

Labour productivity, technical efficiency and profitability in French ruminant production systems: evolution 1988-2016

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Abstract: The evolution of factor and animal productivity in French professional ruminant farms was studied using data from FADN-France. The theory of price indices made it possible to separate the evolution of economic values (output and inputs) over the period 1988-2016 into volume change and price change. This enabled to calculate the evolution of partial factor productivity and the efficiency of production systems, facing the evolution of ruminant farmers' income and return on capital. Ruminants' farmers increased their labour productivity (more productions with less workers) by using more intermediate consumption (feed, fuel, contractor, services) and equipment per unit of agricultural products produced. We observed a slight increase in animal productivity for dairy and small ruminant farmers, thus the technical efficiency of these types of farming remained stable. The animal productivity tended to decrease for beef farmers, the technical efficiency decreased. Despite the increase in the labour productivity, the farm income per worker remained stable for dairy and beef cattle farms. The small ruminants' farms' income increased due to favourable CAP since 2010. These types of farming engaged, in 2016, 30 to 70% more capital than in 1988, produced twice more per farm holder, for an almost identical income expectation. The concept of labour productivity was the main driver of the development model of French livestock farms, a driver that seemed to be opposed to the agro-ecological transition given the decline (or not increase) in the technical efficiency of production systems.

Keywords: factor productivity, livestock production, economics, labour

Acknowledgements: The authors acknowledge financial support from the Centre for Studies and Strategic Foresight (CEP) of the French Ministry of Agriculture in the frame of research project Agr'Income ('Heterogeneity, drivers and trends in the income of French farmers').

Introduction

Factor productivity has always been seen as the main driver of economic growth (Kendrick & Sato, 1963) and competitiveness (Ball *et al.*, 2010). Productivity gains made by agriculture, which outstripped practically every other sector of the French economy over the last six decades, have enabled declining farm production costs and declining farm commodity prices (Charroin *et al.*, 2012). French agricultural production increased by a factor of 2.2 in volume between 1955 and 2010, thanks to the specialisation of farms, and to the ever-increasing use of inputs, equipment and capital, while the share of the agricultural labour force collapsed from 31% to 3.4% of the total French labour force. Herbivores farming is an important part of the French agricultural output and account, in 2018, for 22.5% of the total gross agricultural output economic value. In response to market and policy developments, French cattle and sheep farmers have constantly restructured, adapted and improved their labour productivity in order to preserve their income (Veysset *et al.*, 2014a). The increase in farm sizes – and consequently herd sizes – with less workers has made work organization a central concern for livestock farmers (Madelrieux and Dedieu, 2008). Most livestock farmers tend to address these work organization problems by simplifying farm management practices, this essentially means simplifying feed and herd reproductive management (Aubron *et al.*, 2016; Hostiou and Fagon, 2012). Between structural expansion, herd management simplification, use of inputs and equipment, the technical efficiency of the production system and the economic sustainability are questioned (Lebacqz *et al.*, 2014).

In this study we will focus on French ruminants (dairy cattle, beef cattle and small ruminants) farms. The objective is to analyse the co-evolution of the structures (labour, size) of these farms, the partial and total factor productivity, the technical efficiency and the net farm income over a 28-years period (1988-2016). After presenting the database used, we start by detailing the methodology choices adopted and the way we calculate factors productivities and technical efficiency. We then present the results over the period for each ruminant sector. We go on to discuss the results observed and we conclude.

Method

Database: Farm Accountancy Data Network (FADN)

The FADN is an EU-wide harmonized network that sources and publishes statistics on farming business accounts, revenues and economics since 1968 (European Commission, 2019). FADN-France is representative of the French population of what are termed “commercial” farms. A commercial farm is defined as a farm which is large enough to provide a main activity for the farmer and a level of income sufficient to support his or her family. In practical terms, in order to be classified as commercial, a farm must exceed a minimum economic size, measured by the total Standard Output (SO) of the holding. Farms in the FADN-scope field of survey are classed under a typology scheme based on their type of farming (TF). Types of farming are defined in terms of the relative importance of the different enterprises on the farm (proportion of each enterprise's SO to the farms' total SO). To be classified as specialized farm, the SO from the main product must contribute more than 2/3 of the total farm's SO. The structural characteristics and the average annual economic results for the years 1988 to 2016 of all type of farming are public and available on the statistics website of the Ministry of Agriculture (Agreste, 2019). We will focus our study on three types of farming over this period 1988-2016: dairy cattle (TF45), beef cattle (TF46) and small ruminants (TF48). TF48 included all small ruminants farming system that is to say dairy sheep, meat sheep and goats.

