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French meat sectors under pressure: facing competition and feed supply challenges

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The French livestock sector faces conflicting demands: producing affordable high-quality protein, contributing to French gastronomy, managing the landscape and improving animal welfare; while also reducing water and climate impacts, creating jobs and supporting the balance of trade. Managing these challenges requires a common understanding of both previous and future trends in the sector. This *Study*, based on discussions with professionals between 2022 and 2024, presents a retrospective analysis and a business as usual (BAU) scenario up to 2035 for three meat sectors in France (poultry, pork and beef). The analysis simultaneously considers: (i) the relationships within and between these three value chains; (ii) the domestic, European, and global scales; and (iii) the opportunities and lock-ins resulting from historical transformations in the three sectors.

KEY MESSAGES

Between 1960 and 2024, meat has become an increasingly standardized product, traded on increasingly open markets, making price competitiveness a key factor of the supply-demand equilibrium.

The three sectors studied experienced continuous growth until the 1990s, supplying increasing domestic and global demand. This trend has been underpinned by clear choices: sustaining family and diversified farms; maintaining farmers' autonomy and limiting vertical integration, while supporting cooperatives.

It has been accompanied by:
- significant territorial concentration which, while economically efficient, has had major environmental impacts;
- an increased chicken consumption at the expense of beef; and
- sectoral industrialization.

Since 2000, French actors have experienced difficulties in the export and domestic markets (which have differed from one sector to another). Without new measures, and based on the assumption that demand remains similar, a BAU scenario to 2035 would lead to:
- an increased imbalance between supply and demand on the domestic market for all sectors, with the overall coverage rate falling from 98% in 2020 to 87% in 2035;
- a growing geographic split in production areas, favouring the western regions of France;
- a decline in small and medium-sized farms and industrial sites: a 34% decrease in the number of livestock farms and a 31% decline in associated jobs, along with a 20% reduction in abattoirs and meat processing facilities and a 14% decrease in agro-industrial jobs;
- environmental impacts: the reduction in national greenhouse gas emissions (of approximately 15%) would be compensated by imported emissions; nitrogen surpluses would remain high in western regions despite efficiency gains; grassland area would decline by 18% due to the fall in extensive ruminant production, which would negatively impact biodiversity and landscapes, and lead to the release of CO_2 and an increase in water pollution.

While the debate on the future of livestock farming should continue, discussions need to better integrate issues concerning demand and the full range of challenges facing the sector. This requires an open and transparent modelling approach, such as the one applied in this *Study*, which combines socio-economic and agri-environmental aspects, and examines the links between farms, the agri-food industry and demand.

STUDY

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EXECUTIVE SUMMARY

This *Study* is based on four methodological choices. The first involves accounting for a range of issues beyond price competitiveness and greenhouse gas emission intensities (in CO_2eql/kg produced), including: employment, sector structure, regional dynamics, and biodiversity. The second choice was to view the three sectors analysed as components of a broader meat industry, with their interactions driving the dynamics. The third decision was to analyse the supply and demand at three overlapping levels: France, the European Union and the rest of the world. The fourth choice was to combine a qualitative historical approach to understand the drivers underlying the transformation of these sectors, alongside a quantification of future socio-economic and environmental impacts at the farm, industry, and national levels.

Elements of the retrospective analysis

A foundational European context

From the post-war period to the present day, the meat industry has undergone a dual process of *commodification*[1] and then *liberalization*, driven by three factors. The first of these factors is the development of a technological package that has driven productivity gains and standardized production. This package is based on genetic improvement, the adoption of specialized equipment and the development of concentrated livestock feeds, which have improved the *feed conversion efficiency* (FCE, amount of meat produced per unit of feed consumed) and have led to a situation where livestock farming uses between 60% and 70% of the cereals and oilseeds produced in France and Europe. Secondly, the Common Agricultural Policy (CAP) has supported the development of production then facilitated the liberalization of markets, consistent with the Marrakech Agreement that has been signed at the international level.[2] The gradual dominance of these sectors by industry, followed by supermarkets and the catering industry, has led to increased standardization of production methods.

These developments have had three consequences. Firstly, the market is now organized around standardized products traded on a global scale, with quality standards determined more by the needs of downstream industries than by the quality or the origin of meat. Second, these market developments have led to increased competition: (i) between production areas, within the EU and on a global scale; (ii) between sectors, with the incomparably higher productivity levels of the chicken sector serving as a benchmark; and (iii) between quality ranges, with the development of minced beef resulting, for example, from competition with cheaper and less distinctive types of meat. Thirdly, this result in a growing disconnect between production and consumption.

Against this backdrop, poultry meat (and particularly chicken) has become an increasingly significant component of diets and livestock production. Its share of total meat consumption among French consumers increased from 12% in 1960 to one-third by 2022. Globally, meat production increased sixfold between 1960 and 2022, driven largely by chicken production, which increased 16-fold.

France: changes from 1990 to 2000

In France, the transformation of the meat sector occurred in two key phases. From 1960 until the 1990s, growing demand in both France and Europe drove an increase in production that

[1] The term *commodification* refers to the process by which a product gradually becomes a *commodity*, i.e. a highly standardized and virtually universal commodity, marketed on a large scale. See Vivero-Pol J.L. (2017). The idea of food as commons or commodity in academia. A systematic review of English scholarly texts. *Journal of Rural Studies*, 53, 182-201.

[2] https://www.wto.org/french/docs_f/legal_f/04-wto_f.htm

benefited all countries, while French consumption retained a less standardized character. French production grew through a compromise between industrial development and the preservation of distinctive products, and these approaches were implemented on smaller, more diversified, family-run farms, compared to those in Northern Europe. The coexistence of these two approaches has been sustained by a policy framework that both protects the expanding European market and actively supports production and exports.

From the mid-1990s onwards, the global trend towards liberalization completed the policy changes initiated by the 1992 CAP reform and the Marrakech Agreement (1995). European policies were also seeking to green the production through measures such as nitrate directives, CAP aid conditionality, green payments, and eco-schemes, all compatible with the need for technical and economic efficiency. These two developments have weakened the relative position of French producers compared to their competitors, particularly the European ones: the Netherlands, Denmark and Germany. In the early 2000s, these competitors were joined by the emergence or strengthening of countries such as Poland, Spain and Ireland.

After a significant decline in the late 1990s and again in 2010, consumption is now stabilizing at around 80 kg per person per year–well above nutritional needs–and is increasingly concentrated on standardized products due to sociological changes. In 2012, France shifted from being one of the major meat exporters in the European market to becoming a net importer.

The BAU scenario: the supply-demand gap and restructuring

A growing gap between supply and demand

Our BAU scenario looks ahead to 2035: a date that is close enough to allow technical and economic quantification, while also being sufficiently distant to explore the potential impacts of current trends. Two BAU scenarios could be thought of. A first considers that the repeated crises since the 2020s–health, epizootics, geopolitics, energy–constitute a turning point and are likely to become lasting trends. A second emphasizes the capacity of the livestock sector to absorb these crises and return to the norms of the past two decades. We have adopted this latter approach, making the following assumptions:

- a growing global demand;
- a stronger competition between Member States to serve low-cost food consumption trends;
- limited policy changes to guide food demand, with minimal impacts on food habits;
- public support for sectors within the framework of a "renationalized" CAP, where each country leverages its comparative advantage to strengthen its sectors;
- environmental policies unable to curb the effects of economic dynamics.

Under those assumptions, the 2035 scenario would be marked by the following features: (i) a greater geographical disconnection between the consumption of standardized products and their production areas; (ii) consumption practices that continue to be driven by price signals, stable in volume compared to 2020, while increasingly shifting towards chicken; and (iii) persistent competitiveness differentials between EU Member States, to the disadvantage of France. Such a BAU scenario results in a widening of the domestic supply-demand gap, with sector-specific variations. In the pork and beef sectors, the contraction of supply will be faster than that of demand, with coverage rates declining, respectively, from 103% to 98%, and from 95% to 80%. In the poultry sector, while chicken production increases, it is neither enough to offset the decline in other products (duck, turkey, etc.) nor to compensate for the rise in overall consumption, leading to further increases in the deficit, from 92% to 84%. Overall, these three dynamics lead the coverage rate to fall from 97% to 88% between 2020 and 2035.

Major sector restructuring

Under such a scenario, competition between production regions creates significant pressure to lower production costs, leading to the restructuring of farms and industries. This demand for competitiveness also necessitates maintaining a high animal density in the Grand Ouest region to (i) minimize transport and supply costs and (ii) reduce the risk of under-utilization of slaughtering and cutting facilities.

The number of farms decreases by almost one-third across each sector in the next 15 years, but this decline has varying consequences for the production (expressed in tonnes of carcass weight equivalent [CWE]). In the poultry sector, production remains stable, with productivity gains compensating for the loss of farms. In the beef sector, production falls by 20% due to herd reduction and stagnation of productivity gains. Meanwhile, the pork sector sees a decline of 6.5%, as challenges in farm succession are not fully offset by productivity improvements.

The number of slaughtering and cutting sites decreases by 11% for poultry, 13% for pork, and 23% for beef, resulting in job losses of 7%, 17% and 26%, respectively.

Significant environmental impacts in France and beyond

When examining the agri-environmental implications of the BAU scenario in the context of the dynamics that have been underway since the 2000s, four key issues emerge:

- Crop intensification: The demand for concentrates in France and Europe leads to negative impacts associated with crop intensification, including increased use of synthetic fertilizers, pesticides and irrigation (despite efficiency gains);
- Loss of permanent grassland: the decline of lowland and hillside permanent extensive grasslands would amplify, with an 18% decline projected between 2020 and 2035, and a 26% decrease between 2000 and 2035. This loss has serious consequences in terms of water pollution (release of nitrates over several years, reduced purification capacity), loss of biodiversity and release of stored carbon. Moreover, there is a significant decline in agroecological infrastructures–hedges, copses and ponds associated with extensive ruminants;

- High livestock concentration maintained in the Grand Ouest region: This impedes a structural reduction in nitrogen pressure despite efficiency gains (an 8% decrease); the pressure thus remains higher than what can be agronomically valorised regionally;
- Greenhouse gas emissions: National greenhouse gas emissions linked to livestock farming decreases by 15%. This reduction is due to several factors, including: (i) the reduction of the cattle herd; (ii) increased efficiency in livestock farming systems; and (iii) the improved nitrogen efficiency in crop production, which reduces the climatic impact of concentrate production.

In addition to these issues, the supply-demand imbalance and livestock farming practices contribute to further environmental impacts. While soya imports for animal feed are expected to decrease by 13.3% between 2020 and 2035, they will nevertheless contribute to the pressure on tropical biomes. When taking the imported emissions into account resulting from imported meat products, the reduction in national emissions is only 3%.

Supporting collective debates

The BAU scenario amplifies last decades' dynamics, notably because of the passing of demographic and economic threshold. Looking ahead to 2035, it is clear that further discussion is needed regarding alternative scenarios and strategies to be implemented to support the transition. In that perspective, issues associated with meat production and consumption must be considered beyond a compromise between competitiveness and climate efficiency (expressed in $kgCO_2$ per tonne of meat)–which guides most of the current discussions. Particular attention should be paid to changes in demand, as current and projected consumption levels are significantly above the nutritional needs.

Incorporating this variety of issues in scenario development requires, as proposed in this *Study*, a modelling framework that meets three requirements: (i) it must first be open and transparent, ensuring that the links between hypotheses, normative objectives, and results are clear and understandable; (ii) it must integrate socio-economic dimensions (employment, investment, income), and biophysical aspects (production volumes, nitrogen balance, GHG emissions, agroecological infrastructure); and (iii) it must provide a coherent view of the interplays between the farm level, the agri-food industry and food practices, and reflect as accurately as possible the existing heterogeneity at each level.

However, addressing a wide variety of issues is not only about modelling; it also requires considering the diverse range of stakeholders. These primarily include economic actors in the value chain, but also those affected by changes in the meat sector, such as human health experts, regional representatives, environmental and animal welfare advocates, and policymakers. The future of the meat sector is therefore a collective and multi-faceted issue. Against the discussion would be framed would be crucial–both in defining what is being discussed and, just as importantly, what issues are not being addressed.

This broadening of the focus is even more necessary in the context of a growing number of crises. Although the BAU scenario presented here treats such crises as disruptions that the sector can absorb, it is also possible to consider that they are becoming structural. In this case, the resilience of the sector to shocks and its long-term sustainability become central issues. With this in mind, a more comprehensive future-oriented debate requires taking a broader view of the issues at stake and understanding the changes already taking place.

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1. INTRODUCTION: INTERSECTING ISSUES IN THE MEAT SECTOR

For several years, the livestock sector, at any scale considered, has been the focus of public, political and media attention, for environmental, social, economic and ethical reasons. At the international level, the seminal FAO report (Steinfeld *et al.*, 2006) highlighted the significant share of emissions resulting from livestock farming in the total anthropogenic emissions, which sparked considerable debate. In the European Union, and particularly in France, these debates have predominantly focused on meat production–and above all consumption–thereby neglecting dairy production, even though 60% of beef consumed in Europe originates from the dairy herd (see Bellarby *et al.*, 2013). While this *Study* focuses on the *meat* sector (considering all different types of meat), it makes the necessary connections with dairy production. We also explore the dynamics *between the different types of livestock farming* (poultry, pork, beef) to specifically understand the impacts of substituting one type of meat for another on consumption.

In addition to the environmental challenges facing the sector–particularly climate-related issues (Cour des Comptes, 2023), the declining price competitiveness of French actors and the resulting drop in production over the past two decades have become key political concerns (see, for example, Rouault, 2010; Duplomb, 2019). The debates are intense, with many stakeholders advancing various solutions: some argue that future efficiency gains driven by new technologies could sustain production to meet the demand of French consumers while considerably improving environmental balances; while others consider that reducing meat consumption, particularly beef, is critical for reaching our environmental objectives. Others insist that consumers should not be dictated to, and instead advocate for a major plan to revive livestock farming to restore food sovereignty, as relying on imports only worsens the environmental impacts.

However, these positions are often based on a partial perspective of the situation: whether focusing on climate, which is often reduced to greenhouse gas emissions per kilogram, or on technical, economic, or geopolitical aspects. These different perspectives, while all legitimate, are difficult to reconcile. Consequently, tensions among stakeholders tend to escalate, whereas addressing the challenges requires consensus building based on shared understanding of the issues at stake and the underlying mechanisms. Against this backdrop, this *Study* proposes an analytical framework that integrates these different dimensions (Section 2), to grasp the long-term transformations in the French meat industry (Section 3), and to envisage possible developments over the next 10-15 years (Section 4).

This analysis highlights the growing tensions between purely economic concerns–such as maintaining the competitiveness of the French meat industry and providing affordable animal products to consumers–and social and environmental challenges, such as adapting to environmental change, preserving the positive externalities of livestock farming, reducing its negative impacts, and maintaining the agricultural fabric in rural, and particularly marginal, areas. The BAU scenario also shows that, without strong collective action to change political and market conditions, competitiveness pressures will play a dominant role in the transformation of the sector, accelerating its concentration and specialization, a process that has been underway for several decades. As a result, addressing all the social and environmental issues associated with livestock farming will become increasingly complex, although this alone may not prevent the sector's economic decline, which began two decades ago.

2. ASSESSING THE TRANSFORMATIONS AND IMPACTS OF THE LIVESTOCK SECTOR

Livestock production–both for meat and dairy–is at the heart of the food system, playing a role from biophysical and socio-economic perspectives. In biophysical terms, livestock farming absorbs more than 60% of crop production consumed in France (whether produced locally or imported). It also has a significant impact on the de-organization of biogeochemical cycles, land management and greenhouse gas emissions from the agricultural sector (HCC, 2024). In socio-economic terms, the sector accounts for 50% of direct agricultural employment and 40% of jobs in the agri-food industry. It provides animal protein of a high nutritional quality, supporting a French style of "eating well", while also contributing to the overconsumption of animal protein (on average among the French population) (Vieux *et al.*, 2022).

Against this backdrop, the analytical framework proposed in this *Study,* aims to capture the way in which the livestock sectors operate to understand their impact–both positive and negative–on these various issues, in a way that could be described as a "retro-prospective" approach: the aim is to simultaneously document past transformations and their impacts, to provide a framework for the development of possible future scenarios. There are three stages to this section. After outlining the issues more specifically (Section 2.1), we analyse how changes in the sector–at both farm and industry levels–account for its evolution (Section 2.2). Finally, we consider four main drivers for change in the sector, and also consider how temporal and holistic analyses can be combined to understand the feedback loops between these drivers.

2.1. Issues considered

This *Study,* addresses two categories of issues: environmental and socio-economic. Each issue is considered through various indicators, some of which are easily quantifiable, while others are more challenging or even impossible to measure. Table 1 shows the issues considered, the indicators, and the sources of data used to assess them, where applicable (**Table 1**).

Table 1 shows primarily that the impacts of livestock farming are both positive and negative in both socio-economic and environmental terms. Thus, it is often the territorial configurations that will determine the impact of the meat sectors on what Dumont *et al.* (2019) refer to as a "basket of goods and services"–represented by the issues listed above. Consequently, a territorial approach is often crucial for understanding certain impacts, because a broad national approach based on national or even European metrics may obscure local realities. For instance, nutrient management exemplifies this complexity: nitrogen inputs can provide beneficial fertilization in one area, while causing pollution in another. This territorial aspect is approached differently in the retrospective and scenario analyses. For the retrospective analysis, we utilized the sometimes very detailed data available at the level of the small agricultural region (*petite région agricole*, PRA) for both socio-economic and environmental aspects. For the purpose of quantifying the scenarios, the modelling limitations mean that we "only" consider two French regions: the Grand Ouest (Brittany, Pays de la Loire, Normandy) and the rest of France.

This territorial dimension also raises questions about geographical transfers related to the (dis)connection between supply and demand. The impact of the meat industry is as much about what we consume as it is about what we produce. If production and consumption are uncorrelated (and we shall see that this has become the case to some extent), then it is essential to examine the impacts at both ends of the chain, and consider in particular what we import alongside what we produce. This aspect will be particularly emphasized in the modelling of the scenario's impacts.

2.2. Understanding changes in the meat sector: material flows, agrarian geography and agro-industrial structure

To assess the impact of changes in the meat industry, we first needed to *characterize* these transformations through three key factors: physical flows (balance between supply and demand, role of imports and exports); the place of livestock systems within agrarian systems; and the structure of the agro-industrial fabric.

Analysing physical flows enables us to consider environmental and socio-economic issues together. Indeed, the intensity of these flows are central to the economic functioning of the meat sector: enabling both economies of scale and agglomeration economies (Roguet *et al.*, 2015), and the potential for investment and/or R&D in these industries (Wijnands & Verhoog, 2016). This intensity also significantly influences most environmental issues, particularly through the need for fodder and concentrate feed, as well as the management of manure (Herrero *et al.*, 2015).

To capture the socio-environmental impacts in detail, it is important to document the place of livestock production systems within broader agrarian systems. These systems evolve according to their production factors (land, labour and capital, including livestock) and the specific technical practices employed (see Cochet, 2011, p. 105-106). Furthermore, understanding how livestock systems fit into regional agrarian dynamics is essential, as these dynamics are influenced by soil and climate conditions and the presence of other forms of production.

Finally, the connections established between primary production and the agri-food industries play a central role in the dynamics of livestock farming. Our analysis of the agro-industrial framework therefore focuses on (i) the territorial distribution and technical and economic characteristics of slaughtering, cutting and secondary processing facilities (production capacity, capital intensity and product mix–e.g. the nature and variety of the final products) (Renault, 2015), which are shaped by (ii) the strategies of the groups and companies that own these facilities (Rastoin, 2000).

