DEVELOPMENT OF PRODUCTIVITY OF DAIRY AND PIG FARMS IN GERMANY

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Abstract

The development and change of productivity, as well as of its influencing factors, is of interest in economic research. In this paper we analyse the development of productivity in dairy and pig farms in Germany. Balanced farm panels are selected from the German national FADN. As productivity measure we use the Färe-Primont Index proposed by O'Donnell. Results shows an increase of Total Factor Productivity (TFP) of 1% p.y. of dairy farms, a rather constant TFP level of pig fattening farms and decreasing TFP of farms specialized in piglet production. Due to cyclical pig prices the variation of TFP is rather high in pig farms. Significant scale effects are identified with highest TFP levels of large sized farms. The variation of income in time is much more pronounced than of TFP, which might partially be determined by the rather high aggregation of output and input variables used for FP calculations.

Keywords: Total Factor Productivity, dairy and pig farms, Farm Accountancy Data Network

1. Introduction

The development and change of productivity, as well as its influencing factors, is of interest in economic research. Analysis can be undertaken at the global, sector or micro level. An assessment of productivity changes at the micro level is one of the activities of the OECD 'Network on Farm Level Analyses'. To get own experiences in this area, we used a free software package of CEPA[1] which allows the calculation of Total Factor Productivity (TFP) indexes, i.e., Laspeyres, Paasche, Fischer, Lowe, Malmquist, Hicks-Moorsteen, and the Färe-Primont Index. However, the free-of charge version is limited to the calculation of the last mentioned tree indexes.

In this study we use this programme for productivity analysis for balanced samples of

- dairy farms in the north of Germany (Kleinhanss, 2012a) ,
- farms specialized in pig fattening or piglet production in Germany (Kleinhanss, 2012b).

In addition to global productivity development, the question is how productivity is influenced by the huge variation of output and input prices. A further question is whether or not productivity estimates are similar with, e.g., income indicators. Method and data is briefly described in the following. In a further step results of productivity estimates are discussed and finally compared with income indicators.

2. Methods and data

The estimation methods for productive indexes can be categorized into parametric and non-parametric methods (Grilliches, 1996). 'The former involves econometric modelling of a production function and often uses regression techniques to estimate the relationships between total outputs and major types of inputs, … The residual of these regressions can be used as a measure

[1] Centre of Efficiency and Productivity Analysis, School of Economics, University of Queensland (AU).

of total factor productivity' (Zhao et al., 2012). An example is the analysis of TFP between organic and conventional farms in Germany based on Stochastic Frontier Analysis (Tiedemann and Latacz-Lohmann, 2011). The so-called index methods – Laspeyres, Paasche, Fischer, Tornqvist – as well as Data Envelopment-based Malmquist, Lowe, Hicks-Moorsteen, Färe-Primont – are non-parametric methods.

The Fischer Index is recommended by Zhao et al (2012). It is a combination of the square root of the product of the Laspeyres and Paasche Index. Diewert (1992) shows that the 'Fischer Index is exact for a quadratic cost function'… 'while the 'Tornqvist index is exact for a Translog cost function'. With regard to data requirements, a further advantage is that the Fischer index can work with missing or negative values and is therefore more appropriate for individual farm data. Analyses for US Agriculture based on the Fischer index were realised by Ball et al. (2010).

Referring to the Lowe and Färe-Primont indexes, O'Donnell (2012a) argues that they 'are economically-ideal in the sense that they satisfy all economically-relevant axioms and tests from index number theory, including an identity axiom and a transitivity test. This means they can be used to make reliable multi-temporal (i.e., many period) and/or multi-lateral (i.e., many firm) comparisons of TFP and efficiency'. A further advantage of the Lowe and Färe-Primont Index is that prices for input and output are not required, and shadow prices derived from the Linear Programming solution are used instead. Especially input prices are often lacking at the farm level. An application of the Lowe index for US agriculture at State level was realised by O'Donnell (2012b).

As the Lowe index can only be calculated with the professional version, we focus on the Färe-Primont index, which can be calculated with the free-of charge version of DPIN (O'Donnell 2011). Although shadow prices cannot be listed by the free-of-charge version, they are internally calculated.

