Beef cattle farms in less-favoured areas: drivers of sustainability over the last 24 years. Implications for the future

Veysset P., Mosnier C., Lherm M.

in

Casasús I. (ed.), Lombardi G. (ed.).
Mountain pastures and livestock farming facing uncertainty: environmental, technical and socio-economic challenges

Zaragoza : CIHEAM
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 116

2016
pages 27-38

Beef cattle farms in less-favoured areas: drivers of sustainability over the last 24 years. Implications for the future

P. Veysset[1,2,*], C. Mosnier[1,2] and M. Lherm[1,2]

[1]INRA, UMR1213 Herbivores, F-63122 St-Genès-Champanelle (France)
[2]Clermont Université, VetAgro Sup, UMR1213 Herbivores, BP 10448, F-63000 Clermont-Ferrand (France)
*e-mail: patrick.veysset@clermont.inra.fr

Abstract. Over the past 24 years (1990-2013), the Common Agricultural Policy reforms succeeded one another with subsidies provided to compensate the erosion of farm meat and grain prices. Support was given to grasslands or extensive farming systems. One response to the CAP, but also to market signals, was that French beef cattle farms in less-favoured areas have expanded in size and increased labour productivity by over 70%, chiefly, though not exclusively, through capital intensification (labour–capital substitution) and simplifying herd feeding practices (more concentrates used). The technical efficiency of beef sector production systems, as measured by the ratio of the volume of farm output to volume of intermediate consumption, has fallen by nearly 20%. The environmental performances did not improve, while income per worker has held stable thanks to subsidies and the labour productivity gains made. Among the various beef cattle production systems, grass-based and low inputs systems displayed encouraging performances compared to lowland mixed crop-livestock farming systems. These grass-based suckler cattle production systems in less-favoured areas seem to be better prepared to face the future beef production scheme and societal demand. Public policy also has its role to play by supporting positive externalities of low inputs and grass-based beef cattle farming systems.

Keywords. Suckler beef farms – Less favoured areas – Economics – Environment – Efficiency.

Systèmes d'élevages bovins allaitants en zones défavorisées : déterminants de leur durabilité sur les 24 dernières années. Questions et perspectives.

Résumé. *Au cours des 24 dernières années, en réponse à l'évolution des soutiens aux élevages bovins allaitants en zones défavorisées herbagères, et à leur environnement socio-économiques, ces exploitations d'élevage ont accru leur taille et productivité du travail de 70%. Cette évolution s'est opérée par une intensification de l'utilisation du capital (substitution travail/capital) et par une simplification des pratiques d'alimentation (notamment par une plus forte utilisation de concentrés). L'efficience technique de ces systèmes de production, mesurée par le ratio volume de production agricole sur volume de consommations intermédiaires et capital utilisé, a chuté de près de 20%. Les performances environnementales ne se sont pas améliorées, et le revenu par unité de main d'œuvre s'est juste maintenu grâce aux aides et aux gains de productivité du travail. Parmi la diversité des systèmes de production de viande bovine, les systèmes herbagers et/ou à faibles intrants montrent d'encourageantes, voire meilleures, performances comparativement aux systèmes polyculture-élevage de plaine. Ces systèmes herbagers des zones défavorisées semblent mieux armés face à la potentielle future demande sociétale et à celle des filières concernant la production de viande bovine. Les politiques publiques ont également leur rôle à jouer, principalement en supportant les externalités positives des systèmes herbagers à faibles intrants.*

Mots-clés. *Elevages bovins allaitants – Zones défavorisées – Economie – Environnement – Efficience.*

I – Introduction

European (UE) beef farming systems are relatively diverse, the main system being the cow-calf production system that concerns half of the European commercial beef farms (Sarzeaud *et al*., 2008). The bovine activity of cow-calf farms is based on calf production from a suckler cow herd. The cow-calf farms produce either weaners (cow-calf producers) sold to fatteners, or fatten the majority of the progeny on their farms (cow-calf-fatteners). The UE pure cow-calf producers (60% of the suckler cattle owners) are mainly located in 3 areas: 27% in the grasslands of Britain, Ireland, France and North Europe, 20% in the Mediterranean areas of Spain, Italy, Greece or Portugal, and 16% in the mountain areas of France, Spain and Eastern Europe. This distribution of the beef farming systems on the European territory causes that 71% of the 12.1 million suckler cows of the European Union in 2014, are located in only 4 countries (Eurostat, 2016): France 4.1 million (34%), Spain 1.9 million (16%), United Kingdom 1.5 million (13%) and Ireland 1.0 million (9%).

Suckler cattle farming systems play a key role in agricultural production and rural development of European mountains and grassland areas (McDonald *et al*., 2000; Casasus *et al*., 2007). Grass-based livestock farming systems are highly relevant in both environmental and social terms (Gibon, 2005). Over the last decades, as a response to the evolution of the public aids and subsidies (successive reforms of the Common Agricultural Policy (CAP)) and to their socio-economic environment, these suckler cattle farming systems have considerably changed. The objective of this paper is to analyse past trends in order to check if beef cattle systems are evolving toward more sustainable systems. The sustainability will be assessed in terms of revenue, production efficiency, greenhouse gas (GHG) emissions and fossil energy consumption, based on beef cattle farms data from 1990 to 2013, in French mountain and/or less-favoured areas, from different farm networks. Since mixed crop-livestock farming enjoys broad consensus as an economically and environmentally sustainable farming system (Ryschawy *et al*., 2012), it will be tested if the presence of crops improve beef cattle farms sustainability.