TABLE 1. Issues at stake and the indicators used to assess them

Issue category	Specific issue	Main indicators	Assessment method
Environmental impact	Climate impact	Direct emissions from livestock systems	Quantifying greenhouse gases (GHGs)
		Indirect emissions linked to feed production (including fertilizers)	GHG quantification
		Carbon storage	Not quantified, qualitative assessment
	Biodiversity impact	Land requirements for concentrated feed	Quantifying concentrated feed requirements by modelling
		Permanent grassland & share of semi-natural vegetation	Assessment of permanent grassland and agroecological infrastructure
	Completing nutrient cycles	Regional nitrogen surplus	Quantifying surpluses by modelling
		Fodder/food self-sufficiency of livestock farms at the regional level	Data at the level of small agricultural regions for the retrospective analysis; modelling in two regions (Grand Ouest/rest of France) for the scenario.
	Animal welfare	Farm density	Characterized using the SPCalc tool (see appendix)
		Outdoor access	Characterized using the SPCalc tool (see appendix)
Socio-economic impact	Direct agricultural jobs	Number of salaried and non-salaried jobs	Retrospective data from the Farm Accountancy Data Network (FADN); quantification by modelling
	Farm income	Current income before tax	Retrospective FADN data; not modelled in the scenario
	Direct jobs in the food industry	Number of jobs in the slaughtering, cutting and secondary processing industries	Retrospective public statistic data (Business Demography, PRODCOM and ESANE databases); quantification by modelling
	Indirect employment	Number of jobs created by the presence of livestock production in the region	Not considered in this *Study*
	Rural area network	Number of farms	Agricultural census data; quantification by modelling
		Number of industrial facilities	Retrospective ESANE and PRODCOM data; quantification by modelling
	Investment in farms and the agri-food industry	Investment flows	Not modelled
		Stranded assets	Retrospective ESANE data; quantification by modelling
	Matching supply and demand in France	Volumes produced	Supply balance data; quantification by modelling
		Coverage rate (production/consumption)	Supply balances; quantification by modelling
		Balance of trade	Import-export balance in volumes and in €.

Source: authors

The interplay of physical flows, the integration of livestock production systems into agrarian systems, and the structure of the agri-food industries largely determine the impact of livestock sectors on the abovementioned issues. The next step is to identify the key factors driving these changes, which is the focus of the next section.

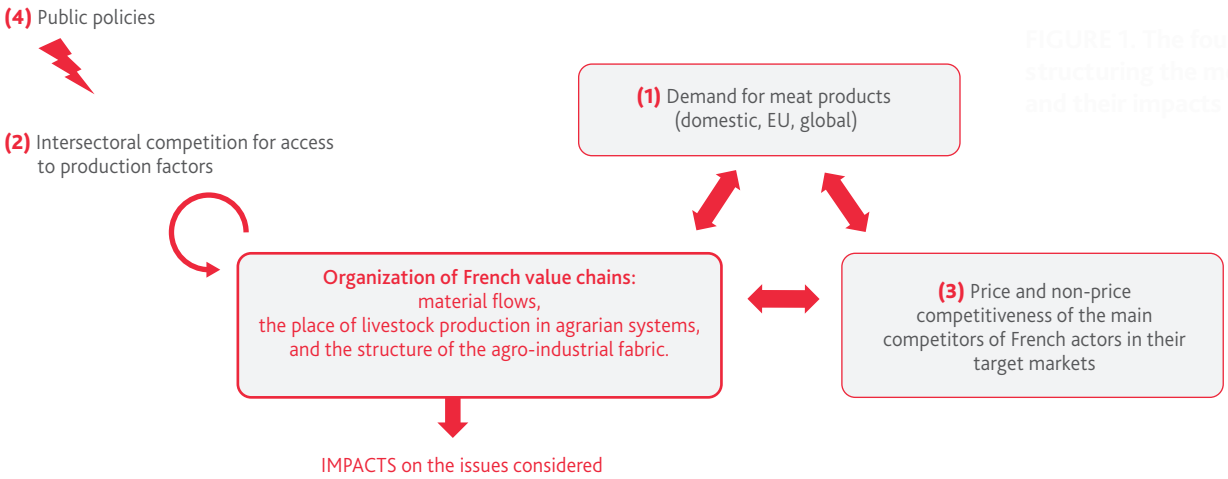
2.3. Determinants of developments in the sector

We hypothesize that the meat sector (red rectangle shown in Figure 1)–understood through its physical flows, the role of livestock farming systems, and the structure of the agro-industrial fabric–is evolving in response to the strategies employed by actors in the sector to: (1) meet the demand for animal products in the domestic, European and world markets, (2) navigate the competition that exists between the various meat sectors within the domestic sphere (poultry/pork/beef, as well as intra-sectoral competition, e.g. between chicken and other types of poultry, and between dairy cattle and suckler cattle), and (3) enhance their performance against competitors operating in the same markets. Public policies (4) mediate the effects of these three determinants on the strategies of actors.

This reasoning can be further elucidated by adopting a more physical approach to the mechanisms involved, as presented in Figure 2. It specifically highlights that the availability of fodder and concentrates (a) is an essential physical determinant of meat production at the farm level (b). This availability is influenced by competition between different uses: energy, human food, biomaterials, and also the return of nutrients to the soil for fertility (c).

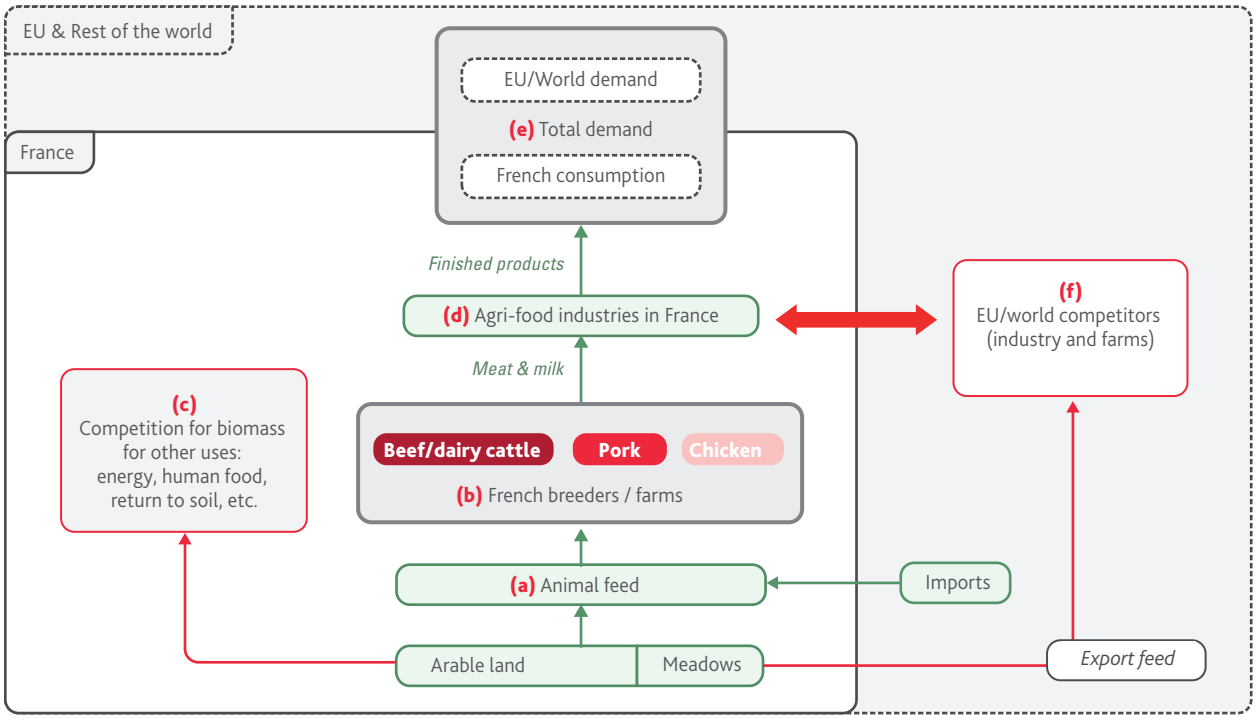
Furthermore, the dynamics of the farm-level depend on the existence of slaughtering and cutting facilities downstream (d), which are essential for supplying consumers in both domestic and export markets (e). As already shown in Figure 1, competition with other countries also plays a significant role at every link (f).

FIGURE 1. The four drivers structuring the meat industry and their impacts



Source: authors.

FIGURE 2. Physical flows and competitive dynamics in the meat industry



Source: authors.

3. COMMODIFICATION AND LIBERALIZATION: THE HISTORICAL DRIVING FORCES BEHIND THE DECLINE IN FRENCH PRODUCTION AND THE RISE OF POULTRY

The situation and challenges facing the French meat sector can only be fully understood by taking a historical perspective on both production and consumption. With this in mind, our retrospective is divided into three parts. First, a long-term approach (1950-2020) enables us to identify the major dynamics underway (Section 3.1). Second, we examine the last 40 years in more detail (1985-2024) to identify and quantify, where possible, the more recent transformations, with a particular focus on the role of public policies (Section 3.2). Finally, the last Section provides an overall assessment of how these changes have affected the issues under consideration, starting with environmental impacts (Section 3.3).

3.1. The long term: the internationalization and standardization of the meat sector

3.1.1. Meat production and consumption in France since the 1960s

AnalyZing changes in the volumes of production, consumption, imports and exports within the French meat sector over the last 60 years allows us to address the intersection of environmental and socio-economic issues. This perspective serves as the foundation for our retrospective analysis chapter.

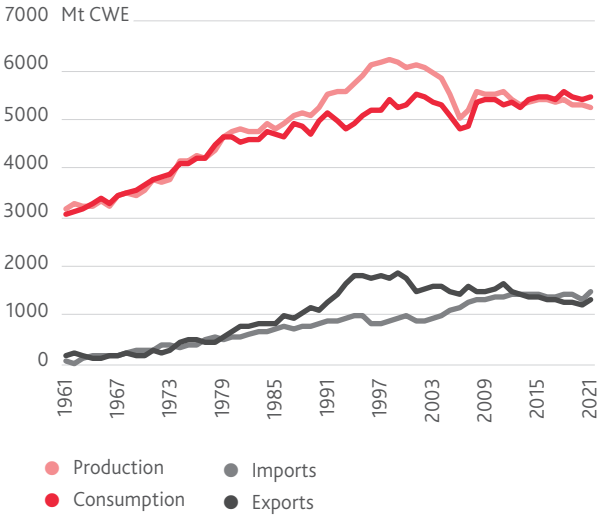
Changes in major balances from 1960 to 2022

Over the last 60 years, production, consumption, imports and exports of the three meats in question–pork, poultry and beef–have undergone profound changes, as shown in **Figure 3**. This Figure shows three dynamics. From 1960 to 1998, production initially grew steadily, followed by a period of decline or stagnation, with fluctuations around 2008. In physical terms, production changed by a factor of 2 (from 3 to 6 Mt CWE) between 1960 and 2000.

Total consumption has also been rising for the past 60 years, driven by population growth (from 45 million in 1960 to 65 million in 2020) and increased per capita consumption. Although there was an initial dip in consumption during the 1980s, a more pronounced decline occurred during the economic crisis of 2007. Following this period, consumption levelled off again and has seen a slight increase over the last decade, rising by 6% between 2013 and 2020 (see Rogissard, 2023). The magnitude of the change between 1960 and 2020 is a factor of 1.7.

The inversion of the production and consumption curves, observable since the late 1990s, indicates a growing decoupling between domestic supply and demand. This shift is reflected in a rise in imports and a decline in exports. As of 2012, France transitioned from being a net exporter to a net importer.

FIGURE 3. Consumption, production, imports and exports of all meats in France since the 1960s, in Mt CWE



Source: authors, based on FAOSTAT data*.

* *FAOSTAT data may be less accurate compared to other European or national sources. However, they provide the longest historical perspective, which justifies their use in this context. While comparisons over more recent periods may highlight these inaccuracies, the overall trends and the dynamics they reflect remain valid.*

However, these overall trends result from very different dynamics among the three types of meat (**Figure 4**). Firstly, poultry meat shows the greatest variation over time. Production increased by a factor of nearly 4.2 between 1960 and 1997, before declining. Consumption has grown very steadily, increasing by a factor of 3.2 in 60 years. Poultry is *the* meat that best explains the general dynamics of the meat consumption curve.

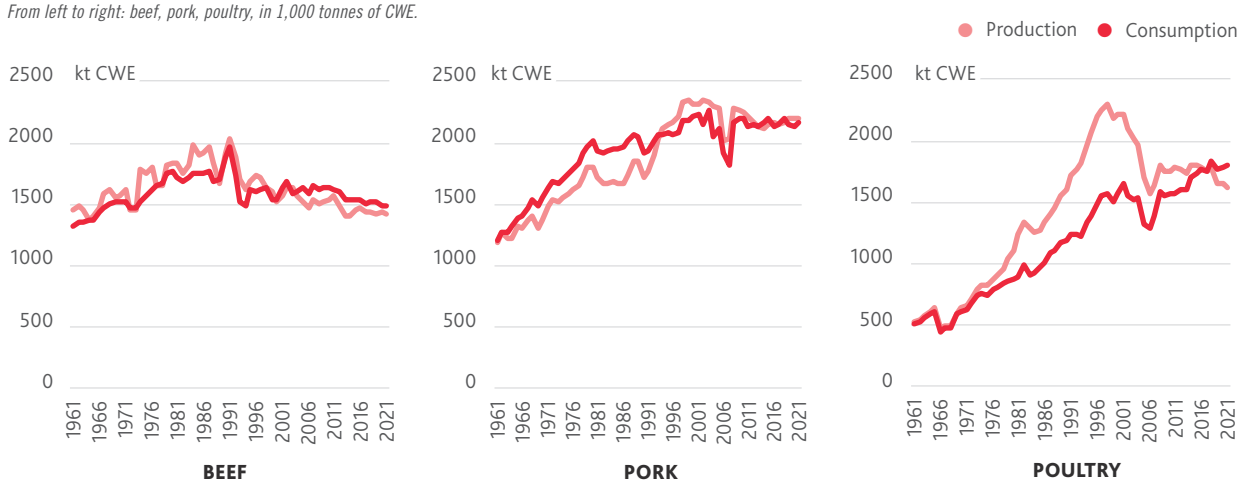
In contrast, pork production "only" increased by a factor of 2 between 1960 and 2000, and has remained virtually stable since, except for during the 2007 economic crisis. Consumption is broadly in line with production, but the net coverage rate became slightly positive from the mid-1990s onwards, after being negative for the first 30 years of the observation period.

Meanwhile, beef production increased by a factor of 1.3 between 1960 and 1990–its peak–before returning to levels seen in the 1970s. Although consumption closely follows production in terms of overall volume, this correlation masks import flows similar to those of exports, amounting to around 20% of consumption. If we include exports of live animals (just over a million grazing cattle annually) in "meat" equivalent terms, France can be considered a net exporter of meat, with a surplus of around 100 kt CWE.

Moreover, input-output flows have increased over the same period: more imports with constant export volumes for poultry; growing pork exports that offset imports in the form of charcuterie, achieving a balance in material terms; and stable meat

FIGURE 4. Meat consumption and production in France since the 1960s

From left to right: beef, pork, poultry, in 1,000 tonnes of CWE.



Source: authors, based on FAOSTAT data.

imports and exports for beef since the 2000s, which account for around 25% of production and consumption.

These trends in production, consumption, imports and exports result not only from short-term fluctuations (e.g. the mad cow crisis at the end of the 1990s, the pork crisis in 2007, bird flu in 2006 and 2021), but also from four long-term dynamics characterized below.

1. The commodification of meat, a term that refers to the process by which meat products have gradually become a highly standardized commodity, that are widely produced and marketed on a large scale (Vivero-Pol, 2017). This concept is explored in greater detail in subsequent sections.

2. Increased competition between meat sectors, including both demand-side and access to production factors on the supply side.

3. Increased dependence of livestock production on animal feed in the form of concentrates.

4. Growing economic competition among producers located in different geographical areas.

The following section examines the post-war situation in France to clarify the significance and respective roles of these four dynamics from 1960 to 2022.

Transformations on an unprecedented scale: the post-war period (1950-1960)

The changes that have occurred over the past 60 years are unprecedented in both volume and nature. The quantitative and qualitive developments in meat production and consumption can be attributed to a combination of technical, economic and political factors that emerged following the war and during the "*Trente Glorieuses*" period.

In the 1950s, meat production could be considered as a co-product of milk production and animal traction from cattle and horses. Specialization in dairy breeds had not yet taken hold and mixed breeds predominated. Pigs and poultry were mainly produced in small-scale units, with animals fed on plant and animal by-products (such as whey for pigs) and domestic or catering waste. There were a few intermediate units between small-scale and pre-industrial production for fattening (e.g. specialized buildings using beet pulp or farms near ports unloading food products), but they were in the minority. Generally, meat production could be described as "opportunistic", essentially utilizing diverse local resources–from meadows to by-products–as part of a circular economy.

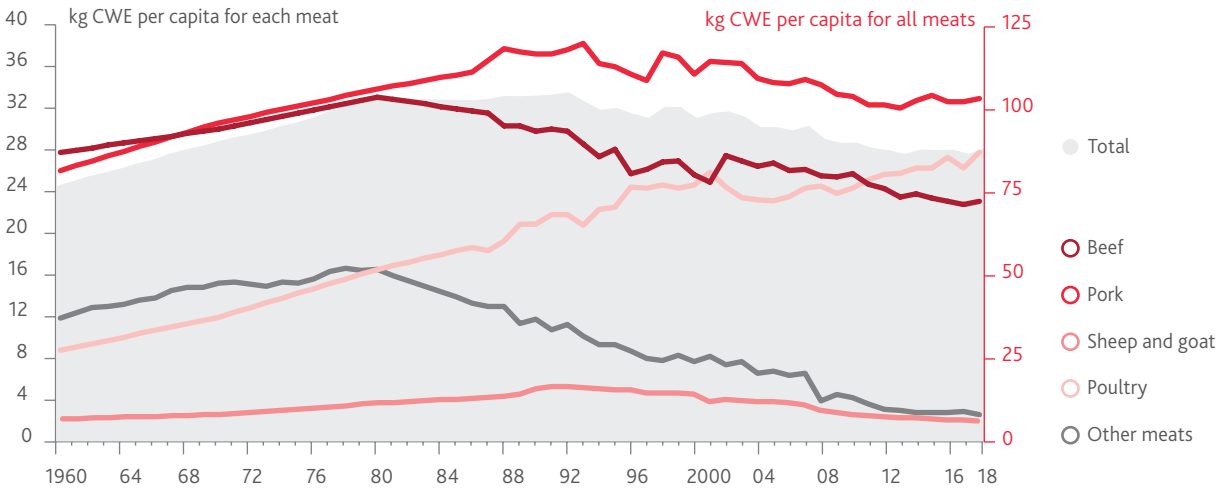
In terms of consumption, **Figure 5** illustrates the significance of beef in the 1960s relative to other meats[1]: 28 kg per capita per year of beef was consumed in 1960, compared to almost as much pork at 26 kg per capita per year. At that time, poultry meat accounted for only 9 kg per capita per year, which was less than "other meats" (12 kg per capita per year). This situation was influenced by the stock reduction of the horse sector, where the number of horses significantly declined while the use of tractors increased dramatically–between 1950 and 1975, there was a sixfold decrease in horses and a tenfold rise in tractor numbers (Gervais *et al.*, 1977).

In 1960, food expenditure accounted for one-third of household consumption (in value terms), with meat representing 7% of that total (Campion, 1968). Sixty years later, these proportions had decreased to 20% and 3%, respectively, despite an increase in the quantity of meat consumed (Rogissard *et al.*, 2021).

For the most part, France is self-sufficient in meat: consumption and production are largely domestic, closely linked to local regions, and reflect a certain cultural specificity, such as a preference for whole or cut products (see Saunier, 1985; Soufflet, 1989), and regional variations in preparation and processing methods. The only notable exception to this domestic trend is

[1] The statistical series begin at this date. It should be noted that changes had already occurred between 1950 and 1960, with significant growth rates in consumption and production (Campion, 1968).