The Färe-Primont index proposed by O'Donnell (2012a) is composed of two indexes developed by Färe and Primont (1995):

$$TFP_{hs,it} = \frac{D_O(x_0, q_{it}, t_0)}{D_O(x_0, q_{hs}, t_0)} \frac{D_I(x_{hs}, q_0, t_0)}{D_I(x_{it}, q_0, t_0)}$$

The Färe-Primont index is calculated referring to a reference farm (to be determined) in the 1st period. To identify a reference farm we use the following procedure. In a 1st run we calculate TFP for all farms referring to Farm i. Then we calculate the mean TFP of the 1st period over all farms. Next we select a new reference (Ref) farm with a TFP closest to mean TFP in period 1. In the 2nd run we use farm (Ref) as reference farm; therefore TFP's of all other farms and periods are referring to Ref.

Farm data are taken from the German national FADN (Farm Accountancy Network).[2] Balanced samples of farms were selected with no-missing data of each input and output used. The sample of **dairy farms** includes 170 dairy farms for 15 periods (1996/97 – 2010/11); farms are located in the north of Germany (Lower Saxony and Schleswig Holstein). Only farms with more than 30 dairy cows in 2009/10 and with milk production in each period are included. For the model we used a rather aggregated set of variables;

- 3 outputs: milk (€), other returns (€), subsidies (€)
- 5 inputs: variable input of crop production (€), livestock (€), other costs (€, excl. land rentals and hired labour costs); UAA (ha), AWU

[2] BMELV-Testbetriebe.

For further differentiation of results we use three size classes (dairy cows): 1: 30-60; 2: 60-100; 3: > 100.

For pig production we distinguished between farms specialised in **fattening** or **piglet production**, covering the period 2000/1 to 2010/11. The balanced panel of fattening farms includes 364 farms, those with piglets 195 farms. Results were stratified wrt average pig livestock units (LU) over the whole period: < 50; 50-100; 100-150 and > 150. For the model we use an aggregated set of variables;

- 2 outputs: Pigs (€), other returns including subsidies (€)
- 5 inputs: variable costs livestock production (€); variable costs crops (€); other variable costs (€, excl. land rentals and hired labour costs); land (UAA ha); labour (AWU)

3. Results

In this chapter we show first results for one farm taken as example. Then we describe changes of productivity for groups of individual farms as well as the variation by farm size. Lastly, we compare these results with the development of income usually taken as main indicator for economic performance.

3.1. Development of productivity of dairy farms

Figure 1 shows the development (change) of productivity (dTFP) over the 15 year period, taking 1996/97 as reference. TFP is rather constant in the first three years, then moves down to 0.89 in 2000/01, which might be an effect of the BSE crisis. It moved up to around 1.17 in 2001/02 and 2004/5 to 2007/8. Periods with negative productivity change (< 1) were in 2002/3 and the following year, as well in 2008/9. The highest level was reached in 2010/11. Therefore productivity increased by 0.37 during this 15-year period. Change of this index is the result of change of aggregated output referring to aggregated input. Under condition of existing milk quota system a high level of aggregated output is a sign for rather high milk prices.

Beside TFP, the model also calculates other indicators, of which only changes in technical efficiency (dTech), changes in output-oriented technical efficiency (dOTE) and changes in output-oriented scale mix efficiency (dOSME) are shown. dOTE is less than 1 in the first periods indicating a low output-oriented efficiency change. Development of dOTE and dOSME is close to dTFP, but with time lags and reaching lower levels in 2010/11.