II – Context, data bases and methods

Suckler cattle farming is a major feature of French agriculture. French beef farmers are cow-calf producers and cow-calf-fatteners. 60% of the males are exported as store cattle to the Italian fattening enterprises. The national beef herd, 4.1 million suckler cows, is mainly composed of various pure breeds. With its 1.5 million cows, Charolais is the main breed. The Charolais area, located in the North Massif Central (a grassland and less-favoured area within Central France), counts 41% of the French Charolais-breed cows, that is to say 20% of the total French suckler cows.

1. Beef cattle farm networks

Two networks were used to analyse recent evolution of beef cattle cattle farms.

***The Farm Accountancy Data Network (FADN*)** is an EU-wide harmonized network that sources and publishes representative statistics on farming business accounts, revenues and economics. Farms in the FADN-scope field of survey are classed by region under a typology scheme based on their type of farming (TF). Specialized beef cattle farms are classified as TF46. Ninety-eight percent of the French beef cattle farms represented in 2013 have suckler cows (cow-calf producers and cow-calf-fatteners). We distinguished the 3 regions where mountains and less-favoured areas are a major part of their territory: Auvergne, Limousin and Midi-Pyrénées (the other French mountains regions, Alpes and Jura, are dairy production oriented). In these 3 less-favoured regions, we found 39% of the total French cattle farms in 1990, and 44% in 2013.

In order to understand the drivers and determinants of evolutions in suckler cattle system farms, an Economics team from INRA set up *a* ***Charolais-region suckler beef farms farm network*** for long-term observational statistics that has been running since the 1970s. Each farm in the network is surveyed every year. Data is collected on labour, structure, land allocation scheme, herd, aggregated intermediate consumption, sales, aids and subsidies, investments and borrowing. To study the main evolutions (structure, productive, economic and environmental performances) over a long period, we were able to form a constant subsample population of 43 farms, from 1990 to 2013 (Veysset *et al.*, 2014a).

As we want to study the performances of grass-based and mixed crop-livestock farming systems, we subdivided a constant group sample of 59 farms from the Inra network tracked over 2 years (2010 and 2011) into three groups: (i) "GF", this group includes 7 farms where the entire utilized agricultural area (UAA) is grassland, (ii) "B/c": 31 specialized farms that only market animal products but that grow cereal crops on-farm for animal feed, and (iii) "B+C": 21 farms that sell both beef and cereal crops to market. MFA covers only 68% of UAA.

2. Expression and analysis of results

We underlined the major evolutions on the structure, farm sizes, and economic results observed on the FADN TF46 mountain (FADN TF46-Mo) and Charolais INRA-network (INRA-Charol). As we had, for the INRA-Charol, values of all structural, technical and economic variables year by year, it was possible to detail the evolutions of the productive performances, feeding and inputs use strategies. The presented results were the respective annual average values of all farms constituting each network.

To question the rationality of the management system and the technical efficiency of the production system, we calculated the volume of the total farm product, the volume of the intermediate consumptions and the volume of fixed capital used each year, for both networks. For that, we have separated the variation of annual economic values of each output/input into volume variation and price variation. The annual values of each product have been weighted with their own index of producer prices of agricultural products (PPAPI). In the same way, the annual mean values of each cost were weighted with their own respective index of purchase prices of the means of agricultural production (PPMAPI). Once weighted to correct for pure price effects, annual evolutions represent evolutions of volumes produced and consumed. The technical efficiency of the production systems was represented by the ratio: volume of farm product over volume of intermediate consumptions plus fixed capital consumed (Veysset *et al.*, 2015). In addition to this evolution of the technical efficiency, we presented, for INRA-Charol, the evolution of the emissions of greenhouse gas (GHG) and non-renewable energy (NRE) consumption per kg of live weight produced (kglw). The methodology to assess the GHG emission and NRE consumption per kglw for each farm was detailed by Veysset *et al*. (2014b).

To assess if there was some significate performances differences between the three identified suckler cattle farming systems (GF, B/c, B+C), we ran a systemic analysis of the three groups (Veysset *et al*., 2014c).

III – Results and discussion

1. Main structural trends

The main structural trends marking beef cattle farms over the 1990-2013 period (Table 1) were:

- large increase in hectarage, herd size, and labour productivity (hectarage and number of livestock units per worker unit, respectively +55% to +78%),
- continued reliance on grassland systems, with extensification,
- considerable capital investment (capital per worker +41% to +52% in constant-euro values).

The networks did not show a land intensification trend, and in INRA-Charolais we observed a de-intensification of the forage area, in 2013 stocking rates were on a par between networks. Charolais farms, in less favoured Charolais area, were less beef-specialised than farms in mountainous areas.