FIGURE 5. Meat consumption in France since the 1960s in kilograms of carcass weight equivalent (kg CWE) per capita per year



1. Human consumption calculated based on slaughtering data, foreign trade flows and stock variations.
2. Carcass weight equivalent (including cutting fat): a unit used to aggregate data by weight for live animals and various forms of meat, such as carcass, boned or bone-in pieces, dried meat, etc.
3. Equine, rabbit and game meat, as well as offal intended for human consumption. The method of recording slaughter data changed in 2008. Scope: France, including French overseas departments from 1996.

Source: INSEE.

pork, with around 5% of consumption being imported, mainly from Belgium and the Netherlands. By the 1990s, the rate of self-sufficiency had declined by up to 20%, primarily due to differences in competitiveness, already driven by the adoption of industrial practices in animal feeding and housing (Teffène *et al.*, 1998). However, the pork situation illustrates France's paradoxical position in the European market since the post-war period. The country has a large utilized agricultural area (UAA), which allows substantial production, while the level of intensification and industrialization remains much lower than that of its neighbours and main competitors. For example, in 1961, the Netherlands, with a UAA of just one-thirteenth the size of France's, produced only three times less pork (1.2 Mt CWE), while Germany produced nearly the same amount of beef despite having only half the UAA of France.

On the industrial side, France's abattoirs are widely distributed throughout the country, with the vast majority being public–a result of an active policy primarily driven by health concerns. In 1942, there were nearly 1,500 slaughterhouses (for cattle, pigs, sheep, goats and horses) in France, most of which were public. The peak was reached in 1964, with 1,700 units, including just over a hundred private abattoirs, on top of which there were 2,700 facilities either on-farm or operated by artisan butchers (Ravaux, 2011). In 1950, on-farm pig slaughtering accounted for nearly a third of the total (Campion, 1968). Poultry abattoirs, however, are not included in the statistics as the vast majority of slaughtering still took place on farms. This extensive territorial network of slaughterhouses reflected the rural nature of France at that time, where consumption was closely tied to regional production. With the cold chain still in its infancy, the distribution of slaughterhouses mirrored that of butcher shops, which served almost daily shopping habits and local demand. In 1956, only 8% of French households owned a refrigerator.

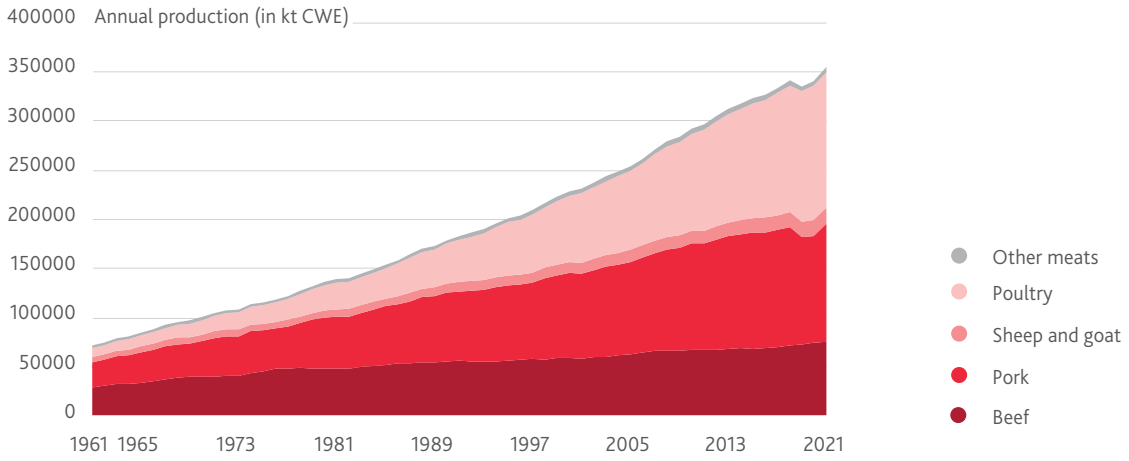
Over a period of 60 years, the entire value chain has been transformed, shifting from a traditional, domestically-oriented system to an industrialized, globalized one. The commodification process, as previously noted, has played a major role in driving these changes.

3.1.2. The commodification of meat: a foundational process

The idea of commodification stems from "commodity" and implies universality and standardization (Vivero-Pol, 2017). The suffix "-ication" denotes a process that, as we see below, has not progressed at the same rate for all types of meat. This process primarily relies on the standardization of the traded product–stability of composition, ease of transport and processing though uniformity in size and shape–factors closely linked to large-scale production methods. This standardization first undermines and then eventually nearly invisibilizes, other important attributes such as taste, nutritional value and the ecological standards of the meat. In the meat sector (and milk, which has followed a similar path), commodification is based on four key technical components that form a system:

- genetic selection, essentially focused on productivity and efficiency criteria which, for example, has reduced the rearing period for chickens from 120 to 40 days;
- the use of animal feed in the form of standardized concentrates, which are themselves commoditized;
- the use of equipment (buildings, tools) designed to increase productivity per unit of labour;

FIGURE 6. Continued growth in global meat production (1961–2022)



Source: Authors, based on FAO data.

— the integration of production units into collection and primary processing regions to achieve economies of scale through production investment and collection density, thereby reducing transport costs.

The combination of these factors explains the quantitative changes observed since the post-war period in France, Europe and globally: poultry production in France increases fourfold between 1960 and 2020, while production in the 27 EU countries grew sevenfold over the same period; globally, total meat production saw an almost sixfold increase (see **Figure 6**).

Supporting policies have been instrumental in driving this development. In France, a speech by the Minister of Agriculture, Edgar Pisani, in 1961 perfectly illustrated this trend:

> "[…] we need to establish mechanisms to conquer trade and adapt our production to the demands of world markets. […] [We need] a group of individuals dedicated to selling, whose passion is selling, whose goal is to sell, who will tell producers […]: 'You may produce the best product, but that's not what we want. Ultimately, you must produce what the world market demands of you.' If tomorrow—and please forgive my little joke—milk must be red to sell, and apples must be square, the *Institut National de la Recherche Agronomique* will need to focus on this task to ensure we obtain products that sell."[2]

These changes in production have repercussions throughout the value chain. The distribution channels established through supermarkets and out-of-home catering (which particularly rely on effective cold chain management) are in turn significantly influencing demand. Supermarkets, in particular, encourage competition between French and foreign suppliers, encouraging the production of large, homogenous batches that offer the best value for money. This supply of increasingly standardized products meets a demand that is increasingly driven by price and convenience. For instance, the beef shank traditionally used for stews in the post-war years has been replaced by frozen nuggets intended for microwaving.

While the comparison may seem exaggerated, it is in fact based on statistical observations from the period in question. In this process, the connection with meat is gradually unravelling: it is becoming increasingly difficult to establish the geographical origin of meat, or its composition may even remain a mystery. In 2013, more than a decade ago, 40% of schoolchildren questioned in a survey did not know what chicken nuggets were made of, and 60% were unaware of the ingredients of minced beef (ASEF, 2013). In the context of a commoditized global market, where one product can be substituted for another, this information appears increasingly secondary to consumers.

3.1.3. Poultry as the driving force in meat market competition

Poultry meat: full commodification on a global scale

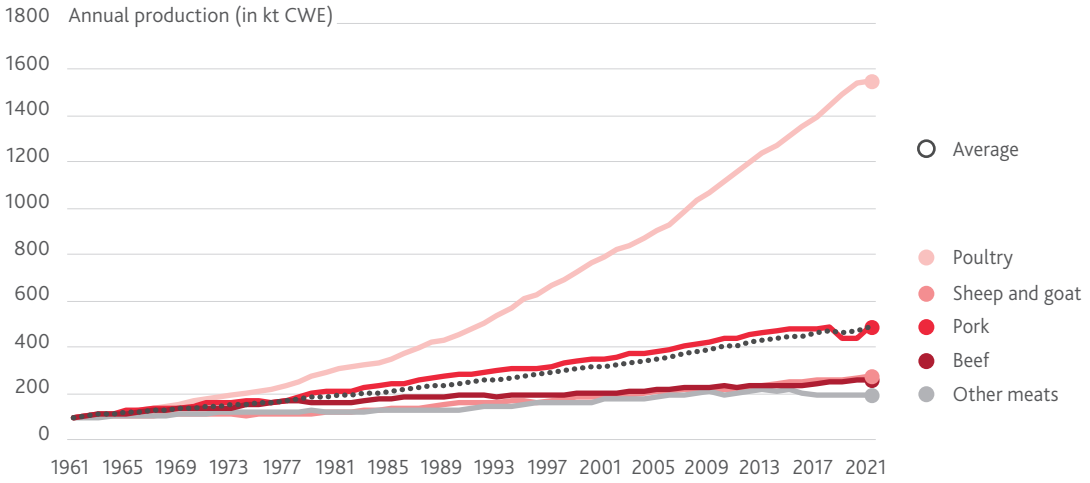
Commodification is an overarching process that takes different forms in different sectors, which explains the *relative* dynamics of beef, pork and poultry production and consumption during the period analysed.

Poultry is the sector where commodification has been the most successful, because it combines all the necessary technical factors: genetic advancements are utilized to shorten the production cycle (by a factor of four) and reduce the feed conversion ratio (by a factor of 2.5),[3] on the basis of optimized feed and denser rearing in specialized buildings.

[2] https://archives.assemblee-nationale.fr/1/qst/1-qst-1961-09-14.pdf

[3] The feed conversion ratio (FCR) refers to the ratio between the quantity of feed ingested and the quantity of meat produced. Currently, the most efficient systems have a FCR of 1.4. By comparison, Label Rouge chickens, with a longer production cycle, have a FCR of around 3.

FIGURE 7. World meat production from 1961 to 2021 (base 100): poultry meat–the engine of growth



Source: Authors' calculations, based on FAOSTAT data.

This revolution in chicken and turkey production began in the 1940s and spread very quickly, first to the United States and then to the industrialized countries of Europe and the Eastern Bloc in the post-war period. The result has been an unprecedented rise in world production, which has increased 15-fold since 1960 (FAO). When we look at the global figures in Figure 6 and express them in base 100, the "gap" between poultry meat (primarily chicken) and other meats is staggering: its production has increased by 1,550%, compared to 500% for pork, and only 250% for beef (see **Figure 7**).

Other meats: positioning through lower efficiency

While pig production has undergone a similar transformation, it has been to a lesser extent than poultry. The inputs are the same, but the production cycle is longer simply due to the animal's physiology, limiting the scope for productivity gains. In contrast to poultry, prolificacy has only increased by 30% over recent decades, and the production cycle has only halved (Rieu & Roguet, 2012). The feed conversion ratio on the most efficient farms is 2.8, which is double than that of poultry.

Lastly, beef production remains poorly positioned in the broader trend of technical intensification. Its production cycle is far longer than that of grain-fed livestock, rumination is less efficient in terms of feed conversion,[4] and genetic improvements have been slower. However, the dairy production sector has followed a trend more in line with grain-fed livestock. As a result, productivity per dairy cow has doubled from 1970 to the present (Pflimlin *et al.*, 2009), which has led to a reduction in the co-production of beef, since fewer cows are required to produce the same amount of milk.

This technical and economic shift has had two major consequences. The first is largely economic and explains the consumption dynamics of the three main meats eaten in France, as shown in **Figure 5**: a gradual replacement of beef and pork by poultry, primarily for economic reasons. In 1960, poultry was a distant second to beef and pork on French plates, despite having a similar price. At the time, there was no economic advantage to choose chicken over beef. However, sixty years later, poultry has become the most widely consumed and most affordable meat, even though a higher degree of processing may be involved. The productivity gains associated with commodification have been passed to consumers and have increasingly influenced consumer preferences among different meats. This shift has occurred against a backdrop of slower economic growth and increasingly constrained household budgets.

Reversing the norms of standard meat

The second consequence is more qualitative and cultural. The commodification of chicken has aligned well with the revolution in food processing, distribution and preparation. From the 1960s onwards, frozen chicken and then pre-cut trays, the tangible expression of commodification for consumers, gradually became standard products, perfectly integrated into the supermarket development model. For a long time, traditional products distributed by butchers coexisted with convenience products sold in supermarkets (Soufflet, 1989). However, the growing market share of these commoditized products is gradually reversing the norm: the labelled products that stand out today are paradoxically closer to those that were produced and consumed in the "standard" way of the 1950s. In the beef sector, the standard product has shifted to minced beef, which has also been commoditized, where the origin and production methods have become secondary. By 2022, minced beef accounted for almost 50% of French beef consumption (Idele & Monniot, 2024). While in the pork sector, charcuterie–previously regarded as a mean of preserving less popular cuts of the pig–is now

[4] However, we are comparing indices with very different meanings, depending on whether or not we consider human-animal competition for grain versus the ability of herbivores to use forage (Laisse *et al.*, 2019).

increasingly produced through industrial methods for a wider range of products, not just ham. This shift has meant that charcuterie now accounts for 75% of pork processing in France.

In this dynamic, meat becomes a standard raw material in a value chain where differentiation occurs downstream, during the processing and cutting/packaging stages. In a competitive context where environmental claims are increasingly important, the environmental standards of the grain-fed sectors–which are based on efficiency per kilo produced, neglecting rebound and scale effects–have become the benchmark for all meats. This focus on efficiency tends to obscure the specific characteristics of ruminants in general and extensive ruminants in particular.

3.1.4. The importance of livestock feed: a hidden variable leading to disruptions

A key component in the commodification of livestock farming

The development of livestock production has relied heavily on the increased use of concentrated feeds, standardized and optimized in their composition, to achieve the most efficient growth for animals. Upstream of the farmer, the industrial manufacture of livestock feed–commonly known as "concentrates" and referred to as such hereafter–has become a key factor.

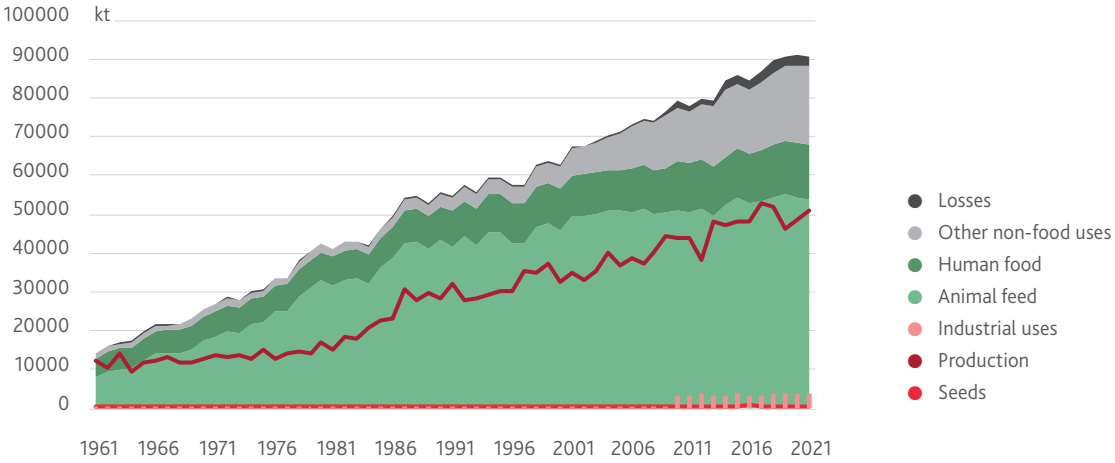
Due to the nature of grain-fed production, which is fast-cycling, the relative share of concentrates in production costs is higher for grain-fed animals than for ruminants, which have greater fixed assets in terms of land and buildings, and the mobilization of fodder requires fewer economic flows. It is estimated that feed[5] accounts for 60% to 70% of total production costs for poultry, 55% to 70% for pigs, and 15% to 30% for beef (Mosnier *et al.*, 2021). However, dependence on concentrates is much more variable in grazing livestock systems, which can, at the extreme, do without them altogether when based entirely on grassland, or, conversely, depend on them for more than 70% in dedicated fattening systems.

The production of concentrates is based on two components: energy, supplied by cereals; and protein, supplied by oilseeds and protein crops (this aggregate includes all oilseed cakes, such as sunflower, rapeseed, soya; as well as protein crops in the strictest sense: peas, broad beans, lupins, etc.). At both European and national levels, trends in the use of cereals and oilseeds and protein crops have been similar over the period under review. Quantities destined for the manufacture of concentrates have thus roughly followed the increase in animal production, with an approximately twofold increase for cereals and a ninefold rise for oilseed and protein crops. By 2021, concentrates represented nearly 60% of cereal use and 65% of oilseed and protein crop use (**Figures 8 and 9**).

However, these trends are the result of very different dynamics. For oilseed and protein crops, this increase involved a fivefold rise in soya imports between the 1970s and the mid-2000s, reaching around 25 million tonnes—around one-third of the volume of concentrates consumed in Europe. Since then, imports have remained high but stable, partly due to slower growth in the demand for concentrates, and partly because of the increase in European supply through oilseeds, particularly rapeseed. Rapeseed has emerged as a co-product of biofuel development since the 1990s (Thomas *et al.*, 2013), with pork being the main beneficiary, while poultry and, to a lesser extent dairy production, continue to depend on soya for their feed.

For cereals, the EU is self-sufficient overall, with France playing a key role in this regional balance as a supplier of wheat and grain maize.

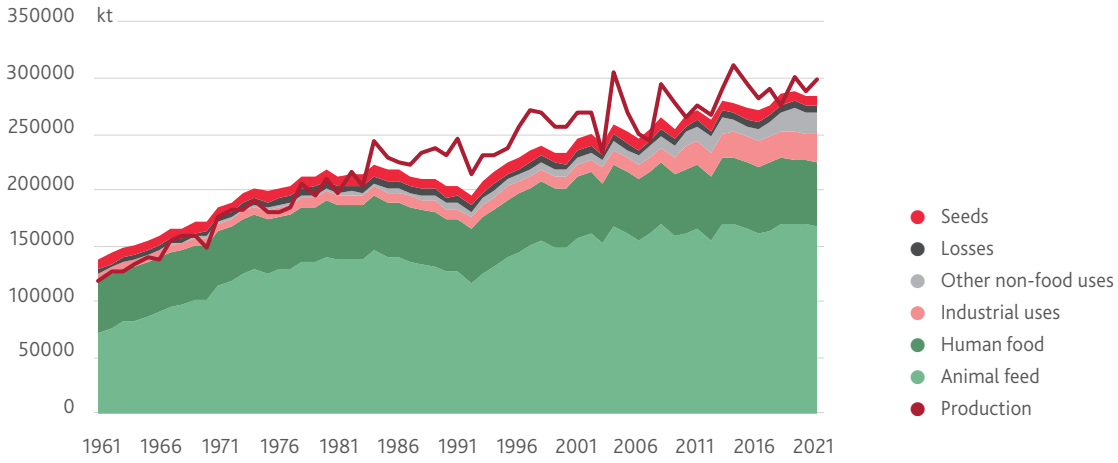
FIGURE 8. Oilseed production and consumption by use in the EU-27 since 1961



Source: FAOSTAT–adjusted for political boundaries.

[5] Fodder crops included. For grazers as a whole, Dronne (2019) estimates that the use of concentrated feed (all cereals and oilseeds, purchased processed–referred to as compound feed) accounts for 30% of the feed used by grazers. This rate is attributed to the importance of dairy production, which consumes more feed than meat production.

FIGURE 9. Production and consumption of cereals by use in the EU-27 since 1961



Source: FAOSTAT–adjusted for political boundaries.