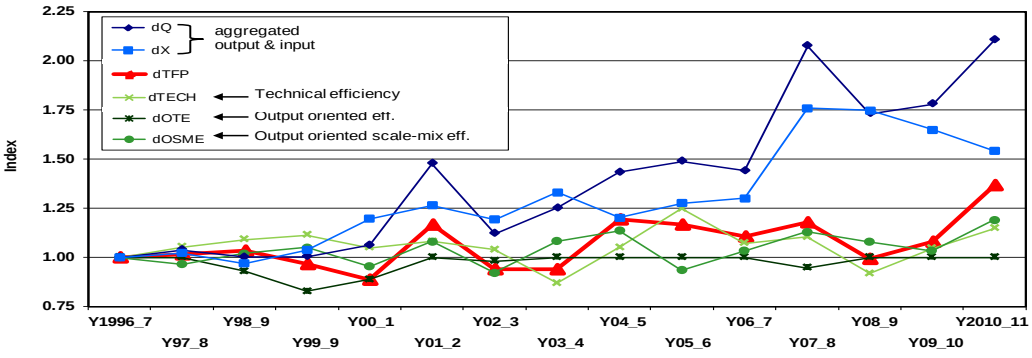

Figure 1. Level and decomposition of productivity of one dairy farm
Source: own calculations based on BMELV-Testbetriebe

Development and variation of TFP over the whole period is shown in Figure 2. The box plot shows the Median and variation (50% of farms between 1st and 3rd Quantile, as well as minimum and maximum TFP's.[3] TFP successively increased until 2000/01, followed by a period of lower productivity until 2006/07. Highest TFP was reached in 2007/8 due to favourable price levels especially for milk. In 2008/09 – due to lower milk prices – TFP was even lower than in the first period. TFP moved up in 2010/11 to almost the same level as in 2007/8. There is a high variation of TFP ranging from 0.65 to 1.3/1.6. Farm ID's indicates that some farms, such as ID = 151 and ID = 166, stay at a high performance level for several years.

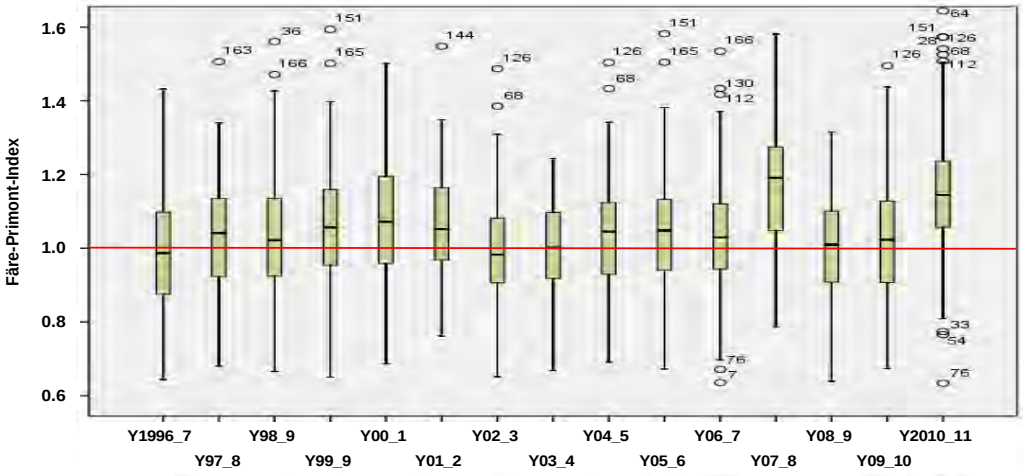

Figure 2. Development and variation of Färe-Primont index of dairy farms
Source: own calculations based on BMELV-Testbetriebe

Figure 3 shows the development of TFP for all dairy farms in the sample and by size classes. Average TFP increased from 1 to 1.08 in 2000/1 and went down to 0.98 in the following 2 years. It stayed at a level of 1.04 until 2007/8, the period when the milk market reform, resulting in lower milk prices, was implemented. TFP significantly increased in 2007/8 by one third to 1.18 thanks to rising milk prices. In the following year TFP decreased to 1 due to the milk price crisis with the lowest milk prices since the existence of the Common Market of the EU. In the last year of the underlying period, TFP increased again to 1.15, which is almost the same level as 3 years before.