FADN provided structural indicators about farms size (agriculture area, UAA in ha), herd size (number of cows, ewes and livestock units, LUs) and work force available on the farms (expressed in annual work units, AWUs). The annual economic value of all agricultural products were detailed per type or products: plant products (cereals, oilseeds, maize, industrial crops, etc.), animals (bovine, sheep, goats, pigs, poultry, etc.), animal products (milk, eggs), aids and subsidies. All the costs were also detailed per type: intermediate consumption, *i.e.* goods and services consumed as inputs by the process of production (feed, fertilisers, seeds, energy, veterinary, consultancy and overheads etc.), depreciation costs (buildings, machinery, equipment), financial costs. The FADN standard results provided income and capital indicators.

Factors productivity and technical efficiency

To produce agricultural outputs, a farm have to engage and to use factors of production. These factors of production are the labour, the land, the intermediate consumption, the fixed capital (machinery, equipment, buildings or other structures) and financial resources (Ball *et al.*, 1997). The factors productivity measures the amount of factors of production used per unit of output, *i.e.* the ratio of output to an input (Latruffe, 2010). The productivity is thus the capacity of production factors to produce goods and services, this definition can be connected to the concept of efficiency (Veysset *et al.*, 2015). High productivity (high volume of a good produced for a low amount of input consumed) can be considered as high efficiency of this input.

The partial factor productivity (PFP) of a given factor i is the ratio of amounts Y_j of all the outputs j on the amount X_i of input i .

$$\text{Partial Factor } i \text{ Productivity } PFP_i = \frac{\sum_{j=1}^j Y_j}{X_i}$$

Technical efficiency (TEf) will be evaluated through the productivity of variable factors used; the variable factors (or resources used) are intermediate consumptions (IC) plus fixed capital consumed (FCC), and the output is gross farm output.

$$\text{Technical Efficiency } TEf = \frac{\sum_{j=1}^j Y_j}{\sum_{k=1}^k IC_k + \sum_{l=1}^l FCC_k}$$

IC_k = amounts the intermediate consumption k

FCC_l = amounts consumed of the fixed capital l

The measure of factors productivity and technical system efficiency thus had to aggregate the volume of all output produced on the farm (meat, cereal crops, etc.) and the various production factors (fertilizers, feeds, fuel, services, equipment and building depreciation etc.). FADN provided the annual economic value of each output and input, that is the result of the product of a volume by a unit price. This economic value of each output or input must therefore be broken down into volumes and unit prices (Butault *et al.*, 1995). This breakdown is not easy for a given year, but year-to-year evolutions in volumes can be assessed if we know the respective price index of each input/output against a base-year point of reference. By weighting each output and input by its respective annual price index to correct for pure price effects, year-on-year evolutions in the economic value at constant price mirror the evolutions of volumes of output produced and input consumed. This allowed us to assess not the productivity of farms for one year, but the productivity gains between two years. A farm that has improved its productivity over a given period will be called more efficient.

Price indices (Eurostat, 2019)

The index of producer prices of agricultural products (PPAPI) was designed as a metric of changes in prices paid to farmers. Eurostat published the updated index (Eurostat, 2019). The base year we used is 2010, PPAPI 2010=100. The annual values of each FADN-surveyed agricultural product farmed under TF45, TF46 and TF48 (cereal crops, industrial crops, other crop products, product from cattle, sheep, pigs, poultry, milk, other animal products, other products) have been reweighted with their own PPAPI where clearly identified (cereal crops, product from cattle, sheep, pigs, poultry, milk). The “other products” subaggregate, which accounts for 1%–5% of annual agricultural product, has been reweighted with the general commodity index excluding fruit and vegetables.

Eurostat also provided the index of purchase prices of the means of agricultural production (PPMAPI). The PPMAPI covers nine investment and intermediate consumption expenditures (seed, fertilizer and soil amendments, veterinary supplies, pest control products, cattle feed, light tools, energy, equipment assets, consultancy and overheads). We also used 2010 as the base year, PPMAPI 2010=100. In the same way as for agricultural products, the annual mean values of each expenditure in the FADN-surveyed sample were reweighted with their own respective PPMAPI. Non-PPMAPI-aggregated expenditures were aggregated with other known PPMAPI expenditures (for example, artificial insemination are aggregated with veterinary expenditures).

