC.

3.2. Productivity

Both the levels of the TFP and the $_{2000}TFP_c$ computed through the linked volume index of the output and the linked volume index of the inputs[15], are displayed in Figure 1. In general, what emerges is the clear difference from the three productive systems.

The productivity of specialist field crops is generally smaller than the unit, due to a common inefficient use of the inputs. The annual index of productivity at a fixed base ($_{2000}TFP_c$) decreases progressively at an average annual rate of 2.1% (Table 4).

A different situation is that of the specialist permanent crops. Apart from an initial first period where the levels of the TFP are constantly smaller than the unit, the ability to effectively turn the inputs into the outputs is evident (Figure 1). In the period 2004-2006 the maximum TFP levels are reached. The analysis of the $_{2000}TFP_c$ displays a growth of an average annual of 2.1%, even if it is only from 2004 that the increase in productivity rises substantially (Table 4).

In the specialist milk production system, good levels of TFP are observed only in the first few years. The increase noted in the levels of the inputs of the following two-year period does not seem to reflect the correspondent increase in the output, faulting the levels of the TFP in the time-span 2003-2006. This situation is highlighted in the $_{2000}TFP_c$ index. Despite the fact that it is noted an average annual rate of growth of 0.4%, the progress of the index highlights the presence of a first period where the productivity increases to replace a period of moderate growth (Table 4).

From the analysis of the levels of the PFP of chemical input, somewhat similar situations emerge (Figure 2). Excluding the two-year periods from 2001-2002 and 2003-2004, the farms of the specialist field crops and the specialist permanent crops show good levels of partial productivity. In particular, in the period 2001-2002, the PFP to be compromised by an excessive use of chemical input with respect to the output The analysis of the $_{2000}PFP_c$, computed through the linked volume index of the output and the linked volume index of the chemical inputs shows, just like the period of 2000-2009, that the PFP of this category of input tends to rise progressively. With regards to the specialist field crops the annual average growth of the $_{2000}PFP_c$ is 2%. In the specialist permanent crops a 7.7% annual average growth is registered. The level of the PFP of the fodder and supplements in farms specialized in milk production is characterised by a seesawing situation. The analysis of the $_{2000}PFP_c$ shows, however, a progressive decrease in the partial productivity of the fodder and supplements at an average annual rate of 0.4%.

[15] In the awareness that the linking of the indices represent a forcing, it may however offer useful information for the calculation of TFP with a fixed base, helpful in identifying a trend in the productivity.