Although the smallest farms are not included in the sample, significant differences of TFP exist between farm sizes. Farms with 30-60 dairy cows show TFP of about 0.05 less than average. TFP of size class 50-100 is about 0.02 higher than the average. The largest farms (> 100 dairy cows) show 0.05 to 0.08 higher TFP than the average. They reach the highest TFP of 1.25 in 2007/8. It's interesting to see that TFP in the year of milk price crisis was almost 1 for all size classes, whilst under favourable economic conditions the spread is about 0.1 in favour of large farms. Relative changes of TFP from 1996/7 to 2010/11 are almost the same for all size classes.

[3] Minimum and maximum values are defined by 1.5 times of the distance of the box (representing 50% of observations. Outliers are defined by the distance between 1.5 to 3 times of the distance of the box; greater than 3 times of the distance of the box are defined as extreme values.

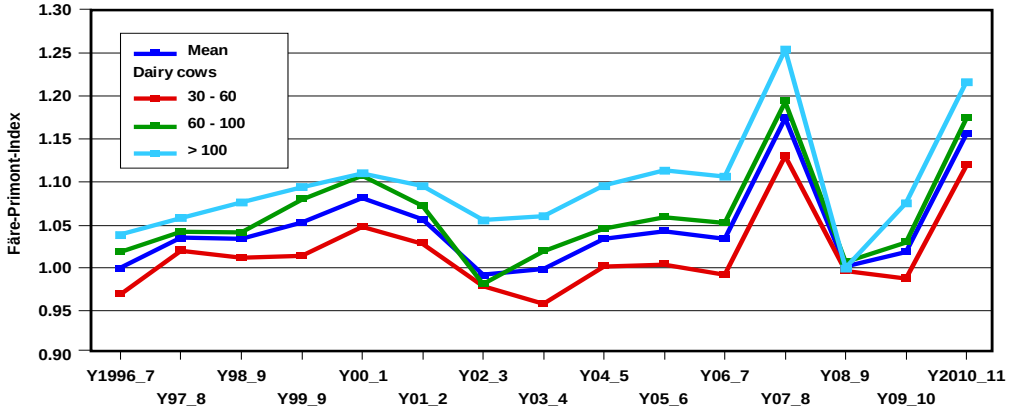

Figure 3. Development of TFP by size of dairy farms
Source: own calculations based on BMELV-Testbetriebe

3.2. Productivity change in specialized pig farms

As will be shown later, the income development of pig farms is largely influenced by pig price cycles. In the last few years it has been further influenced by rising feed costs inducing price pressure especially for piglets. While income development was similar in pig fattening and piglet production until 2006/7, it became rather unfavourable in piglet production. In the following, TFP results are differentiated between farms specialized in pig fattening or piglet production.

Figure 4 shows the development and variation of TFP in farms specialised in **pig fattening.** In the first year, 50% of farms reach TFP levels between 0.94 and 1.07. TFP levels decreased in the following three years and then increased to almost 1.0 on average in 2004/5, 2007/8 and 2010/11. In the interim years, TFP was around 0.95. Referring to the beginning and ending year, there is almost no increase of TFP. The spread of TFP for 50% of farms (box) is almost the same over the years. However there is a large variation from about 0.75 to 1.3 indicated by the vertical bars. Also, many individual coef-

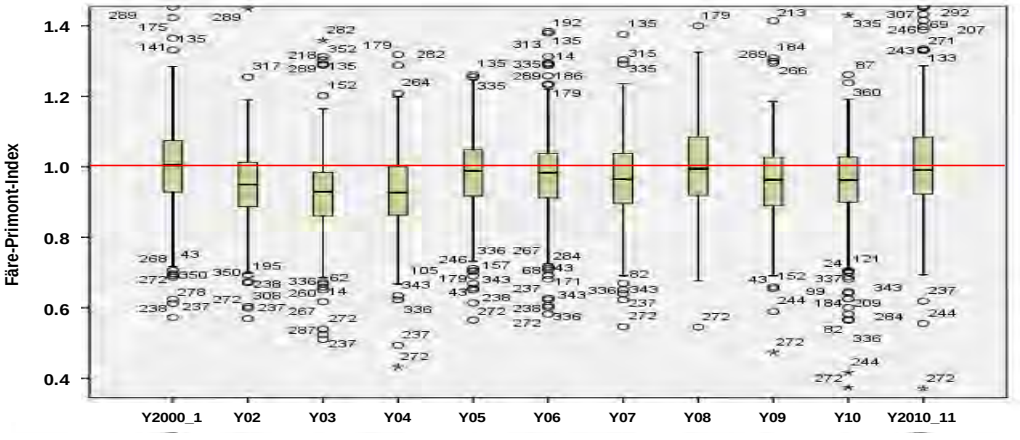

Figure 4. Development and variation of TFP of farms with pig fattening
Source: own calculations based on BMELV-Testbetriebe