Despite this strong increase in labour productivity, income per worker has remained relatively stable in the two networks, with strong interannual variability (Fig. 1). The trends ran parallel between both networks, the revenue differential between the FADN sample and the INRA–Charolais sample was due to difference in structures, breeds and regions.

Table 1. Main structural characteristics of the Farm Accountancy Data Network, French mountains, type of farming beef cattle farms (FADN TF46-Mo), and the constant INRA–Charolais-network sample of 43 beef cattle farms: 1990 *vs* 2013. Average values of each variable for each sample

		1990	2013	Trend, %
Annual work units, AWU	FADN TF46-Mo	1.54	1.36	-12
	INRA–Charolais	2.09	2.00	-4
Utilized Agricultural Area, UAA, ha (UAA/AWU)	FADN TF46-Mo	65 (42)	102 (75)	+56 (+78)
	INRA–Charolais	122 (58)	191 (95)	+57 (+64)
Livestock Units, LU (LU/AWU)	FADN TF46-Mo	70 (45)	108 (80)	+54 (+75)
	INRA–Charolais	123 (59)	183 (91)	+48 (+55)
Main Fodder Area, MFA, % UAA	FADN TF46-Mo	87	88	+1
	INRA–Charolais	82	83	+1
Stocking rate, LU/ha MFA/year	FADN TF46-Mo	1.23	1.23	≈
	INRA–Charolais	1.29	1.22	-6
Specialization†	FADN TF46-Mo	88	89	≈
	INRA–Charolais	83	86	+3
Non-land assets, k€/AWU††	FADN TF46-Mo	167	235	+41
	INRA–Charolais	190	289	+52

† Specialization = gross product on cattle (excl. aids) / gross farm product (excl. aids).

†† Non-land assets: constant-euro values for 2013 (deflator: national consumer price index).

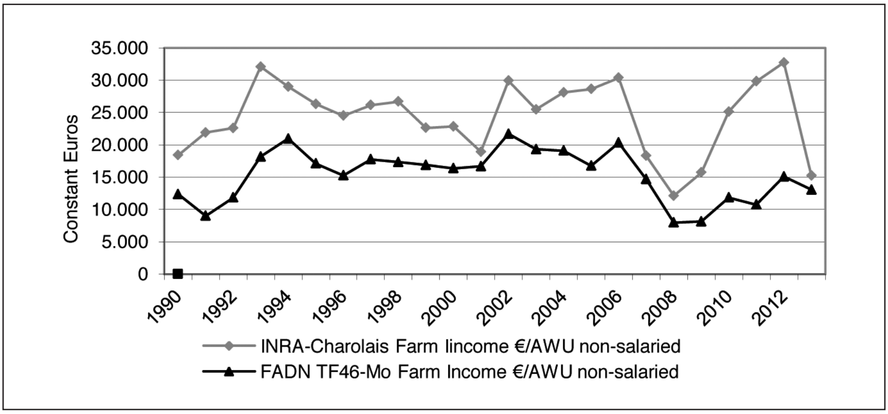

Fig. 1. 1990-2013 evolution of the farm income (FI) per non-salaried worker (AWU non-salaried).

Income in constant-euro values for 2013 (deflator: national consumer price index). FADN TF46-Mo: Farm Accountancy Data Network, type of farming beef cattle farms, in mountain. INRA-Charolais: constant sample of 43 Charolais beef cattle farms.

All the French suckler cattle farms were more and more dependant to the aids and subsidies, especially since the Mc Sharry CAP reform in 1992 (Veysset *et al*., 2005a). Aids and subsidies represented 60% to 90% of the farm income in the early 90's. Since 1995, aids and subsidies were higher than the farm income in the two networks, without aids the farm income will be negative. Since the mid 2000's, aids and subsidies represented more than 200% of the farm income. Suckler cattle farms in mountainous areas were not more (or less) dependant to the subsidies than the average of the French suckler cattle farms.

2. Evolution of technical performances

The analysis of the INRA-Charolais network show that numerical productivity (number of calves weaned per 100 cows serviced) decreased by 1.4 percentage units in 24 years (86.9% in 2013 *vs* 88.3% in 1990). This numerical productivity decrease was related to lower pregnancy rate (from 94% to 91%) and a slight increase in calf mortality: 7.5% to 9.5%, trends observed in large herds (Veysset *et al*., 2004). Given the strong and constant demand from Italian fatteners for young and heavy weanlings, the share of animals finished on-farm for slaughter has dropped: in 2013, only 24% of males sold to market were finished on-farm, against 42% back in 1990. However, the drop in numerical productivity and finishing was offset by the genetics gains and feeding practices leading an increase in body size (carcass weight of cull cows has gained 50 kg, i.e. +13%), and beef live-weight output per livestock unit (kglw/LU: weight productivity) increased from 295 kg in 1990 to 313 kg in 2013, i.e. a 6% gain.

The increase in extensification premiums with Agenda 2000 (the 2000 Common Agricultural Policy reform package) was a strong incentive. Mean stocking rate dropped below 1.25 LU/ha MFA/year in 2002 and has stayed there ever since. The decrease in stocking rate corresponded with a drop in mineral fertilizers use per ha UAA: from 50 kg N/ha to 43 kg N/ha (-14%). This decrease in stocking rate practically cancelled out the increases in average weight productivity, with beef live-weight output per ha of forage area increasing by a modest 2 kg in 24 years (+0.6%) when beef live-weight output per LU gained 18 kg.