Variables and indicators analysed

Indicators provided by FADN make it possible to observe the evolution of the average farms size per type of farming as well as the working collective. After having weighted the agricultural products and the different inputs by their respective price index, we calculate partial factor productivity, as well as some animal productivity indicators (Table 1). Among intermediate consumption, fertilizers, feed, mechanization (fuel, machinery maintenance, and contractor) and various services (fees, advice, electricity, etc.) were the main items, accounting for 80% of this intermediate consumption. All these variables are presented on evolution over the whole period (1988-2016), and the average annual growth rate is given.

Indicators	Calculation
Labour productivity	Agricultural output (euros PPAPI deflated) / AWU ¹
Land productivity	Agricultural output (euros PPAPI deflated) / ha UAA ²
Intermediate consumptions productivity	Agricultural output (euros PPAPI deflated) / intermediate consumption (euros PPMAPI deflated)
Equipment productivity	Agricultural output (euros PPAPI deflated) / fixed capital consumed ³ (euros PPMAPI deflated)
Fertilizers productivity	Agricultural output (euros PPAPI deflated) / fertilizers (euros PPMAPI deflated)
Feed productivity	Livestock product (euros PPAPI deflated) / feed (euros PPMAPI deflated)
Mechanization productivity	Agricultural output (euros PPAPI deflated) / fuel + contractor + machinery maintenance (euros PPMAPI deflated)
Services productivity	Agricultural output (euros PPAPI deflated) / services (euros PPMAPI deflated)
Beef cow productivity	Bovine product (euros PPAPI deflated) / suckler cow
Dairy cow productivity	Milk product (euros PPAPI deflated) / dairy cow
Small ruminants productivity	Sheep, goats and milk product (euros PPAPI deflated) / number of sheep + goats

Table 1. Indicators of partial factor and animal productivity, calculation of these indicators. ¹ Annual work unit; ² Useable agricultural area; ³ Fixed capital consumed being assessed by the depreciation costs of the capital;

The profitability of the farms was assessed by the net farm income. The return on capital (excluding land) was assessed by the ratio gross farm income to assets excluding land with:

Gross farm income

$$= \text{gross farm output} + \text{subsidies} - \text{intermediate consumption} - \text{rent paid} - \text{wage paid}$$

Net farm income = *gross farm income* – *depreciation* – *interest paid*

Results

Evolution of the structures

Over the 28 years (1988-2016), the usable agricultural area (UAA) has increased in the three types of farming (TF) studied (Table 2). This growth was at an average rate of 3.15%, 2.12% and 1.81% per year for dairy cattle, beef cattle and small ruminants respectively. The increase in surface area was accompanied, with almost the same growth rate, by an increase in herd size (number of livestock units, LUs) for all three types of farming. The number of workers per farm (AWU) tended to decrease for beef

cattle and small ruminants (-0.11%/year and -0.05%/year), while it increased for the dairy cattle, which had an annual UAA growth rate of over 3%. In general, the average annual growth rate of AWU was much lower than that of agricultural production in volume terms, which increased at a rate of 3.87%/year for dairy cattle, 1.97%/year for beef cattle and 2.56%/year for small ruminants.

	Dairy cattle TF45	Beef cattle TF46	Small ruminants TF48
Agricultural area (ha UAA)	+3.15	+2.12	+1.81
Total annual work units (AWU)	+0.80	-0.11	-0.05
Livestock units (LU)	+2.92	+2.03	+1.82
Agricultural output (€ PPAPI deflated)	+3.87	+1.97	+2.56

Table 2. Average annual growth rate of the structural characteristics of the three ruminant livestock types of farming (TF), in % per year, between 1988 and 2016 (FADN-France, authors' calculations).

From 1988 to 2015, the growth of the agricultural production for dairy cattle farms was continuous. We observed a slight decrease of the production in 2008-2009 and 2015, years of a milk crisis due respectively to a sharp fall of milk price and the end of milk quotas (Figure 1). While the production increased (+180% from 1988 to 2016), the number of workers per farm remained stable until 2002 (Figure 2), and then tended to slightly increase (+13% from 2002 to 2016). The increase of the agricultural production for beef cattle and small ruminant farms was lower (+61%) and started from 1995 (Figure 1). From 2010, as a response of the new common agricultural policy (CAP) in France (more aids for very low profitable productions) small ruminants farms sped up the increase of their production, while beef cattle farms maintained their same growth rate. For beef cattle farms, number of workers slightly decreased until 1994, and then remained stable over the rest of the period (Figure 2). The number of workers in small ruminants farms decreased until 2010, and then increased to reach the same level as 1988.