The biophysical, economic and geopolitical challenges of feed supply

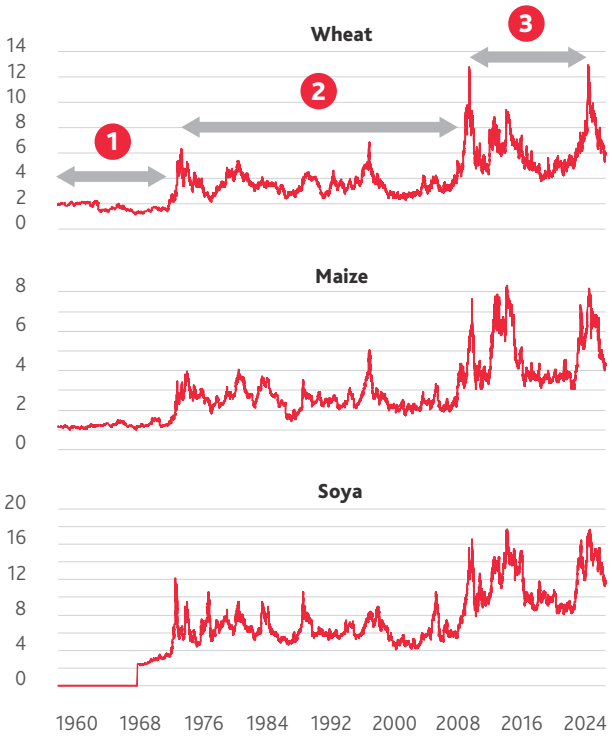
The growing dependence of livestock farms on concentrates raises important questions regarding their availability and accessibility across three closely related areas:

- physical–is there enough plant biomass to simultaneously meet the needs of livestock farming as well as other demands? Have yield shocks affected or could they affect this availability? (see Aubert *et al.*, 2023)
- economic–is the selling price of concentrates compatible with the limits of production costs based on consumer willingness to pay?
- geopolitical–will the countries from which the ingredients for concentrates are sourced always be willing to supply these materials/and will we consistently seek to buy them from these countries?

A comparison of world prices of the three main constituents of concentrates (wheat, maize and soya) since the 1960s reveals three main periods:

- Before the 1973 oil crisis: stable, low prices;
- From 1973 to 2008: an initial plateau, followed by fluctuations, particularly during the agricultural price crisis of 2007-2008;
- From 2008 to the present day: a further increase in prices and greater fluctuations, particularly due to the war in Ukraine, which caused major disruption (not visible in the figure) (**Figure 10**).

FIGURE 10. Wheat, maize and soya prices since 1960 - current dollars



Source: Macrotrend.

The market for the agricultural raw materials needed to produce concentrates is fully commodified and highly financialized (Clapp & Helleiner, 2012). Price fluctuations are therefore the product of supply-demand equilibria that encompass a large number of parameters. Four factors, in particular, have played or are playing a central role in the observed dynamics (see also HLPE, 2011):

- the energy price, driven by the dependence of crop production on synthetic fertilizers (which require substantial energy for production) and mechanization;
- environmental changes, particularly climatic shocks, which lead to supply disruptions and increased yield variability in major producing countries (USA, EU) (see in particular Ray *et al.*, 2013; Gerber *et al.*, 2024);

— the financialization of the commodities market, which amplifies both upward and downward price fluctuations (FAO *et al.*, 2011; Lecoq & Courleux, 2011);
— geopolitical or "macro-political" events, which temporarily or over longer periods disrupt trade flows and structures, generating price increases or decreases–exemplified by the war in Ukraine and the Covid-19 pandemic.

Changes in access to concentrates, situated at the intersection of physical, economic and geopolitical issues, emerge as a central variable in the prospective scenarios to be explored, particularly in terms of competitiveness. Given that the proportion of feed is high and difficult to reduce–especially for monogastric animals–other cost factors (such as investment and labour) are becoming increasingly significant in production costs. In this context, the unique situation of French livestock farmers is worth highlighting. More than in any other European country, these farmers self-produce a significant proportion of their feed, particularly for pork, at around 50%. This compares with a European average of 36%, a Figure that is notably even lower in competitor countries such as Spain and the Netherlands, where it is less than 10%.

So far, despite the major fluctuations described above, this self-production has not proved to be a major factor in reducing the competitiveness gap. In contrast, countries such as Spain and the Netherlands, with their heavy dependence on imports and the nearly total separation between animal and crop production, do not view this situation as problematic, despite its environmental implications (see for example Soto *et al.*, 2016; van Selm *et al.*, 2023). These countries perceive the competitive advantages associated with this situation as more important. The following Section examines this issue of competition between production regions.

3.1.5. Increased competition: France, Europe, the world

If France has gone from being an exporter to an importer, it is because other countries have managed to better position themselves to sell their production. On the commodity markets described above, the products in competition are virtually interchangeable: Spanish hams can come from Denmark, minced beef can come from any dairy farm, and chicken can come from Thailand, where it costs less to cut it up. This competition between production areas is structured around three components:
— the cost price per kg produced at the farm gate;
— the cost of the logistical organization for collection and transport to slaughtering and processing plants;
— the cost of slaughtering and cutting.

Competitiveness in production systems

France's competitive disadvantage in the monogastric sector became apparent in the 1970s, particularly in relation to its competitors in Northern Europe (Teffène *et al.*, 1998). For this type of production, the French sector adopted new techniques, applying them to existing farm structures by adding intensive indoor farming buildings that were relatively small compared to those of its Dutch, Belgian and Danish competitors, using selected animals and purchasing animal feed. From the outset, this production was concentrated in Brittany, driven by two key competitiveness factors: the proximity of ports for soya imports (which reduces logistics costs) and the region's lagging economic development, making livestock farming a major economic opportunity (see Gervais *et al.*, 1977).

Despite these relative competitive disadvantages, France has managed to retain a market share.[6] However, the situation is more problematic for poultry meat. From a competitiveness standpoint, the sector's development can be divided into two main phases:
— an initial period, from 1960 to the end of the 1990s, during which production increased across the board: in the quality sector (characterized by long rearing periods), in the commodified export sector, and the intermediate sector. This growth was achieved with farms that were generally uncompetitive, but in a context where European demand was outpacing supply, and where the political framework encouraged French actors, notably through export refunds;[7]
— the 2000s, which marked a turning point as the competitiveness gap that had been evident since the 1970s (Saunier, 1985) necessitated a restructuring of livestock farming and production. International competition began to drive down consumption in the premium and intermediate ranges, while the commoditized proportion demanded by consumers was increasingly produced at lower costs elsewhere in Europe and around the world.

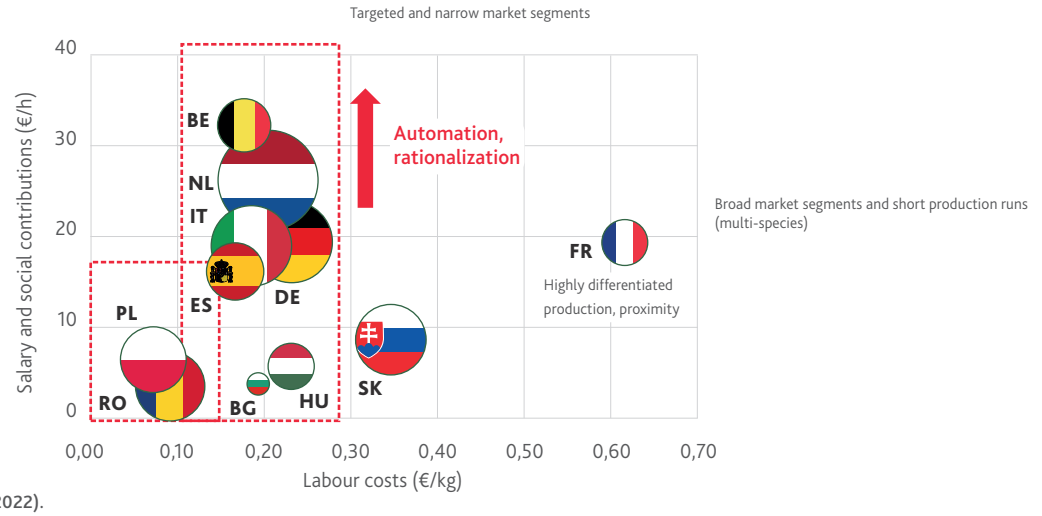
Figure 11 clearly illustrates the "intermediate" position of France for poultry compared with its European competitors: neither fully committed to the "automation/economies of scale through concentration" strategy (to maintain non-specialization by species and territorial coverage), nor well positioned in the "low labour costs" strategy. This positioning explains why French production has stalled and why imports have increased in the face of a demand that is not weakening, especially since supplies continue to be economically attractive.

In the beef sector, there is competition on two levels: between the suckler and dairy sectors, and between the dairy sectors in different countries. The establishment of a suckler cow sector is a recent development, limited to just a few EU countries, including France, which accounts for over 30% of Europe's livestock. This sector was created in the 1970s in response to

[6] The competitiveness differential between countries cannot be interpreted in black and white terms, where a country is either competitive or not, and is wiped off the map. What we have seen in the French sectors in particular is a process of building up sufficiently competitive but structurally heterogeneous sectors up until the 1990s, and since then a reorganization with lower production volumes. In the final analysis, what counts as a measure of the difference between countries is the difference in aggregate growth/decline rates between competitive and uncompetitive production units.

[7] Export refunds were a mechanism of the Common Agricultural Policy, which was abandoned in 2013. They consisted of subsidizing European exports to bring them up to world prices when these were lower than those on the domestic market.

FIGURE 11. Comparison of labour costs in the chicken industry in France and Europe



Source: (Duplomb *et al.*, 2022).

the need to increase meat production, at a time when genetic improvements in milk production were leading to the emergence of a specialized sector. This resulted in differentiation into two breed types: milk and meat, which had previously been mixed. However, with the declining demand for ruminant meat and its commodification, it is meat from the dairy herd that now serves as a "guide" value in the beef market. Its opportunity cost is lower than that of suckler cows, as it is a co-product of milk production. The development of minced and vacuum-packed meat has made cull cows particularly relevant from an industrial perspective (Soufflet, 1989); in the French market, they are even preferred as their meat has a deeper red colour, compared to meat from young cattle. By contrast, despite the income from the sale of grazing cattle, suckler farms are only profitable because of public subsidies; without these, their income would be negative (Cour des Comptes, 2023). Productivity in the beef sector is directly linked to that in the dairy sector, giving a competitive advantage to those countries that exploit economies of scale. In addition, there is a mechanical effect of reduced supply as milk productivity per cow increases. Milk quotas largely buffered these dynamics between 1984 and 2015, when they were abolished, but did not alter the logic of increased trade between production and consumption regions based on cost differentials and material balances between different cuts (front and back of the animal) and sex (with females preferred by French consumers) according to national markets.

Competitiveness of the meat processing sector

In addition to producers, the meat processing industries also face competition from their buyers, particularly the central purchasing units of major retail groups, which play a leading role on a European scale. Two activities should be considered together:

— the slaughtering of animals (which can sometimes be combined with cutting), which relies on a geographically concentrated supply region;

— the cutting and processing into more specialized products (charcuterie, cured meats, ground meats) with higher added value.

The economic mechanisms underway in the industry are comparable to those of production systems: concentration and automation are pivotal factors influencing competitiveness. Furthermore, the competitiveness of the slaughtering-cutting segment plays a vital role in the competitiveness of the sector as a whole. For instance, while French pig farms have lower production costs compared to their Spanish counterparts, the latter benefit from more economically efficient processing facilities (Diamantis *et al.*, 2011).

This has led to an increasing geographical concentration of slaughtering and cutting facilities in the key production areas: the Grand Ouest region in France, as well as in Germany, northern Europe, and more recently Spain and Poland (for the European Union). In addition to these tools, the industrial *groups* have also become concentrated and a significant proportion of European competitors have internationalized (Trégaro, 2012b). As a result, the volumes handled by each operator have increased sharply, facilitating investments in increasingly efficient tools and product innovation–particularly in downstream processes.

In this process, competitiveness depends on the ability of actors to assemble a coherent commercial and technical-industrial package ahead of their competitors. From a commercial perspective, this involves securing supplies of carcasses or live animals while developing a product range that meets the needs of buyers in terms of product type, volumes and reliability of supply. From a technical perspective, the goal is to possess the necessary tools to process these products at the lowest possible cost and with consistency. In each of the three sectors, the emergence and subsequent strengthening of leading French and, above all, European actors can be attributed to their capacity to position themselves commercially upstream, and to invest in and drive producer groups (Trégaro, 2012b). Public policy plays an important role in this process and requires a more detailed analysis.

3.2. Public policy: from market protection to "green" liberalization

Four key processes in the transformation of the meat sector were identified earlier in this *Study:* commodification, competition between the meat sectors, growing dependence on concentrates, and competition between production regions. However, the impact of these processes on the structure of the French meat sector has been significantly influenced by the public policies implemented. To understand their role, this section examines the changes that occurred at the turn of the 1990s. Until then, all meat categories were experiencing steady growth, with production peaking in the 1990s: 1991 for beef, 1998 and 1999 for poultry and pork. Then, from the end of the 1990s to the 2020s, all three sectors experienced stagnation or even marked decline. The 1990s also saw two major political changes–albeit implemented gradually: the liberalization of agricultural markets, beginning with the 1992 MacSharry reform of the CAP, followed by the Marrakech Agreement on Agricultural Trade in 1995; and the introduction of new environmental standards: the Nitrates Directive (1991), the Habitats Directive (1995), the Animal Welfare Directive (1998), and the Water Framework Directive (2000).

3.2.1. From the post-war period to the 1990s: a supported sector in a protected market

A market protected until 1992 by the Common Agricultural Policy

The development of the meat sector depends first and foremost on agricultural policies, the most important of which is the Common Agricultural Policy (CAP). Introduced in 1962, the CAP covered three main aspects until the MacSharry reform of 1992. Firstly, protecting the European market through high customs duties protected French producers from competition from third countries, while at the same time organizing competition with their European counterparts on the single market. This protection applied to all three sectors, even if the tariffs imposed varied in nature and magnitude.

Export support measures enabled the export of surpluses to the rest of the world, despite the differences between domestic production costs and world prices. These measures are particularly significant for poultry (Tregaro, 2015), but less important for pork (Paboeuf, 2011) and beef (EY, 2007).

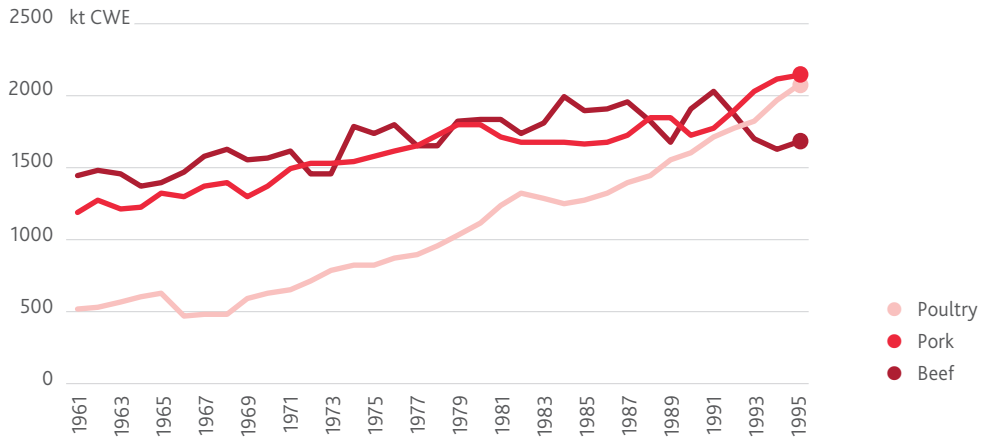
Lastly, production support was organized differently for each sector. In the beef sector, structural support was introduced very early on to aid the meat industry, notably via the suckler cow premium (1980) and the special premium for male cattle (1987). At the same time, the active policy to develop milk production–until the introduction of quotas in 1985–virtually 'tied' beef production to milk production (Trégaro, 2012a). In addition, the Common Market Organisation (CMO) for beef established intervention prices, which were activated on a regular basis without managing to stabilize the market; while they thus played an important role in stabilizing farmer incomes (EY, 2007, p. 41), they also led to a dangerous increase in public stocks (due to public buy-backs to stabilize markets), which reached 900,000 tonnes in 1991 (Risse, 2010). On the other hand, there was virtually no support for the pork and poultry industries, either through their CMOs, which are very liberal in their approach, or through support measures. It was accepted that support for these industries was provided indirectly through assistance to the cereals sector, which supplied them with low-cost feed.

Proactive national policies based on strong choices

On a national scale, the agricultural orientation laws of 1960 and 1962 explicitly supported the development of *diverse family* farming. Unlike in Northern Europe, for example, various measures were implemented to control the size of production structures, enabling them to be passed on within a family framework (Muller, 1984). In 1966, these laws were supplemented by legislation focused on breeding, aimed at improving animal genetics and selection. With substantial resources, primarily allocated to the cattle industry, this initiative was a key driver of progress in cattle breeding and enhanced animal productivity (Risse, 2010). In 1970, the government introduced a *plan to rationalize pig production*, providing several hundred million francs in funding for the development and renovation of livestock buildings to improve the sector's productivity and production capacity (Déplaude, 2022). At the same time, with a view towards regional planning, the 1986 Mountain Law aimed to mitigate the effects of unequal competition between production regions by introducing aid per head of ruminant livestock, with a relatively high ceiling for livestock density.

This encouraged significant growth in production, supplying both domestic and export markets (see **Figure 12**). During this period, French consumption appeared somewhat atypical compared to other European countries, with a preference for minimally processed/butchers' products, or even whole products as for poultry, while frozen and standardized products were already being consumed elsewhere. According to Saunier (1985) and Soufflet (1989), the end of the 1980s marked a dualization of the meat sector. A wide variety of operators continued to supply a domestic market organized around artisan butchers, although this market was gradually shrinking. Concurrently, gradual industrialization led to the emergence of national champions in all three sectors. In the beef sector, these national champions included companies like Socopa, Unicopa, and Arcadie (see Soufflet, 1989; Mainsant, 2012). In the pork sector, Cooperl-Arc Atlantique quickly established itself as a leading actor (Tregaro, 2011). These champions tended to be cooperatives that mainly targeted the domestic market and sold their products to supermarkets, which began to play an increasingly important role in the organization of the food market. In the poultry sector, two industrial groups (Tilly and Doux) worked together since the 1950s to develop production and conquer export markets. To achieve this, they benefited from generous export refunds from the European Union, which represented between 15% and 20% of the export price (known as free on board) throughout the period. Between 1975 and 1983, exports thus rose from 53 kt/year to over 330 kt/year, making France the world's leading exporter ahead of Brazil and the United States until the mid-1990s (Tregaro, 2015).

FIGURE 12. Continued growth in the French meat sector until the mid-1990s



Source: authors, based on FAOSTAT data.

This industrialization of the French meat sector has also been less reliant on vertical integration compared to other countries, such as Spain (for all sectors, see Clar, 2010) or Northern Europe (for pork, see Roguet & Rieu, 2011). While this integration clearly developed in poultry, it has been to a lesser extent than previously envisaged (Saunier, 1985). In the pig industry, integration has long been perceived as a deterrent for many farmers (Nicourt Cabaret, 2014). In this context, cooperatives, supported by public authorities through fiscal support, played a major role in structuring the sector from upstream to downstream. Between 1975 and 1991, their share in meat production increased from 28% to 41%, and continued to increase until the beginning of the 21st century (Risse, 2010, p. 89), raising a number of questions in the subsequent decades (Mainsant, 2012).

Finally, it is important to highlight the major development in the export of lean cattle at the turn of the 1960s. Italy gradually became an essential trading partner for French livestock farmers, absorbing and then gradually stimulating the bulk of lean cattle exports from France. In response to this trend, French cow-calf breeding evolved to meet Italian demand for lean, well-conformed grazers (Fayard, 2022). By the early 1990s, over 70% of lean cattle exports went to Italy, accounting for nearly half of all births from the French suckler herd (Chotteau, 2010).