ficients are shown, indicating high TFP's in the upper part and low TFPs in the lower part of the figure. Some farms stay in the same category, i.e., ID = 272 with very low TFP and ID = 292 with a high TFP.

TFP of farms specialised in **piglet production** is shown in Figure 5. The figure shows a cyclic development of TFP of about 3 to 4 years. It reached its highest level in 2000/1, and then decreased to 0.83 in 2002/3 to 2003/4. It increased again in 0.95 in 2004/5, went down until 2006/7 and fell to the lowest level in 2007/8. On top of the pig price cycle, high price of feed induced this low level of TFP. In 2008/9 TFP raised again to 0.95 and dropped to 0.9 until 2010/11. Therefore TFP decreased by 1% p.a. Variation of TFP is about 0.2 for 50% of farms; it is rather stable in time. The variation between min and max TFP values is rather high and shows a cyclical development, as well.

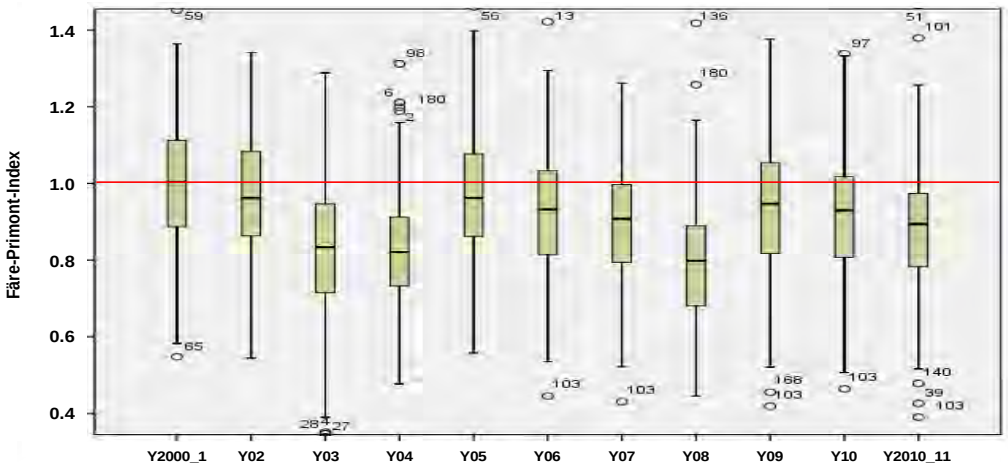

Figure 5. Development and variation of TFP of farms with piglet production
Source: Own calculations based on BMELV-Testbetriebe

Figure 6 shows average TFP for both samples as well as by size classes, expressed in pig livestock units (LU). Average TFP of **fattening** farms is rather constant; it is close to 1 in the beginning, middle and end of the underlying period. It decreased to 0.92 in 2002/3 and the succeeding year and to 0.95 in 2008/9 and 2009/10. Small farms show TFP levels between 0.8 and 0.9. Farms with 50 to 100 LU show TFP levels of about 0.05 less than average. TFP for farms with 100 to 150 LU is close to average, while those of the largest farms is about 0.03 higher.

Development of TFP in **piglet production** is more cyclic than in pig fattening with levels of only 0.8 in 2002/3 and 2007/8. Even at the end of the period, TFP is only 0.9, indicating a decrease of TFP. Small farms show low TFP levels of about 0.85 at the beginning, 0.75 in 2002/3 and 2007/8 and of around 0.8 in the remaining years. TFP of size class 50-100 LU is slightly below average and those of size class 100-150 LU 0.05 above average. The group of largest farms show TFP of 1.12 at the beginning and of about 1.05 in 4 other years. It dropped to about 0.85 in 2002/3 and 2007/8. It is worth mentioning that the spread of TFP between large and small farms became rather small in the bottom of a cycle while it exceeds up to 0.3 under favourable economic conditions.