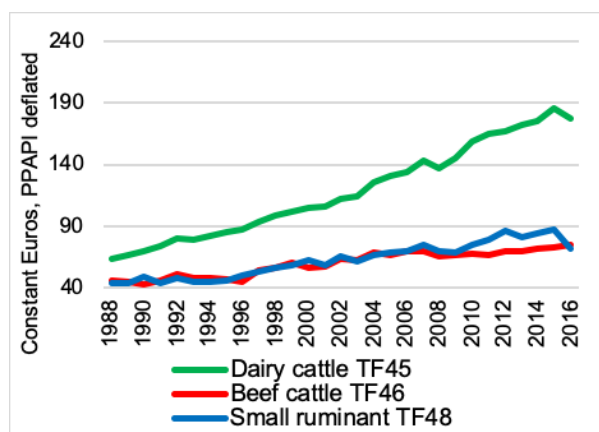


Figure 1. Evolution between 1988 and 2016 of the agricultural production, in euros deflated by index PPAPI, for the three TF for ruminant livestock (FADN-France, authors' calculations).

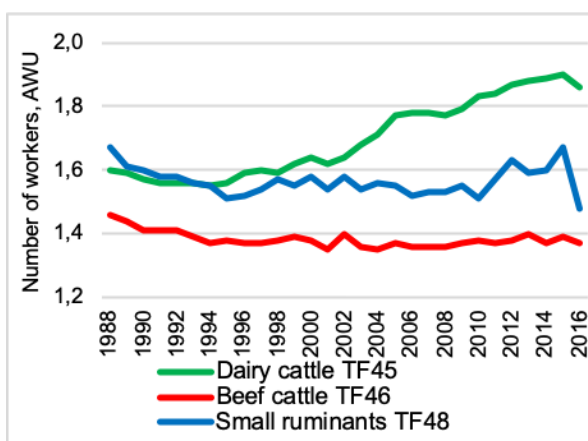


Figure 2. Evolution between 1988 and 2016 of the number of workers per farm (AWU), for the three TF for ruminant livestock (FADN-France).

Factor productivity and technical efficiency

Labour productivity for all TF increased significantly during this period (+3.07%/year for dairy cattle, +2.08%/year for beef cattle, +2.60%/year for small ruminant), while land productivity evolved much less (Table 3) with a downward trend for beef cattle (-0.15%/year). The productivity of intermediate consumption declined in beef cattle and small ruminant, and almost stagnated in dairy cattle. Due to major investments in buildings and equipment over the 28 years, not fully translated into an increase in production volumes, the productivity of equipment decreased for the two cattle TF, and increased only slightly for small ruminants. These rather downward (or at best stagnant) trends in the productivity of intermediate consumption and equipment meant that the technical efficiency of the production system declined for beef cattle and small ruminant (-0.61%/year and -0.17%/year respectively), and it increased very slightly for dairy cattle (+0.12%/year).

	Dairy cattle TF45	Beef cattle TF46	Small ruminants TF48
Labour productivity	+3.07	+2.08	+2.60
Land productivity	+0.70	-0.15	+0.74
Intermediate consumptions productivity	+0.29	-0.51	-0.28
Equipment productivity	-0.37	-0.84	+0.26
Animal productivity	+1.44	-0.23	+1.25
Fertilizers productivity	+4.19	+3.28	+3.82
Feed productivity	-0.27	-1.52	-0.83
Mechanization productivity	-0.30	-1.19	-0.64
Services productivity	-0.25	-1.19	-1.62
Technical efficiency	+0.12	-0.61	-0.17

Table 3. Average annual growth rate of partial factor productivity and technical efficiency of the three ruminant livestock types of farming (TF), in % per year, between 1988 and 2016 (FADN-France, authors' calculations).