The de-intensification of forage area has not slowed efforts to improve the quantity and quality of forage harvested: the proportion of grassland mowed every year increased from 38% in 1990 to 47% in 2013, and the proportion of this mowed grasslands bale-wrapped climbed from 7% to 21% to the detriment of hay. Despite less on-farm fattening and more conserved forages available, the amount of concentrate distributed per kg of live-weight have increased substantially: +33% in 24 years (1.63 kg concentrate/kglw in 1990 *vs* 2.18 in 2013). Note that to produce one kg of beef live-weight, concentrate produced on-farm (self-supplied) and concentrate bought off-farm have co-increased in use in the same proportions. The net result over 22 years was a 6 percentage unit drop in forage feed unit (FU) feed self-sufficiency (share of the herd's annual FU needs covered by FU from forages produced on the farm: 88% in 1990 *vs* 82% in 2013) and a 2 percentage point drop in total FU feed self-sufficiency (share of the herd's annual FU needs covered by FU from all feed produced on the farm: 94% in 1990 *vs* 92% in 2013). Over the period, cereal crop yield remained stable at around 4.7 tons/ha.

3. Global technical farm system efficiency

Volume of French beef cattle farm output (meat and crops) per ha UAA stayed flat over the last 24 years, nevertheless with a slight rise trend for the farms in mountain areas (Fig. 2). This flatlined land productivity was associated with less intensive consumption (in volume terms) of fertilizer (-24% and -43% respectively for INRA-Charolais and FADN). However, these costs were the only expenditures to have decreased in volume terms over the period studied. Amounts used per ha UAA increased across the board for all other intermediate consumption expenditures, including: cattle feed (+29% and +38% respectively), veterinary supplies (+31% and +8%), fuel (+55% and +47%), equipment maintenance and repair (+32% and +34%). In global trend terms, aggregate volume of intermediate consumption per ha UAA increased 0.64% and 0.55% per year respectively for FADN and INRA-Charolais. Despite the increase in farm size, annual fixed capital consumption (FCC) per ha UAA also increased, growing at a rate of 0.02% and 0.26% per year respectively for FADN and INRA-Charolais. Equipment expenditure was the main cause of this increase, accounting for more than 60% of annual fixed capital consumption per ha UAA.

The strong increase in physical labour productivity drove a 76% and 61% increase in output per worker (AWU) between 1990 and 2013 respectively for FADN and INRA-Charolais. However, over the same period, beef cattle farms registered strong increases in volume of intermediate consumption and fixed capital consumption per AWU (from +66% to +105% depending to the networks), with the result that value added per AWU fell by more than 35%. Net gains in labour productivity did not lead to net increase in value added per worker.

Stable volume of farm output per ha even at heavier intermediate and fixed-capital consumption per ha meant that technical farm system efficiency has declined over the last 24 years, in parallel across the two subsample populations surveyed (Fig. 3). Annual decline in technical efficiency was -0.5%/year for FADN-sample beef cattle farms and -0.7%/year for INRA–Charolais-sample beef cattle farms.

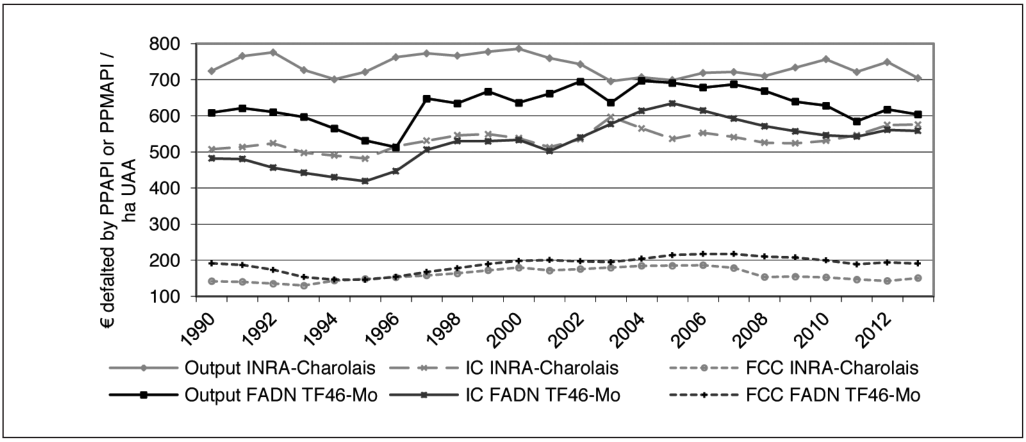

Fig. 2. Year-on-year trends in output volumes, intermediate consumption (IC) and fixed capital consumption (FCC) per ha agricultural area (UAA).

Figures in € deflated by index of producer prices of agricultural products (PPAPI) and index of purchase prices of the means of agricultural production (PPMAPI). FADN TF46-Mo: Farm Accountancy Data Network, type of farming beef cattle farms, in mountain. INRA-Charolais: constant sample of 43 Charolais beef cattle farms.