A concentration/consolidation dynamic enabled by four key factors

The development and industrialization of the meat sector has been accompanied by a dual process of consolidation and territorial concentration of production facilities. The pork sector illustrates this trend (discussed in more detail in Section 3.3): between 1968 and 1995, 90% of farms with at least one pig disappeared, while the number of slaughtering and cutting plants reduced to one-fifth of the size (Teffène *et al.*, 1998). From a territorial perspective, pig, dairy and poultry farms gradually became increasingly concentrated in the Grand Ouest (Brittany and Pays de Loire)–even though this concentration was limited for dairy cattle due to the introduction of *territorialized* milk quotas in 1985. While these two regions accounted for over 40% of livestock production in 1975, by 1991 they represented nearly 60% (Risse, 2010, p. 88). The agri-environmental implications of these trends are revisited in Section 3.3.

Four factors came into play: the protection of the European market, enabled by the CAP framework; the possibility of access to cheap and apparently abundant concentrated feed (see Section 3.1.4); low environmental standards, which gave entrepreneurs free rein to develop their activities wherever and however they wished; and lastly, at least until the end of the 1970s, the country's economic prosperity, which enabled all those sidelined from the livestock sector, because of their lack of competitiveness, to find employment or a source of income, according to the well-known dynamic of *structural transformation* (Timmer, 2007). At the turn of the 1990s, these different factors shifted considerably, contributing to major changes within the meat sector.

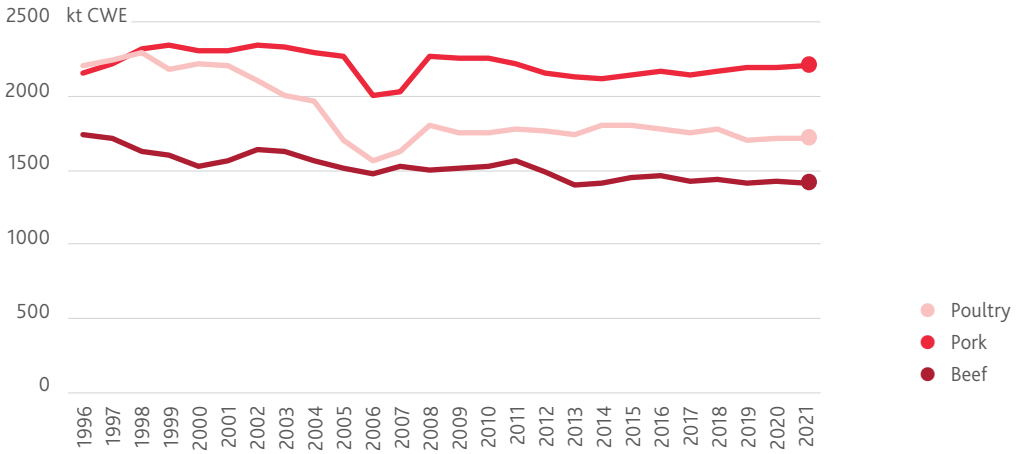
3.2.2. From the 1990s to 2022: greening livestock farming and liberalizing markets

As **Figure 13** shows, the period was marked by stagnation and even a decline in national production. The liberalization of agricultural markets, along with the introduction of environmental standards and their implementation in France, played a major role in these developments. These changes occurred alongside transformations in domestic meat demand and a strengthening of the main competitors on the European market.

Market liberalization: a multi-faceted political choice

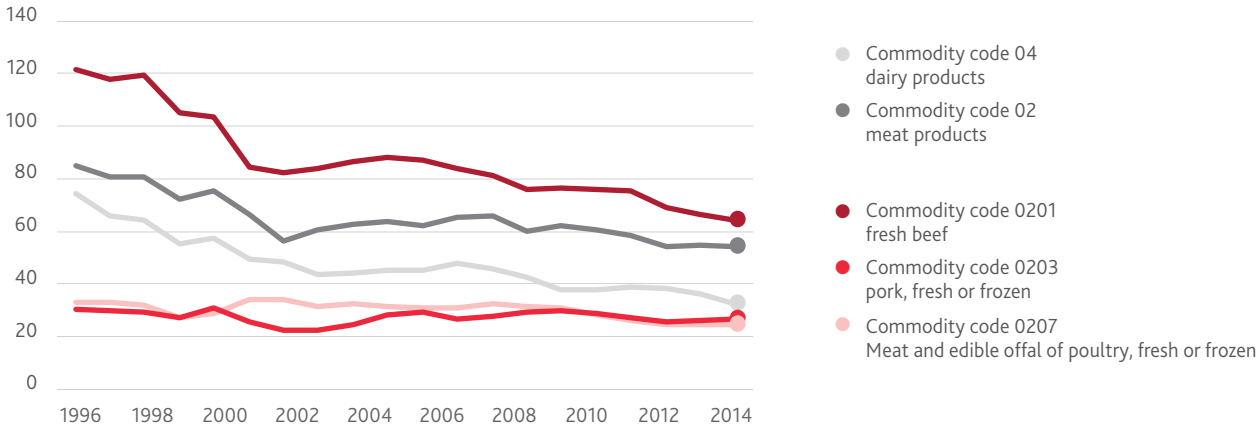
The 1992 CAP reform and the 1995 Marrakesh Agreement on world agricultural trade both intended to initiate the liberalization of agricultural markets, a process that has largely continued since. When the Marrakech Agreement was signed, the protection of the European market was the first aspect to be called

FIGURE 13. Stagnation then decline in French production for the three meats considered



Source: authors, based on FAOStat data.

FIGURE 14. Trends in ad valorem customs duties between the EU and the rest of the world



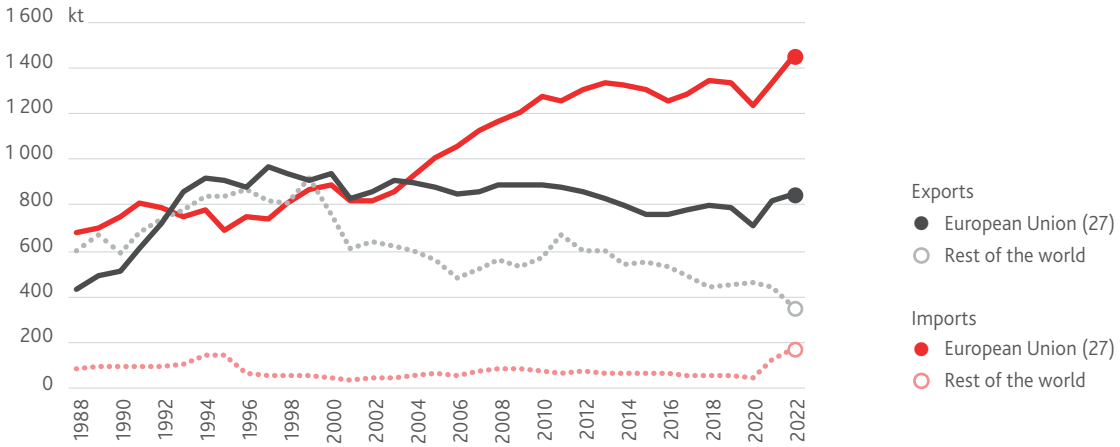
Source: authors, based on TRAINS/World Bank data.
Customs duties expressed as a percentage of the value of imports and calculated as a weighted average.

into question. Between 1995 and 2014, ad valorem customs duties on meat products fell by *an average of* 36%. However, this average trend masks significant differences between meats (**Figure 14**): beef was by far the most affected, with customs duties falling by 47%, compared with only 12% for pork and 25% for poultry. It should be noted, however, that the European pork market has long been protected by substantial non-tariff barriers to trade with the rest of the world (Trégaro, 2012b, p. 265). While average customs duties for beef remained high until 2014 (the latest year available from the TRAINS database), the beef market has been significantly impacted by the signing of bilateral trade agreements after 2010, or those still in discussion. These agreements allow (or envisage) increased beef quotas on the EU market at zero duty from several key partners, notably Canada and South America.

The Marrakech Agreement also brought an end to export subsidies, which impacted particularly poultry. However, export refunds were maintained for more than 20 years after the agreement was signed, and were not definitively eliminated until 2013. Some viewed this as an obstacle to restructuring the sector, whereas production declined steadily by almost 5% per year between 1998 and 2006 (Jez *et al.*, 2010). By the end of this period, a "third country export" sector remained in France, but it had shrunk from over 180 kt/year in 2010 to 80 kt/year today.

The third consequence of the Marrakech agreement and the MacSharry reform was the gradual ending of guaranteed prices for cattle (pigs and poultry were not included) and changes in production support measures. Between 1992 and 2013, these changes were limited by France's decision to maintain the main suckler premiums (PMTVA and PSBM). After 2013,

FIGURE 15. Imports (all meat) primarily to the European market



Source: authors, based on Comext data.

the introduction of an aid for dairy herds (in addition to the historical aid for suckler herds), confirmed in 2022, led to a significant reduction in support for suckler farmers, reallocating around 20% of funds to dairy herds.

The abolition of milk quotas, agreed in 2009 and effective in 2015, was part of the same liberalization drive, and has had major implications for French beef production. In France, milk quotas were territorially based, which helped maintain milk production in less productive and less competitive areas in the centre and south-west of France, where dairy farms contributed to the significant co-production of meat.

Finally, the reforms of 2013 and 2022 confirmed the growing subsidiarity among Member States in CAP implementation. While this situation did not strictly qualify as "liberalization", this subsidiarity reinforced competitive dynamics in the common market and intensified the race for price competitiveness. This occurred at a time when international competition became a predominantly European issue, as shown in **Figure 15:** most imports have originated from within the European Union since the mid-2000s.

Environmental measures

From 2003 onwards, CAP reforms have gradually incorporated environmental issues, beginning with conditionality (2006), followed by greening (2013), and finally eco-schemes (2022). However, the first environmental policies targeting the agricultural sector were introduced in 1991 with the adoption of the Nitrates Directive. This directive aimed to combat "pollution linked to nitrogen of agricultural origin [and] concerns nitrogen in all its forms, from all sources (chemical fertilizers, livestock effluents, agri-food effluents, sludge, etc.) and all waters (underground, surface, coastal, etc.)". In France, application of the directive has focused in particular on improving effluent management through substantial public funding. One major component has been controlling pig numbers and farm sizes, which has limited the industry's development (Le Goffe, 2013).

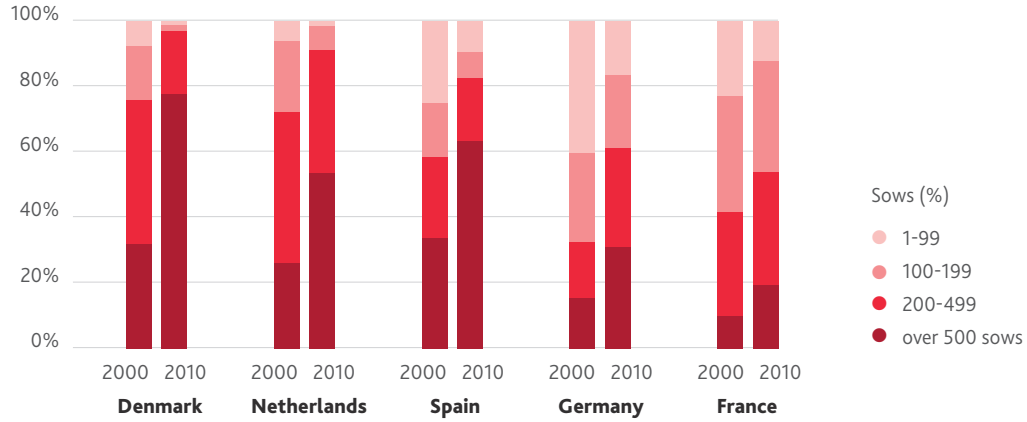
Cross-compliance and greening have subsequently incorporated new issues, particularly the ban on converting grassland in vulnerable areas, and the monitoring of grassland ratios at the regional level. Animal welfare concerns were also addressed through a series of directives in the late 1990s and early 2000s, which established common standards for all Member states regarding stocking density, access to feed and light, as well as procedures for the slaughter and transport of animals. While compliance with these measures does not necessarily guarantee high environmental performance, they impose new obligations on livestock farmers, which vary from country to country as they are adopted through directives.

The dynamics of the sector

Against this backdrop, and despite the slowdown in the French meat sector, the territorial concentration and consolidation of actors continued. At the farm level, 66% of farms producing pork, poultry or veal in 2000 had disappeared or had abandoned this type of production by 2020, representing an annual disappearance rate of over 5%–11% in the specific case of poultry. At the same time, the number of animals (sows, chickens or suckler cows) per farm increased, respectively, by 68%, 1,100% (from 1,000 poultry in 2000 to over 12,000 in 2020) and 60% over the same period. Nevertheless, French farms remain structurally smaller than those of their neighbours, due to ongoing political efforts to reconcile family farming with European and global competition in commoditized production. **Figure 16** illustrates this phenomenon in the pork sector: in 2010, farms with more than 500 sows accounted for only 19% of all sows in France, compared to nearly 80% in Denmark.

The concentration of farms is closely linked to the pursuit of territorial specialization, a trend further amplified by the ending of milk quotas. This specialization affected both farms and industrial facilities, driven by the economies of scale and agglomeration resulting from the co-location of livestock farming activities, as comprehensively described by Rogue *et al.* (2015).

FIGURE 16. Distribution of the number of sows per farm in the five main pork-producing countries in Europe



Source: Roguet *et al.*, 2017.

At the level of industrial actors, the three sectors underwent consolidation or restructuring of existing oligopolies that were already present to varying degrees. In the beef sector, restructuring proved detrimental for the cooperative sector (Mainsant, 2012), which gradually disappeared, giving way to the emergence of a national and European champion: Bigard-Socopa. In poultry, the rise of the Lambert Dodard Chancereul Group (LDC) through external growth compensated for the setbacks faced by Tilly-Sabco and Doux, both of which went bankrupt during the period (Tregaro, 2015). LDC has also established itself as a European leader capable of investing in several European countries and beyond, even extending its reach to include Ukraine. In the pork sector, the consolidation of the Cooperl-Arc Atlantique cooperative group, which slaughters around 30% of French pigs, has not led to the emergence of a European-scale actor, compared to its northern European competitors, such as Danish Crown or Vion, which slaughter four to five times as many pigs annually.

The last two decades seem to reveal a paradox: while the meat sectors are in difficulty, some economic actors are emerging as undisputed European leaders. One key to understanding this paradox may lie in the specific relationship in France between the agricultural sector, which remains extremely diversified (particularly in beef and poultry), and the agro-industrial sector, which has undergone major restructuring over the past 30 years.

3.3. The socio-environmental impact of the changes underway

In the space of 30 years, physical flows, farming systems, the industrial fabric, and consumption patterns have undergone profound changes. At the heart of these transformations is a growing disconnect between supply and demand in terms of physical flows, along with a dual movement towards territorial concentration and consolidation of production tools at both the farm and industrial levels. We first examine the environmental effects (3.3.1) and then the socio-economic impacts of these changes (3.3.2).

3.3.1. Environmental impacts: agrarian dynamics, imported impacts and system efficiency

To understand the agri-environmental effects of the territorial concentration of production, we analysed animal-plant balances in territories. This analysis highlights three aspects: (i) nutrient balances, particularly nitrogen cycling (or excess nitrogen) (Sutton *et al.*, 2011); (ii) the reliance on concentrates from outside the region, which indirectly exerts pressure on other arable land; and (iii) competition for land use within each agrarian region, especially regarding changes in the role of grassland, in particular extensively managed ones. This initial approach is complemented by an evaluation of the performance and efficiency of the farming systems themselves, as well as an analysis of imported impacts, which are as important as local impacts.

Agrarian dynamics

Building on the analysis of Jouven and colleagues (2018), we examine the territorial balance between crop and livestock production. We approach this balance as the capacity of a small agricultural region (PRA)[8] to supply feed to the animals reared there, whether in the form of fodder or concentrates. This enables us to address the risks of local pollution associated with livestock farming and the demand for concentrates. Regions experiencing a shortage of concentrates (see Table 2) become dependent on regions with a surplus, both in France and beyond. It is therefore essential to include not only crop production but also dairy production when analysing the environmental impact of meat production.

[8] The PRAs correspond to statistical units with homogeneous agrarian features, such as soil, relief, landscape, structure, and dominant production. There are 713 of these units in mainland France.

TABLE 2. Typology of regional agri-environmental situations in livestock farming

Typology based on Jouven *et al.*, (2018)	Typology used in this *Study*	Key characteristics for this *Study*
PV — Dominant crop production	PV_plaines (lowlands)	Productive soils with a very high proportion of arable land where livestock farming has long disappeared
E_Four — Balanced animal and crop production, with forage surplus	E_Four_montagnes et collines herbagères (mountains and grassy hillsides)	Historical presence of grazing or pastoral ruminant systems with marginal potential for arable land
E_Conc — Balanced animal and crop production, with surplus concentrates	E_Conc_plaines et coteaux labourables (lowlands and hillsides suiTable for cultivation)	Historical competition between arable land and permanent grassland
	E_Conc_zones défavorisées (marginal areas)	Low potential for arable land. Mountain or hillside areas with severe natural constraints
Rum + Four — Ruminant production with self-sufficiency in forage but not in concentrates	Rum + Four_Grand Ouest (Grand Ouest)	Complementarity between permanent grassland and arable land, with high potential for arable land
	Rum + Four_montagnes humides intensives (humid mountain agriculture)	Productive permanent grassland with low potential for arable land
PA — Dominant livestock production [deficient in forage and concentrates]	PA_Bretagne (Brittany)	Complementarity of permanent grassland and arable land, with potential for arable land and historical socio-economic factors for the development of grain-fed livestock farming

Source: authors, based on Jouven *et al.*, (2018) and Perrot (2023)

The issue of competition between land uses is crucial in this approach, particularly for understanding changes in grassland. A region with an animal-plant imbalance can either: reduce livestock production in favour of crop production when grassland is arable, with a tendency for livestock farming to disappear completely; or adopting extensive livestock production, particularly by maximizing the use of grassland resources. This latter scenario is especially common in marginal areas (see, for example, Perrot, 2023).

In **Table 2**, we present a refined typology, based on the work of Jouven *et al.*, which captures these various issues. The geographical distribution of the different types is shown in **Figure 17**.

Synoptic analysis of agri-environmental dynamics in different French regions since the post-war period

The analysis of the environmental dynamics at work in each of the territorial types defined above is based on four considerations: (i) changes in the balance between crops and livestock, based in particular on Poux (2006) and Perrot *et al.* (2013); (ii) natural resource management, including water resources, closing the nitrogen cycle and phytosanitary pressure (Billen *et al.*, 2019; Garnier *et al.*, 2019); (iii) changes in landscape structure and biodiversity, assessed through changes in the permanent grassland area, the stocking rate in livestock units per hectare (LU/ha), and the importance of agroecological infrastructure (see in particular Pointereau *et al.*, 2010; Poux & Pointereau, 2014); and finally (iv) changes in greenhouse gas emissions, particularly in relation to the efficiency gains achieved over the last two decades.