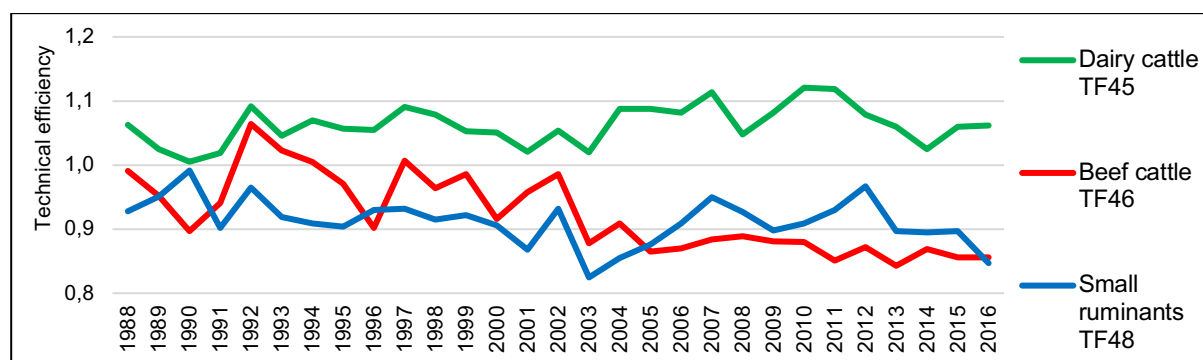


Figure 3. Evolution between 1988 and 2016 of the technical efficiency for the three ruminant livestock types of farming (TF) (FADN-France, authors' calculations).

Type of farming dairy cattle

Due to the increase in agricultural production, which is much faster than the increase in the number of workers, labour productivity increased by 2.5 over the period (Figure 4). The continuous increase in labour productivity has been possible thanks to investments in adapted buildings, automation (especially for milking) and outsourcing of certain tasks (contractor). Investments in buildings and equipment were also required to meet environmental regulations (effluent storage) in the 1990s. The volumes of equipment needed for the proper management of the growing herds grew faster than agricultural production, resulting in a slight drop in equipment productivity. The use of these equipment entailed an increase in the use of fuel and equipment maintenance, the mechanization productivity decreased by 0.30%/year. From 1988 to 2016, agricultural production volumes grew slightly faster than farm size, so there was an intensification of land use. Land productivity has increased by 20 points, particularly since the late 1990s, when investment in equipment was almost complete. The productivity of intermediate consumption remained stable. Despite the increase in land productivity, dairy farmers used much less fertilizer during the period, resulting in a sharp increase in fertilizer productivity (+4.19%/year, Table 3). On the other hand, the increase in the feed and services use was higher than the increase in animal productivity (+1.24%/year), feed and services productivity decreased. All this cumulated meant that, in 28 years, the technical efficiency of dairy production systems has not changed (Figure 3). The gains in animal productivity have been achieved through increased use of feed, mechanization, services and heavy investment. Labour has been replaced by capital and inputs, with no technical efficiency gains in the management of dairy systems. We observed that technical productivity remained above one, *i.e.* the systems produced wealth; the volume of agricultural production was always higher than that of intermediate consumption and the equipment used.

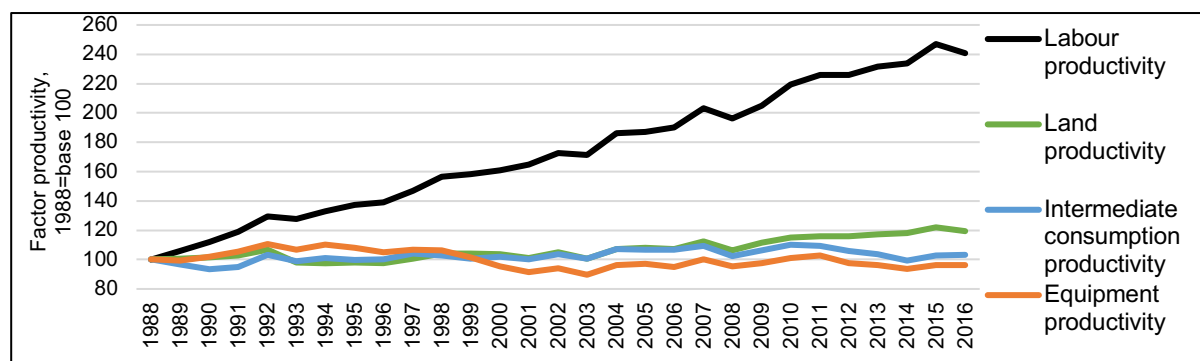


Figure 4. Evolution between 1988 and 2016 of the factor productivity for the dairy cattle (FADN-France, TF45, authors' calculations);

Type of farming beef cattle

The labour productivity of beef cattle farmers also increased strongly (x1.8, Figure 5). The increase has not been steady, this is the result of the various CAP reforms that have followed one another over the period (Veyssset *et al.*, 2014). Beef production is one of the most heavily aided agricultural productions, with aids that remained coupled to the cow and aids for extensification systems also coupled until 2006. The unit amount of these aids has changed over time as well as the conditions for granting them, encouraging farmers to increase or maintain their production depending on the period. With the incentives for extensification, land productivity declined until 1996; it increased slightly from 1996 to 2006, with a slight downward trend thereafter. In the end, land productivity lost 13 points over the period,