This technical farm system efficiency was strongly positively correlated to the feed self-sufficiency, itself negatively correlated with the farm size. Feed self-sufficiency was directly linked with the amount of purchased concentrates used per livestock unit. Despite a relative low variability in the total feed self-sufficiency, the largest herds (more than 250 LU) posted systematically lower results. We also observed that the farms with the lowest feed self-sufficiency (less than 82%) posted systematically low farm income per worker. Anyway, the technical efficiency is a positive determinant of income per worker.

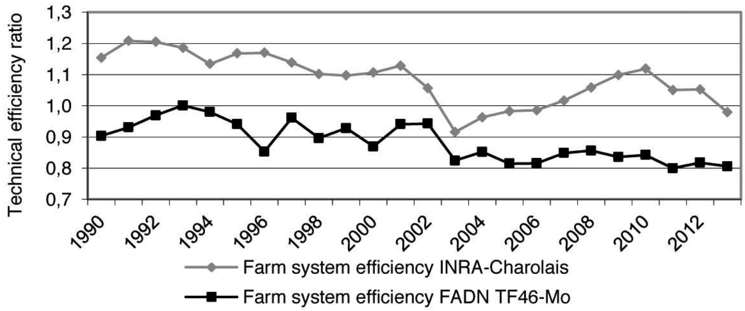

Fig. 3. Evolution of technical farm systems efficiency: farm product excluding aids in euros deflated by index of producer prices of agricultural products (PPAPI) / intermediate consumptions plus fixed capital consumed in euros deflated by index of purchase prices of the means of agricultural production (PPMAPI).

FADN TF46-Mo: Farm Accountancy Data Network, Mountain type of farming beef cattle farms.
INRA-Charolais: constant sample of 43 Charolais beef cattle farms.

4. GHG emissions and fossil energy consumption

In the INRA-Charolais network, emissions of GHG per kg of live-weight produced tended to slightly decrease, while NRE consumption tended to increase (Fig. 4). The decrease in GHG emission was due to the slight increase in the animal productivity (kglw produced per livestock unit), so to the dilution of emitted methane (CH_4). The method used to assess the GHG emissions at the farm level (GES'TIM, Gac *et al*., 2010), allocated a fixed CH_4 emission per bovine animal, so this CH_4 emission per animal was the same in 1990 and in 2013, although animals were heavier in 2013.

A consequence of the decrease in technical farm system efficiency (more inputs and capital for the same volume produced), was the 15% increase in fossil energy consumed per kglw.

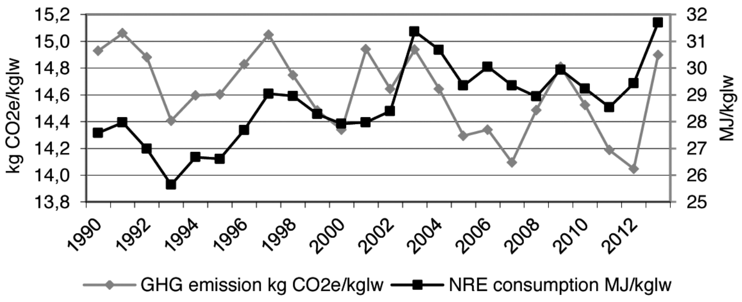

Fig. 4. Evolution of greenhouse gas (GHG) emissions in kg CO_2e and non-renewable energy (NRE) consumption in MJ, per kg of live weight produced (kglw) for the INRA-Charolais network, constant sample of 43 Charolais beef cattle farms.

5. Grass-based and mixed crop-livestock farming systems

Main performances of the three groups: grassland farms (GF), beef farms that grow cereal crops on-farm for animal feed (B/c), mixed crop-livestock farms (B+C), over two years (2010 to 2011), were reported in Table 2. The size of the farms were not significantly different between the 3 groups, the stocking rate was lower in the grassland farms.

Table 2. Main characteristics and performances of the three groups: grassland farms (GF), beef farms that grow cereal crops on-farm for animal feed (B/c), mixed crop-livestock farms (B+C), over two years (2010 to 2011)