FIGURE 17. Mapping of typical areas selected for agri-environmental analysis

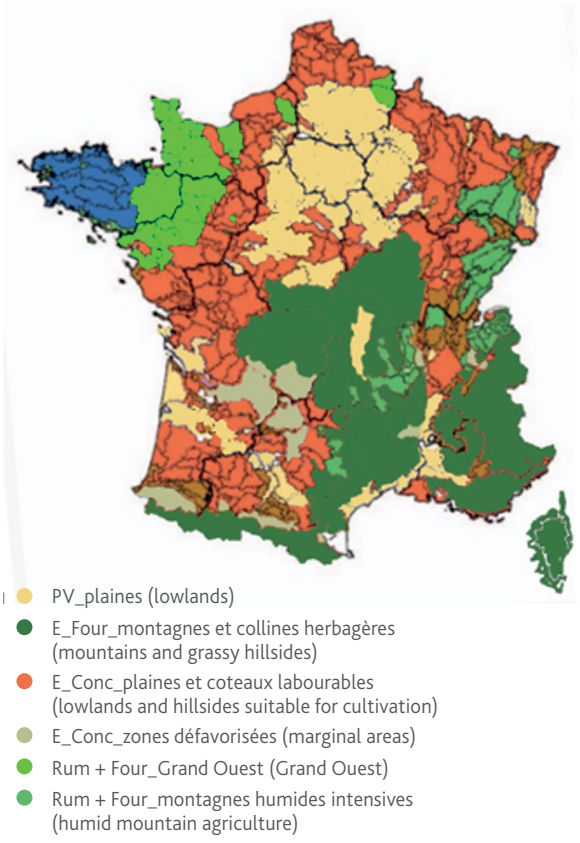


TABLE 3. Agrarian dynamics and their environmental impact in France

	Agrarian dynamics	Natural resources and closing of nitrogen cycle	Landscape and biodiversity	GHG emissions, for France and regional[9]
General trends	Larger farms, less labour per hectare		Enlarging plots, simplifying the management and maintenance of agroecological infrastructure in the landscape	Livestock: Decline due to the combined effect of the number of ruminants (milk and meat) and improved GHG balance per kilogram produced Crops: Improvement in mineral nitrogen efficiency
A) PV_plaines	Livestock farming has all but disappeared in favour of arable farming (former C zones)	Little pollution directly linked to livestock farming, but significant use of synthetic nitrogen and phosphorus inputs, resulting in diffuse pollution. Nitrogen use efficiency has been improving since the 1990s. Loss of soil organic matter	Virtual disappearance of permanent grassland and agroecological infrastructure	Very low GHG emissions from livestock farming, high emissions from synthetic nitrogen
B) E_Four_montages et collines herbagères	Decline in livestock production, trend towards extensification of forage production	Little pollution	Local abandonment	Low emissions, forest fire risk
C) E_Conc_plaines et coteaux	Decline in livestock production in favour of crops (trend towards A)	Nitrogen pollution from converting grassland and nitrogen fertilisation on crops. Increase in surface area receiving synthetic inputs	Very marked decline and intensification of permanent grassland Loss of agroecological infrastructure	Low, sharp drop
D) E_Conc_zones défavorisées	Moderate decline in livestock production, trend towards extensive grassland farming	Little pollution	Maintenance or even development of permanent grassland Conservation of biodiversity Productive woodland	Average, moderate decline
E) Rum + Four_ Grand Ouest	Concentration of standard milk production	Nitrogen pollution from converting grassland. Similar to A, but less intense overall	Decline and intensification of permanent grassland Loss of agroecological infrastructure	High but moderate decline due to ruminant concentration Impact of imported soya
F) Rum + Four_montagnes humides herbagères intensives	Concentration of PDO milk production	Nitrogen and phosphorus pollution from livestock production	Maintaining permanent grassland but with intensification Loss of agroecological infrastructure	Average, moderate decline due to ruminant concentration
G) PA_Bretagne	Relative concentration of all ruminant production previously present in other regions, except B and E, and development of grain-fed livestock production Relative fall in number of animals	Nitrogen pollution: nitrogen imports/ conversion of grassland Marginal improvement in regional nitrogen balance, local pollution linked to the structural concentration of livestock farms Phosphorous pollution and excess in soil organic matter	Marked decline and intensification of permanent grassland Loss of agroecological infrastructure	Very high, but decline due to the combined effect of: - the number of ruminants (milk and meat) - improvement in the GHG/kg balance Impact of imported soya

Source: authors

[9] We therefore estimate the total emissions by multiplying the unit emissions per animal by the change in the number of animals.

Four lessons can be drawn from **Table 3**. The first relates to the links between the intensification of plant production and animal feed: the latter is the primary recipient of the former, absorbing 53% of the cereals consumed in France and 64% of the oilseed and protein crops.[10] This intensification is driven by an increasing reliance on concentrates, the production of which is based on the use of synthetic fertilizers, pesticides and irrigation.[11]

The second lesson concerns the conversion of permanent grassland in lowland and hillside regions, which has negative consequences in terms of pollution and on the water cycle (release of several hundred kilograms of nitrates over several years, decrease in hydrological filtration capacity), biodiversity loss and a decrease in carbon sequestration from the atmosphere over several decades (permanent grassland stores 80 tonnes of carbon in the soil compared with 40 to 50 tonnes for crops). Furthermore, the decline of agroecological infrastructure, such as hedges, copses and ponds, which are associated with grazing livestock, goes hand in hand with the reduction of grasslands.

Thirdly, the significant geographical concentration of livestock farming results in nitrogen pressure that exceeds the capacity of the environment to recover and mitigate the impacts of nitrogen. The concept of a zone with a structural surplus was based on this idea, as reflected in the analysis by Jouven *et al.* (2018).

Finally, the period shows an overall but limited reduction in GHG emissions associated with livestock farming. This reduction is due to: (i) the reduction of the cattle herd; (ii) increased milk production per cow and the improved efficiency of livestock farming systems; and (iii) improved nitrogen efficiency in crop production, which reduces the climatic impact of concentrate production.[12]

In this analysis, emissions per kilogram is only one parameter of the sector's environmental performance, alongside the other dimensions to be considered. Furthermore, in addition to unit performance per kilogram, it is essential to consider the sector's overall emissions (i.e. GHG emissions per kilogram multiplied by total kilograms produced). This assessment should also include imported emissions resulting from supply-demand imbalances (from concentrates and meat).

Considering imported (and exported) environmental impacts beyond emissions

The imbalance between supply and demand leads to imports that generate emissions and require land area for production, which can be expressed in terms of tCO_2 equivalent and hectares. However, these figures must be complemented by an analysis of the geography and production methods from which these flows originate, and take into account the diversity of environmental issues.

Almost all feed imports are protein cakes, primarily soya or (to a much lesser extent) sunflower. Regarding soya, the French sectors have made significant efforts in recent years to ensure the traceability of their supply chains, thereby reducing the risk of deforestation directly linked to their operations. However, it is crucial to acknowledge that, despite sourcing from "non-deforesting" suppliers, French demand still contributes to the overall increase in international soya demand. This, in turn, drives deforestation and leads to greater use of synthetic inputs (pesticides and fertilizers) in the regions where these crops are cultivated.

Since the mid-2010s, France has become a net importer of meat due to the growing imbalance between supply and demand. These net imports also generate emissions and require imported surface area, that should, strictly speaking, be attributed to France according to their origin.

However, too much focus on GHGs might suggest that reducing environmental impact equates to prioritizing the most efficient production methods in terms of GHG emissions per kilogram of meat. However, the examples of Ireland and Northern Europe highlight the limitations of this perspective and the importance of a multi-dimensional approach. In Ireland, the *Origin Green* label aims to promote intensive grass-based dairy and beef production for export. Efficiency in terms of GHG emissions serves as the primary environmental metric of the programme, which actively communicates on this theme, with an 8-9% reduction in emissions per kilogram of milk and meat between 2012 and 2023 (Bord Bia–Irish Food Board, 2023). While these unit performances are commendable, the expansion of this "virtuous" form of production has led to an overall increase in emissions from the agricultural sector (37% of national emissions). At first glance, this may seem to be a good climate strategy that could be implemented at the European level (maximizing low-impact production and consumption), as well as promising for Ireland too. However, the increase in production is having a significant impact on water quality and biodiversity, resulting in increased nitrate and phosphorus water pollution over the past decade[13] and a decline in the abundance index of common birds found in Irish farming environments (Gilbert, 2021).

In Ireland, as in other regions, environmental issues are closely linked to the geographical concentration of production. Importing carbon-efficient meat often negatively impacts biodiversity and water quality in the producing countries, especially when production exceeds the capacity to feed local livestock. Furthermore, in Ireland again, intensification has led to an increase in soya imports from 18 million tonnes in 2013 to 27 million tonnes in 2023 (source: World Bank).

The Irish case is not isolated: the situation is equally problematic, if not more so, in all the intensive livestock farming regions of Northern Europe, which nevertheless claim

[10] For more details, the GIS Avenir Élevage provides the following for concentrate consumption in 2015: 7.6 million tonnes (Mt) for pigs, 6 Mt for meat poultry, 8.2 Mt for dairy, and 3.9 Mt for beef, including for soya alone, 0.2 Mt for pigs, 1.1 Mt for poultry, 1.4 Mt for dairy and 0.3 Mt for beef. https://www.flux-biomasse.fr/

[11] Arambourou et al (2024) estimate that 30% of the water used for irrigation in France is used for domestic animal feed, with a further 9% used for animal feed sourced from outside France.

[12] GHG emissions from agriculture in France have fallen from 96 Mt in the 1990s (historical peak) to 65 Mt of CO_2eq today (primap.org).

[13] https://iwt.ie/wwf-and-origin-green/

exceptional unit performance (Wirsenius *et al.*, 2020). However, the issues of nitrogen pollution and biodiversity loss[14] remain extremely concerning.

These shifts in environmental impacts within Europe, which are often overlooked in current environmental metrics, are essential for a comprehensive environmental assessment. In the same way that climate change is rightly regarded as a global issue, the same approach must be adopted for biodiversity and natural resource conservation in Europe and throughout the world.

3.3.2. Socio-economic impacts: trade deficit, farm growth, and jobs

The socio-economic impact is felt at several levels. The above-mentioned supply-demand imbalance has a direct economic impact in terms of the trade balance. Although France became a net importer of meat by volume in 2012, it was not until 2022 that the trade balance for meat became negative - if we include live exports of grazers in the analysis, which represent 30% of export value. Furthermore, a steep decline in 2022 was also driven by a severe avian flu outbreak in France, which devastated the industry's production capacity and led to large-scale poultry imports (**Figure 18**).

There have also been striking changes at the farm level. A comparative analysis of the evolution of *specialized* farms, along with *livestock* farms shows a strong trend towards specialization (see **Figure 19** and **Figure 20**). Between 2000 and 2020, 66% of all farms with livestock either disappeared or stopped farming livestock, particularly in the poultry sector. However, the decline is less pronounced for farms *specializing* in livestock production. In other words, farms with livestock are becoming increasingly specialized in a single type of production, while mixed crop-livestock systems, and even mixed livestock systems, played a central role until the early 2000s.

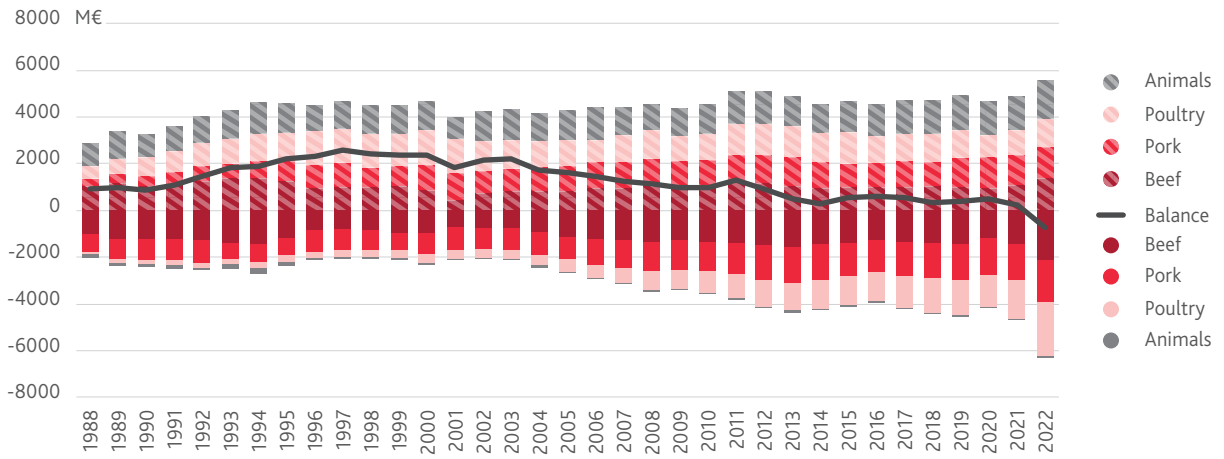
This decline in the number of farms in France has been accompanied by a relative reduction in the diversity of farming systems–although diversity remains much higher than elsewhere in Europe, as noted by Perrot *et al.* (2024). **Figure 21** illustrates this diversity and the relative importance of the most specialized systems in production. It also presents the typology of systems used in the modelling tools discussed in the following section to assess the implications of the BAU scenario.

This decline has also been accompanied by significant job losses on farms, with a 31% fall for all types of farming (French OTEX classification–*Orientation Technico-Economique des Exploitations*, Technical and Economic Orientation of Agricultural Enterprises) combined. This loss cannot be offset by the increase in salaried employment generated by the growth in farm size (see **Figure 22**).

At the industrial level, employment has increased in direct proportion to production: an 88% rise between 1962 and 1995, and by 9% between 1996 and 2020. However, this correlation between production volumes and jobs conceals two contradictory dynamics: one involves gains in physical productivity in "essential" operations, particularly slaughtering and cutting, while the other relates to the rise of increasingly complex products that require more labour per unit. Moreover, this maintenance of employment in the slaughtering and meat processing stages can be attributed to France's labour productivity, which remains significantly below that of major competitors. For example, in poultry slaughtering and cutting, labour productivity in France is a third of that in the Netherlands.

Figure 23 summarizes the main changes taking place in the meat industry from 2000 to 2020, based on the analytical framework presented in Section 2.

FIGURE 18. A deteriorating trade balance between 1988 and 2022



Source: authors, based on EUROSTAT/Comext data.

[14] https://www.clo.nl/en/indicators/en147914-farmland-bird-indicator-1915-2021. The situation of farmland birds is very problematic in the Netherlands, more so than in France.

FIGURE 19. Change in the number of livestock farms across all types of farming (OTEX) combined

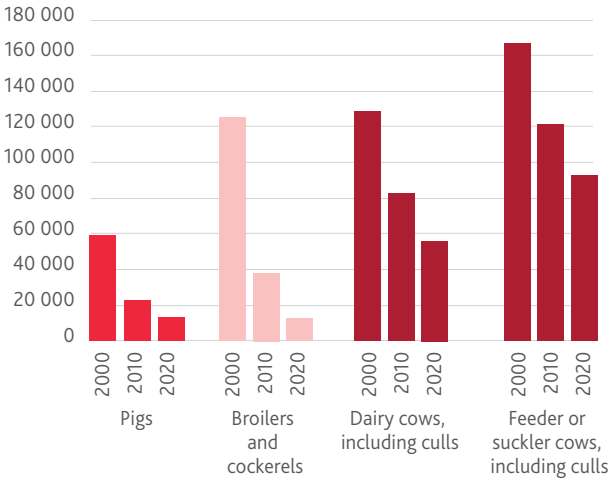


FIGURE 20. Change in the number of specialized meat production farms, 2000-2020

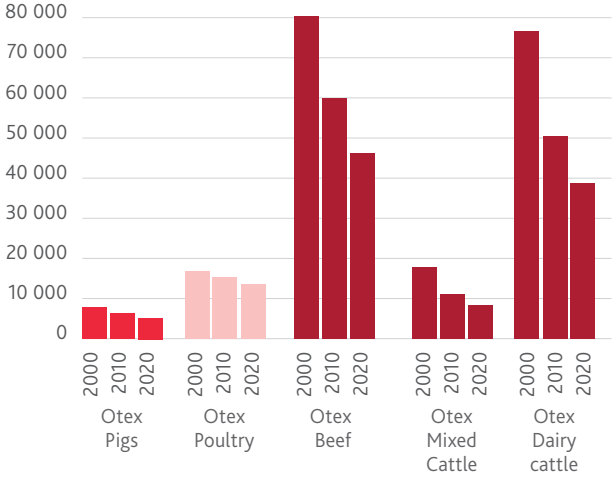
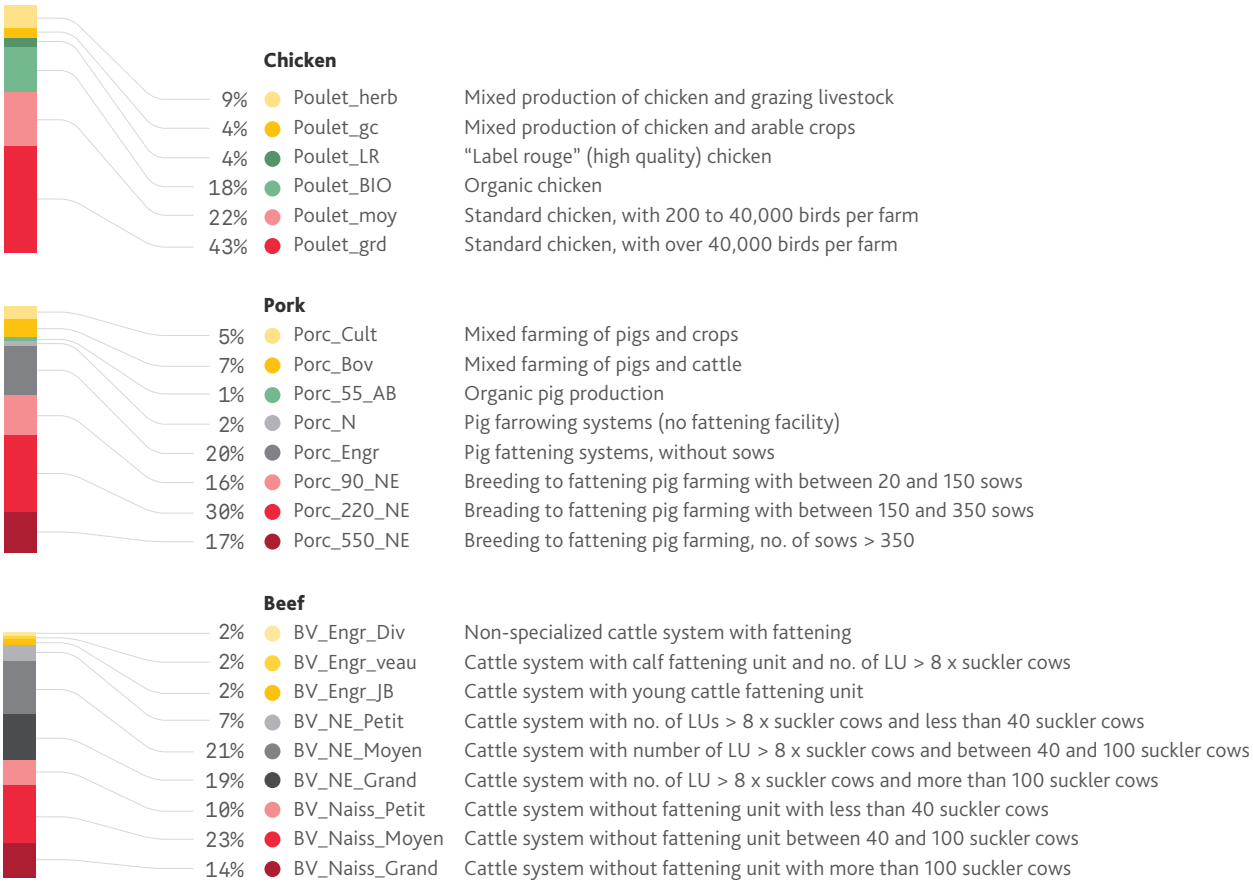
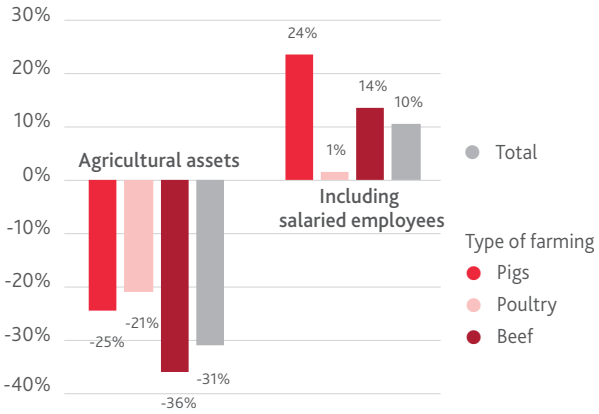


FIGURE 21. Production remains diversified but is dominated by the most concentrated and specialized systems



Note: the contribution of each system is expressed as a percentage of total production for poultry, and as a percentage of LUs for pork and suckler systems.
Source: authors, based on RA and FADN data.