so the extensification incentives were successful. For the same reasons as for milk producers (labour and compliance with environmental standards), investment in equipment and buildings was very high in the 1990s, with a drop in productivity from 1992 onwards, finally losing 13 points over the period. The productivity of intermediate consumption also lost 13 points with a slow and steady decline over the period. Faced with the de-intensification of land, the use of fertilizers has fallen sharply and their productivity has increased (+3.28%/year, Table 3). Despite a lower stocking rate per hectare of agricultural land, beef cattle farmers have used more and more mechanization and feed, while animal productivity decreased (-0.23%/year). As a result, feed productivity decreased (-1.52%/year), as did the mechanization and services productivity (-1.19%/year). The consequence of the drop in the productivity of intermediate consumption and equipment was that the technical efficiency of the beef cattle systems fell over the whole period (Figure 3) and lost 14 points. The technical efficiency was less than one (equal to one in 1988), it was 0.86 in 2016. French beef producers therefore consumed more resources than they produced; the creation of wealth in this sector was negative.

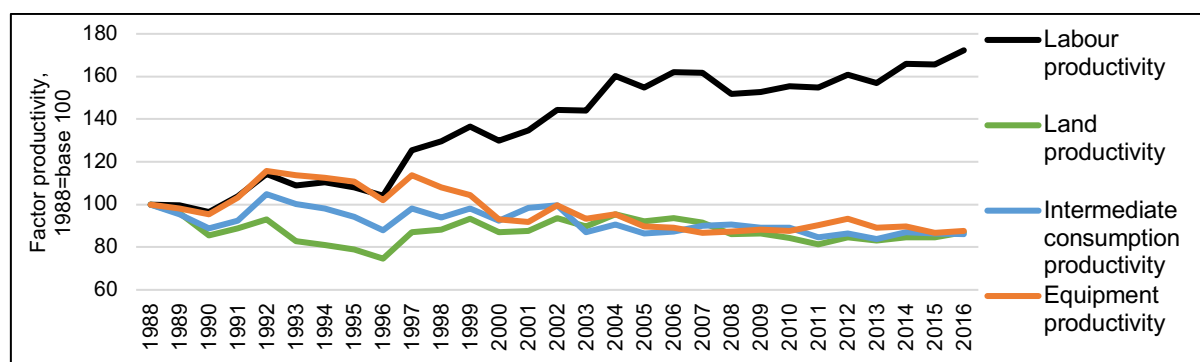


Figure 5. Evolution between 1988 and 2016 of the factor productivity for the beef cattle (FADN-France, TF46, authors' calculations);

Type of farming small ruminants

The labour productivity of small ruminants farmers increased until 2012 (x2 from 1988 to 2012, Figure 6), remained stable from 2012 to 2014 and then, tended to decrease. At the same time as labour productivity increased, small ruminant farmers have intensified their system, with land productivity increasing by 34 points from 1988 to 2011. Land productivity then dropped 30 points to the same level as in 1988. Investments were proportional to the increase in production, with equipment productivity remaining stable until 2004. Afterwards, this productivity increased until 2012, investments made in previous years allowed production to continue to increase. Then, the productivity of the equipment decreased with production, with the result that no gain was observed over the period. Over the whole period, the productivity of intermediate consumption remained stable. As with other types of livestock farming, small ruminant farmers have sharply reduced their fertilizers consumption, with fertilizers productivity increasing by 3.82%/year (Table 3). Animal productivity has increased (+1.25%/year), but less rapidly than feed, mechanization and service consumption, resulting in lower feed, mechanization and services productivity (-0.83%/year, -0.64%/year and -1.62%/year respectively). The technical efficiency tended to remain stable around 0.9 (Figure 3).

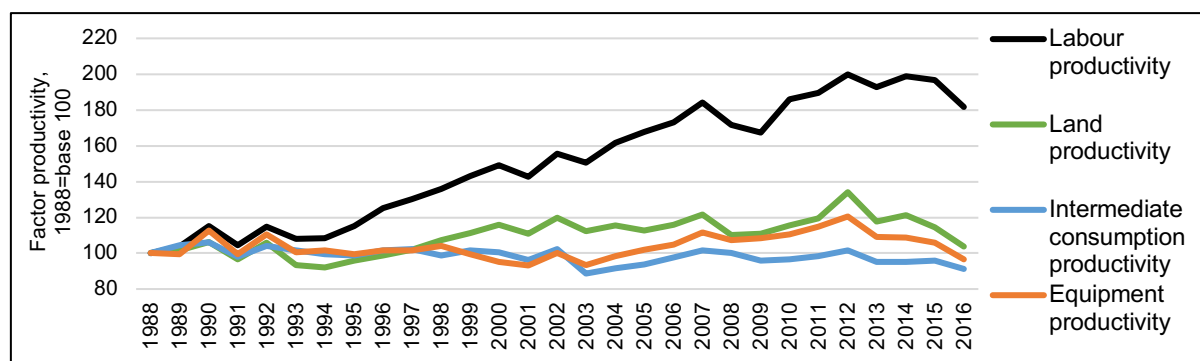


Figure 6. Evolution between 1988 and 2016 of the factor productivity for the small ruminants (FADN-France, TF48, authors' calculations).