	GF	B/c	B+C
Structural characteristics			
Annual Work Units (AWU)	1.62 ^{a}	1.99 ^{a}	1.84 ^{a}
Usable Agricultural Area (UAA), ha	159.7 ^{a}	161.7 ^{a}	179.9 ^{a}
Main Fodder Area (MFA) % UAA	100 ^{c}	89 ^{b}	68 ^{a}
Total Cattle Area† (haCatt) % UAA	99 ^{a}	96 ^{a}	77 ^{b}
Livestock units (LU)	176.3 ^{ab}	179.6 ^{b}	158.8 ^{a}
LU stocking rate / ha MFA / year	1.15 ^{a}	1.24 ^{b}	1.27 ^{b}
LU stocking rate / haCatt / year	1.15 ^{a}	1.16 ^{a}	1.16 ^{a}
Technical performances			
Numerical productivity††, %	84.6 ^{a}	85.3 ^{a}	83.8 ^{a}
Kg live-weight produced (kglw) / LU	320 ^{a}	317 ^{a}	320 ^{a}
% fattened cattle sold	31 ^{a}	45 ^{b}	30 ^{a}
Kg live weight (kglw) produced / ha MFA	370 ^{a}	395 ^{a}	408 ^{a}
Kglw produced / haCatt	373 ^{a}	368 ^{a}	372 ^{a}
Total concentrates, kg / LU	638 ^{a}	740 ^{a}	834 ^{a}
On-farm concentrates, % total concentrates	0 ^{a}	56 ^{c}	58 ^{b}
Total concentrates, kg / kglw produced	1.98 ^{a}	2.29 ^{b}	2.60 ^{b}
Feed self-sufficiency, Forage Units %	83 ^{a}	90 ^{b}	90 ^{b}
Mineral nitrogen, kg N / ha MFA	9 ^{ab}	20 ^{bc}	33 ^{c}
Cereal yields, t / ha Cereal crop	–	4.95 ^{b}	5.59 ^{b}
Mineral nitrogen, kg N / ha Cropland	–	92 ^{b}	116 ^{b}
Economic and environmental performances			
Operational herd costs, % gross product on cattle	34 ^{ab}	32 ^{a}	38 ^{b}
Gross margin on cattle, € / LU	560 ^{b}	508 ^{b}	448 ^{a}
Farm income, € / AWU	24,708 ^{a}	25,112 ^{a}	24,140 ^{a}
Aggregate aids, € / AWU	45,756 ^{b}	36,714 ^{a}	38,048 ^{ab}
N balance, kg N / ha UAA	+31 ^{a}	+32 ^{a}	+41 ^{b}
Gross GHG kg CO_2e / kglw	12.35 ^{a}	12.56 ^{a}	13.27 ^{ab}
Carbon offset % Gross GHG	27.7 ^{b}	20.0 ^{a}	20.9 ^{a}
Net GHG kg CO_2e / kglw	8.95 ^{a}	10.02 ^{ab}	10.48 ^{b}
Non-renewable energy (NRE) MJ / kglw	27.0 ^{a}	29.7 ^{ab}	32.5 ^{b}

Notes: a, b, c – same-row values with different-letter superscripts indicate groups from statistically-different populations at $P < 0.05$.

† Total Cattle Area (haCatt): area dedicated to the cattle herd = MFA + area of annual on-farm crops sidelined for cattle feed.

†† Numerical productivity: % calves weaned per cow serviced.

Livestock productivity (kglw/LU) was not significantly different between the 3 groups. B/c farms tended to fatten more animals. Live-weight of weanlings sold to market and carcass weight of fattened cull cows were virtually identical across the 3 groups. The two groups that produced concentrate on-farm (B/c and B+C) were the two heaviest consumers of concentrate per LU and per kg of beef produced. The GF group was logically the group that bought in the most concentrates, on B/c and B+C farms, concentrate self-sufficiency (on-farm concentrate-to-total concentrate ratio) was 57%.

Due to a lower rate of operational costs on gross bovine product, the gross margin on cattle was higher on GF and B/c. On average, over the two years studied, we did not observed differences on farm income per worker between the 3 groups. Total amount of aids and subsidies per worker was highest for 100%-grassland farms (GF) and lowest for B/c farms. Aid entitlements under the CAP second pillar (green grassland premium, compensatory allowances for natural handicaps scheme) were then picked up on top of the aid entitlements under the CAP first pillar for grassland-based farms.

With higher mineral fertilization per ha UAA than the other farms without concomitant more intensive beef production, the B+C farms had the highest surplus of farm-scale apparent N balance, excluding symbiotic N fixation by legumes. Gross GHG emissions per kg beef live weight were highest B+C farms due to heavier use of inputs. With their higher grassland-to-UAA ratio, GF were able to offset 28% of gross GHG emissions due to carbon storage in grassland soil (a carbon sink). Consequently, the net GHG emissions per kg beef live weight produced were lower on GF farms. The 100%-grassland farms (GF) also registered the lowest NRE consumption per kg beef live weight produced (they purchased all their concentrates, but they used less fuel and fertilizer).

6. Discussion, perspectives

Over the 24-year period studied, the main changes observed were the large increase in farm sizes, and consequently herd sizes, at constant labour level. This entailed an increase in labour productivity, possible due to a more intensive use of intermediate consumptions and due to a substitution labour/capital. These changes, and direct aids to farmer, had just allowed maintaining the farm income per worker. We observed these same trends in the Spanish Central Pyrenees (Garcia-Martinez *et al*., 2009).

Productivity gains have been “redistributed” (Boussemart *et al*., 2012) further downstream (drop in farmed commodity prices) and further upstream (farming supplies and machinery). The size increase has not therefore produced economies of scale. Size has long been a major driver in protecting livestock farmer income levels, initially through the increase in output volumes and then, from the mid-1990s, through the aid support granted to farms without size limits (Veysset *et al*., 2005a). Diversifying into mixed crop-livestock farming did not necessarily bring about economies of scope (Perrot *et al*., 2013).