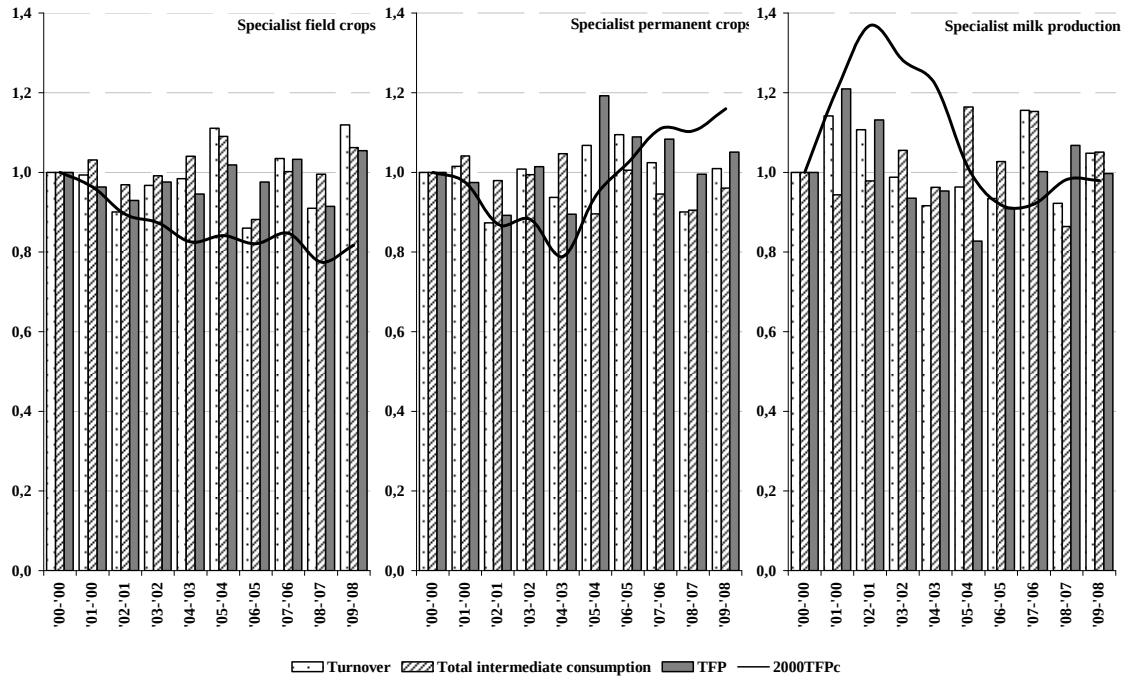

Figure 1. TFP, Output, Input and TFP chained

Table 4. Chained TFP growth rates (%)

Years	Specialist field crop	Specialist permanent crop	Specialist milk production
2000	100.0	100.0	100.0
2001	96.3	97.5	121.0
2002	89.5	86.9	136.9
2003	87.3	88.1	128.1
2004	82.5	78.9	122.0
2005	84.1	94.0	101.0
2006	82.0	102.4	91.8
2007	84.7	110.9	92.0
2008	77.5	110.4	98.2
2009	81.7	116.0	97.9
Average (%)	**-2.1**	**2.1**	**0.4**

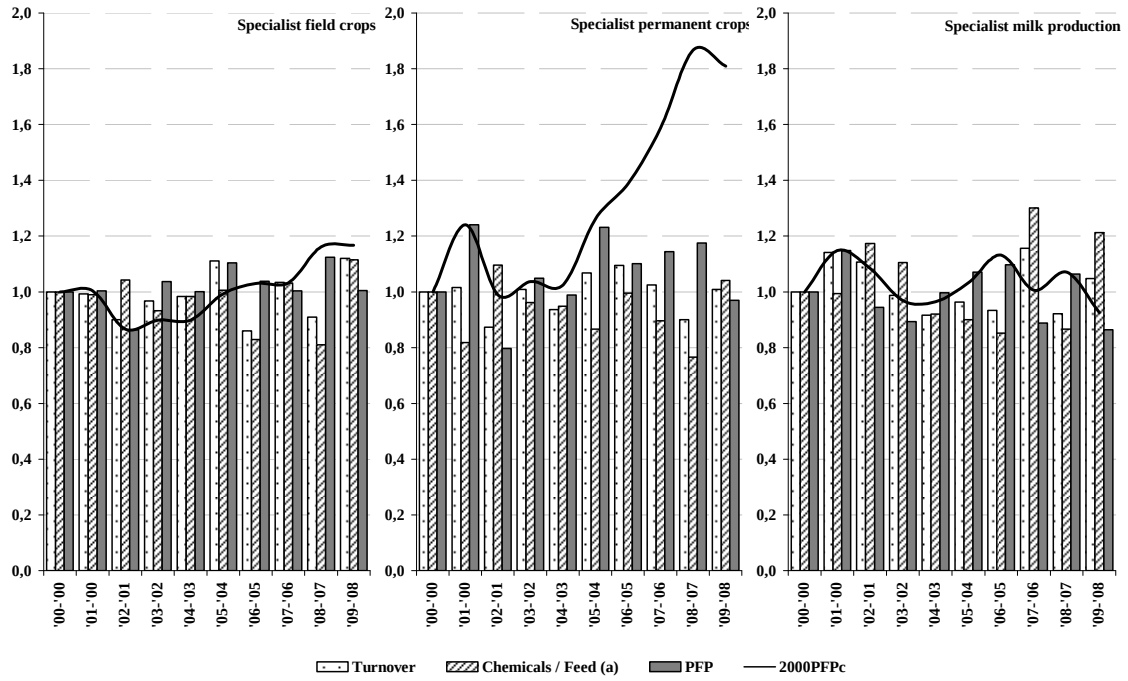

Figure 2. PFP, Output, Input

Note:
(a) = Volume index of chemical in the cases of specialist field crop and permanent crop; Volume index of feed for specialist milk production.