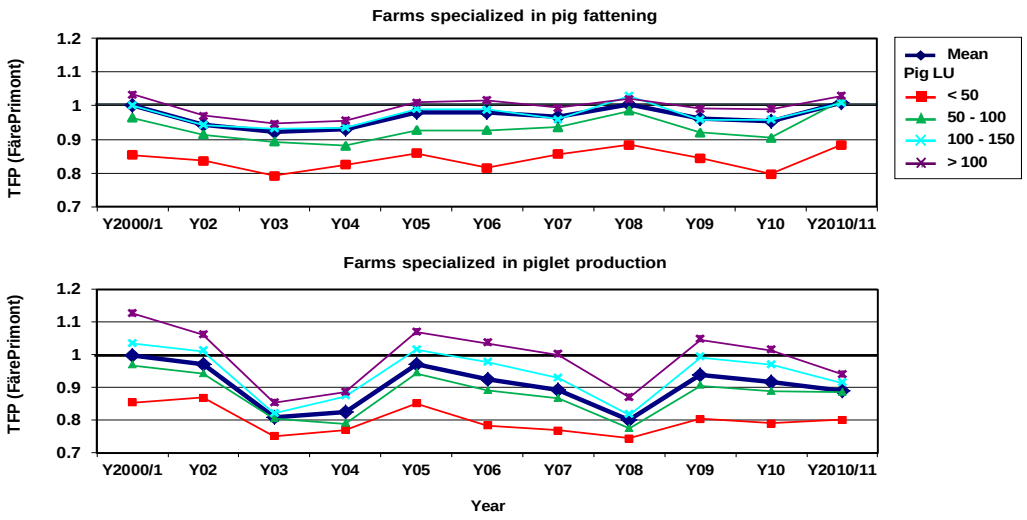

Figure 6. TFP of farms specialized in fattening/piglet production by farm size (LU-pigs)
Source: Own calculations based on BMELV-Testbetriebe

3.3. Comparison of TFP and income

In the following we compare development of TFP with income. Family Farm Income (FFI) expressed in € per farm is used as income indicator.

The development of average TFP and FFI for **dairy farms** relative to the base year (= 100) is shown in Figure 7. As already mentioned, changes of TFP are rather low; in most of the years it is close to 1 and only in 2007/8 and 2010/11 does it move up to around 120. The development of FFI is more significant; it increases to 150 in 2000/1, and then goes down to near 100 in 2003/4 and the succeeding year. In 2007/8 it switches to its highest level of 270. In the year of crisis (2008/9) it fell again close to 100. It recovers to 230 in 2010/11.

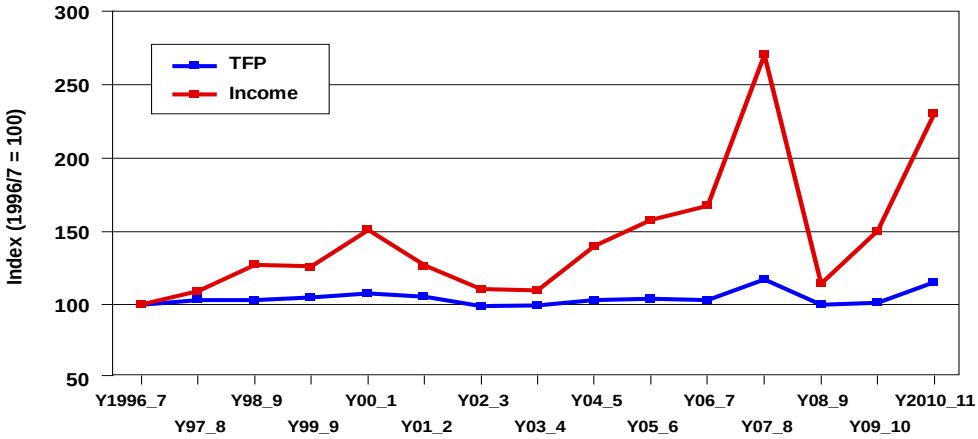

Figure 7. Comparing the development of TFP and income (FFI) dairy farms
Source: Own calculations based on BMELV-Testbetriebe