Net farm income and capital per farm holder

Overall, net farm income per farm holder has changed very little for dairy and beef cattle farmers (Figure 7), the annual growth rates were +0.24 and +0.36%/year respectively. Incomes increased between 1988 and 1993, then remained between 22 and 23 k€ on average per year and per farm holder between 1993 and 2007. A strong crisis caused incomes to plunge in 2009, and then rose a little faster for dairy cattle to remain in the range 20-25 k€/year/worker. The income of small ruminant farmers stagnated at around 15 k€ per year, *i.e.* at a level 30% lower than that of cattle farmers, until 2009. Since the CAP reform of 2010, which favours low profitability productions, the income of these farmers has increased to reach that of cattle farmers at around 20-25 k€ per year and per farm holder.

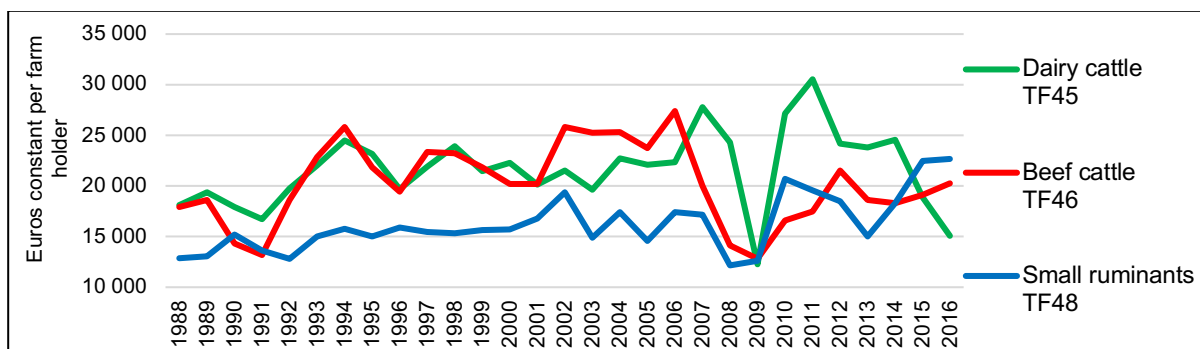


Figure 7. Evolution between 1988 and 2016 of the net farm income per farm holder of the three ruminant livestock types of farming (TF) (FADN-France).

Despite the large increase in labour productivity, income per worker have changed very little. The increase in the income of small ruminant farmers was mainly due to a more favourable CAP for them from 2010 onwards. The consequence of the increase in labour productivity, and the necessary investments made, was high capitalisation. Capital (excluding land) per farmer increased by 107%, 50% and 58% respectively for dairy, beef cattle and small ruminants farmers. In 2016, a farmer must commit 50 to 100% more capital than in 1988, for an almost identical income expectation. This capitalization can be considered as deferred income, since the farmer will benefit from it when he stops working (Jeanneaux, 2019). Beef production is the most capital intensive (assets per farm holder was 190 k€ in 1988 and 280 k€ in 2016), with the lowest return on capital (gross farm income/assets) remaining at

around 15% over the whole period. Dairy farmers have invested the most (assets per farm holder rose from 120 k€ to 250 k€), particularly in new technologies (feed automatic distributor, milking robots), but despite a positive response from animal productivity, the rate of return on capital has fallen slightly, from 22% in the late 1980s to 18% in mid-2010. Small ruminant farmers have increased their capital the least (from 115 k€ to 180 k€ per farm holder), while at the same time improving animal productivity. The return on capital for these farmers therefore improved from 20% at the beginning of the period to 22% at the end of the period.