FIGURE 22. Employment trends in specialized production systems for pork, poultry and beef



Source: authors, based on FADN data.

FIGURE 23. Summary of the main changes in the French meat industry

DRIVING FACTORS 1960-2020

Demand and competition between sectors: the process of commodification has triggered an increase in poultry consumption (from 16% of meat consumption in 1960, to one-third in 2020) and in market share.

Public policy:

- 1960-1995: Support for production and market protection through the CAP, along with a commitment in France to maintain family and diversified agriculture
- 1995-2020: liberalization and the pursuit of greening, while ensuring technical and economic efficiency

State of competition: competition primarily occurred within the European market. EU competitors increased their productivity at a faster rate than French actors, leading to competitiveness disparities following liberalization.

DEVELOPMENTS IN THE MEAT INDUSTRY 1960-2020

Flow structure:

- 1960-1995: supply increased faster than demand, leading to an increase in trade.
  - **Chicken :** maximum production in 1999, up 345% compared to 1961, at 141% coverage rate
  - **Pig :** maximum production in 1999, up 100% compared to 1961, at 107% coverage rate
  - **Beef :** maximum production in 1991, up 40% compared to 1962, at 103% coverage rate.
- 1995-2020: gradual decoupling of supply and demand, decrease or stagnation of supply and decrease of coverage rate (Chicken : 141-> 93% ; Pig: 104 -> 103% ; Beef: 113 -> 98 %)

Livestock farming systems: geographic (in the Grand Ouest) and economic concentration and specialization (increase in LU/farm and decrease in number of farms with livestock)

- For example, in Pig: a 7.6% decline in farms/year between 1968 and 2020 on a stable basis

Slaughtering and cutting industry: concentration in the Grand Ouest, increase in unit sizes, increase in the level of downstream processing
(For example, in P: 75% of production processed into charcuterie; in B, 50% into minced beef)

IMPACTS 2000-2020

Socio-economic impact

- Agricultural employment: 32% fall between 2000 and 2020, concentrated in B (36% decline, compared to 20% decline in V)
- No. of farms: 64% decline between 2000 and 2020, concentrated in V (90% decline in V compared to 44% decline in B)
- Agro-industrial jobs: sTable as productivity gains are offset by the increasing complexity of the downstream production chain
- Trade balance in value: down 79% from €2.4 billion in 2000 to €505 million in 2020

Environmental impact

- 7% loss of grassland
- Reduced emissions due to livestock reduction and efficiency gains
- High nitrogen balance per hectare in the Grand Ouest region

Source: authors.

4. THE BAU SCENARIO TO 2035 RAISES MANY QUESTIONS

For decades the French meat sector has faced discouraging economic and social trends, while its various environmental impacts remain problematic. Over the past 15 years, a series of reports and prospective studies have identified the causes of these trends and proposed potential solutions (Jez *et al.*, 2010; Malpel *et al.*, 2014; Rieu *et al.*, 2014; Cerles *et al.*, 2016). Although the loss of price competitiveness has been identified as a central issue, the French authorities have struggled to address it, particularly in a context where the EU is primarily responsible for the regulations (agricultural and trade policies). In addition, while the agri-environmental dimension is raised in these analyses, it has often been relegated to secondary importance in the sector's actual orientation, despite being crucial to its operation.

In this context, the BAU scenario that we have developed proposes a comprehensive approach that considers both the socio-economic and environmental implications of changes in the meat sector up to 2035. We regard this as a "probable" scenario, in the absence of any significant changes in the current dynamics, major crises, or external shocks (Godet, 1983).[15] However, it is important to note that no *single* BAU scenario can ever be imposed with complete objectivity; every scenario is based on a set of hypotheses, and we have tested these hypotheses with stakeholders and experts from the relevant sectors.

4.1. A widening gap between supply and demand in 2035

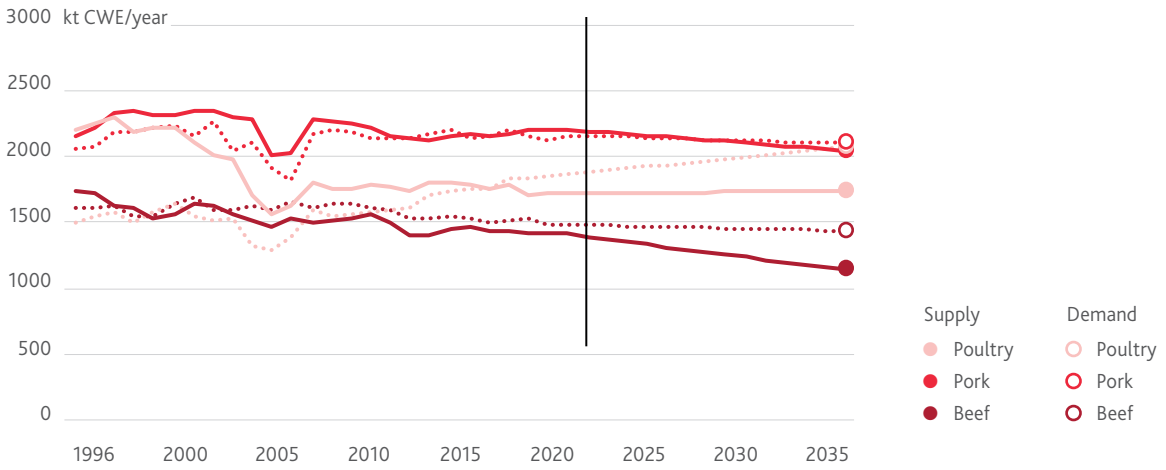
As a core principle for the BAU scenario, none of the underlying trends identified in the retrospective analysis are anticipated to change by 2035: commodification will persist, chicken meat will remain dominant, competition between production regions on the European market and beyond will continue, and dependence on concentrates will grow. In this context, the BAU scenario that emerges primarily points to an increasing imbalance between supply and demand. We outline this scenario in more detail and then analyse the main driving factors.

4.1.1. Contrasting dynamics between sectors

The gap between supply and demand evolves differently across the three sectors studied. Regarding pork and beef, supply shrinks faster than demand, shifting the former from a slight surplus (102-103%) to a slight deficit (98%), and the latter to an increased deficit (from 95% to 80%). In the poultry sector, the stabilization of production (driven by increased chicken production and a decline in other poultry types) fails to meet the continued increase in consumption, and leads to a widening of the deficit from 92% to 84% (see **Figure 24**). During the period 2022-2035, the impact of these three dynamics would lower the overall coverage rate from 97% today, to 88% in 2035 (see **Figure 25**).

Under this scenario, the rise in demand, together with a decline or stagnation in supply, can be attributed to the assumptions made regarding public policies and changes in competition in the European market.

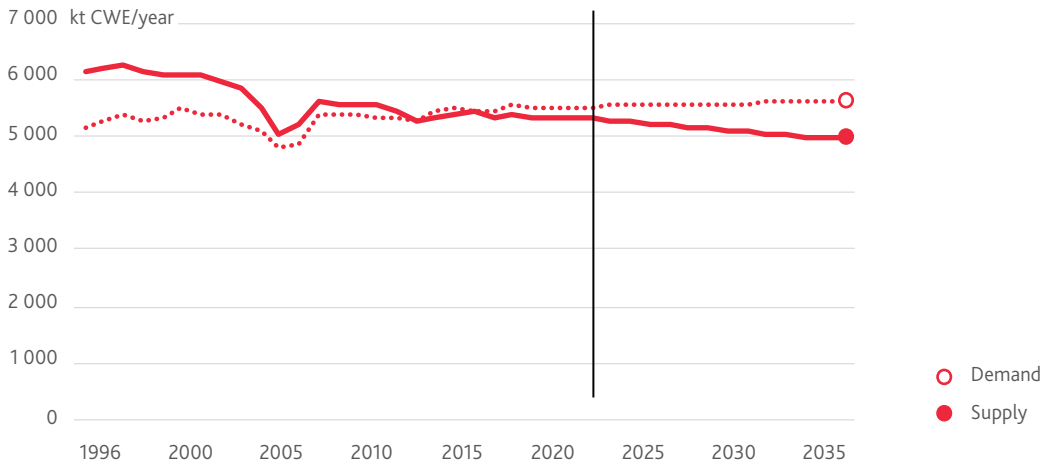
FIGURE 24. Supply-demand equilibrium in the BAU scenario: contrasting trends between sectors



Source: authors, based on FAOSTAT data.

[15] In this case, the proliferation of recent crises (Covid-19, war in Ukraine, drought in 2022 and bird flu) could have led to the development of a BAU scenario marked by recurring crises. This makes it more difficult to quantify the impact of these crises.

FIGURE 25. Supply-demand balance for the three meats studied: a widening gap



Source: authors, based on FAOSTAT data.

4.1.2. Public policies that take little action on domestic demand amid growing global demand

Over the last decade, total domestic demand for all types of meat has risen slightly, due to higher individual consumption of poultry and a slight fall in pork and beef consumption (Rogissard, 2023), alongside a population increase of 6% between 2010 and 2020. We assume these individual consumption trends will continue, combined with a population increase of 2.3% based on INSEE projections (a population increase from 67.4 to 69 million between 2020 and 2035). Consequently, poultry consumption, particularly chicken, is expected to rise by 10%, while total pork demand stagnates (reflecting a very slight decrease of 3% in consumption per person). Beef demand is anticipated to continue to decline but at a slower rate of 7% per person (compared with a decline of 18% per person from 2002-2022), which equates to an aggregate decline of 4.5%.

This trend can be primarily explained by the continuation of "low-key" public action on consumption, reflecting the highly political and sensitive nature of public debates surrounding meat (Piazza *et al.*, 2015; Michielsen & van der Horst, 2022). While current measures are being maintained, their impact on dietary habits remain limited (Brocard & Saujot, 2023). This includes communication campaigns as part of the National Nutrition and Health Programme (PNNS), the development of various forms of environmental labelling that drive consumers towards a preference for poultry (further strengthening its advantage on the market), and the continuation of policies promoting meats with specified origins and labels.

Secondly, this trend is likely to result from an increase in the degree of meat processing, which presupposes the use of undifferentiated and standardized raw materials (Soler *et al.*, 2011), for which poultry, particularly chicken, are ideally suited.

These developments will not replace differentiated production, which is currently well-established and protected by geographical indications or other standards. However, its market share will continue to fall in areas where it holds a significant presence (particularly chicken, currently 15% of the market) without seeing similar growth in pork (less than 2% of the current market) or beef. Although the Egalim Law (which aims to balance commercial relations in the agricultural sector and to promote healthy and sustainable diets) will continue to require that at least 50% of the food served in collective catering meets the standards of certain labels, this measure will not be sufficient to change the French population's relationship with different types of meat.

These trends in domestic consumption will take place against a backdrop of a probable decline in total European demand, but strong growth in global demand (see EC, 2023). While this factor does not directly affect national balances, it is likely to drive other European actors to seek opportunities for growth, which may well lead them to find outlets onto the French market.

4.1.3. Limited changes in public support for supply in a highly competitive environment

We anticipate that supply-side support policies will change little over the period. Thus, support for suckler cattle will continue to slowly decline (to the benefit of dairy farms in particular), while support for crop production will be maintained–favouring monogastric production. At the same time, public intervention during crises will not be changed (Bonvillain *et al.*, 2024), strengthening the position of actors in systems that are highly exposed to shocks, particularly in the pork sector where fluctuations in the "pork cycle" can be significant.

Furthermore, while generational renewal is a topic of public debate, the measures taken are insufficient to prevent the decline of the workforce, particularly in the suckler cattle (Perrot, 2023) and pork sectors. Lastly, the flexibility promised to encourage expansion and new installations in the monogastric livestock sector will lead to significant growth (we estimate that 150 new farms, each with 100,000 places, will emerge between 2020 and 2035–see **Figure 26**), although at a slower pace than anticipated.

FIGURE 26. Changes in chicken production systems, 2020-2035

Source: authors, based on RA and FADN 2020 data.

The competitive dynamic remains intense on two levels: between sectors, and between production regions, especially within the European market, which remains the most important market for French producers. Competition between sectors will continue to give an advantage to poultry, as generational renewal remains easier in this sector, due to the lower cost of farm succession and more promising market prospects.

European competition is partly exacerbated by increased subsidiarity in the implementation of the Common Agricultural Policy, which has been in place since the 2013 reform, leading to a form of renationalization (Anania & d'Andrea, 2015, p. 71). We therefore assume that the main competitors, regardless of the sector, will remain powerful and well-positioned, and more competitive than French actors. Their ability to penetrate the domestic market will remain strong, while their presence makes it difficult for French production to maintain or establish a presence in intra-EU export markets.

More specifically, Northern European actors have no reason to expect their competitive strength to diminish, as they are far ahead in the race and have been for many years (Trégaro, 2012b). However, in the pig sector, concerns could be raised regarding the future of Spanish production, particularly in Catalonia, given the recurrent droughts that have severely affected the region. This situation could significantly impact a key actor in the pork sector, as well as the beef sector to a lesser extent. Conversely, Eastern European actors that have already established themselves (e.g. Poland) still have potential to increase their competitiveness and productivity. For instance, gains in slaughtering and cutting efficiency are significant: employment intensity (i.e. the number of full-time equivalents (FTEs) needed to process 1,000 tonnes of meat) has fallen by 60% in the past decade (source: Eurostat data). In countries where production has not yet developed (e.g. Romania, Bulgaria), substantial investments are likely, which could help the monogastric livestock sectors to emerge. Finally, the specific case of chicken production in Ukraine may require major dedicated developments, although it is not central to our scenario. We assume that production here will be maintained at a minimum, with a level of price competitiveness that remains better positioned than that of the majority of French actors.

In the following section, we examine how French production tools–farms and industries–evolve across the three sectors in light of these hypotheses.

4.2. French production undergoing major restructuring

Although the three sectors are evolving differently, they all face intense competition and increasingly undifferentiated demand, therefore necessitating better positioning in terms of price competitiveness. This results in strong pressure to reduce production costs, leading to major restructuring at both the farm and industry levels.

This demand for competitiveness also has spatial implications: the density of livestock in the Grand Ouest region must be sufficient to meet the supply needs of slaughter and cutting plants, to avoid harming their economic viability through excessively high supply costs or having to operate under capacity. Consequently, declines in pig and beef production are concentrated outside the Grand Ouest. This dynamic contributes to the persistence of heteronomous animal feed systems in western France, as described in the previous section, and leads to the

erosion of permanent grassland outside the Grand Ouest, particularly in intermediate areas, where cattle production declines.

4.2.1. The poultry industry: chicken production drives growth

In the poultry sector, chicken and other types of poultry production are following very different trends: sustained growth for the former (10% increase compared with 2020), and a decline in other poultry production (16% fall). Regarding chicken, assuming a return to normal conditions post-bird flu, the projected annual growth rate is lower than the rate over the last decade, going from 1.3% per year to 0.7% per year. This growth is occurring in increasingly large poultry houses that are part of increasingly specialized systems, with new installations continuing to be established at a pace sufficient to support industry development. The development of larger, more specialized poultry houses is accompanied by efficiency gains. These larger systems are aiming for higher live weights of 2.5 kg (compared with just under 1.9 today), with improved feed conversion ratios, down by around 5% to 1.55.

The proportion of chickens raised according to certification standards (such as Label Rouge, organic or free-range) continues to decline, now accounting for 12-13% of the market, while poultry houses continue to expand in size. Meanwhile, systems geared towards third countries exports of "light weight" chicken are holding steady. It is assumed that the influx of Saudi capital, among other investment, to acquire Doux's large-scale export business will maintain demand for French-origin chickens from Gulf States.

Figure 26 illustrates the structural changes in chicken farming between 2020 and 2035

At the industrial level, LDC's leadership is not expected to be challenged. The group will be able to modernize its slaughtering and cutting facilities to handle larger volumes while improving labour productivity. Smaller plants, particularly those outside the Grand Ouest region, are closing, contributing to an *average* increase in French productivity of around 9%. Although substantial, this increase is unlikely to close the competitiveness gap between France and its main competitors. In 2020, labour productivity (e.g. number of tonnes of carcass equivalent slaughtered per FTE) was three times higher in the Netherlands than in France.

4.2.2. Pig production: controlled stock reduction that raises questions

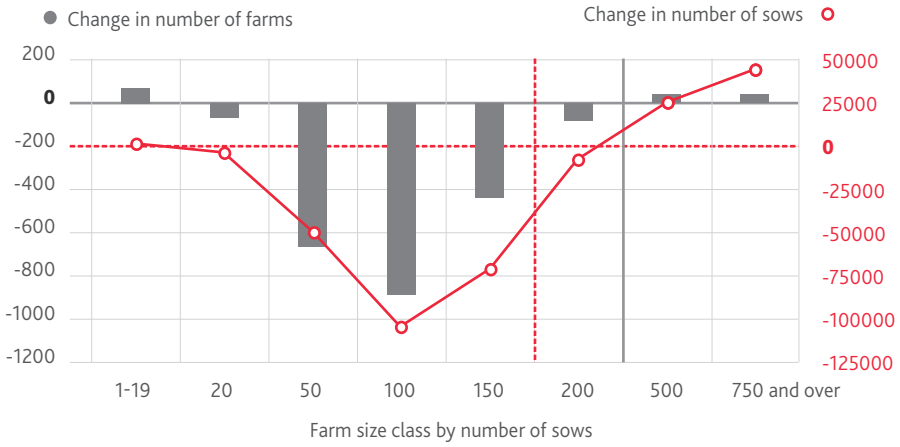
In the pig sector, ongoing concentration (as described by Roguet *et al.*, 2022) is expected to lead to large farms (with more than 600 sows) playing an increasingly dominant role, accounting for 30% of total production by 2035–while representing only 10% of farms (**Figure 27**).

These larger farms are also becoming significantly more efficient: *on average,* they perform at the level of the top third of today's most efficient systems, improving sow prolificacy, manure management and nitrogen excretion levels through better feed control. Their unit emissions (e.g. kgCO_2eql/kg pig produced) are also being significantly reduced. In addition, considering the dynamics already underway, most large farms are expected to install anaerobic digestion plants, which will double the volume of manure processed by anaerobic digestion compared to 2020.

Conversely, medium-sized farms (100-200 sows) can either expand their capacity to around 400 sows, or risk closure due to a lack of competitiveness. Some of those that manage to expand will also achieve efficiency gains, although these gains will not be as pronounced as in the largest systems. Lastly, very small units (< 50 sows) are likely to maintain their presence, but will make little contribution to total production. Mixed systems will increasingly disappear as the pressure to increase competitiveness intensifies. Fattening operations will also develop, accounting for 25% of production by 2035. **Figure 28** illustrates these trends.