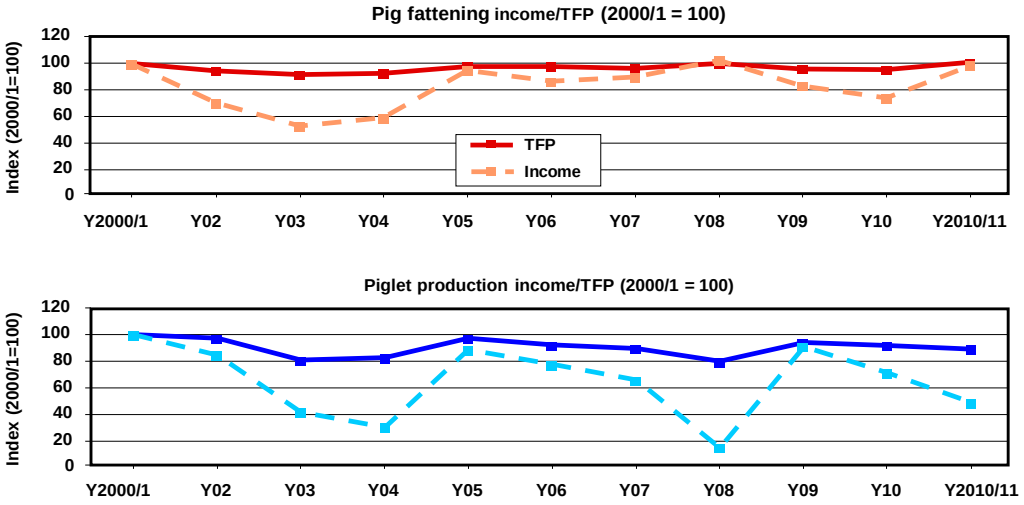

Figure 8. Comparing the development of TFP and income (FFI) of pig farms
Source: Own calculations based on BMELV-Testbetriebe

The development of average TFP for pig fattening farms (Figure 8) is rather continuous, even under worse economic conditions TFP index is only 5% lower. Variation of income is more pronounced; it was 40% less in 2002/3 and 25% less in 2009/10. TFP of specialized piglet farms show higher periodic variation and a decreasing trend of TFP. Income variation is extremely high; it reached only 35% of first period in 2003/4 and less than 20% in 2007/8. After recovering in 2008/9 it halved again in 2010/11.

Based on these results it can be concluded that TFP estimates show much lower variation than the development of income. One reason is that TFP estimates are based on a rather aggregated set of output and input variables; not all variables influencing income are included.

4. Conclusions

This paper is a first step in analysing the development of TFP at the micro level. It is based on balanced samples of dairy and pig farms in Germany. Both sectors are of interest due the high variation of prices and other determinants of income. For the TFP calculations we used a free of charge program. It has the advantage that prices of physical factors are internally derived from shadow prices of the Linear Programming model.

The calculation shows a rather low increase if TFP of dairy farms of about 1% p.a. It is largely determined by milk price development. TFP in small farms is significantly lower than in large farms. The variation of income is much more pronounced between size classes in years of high milk prices.

TFP is rather stable for farms specialized in pig fattening; it shows a higher variation and decrease of 1% p.a. in piglet production. Variation of income is much higher in pig fattening (40% less than average in the years 2002/3); it is extremely high in piglet production with around 80% lower incomes in two periods. In the year 2007/8 incomes fell by 80% while in pig fattening incomes increased slightly to a long term trend. This situation is influenced by changes in the market power of fattening farms against piglet producer: rising feed costs were entirely compensated by lower piglet prices, but also due to competition with piglet imports from Denmark and The Netherlands which considerably increased at the same time.

5. References

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