Feed self-sufficiency was a key factor in the technical and economic efficiency (Ripoll-Bosh *et al*., 2014) of suckler beef production systems. However, all these variables were significantly negatively correlated to farm size. One of the objectives of the 1992 Common Agricultural Policy reforms was to use incentivization mechanisms to promote the incorporation of EU-farmed cereals into animal feed as a substitute for imported cereal-crop by-products. This incentivization policy manifested as a sharp drop in cereal crop prices (–50% in constant-euro values between 1992 and 2005). Livestock farmers were consequently able to increase herd size and simplify the feed work burden by distributing more concentrates (easy to store and distribute, and with known and reliably stable nutritional value) with only small increases in expenditure on feed. This feeding strategy was also pulling by the downstream sector demanding for more homogeneous ‘standard’ cattle weight and conformation. Farms, also growing cereals on-farm, logically achieved a higher feed sufficiency for their herds than the 100%-grassland farms that had to buy in all the needed concentrates. However, these 100%-grassland farms used more efficiently the concentrates; as MC-L farms enjoyed a feed resource (cereal crop) that grassland farms did not, they tended to distribute more of it to their livestock, without getting significantly higher beef live-weight at the farm gate.

Due this more efficient use of concentrates, a lower use of fertilizers, seeds and pesticides, grassland farms in less favoured areas showed better environmental performances.

Perspectives

Public policies are strong drivers of livestock farming systems evolutions (Veysset *et al*., 2005b, Matthews *et al*., 2006, Garcia-Martinez *et al*., 2011). The new CAP 2014-2020 (European Commission, 2013), for the French part, aims to "rebalance aids for livestock and employment, without unbalancing the sectors, for a CAP fairer, greener, more regulatory and targeting young people". Concerning the beef cattle sector, the suckler cow premium remains coupled, but with a digressive amount above 40 cows. To limit the continuous expansion and to support employment, a redistributive payment is set up to promote small and medium structures with an extra-premium to the first 52 ha. For a greener CAP, 30% of the payment from the first pillar (pillar for the agricultural production) would be a "green payment". This payment implies maintaining permanent grassland, a problem for farms in less-favoured areas, where more than 90% of the UAA is allocated to permanent grassland; these farms seeking to improve their feed and straw self-sufficiency with forage cereals. This search for self-sufficiency can help secure the production system and to spread the risk in relation to climate hazards on some alternative crops (fodder or not) for a small portion of the surface. The diversification of the forage system is part of the production system security strategies; this self-insurance will be a key point in the decision of farmers to purchase or not, and in what amount an insurance against climate risks (Mosnier, 2015). Less-favoured areas will benefit from the 15% revaluation of the compensatory allowance for natural handicaps.

Overall, all things being equal, the CAP guidelines 2014-2020 should result in a substantial improvement of the income of beef suckler farms in mountainous areas. The income of lowland farms should be impacted in contrasting ways, depending on the size and specialization of the farm: income increase for cow-calf systems, slightly increase for cow-calf-fatteners and mixed crop-livestock systems. The major novelty of this CAP reform is the split of the proportionality between the amount of aids received and the size of the farm. For the first time since 1992, the encouragement of the size expansion is restricted.

In a longer term perspective, the possible scenarios of a decrease in beef consumption, and greater consideration for the environment and animal welfare, could be favourable to systems in mountainous areas: low-input systems based on grazing, carbon sequestration in grasslands, biodiversity maintenance, meat "quality" from long production cycles (Bernués *et al*., 2011). The possible pursuit of a liberal scenario based on volumes and prices should also help to maintain cow-calf systems in mountains, capable of producing calves cheaply over large areas. In all cases, there is not much alternative agricultural production, and farming systems, for farms in mountainous areas, which could have advantages to meet the demand for beef, taking into account societal and economic developments.

IV – Conclusions

Over the decades, suckler cattle production systems have re-adapted to regular CAP reforms and changing market trends by constantly increasing farm size and physical labour productivity. These adaptations entailed a heavier use of off-farm resources (inputs and capital) to the detriment of better use of on-farm resources (genetic potential of livestock and plant resources). The animal productivity gains were counterbalanced by evolutions in practices, the result is that we observed a decrease in the wealth created by the beef cattle farming activity, and no gain on farm income and environmental performances.

Despite this gloomy picture, among the various beef cattle production systems, grass-based and low inputs systems displayed encouraging performances compared to lowland mixed crop-livestock systems. These suckler cattle production systems seem to be better prepared to face the future beef production scheme and societal demand.

The main concerns of beef production systems in mountainous areas will be to reinforce the wealth created and to maintain the ecosystem services they provide. The future challenge is to develop the fattening activities on farm without purchasing human-edible proteins. These systems have to value their unique feed resource: grass, by adopting adapted breeds and practices. Public policy also has its role to play by supporting positive externalities of low inputs and grass-based beef cattle farming systems.

Acknowledgments

The authors would like to thank the farmers who kindly provided the yearly data from their registers to complete these studies.

References

Bernués A., Ruiz R., Olaizola A., Villalba D. and Casasús I., 2011. Sustainability of pasture-based livestock farming systems in the European Mediterranean context: Synergies and trade-offs. *Livestock Science,* 139, 44-57.