Discussion

In ruminant farming, an increase in physical labour productivity does not necessarily equate to an increase in the main indicators of economic performance. Over the 28-year period studied, expansion and labour productivity appeared to have been the main drivers for the development of cattle and small ruminant farms. Over this long period, as shown by the high expenditure on inputs, services, buildings and equipment, there have certainly been significant genetic, technical and technological advances; moreover, research has produced new knowledge and agricultural development has produced new tools for advice and knowledge dissemination. However, the technical efficiency of livestock systems at best is stagnating. There has therefore been a substitution of labour by capital and inputs, without any overall productivity gain which may lead to higher fossil energy consumption and greenhouses gas emissions per kg of milk or meat produced (Veysset *et al.*, 2014b). Among the intermediate consumption, purchased feed was the item that had the most increased, with a decrease of their productivity for the three types of farming. This increased consumption of concentrated feed met one of the objectives of the 1992 reform of the Common Agricultural Policy (MacSharry reform) which was to promote the incorporation of cereals grown in the EU into animal feed as a substitute for the by-products of imported cereal crops. This incentive policy resulted in a sharp fall in cereal prices (-50% in constant euros between 1992 and 2005). Livestock farmers were thus able to increase the size of their herds and simplify the workload related to feeding (Aubron *et al.*, 2016) by distributing more concentrates (easy to store and distribute, and whose nutritional value is reliably known and stable).

These trends observed in the productivity of French livestock farms are also observed in the UE agriculture (European Commission, 2016). Productivity in the EU-28 has increased over time, albeit at a slower rate in recent years than in the past. When comparing the total factor productivity growth to partial productivity indicators over the longer run, it becomes clear that labour productivity growth has contributed most to productivity gains. Labour has to a large extent been substituted by capital. Capital productivity shows an overall decreasing trend, while there are no gains on intermediate consumption productivity. Technical efficiency of the whole UE-28 agricultural sector did not increase over the last 20 years.

The size increase has not produced economies of scale. There is still no consensus over the linkages between farm size and farm system efficiency. Some authors reported scale efficiencies with increasing farm size (Morrison Paul *et al.*, 2004; Mosheim and Knox Lowell, 2009) whereas others showed that the linkage was not necessarily linear and that efficiency may even fall (scale inefficiency) after a certain size threshold (Helfand and Levine, 2004). In some cases, the increase in farm size may unlock opportunities to capitalize on new techniques, technologies and practices that can improve productivity based on the concept of economies of size (Hallam, 1991). This concept of economies of size seems to have worked for dairy farms. In fact, investments in new technologies made possible by the increase in agricultural output led to an increase in animal productivity. On the other hand, for beef cattle farmers,

the increase in herd size and labour productivity have made heavy investment in equipment necessary; these investments have made work easier, without any increase in animal productivity.

Despite a labour productivity that has more than doubled in 28 years, the income of ruminant farmers has not changed, except for small ruminant farmers who have increased their income, which was very low at the beginning of the period. These productivity gains have been "redistributed" (Veysset *et al.*, 2019), particularly towards the downstream sectors (from the farm gate to the consumer). The cumulative 1988-2016 economic surplus generated by the farms thanks to their productivity gains, subsidies and certain reductions in input prices was captured by 83%, 67% and 54% respectively by the downstream sectors of dairy cattle, beef cattle and small ruminants in the form of lower prices for animals and animal products (Boukhriess and Veysset, 2019). Given the capture of productivity gains in the form of lower prices, and the remaining low return on capital, the place of farmers in the sectors and the renewal of generations are future challenges for ruminant farmers.

Conclusion

The concepts of labour productivity and economies of scale were the main drivers of the development model of French livestock farms. The continuous increase in the size of farms and the constant search for greater labour productivity has led to a greater use of external resources (inputs and capital) to the detriment of a better valorisation of internal resources (genetic potential of animals and plants) without increasing the productivity of the farmland used and without technical efficiency gain. The stagnation, or even decline, in the productivity of the factors of production - and therefore of the wealth created by the activity of ruminant farming - should lead to a thorough and critical reassessment of the business model of the sector and of how we should make better use of genetic, technical, technological and knowledge progress. Faced with the increased physical and mental workload, farmers tended to simplify their practices, to over-equip themselves. Family farms, an agricultural model defended and maintained in France, are certainly becoming too large for a single person (or a small group of people) to hold the capital, make strategic and operational decisions and carry out the work. The transmission of these large farms requiring a large amount of capital to be funded by the buyer with little prospect of improving profitability is a challenge for the future. In the agro-ecological transition framework, the search for efficiency in production systems, *i.e.* minimising the use of inputs for production, is one of the objective. To meet this challenge of agro-ecological transition, the question of the scale and structures in which this form of sustainable agriculture can really and effectively be implemented must be addressed.

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