Table 5. Chained PFP growth rates (%)

Years	Specialist field crop	Specialist permanent crop	Specialist milk production
2000	100.0	100.0	100.0
2001	100.4	124.1	114.8
2002	86.7	98.8	108.4
2003	89.9	103.6	96.8
2004	89.9	102.4	96.5
2005	99.2	126.2	103.2
2006	103.1	138.9	113.3
2007	103.4	158.8	100.6
2008	116.1	186.7	107.0
2009	116.7	181.0	92.5
Average (%)	2.0	7.7	-0.4

4. Final remarks

The analysis highlights a varied ability of the productive system which has been considered to turn inputs into the outputs. In the case of the specialist field crops, the productivity tends to decrease, blemishing the sustainability of this productive system. The analysis of the productivity related to the chemical inputs, compared to the total productivity, is characterised by an opposite pattern. A joint analysis of the two indices, suggests that the technical and/or a scale inefficiency is linked to the use of other factors of the production which are not the chemical input.

In the case of specialist permanent crops, after an initial first period characterized by an inability to turn the resources used into adequate quantities in the output, there are progressive rises registered in the following productivity. By examining in detail the volume index of the outputs and the inputs, the negative performance of the initial period seems to be induced above all by the low volumes of output obtained. Exogenous factors like seasonal changes and adverse climatic conditions could have influenced the performance of the system.

The specialist milk production displays an opposite situation. After an initial first period in which there is a good trend of the productive system, the performance progressively goes down only to be inverted in the final years.

What is drawn from the analysis is how the TFP is certainly an effective way to evaluate the productivity of the system. Bearing in mind that the present work is only an initial phase of the analysis on the productivity and the sustainability of the agricultural productive systems in Emilia-Romagna, the TFP allows for a very interesting initial screening of the phenomena observed. The use of other indices and other ways of evaluating the productivity could however reveal useful tools for reading the situation of the same phenomena. The availability of information on the costs and quantity of the input and output, also through specific studies for each observed situation, could certainly allow for calculations for other volume indices more adapt to the study of the TFP. The use of measuring tools of the productivity like the DEA or the SFA, would however allow for an in depth analysis of determinants of the productivity.

5. Limitations and future research

Even if the results of the research are certainly very interesting, we need to highlight certain critical aspects of the study.

The first aspect is linked to the incapability to have a constant group of farms for such a long time-span like those that were analysed. The decision to consider only those farms present in a consecutive two-year period, is a type of “go between” in regards solving this limitation. What we need to bear in mind is how this decision implicates important matters such as the criteria of choice and the application of the index of prices and the interpretation of the obtained results. With regards to the first aspect, the decision to use a price index at a chain base is to adapt in respect to the standard criteria of the calculation of the TFP and in allowance for the available data. A reading into the development of the TFP and the PFP, taking in mind these aspects, clearly reveals a challenge as regards the interpretation. What also needs to be considered is that the group of farms which were constant over the two-year period, tend to be very close to the natural turnover of farms within the regional agriculture. Thus it is possible to accept the hypothesis that the group of farms, although not constant, may be considered very close to such a situation. In this case the linking of the volume index of the output and that of the input, gives results which are close to that of the index volume of Paasche, from a fixed base obtained with constant sample. Therefore, it is possible to get a clear indicator of the TFP and the PFP at a fixed base which was very handy for a dynamic reading of the productivity of the factors used in each of the three productive systems.

A further innate aspect of the use of the TFP index is the limited capability to diagnose the causes of the productivity and of the sustainability of the productive system. The TFP, in fact, is not able to probe the effects by the eventual technological changes in the productivity which happened during the years. Finally, a study should be done on the technical efficiencies, on the technological changes and efficiency on a scale of the principal components of the productivity. In this sense the use of the DEA and the SFA, reveal themselves as interesting approaches of analysis to further research of the results obtained in their attempts to tackle the causes of the level of productivity.

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