Boussemart J.P., Butault J.P. and Ojo O., 2012. Generation and distribution of productivity gains in French agriculture. Who are the winners and the losers over the last fifty years? *Bulletin USAMV, Hoticulture,* 69(2), 55-67.

Casasus I., Bernues A., Sanz A., Villalba D., Riedel J.L. and Revilla R., 2007. Vegetation dynamics in Mediterranean forest pastures as affected by beef cattle grazing. *Agriculture, Ecosystems and Environment,* 121, 365-370.

Eurostat, 2016. http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do (accessed 3 February 2016).

European Commission, 2013. http://ec.europa.eu/agriculture/cap-post-2013/index_en.htm (accessed 15 February 2016).

Gac A., Deltour L., Carriolle M., Dolle J.B., Espagnol S., Flénet F., Guingand N., Lagadec S., Le Gall A., lellahi A., Malaval C., Ponchant P. and Tailleur A., 2010. GES'TIM, guide méthodologique pour l'estimation des impacts des activités agricoles sur l'effet de serre. Version 1.2. Paris : Institut de l'Elévage, 156 pp.

García-Martínez A., Olaizola A. and Bernués A., 2009. Trajectories of evolution and drivers of change in European mountain cattle farming systems. *Animal,* 3, 152-165.

García-Martínez A., Bernués A. and Olaizola A., 2011. Simulation of mountain cattle farming system changes under diverse agricultural policies and off-farm labour scenarios. *Livestock Science,* 137, 73-86.

Gibon A., 2005. Managing grassland for production, the environment and the landscape. Challenges at the farm and the landsacpe level. *Livestock Production Science,* 96, 11-31.

Matthews K.B., Wright I.A., Buchan K., Davies D.A. and Schwarz G., 2006. Assessing the options for upland livestock systems under CAP reform: Developing and applying a livestock systems model within whole-farm system analysis. *Agricultural Systems,* 90, 32-61.

McDonald D., Cabtree J.R., Wiesinger G., Dax T., Stamou N., Fleury P., Gutierrez J.L. and Gibon A., 2000. Agricultural abandonment in mountain areas of Europe: environmental consequences and policy response. *Journal of Environmental Management,* 59, 47-69.

Mosnier C., 2015. Self-insurance and multi-peril grassland crop insurance: the case of French suckler cow farms. *Agricultural Finance Review,* 75, 533-551.

Perrot C., Caillaud D. and Chambaut H., 2013. Économies d'échelle et économies de gamme en production laitière. Analyse technico-économique et environnementale des exploitations de polyculture-élevage. *Notes et études socio-économiques,* 37, 7-32.

Ripoll-Bosch R., Joy M. and Bernués A., 2014. Role of self-sufficiency, productivity and diversification on the economic sustainability of farming systems with autochthonous sheep breeds in less favoured areas in Southern Europe. *Animal,* 8, 1229-1237.

Ryschawy J., Choisis N., Choisis J.P., Joannon A. and Gibon A., 2012. Mixed crop-livestock systems: an economic and environmental-friendly way of farming? *Animal,* 6, 1772-1730.

Sarzeaud P., Bécherel F. and Perrot C., 2008. A classification of European beef farming systems. In: *EU beef farming systems and CAP regulations,* EAAP Technical Series, 9. Ed. Sarzeaud P., Dimitriadou A. and Zjalic M., ISBN 978-90-8686-058-6. 23-31.

Veysset P., Lherm M. and Bébin D., 2004. Performances technico-économiques pour les grands troupeaux bovins allaitants: le cas du Charolais. *Rencontres Recherches Ruminants,* 11, 141-144.

Veysset P., Lherm M. and Bébin D., 2005a. Evolutions, dispersions et déterminants du revenu en élevage bovin allaitant. Etude sur 15 ans (1989-2003) à partir d'un échantillon constant de 69 exploitations. *INRA Prod. Anim.,* 18 (4), 265-275.

Veysset P., Bébin D. and Lherm M., 2005b. Adaptation to Agenda 2000 (CAP reform) and optimization of the farming system of French suckler cattle farms in the Charolais area: a model-based study. *Agricultural Systems,* 83, 179-202.

Veysset P., Benoit M., Laignel G., Bébin D., Roulenc M. and Lherm M., 2014a. Analyse et déterminants de l'évolution des performances d'élevages bovins et ovins allaitants en zones défavorisées de 1990 à 2012. *INRA Prod. Anim.,* 27, 49-64.

Veysset P., Lherm M., Bébin D., Roulenc M. and Benoit M., 2014b. Variability in greenhouse gas emissions, fossil energy consumption and farm economics in suckler beef production in 59 French farms. *Agriculture, ecosystems and Environment,* 188, 180-191.

Veysset P., Lherm M., Bébin D. and Roulenc M., 2014c. Mixed crop-livestock farming systems: a sustainable way to produce beef? Commercial farms results, questions and perspectives. *Animal,* 8, 1218-1228.

Veysset P., Lherm M., Roulenc M., Troquier C. and Bébin D., 2015. Productivity and technical efficiency of suckler beef production systems: trends for the period 1990 to 2012. *Animal,* 9, 2050-2059.