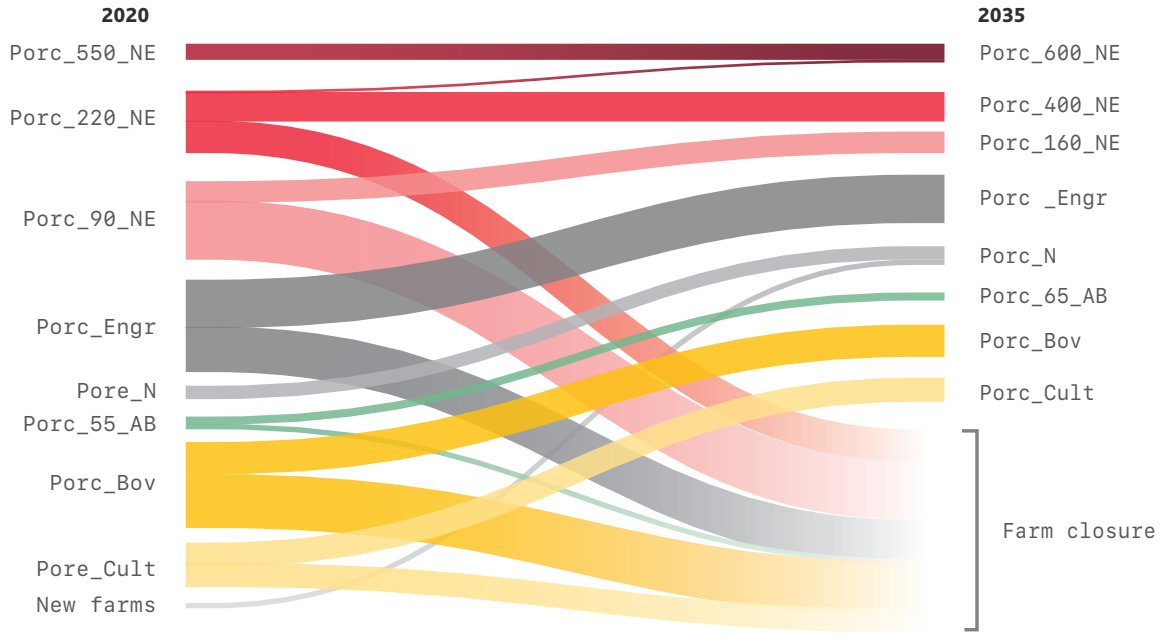
On the industrial side, the dynamics are similar to those described for poultry, with the key difference that, as volumes decline, restructuring becomes more pronounced.

FIGURE 27. Number of farms and sows per size class between 2010 and 2020



Source: Roguet *et al.*, 2022.

FIGURE 28. Changes in pig production systems, 2020-2035



Source: authors, based on RA and FADN 2020 data.

The concentration of slaughtering and cutting facilities, combined with the fall in volumes, has led to a 25% reduction in the number of units. The implications are less severe for the secondary processing/seasoning sector (which processes 75% of the volumes slaughtered in France), where "only" 13% of sites will disappear. This is due to (i) the reliance on imports for supply, and (ii) the ability to leverage France's unique characteristics.

4.2.3. Beef: insufficient recovery to counter herd reduction

In beef production, longer production cycles compared to pork and poultry mean that trends are influenced by two major factors: changes in the number of breeding animals, both dairy and suckler cows, and changes in exports of live animals not fattened in France.

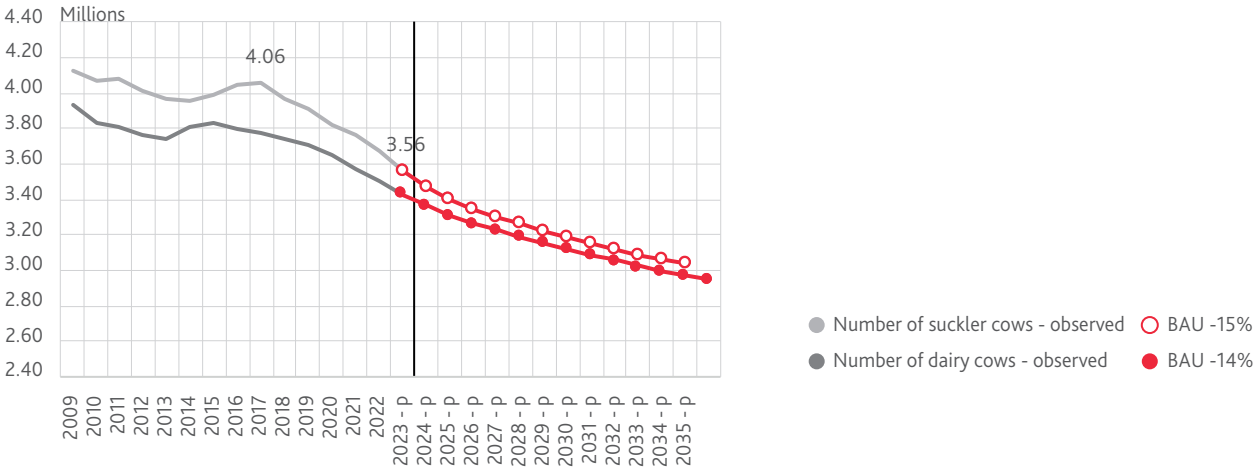
The scenario regarding the number of breeding animals is based on the herd reduction assumptions outlined by Groshen *et al.* (2023), as illustrated in **Figure 29**. The reduction of the herd is projected at approximately 15% between 2022 and 2035, translating to 0.9% per year for both the dairy and suckler sectors. However, the underlying reasons for this decline differ significantly between the two sectors. In the dairy sector, the number of farms is expected to fall by almost 4% per year, although consolidation among existing farms will partly offset the overall decline in livestock numbers with an increase in the number of cows per farm. The suckler farming sector faces an attrition rate of 1.5% per year, with larger farms capping the maximum size of their herd. As a result, the number of farms is becoming the key factor influencing changes in livestock numbers.

Faced with a decline in livestock numbers, one option for maintaining meat production (or reducing it at a slower rate) is to limit live exports and instead develop fattening facilities in France. In 2022, around 1.2 million grazing cattle and 400,000 calves are exported live and lean, mainly to Spain and Italy. Conversely, a large proportion of suckler cow systems in the Massif Central are specialized in calving, to supply Italian fatteners with grazers in a highly structured way (see Fayard, 2022, p. 230-231). The issue of the development of fattening is not new; it was already being addressed at the end of the 1980s, for example in Soufflet (1989). Until recently, however, the price paid by Italian fatteners has always been sufficiently high to discourage the establishment of a French fattening industry (Chotteau, 2010), despite available public subsidies (Trégaro, 2012a).

However, **Figure 29** highlights that herd reduction has never been so pronounced. In this scenario we therefore assume that the decline in volumes will encourage downstream operators to raise the prices paid to producers to encourage fattening, and thus maintain a sufficient volume at the slaughterhouse gate. This will lead to a slight increase in the number of young cattle fattened per suckler cow, and therefore to a 19% fall in live cattle exports. It is assumed that the increase in fattening takes place mainly on breeder-fattener farms with enough land to feed more animals without relying too heavily on concentrates (> 200 dams, > 200 ha of UAA). Conversely, medium-sized and, to a lesser extent, small farms will struggle to maintain their position. **Figure 30** illustrates these trends.

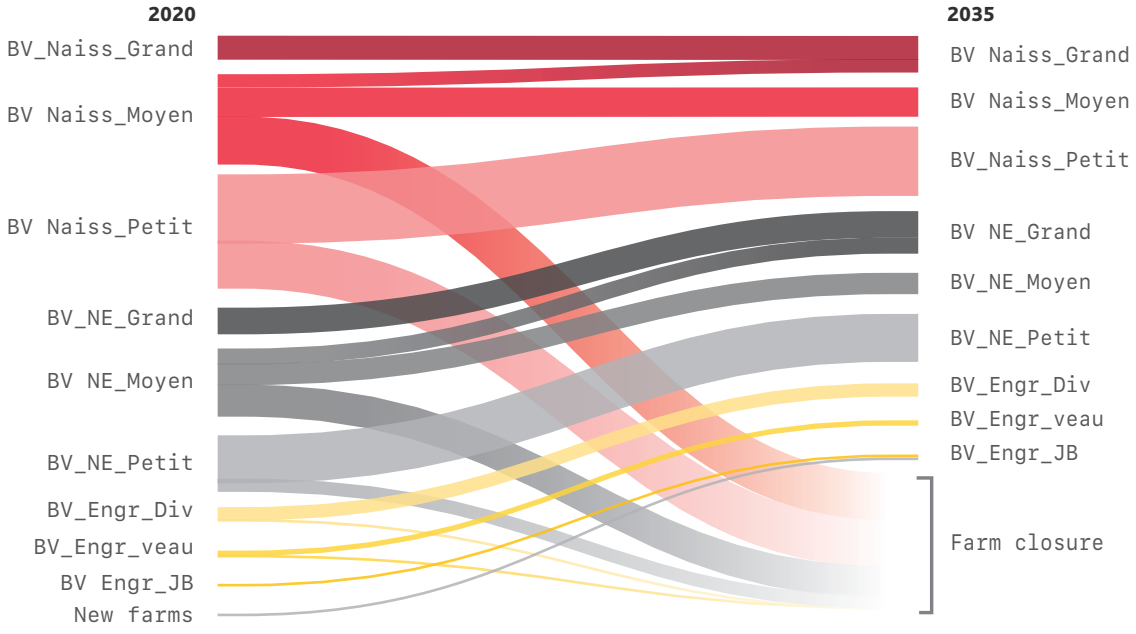
The simplicity of the categories used in Figure 30 should not lead us to assume that the situations and strategies of suckler farmers are homogeneous. On the contrary, recent analyses by

FIGURE 29. Changes in the number of dairy and suckler cows, 2009-2035



Source: (Groshen *et al.*, 2023).

FIGURE 30. Trends in beef cattle production systems, 2020-2035



Source: authors, based on SPCalc, RA, FADN.

Perrot *et al.* (2024) show extreme diversity. The typology on which this modelling is based focuses on two essential variables: farm size, and status as a breeder or breeder-finisher.

The decline in production volumes, which reaches 15% between 2022 and 2035, will necessitate significant restructuring at the slaughterhouse level: it is projected that 23% of sites will close, allowing the remaining sites to increase their productivity and therefore maintain market competitiveness–with an increase in physical labour productivity of around 10% over the period.

4.3. Problematic socio-economic and environmental implications

The changes in the political and market context outlined in Section 4.1 and their implications for the development of the sector, discussed in Section 4.2, point towards a future that is unlikely to be positive. To objectively assess the impacts, the quantification work carried out is based on the combined use of the three modelling tools presented in the appendix: SPCalc for production systems, IAACalc for industry, and MOSUT for

physical equilibria. This quantification exercise ensures consistency in the assumptions made at the various levels of the meat sectors, as well as between the biophysical and techno-economic aspects. Firstly, Section 4.3.1 details the socio-economic implications of the scenario for the agricultural and agri-food components, and their translation in terms of labour productivity, employment and the number of production units. Section 4.3.2 then addresses the environmental impacts of the scenario, considering both national and global levels.

4.3.1. Major socio-economic impacts driven by concentration and falling volumes

The farm level

The concentration of farms combined with a reduction in the number of employees will lead to significant changes in the number of farms, job availability and animal density. Over the next 15 years, 34% of farms in the meat sector will disappear, along with 31% of jobs (the difference being due to an increase in the use of salaried workers, particularly in pork systems), while overall production will "only" fall by 4%. The farms that remain will be larger and more intensive, with a 20% increase in livestock units per farm relative to a 15% increase in UAA: from 2.3 livestock units per hectare of UAA (including permanent grassland) to almost 2.6, an increase of 12%. This increase in livestock density is due to the relatively greater loss of grazing cattle systems, where non-free-range poultry systems will expand.

The remaining farms are expected to show greater labour productivity, with each FTE farming 15% more LUs in 2035 than in 2020. **Figure 31** illustrates these trends across all sectors. While concentration persists in the monogastric and dairy sectors (the trends of which are not documented in detail here), the growth in the size of suckler systems remains minimal.

These 15-year trends are ultimately consistent with observations from the past 20 years, as shown in **Figure 32** for pigs and suckler cattle. The annual rate of the closure of farms with at least one productive animal, which corresponds to the scope of this *Study,* follows a consistent trend. For pigs, the annual closure rate decreases from 9% per year to 5% per year between 2000-2010 and 2010-2020. Between 2020 and 2035, it is expected to continue declining to 4% per year in our scenario.

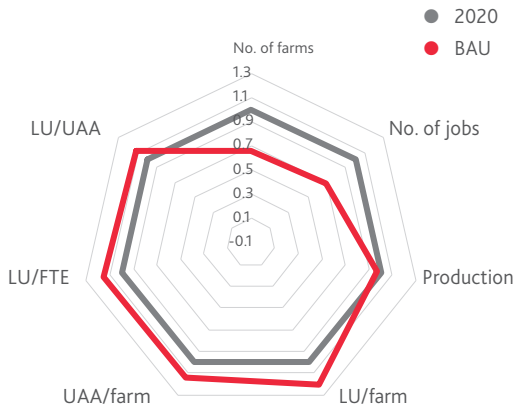
The food industry level

These changes in livestock farming systems will be accompanied by similar changes in the food industry. Thus, the maintenance of production in the Grand Ouest region, which is leading to a growing imbalance with the rest of France, will further reinforce the importance of facilities located in this region within the broader organization of the agro-industrial landscape. At the same time, labour productivity will increase by 8-10% to remain competitive. The combined effect of falling volumes and improved productivity will lead to a fall in employment of around 20% in the three sectors, primarily beef and, to a lesser extent, pig farming (**Figure 33**). This sharp decrease in employment contrasts with recent trends and needs clarification. The underlying assumptions are twofold: (1) without an increase in labour productivity in the industry, the ability of French operators to sustain themselves in the markets appears limited; (2) the diversification or complexification of labour-intensive transformation processing will not increase to such an extent that it will offset the productivity gains achieved in simpler operations (as has been the case over the last 20 years, cf. 3.3.2).

As part of this dynamic, production sites will concentrate and process larger volumes each year: in poultry, for example, there is a shift from plants processing an average of 74 tonnes CWE per year in 2020 to 81 tonnes CWE per year by 2035, a gain of 15% over 15 years. These gains are twice as pronounced for pork, which has much greater leeway when compared to competitors, and are comparable for cattle.

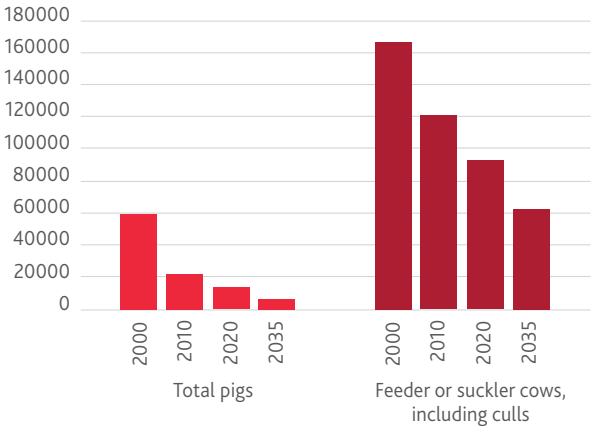
The concentration/restructuring dynamic (coupled with declining volumes in pork and beef) has resulted in the closure

FIGURE 31. Structural changes in average French agriculture across the three meat sectors



Source: authors, SPCalc data.

FIGURE 32. Evolution of farms with at least one animal from 2000 to 2035 under the BAU scenario



Note: Poultry is not represented in this graph because the production systems model only covers chicken production, whereas official statistics data covers all poultry.

Source: authors.

of a significant number of facilities across all three sectors: 11% in poultry, 27% in beef, and 13% in pork. This has generated over €400 m in stranded assets, representing 12% of the value of assets in 2020 (**Figure 34**).

4.3.2. Significant agri-environmental impacts in France and throughout the world

Farming system dynamics associated with the BAU scenario

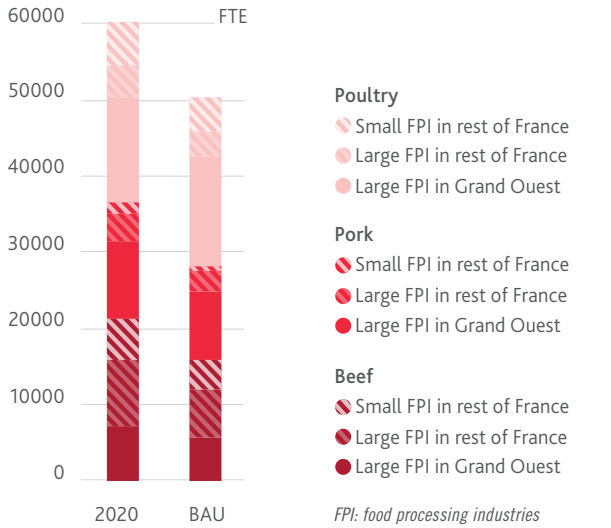
Without going into the detail of regional types described in Section 3.3.1, three major territorial agri-environmental issues emerge from the BAU dynamics. These issues result from the geographical dualization of livestock production, characterized by its concentration in the Grand Ouest and the corresponding decline in other French regions.

In the Grand Ouest,[16] maintaining a high livestock density only marginally improves the regional nitrogen balance: the nitrogen surplus per hectare decreases by 8% but remains high at over 40 kg N/ha/year. The expansion of farms leads to a simplification of landscape structures, resulting in the loss of agroecological infrastructure and a reduction in grassland of around 17%, particularly grazed grassland. While nitrogen efficiency is increasing, the pressures on water resources and biodiversity remain at very high levels, at odds with the restoration of environments and resources quality. Furthermore, maintaining a high livestock density maintains a dependency on the import of concentrates from outside the region.

In the intermediate zones,[17] the decline in dairy and suckler livestock will continue, leading to increased crop specialization. In addition to grassland loss, which reaches 18%, some grassland will be converted for other uses, generating significant impacts including the release of carbon that was previously sequestered in the soil, and increased nitrogen leaching. In addition, the reduction in grassland increases the proportion of UAA treated with pesticides, which has a significant impact on biodiversity. This development also contributes to the opening of the nitrogen cycle, as organic fertilizers from forage legumes are replaced by mineral fertilizers. Maintaining a high demand for biomass (feed and other uses) also leads to increased irrigation in a context of increased climatic variability, creating a systemic risk of maladaptation.

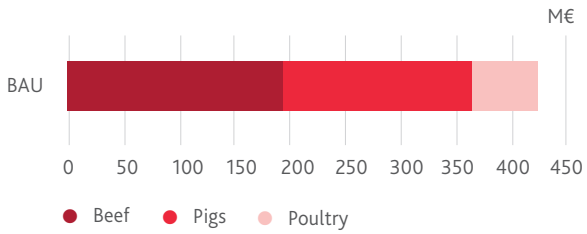
In extensive livestock farming areas,[18] the decline in cattle farming will also lead to a decline in grassland of over 18.5% (compared with a national average of 18%), despite ongoing strategies for the extensification of fodder production. Depending on the context, some of these meadows could be cultivated in a similar way to the previous areas, while the majority could be converted to woodland. The ecological quality of the landscape will depend on how these woodlands are managed (from intensive coniferous forestry to natural regeneration). There would also be an increasing risk of fire due to the decline in silvopasture. Overall, the loss of biodiversity in these areas, which contain some of the richest open grassland habitats, would be significant.

FIGURE 33. Changes in FTEs in the slaughter-cutting sector



Source: authors, based on IAACalc, FARE and ESANE data for the baseline.

FIGURE 34. Changes in stranded assets



Source: authors, based on IAACalc, ESANE and FARE.

Greenhouse gas emissions and land requirements

The reduction in production combined with the adoption of several efficiency measures will enable a 15% decrease in direct *French* emissions (from animals, buildings, manure and feed) between 2020 and 2035. However, when considering the overall environmental *footprint* including emissions linked to the import of meat products into France, a different picture emerges. As an initial approximation, we applied *the same emissions factor* to imported production as to French production for the 2020–2035 period, focusing solely on the net balance (without accounting for the imported and exported volumes as such). Using this method, total emissions remain virtually stable, with our calculations estimating only a 3% decrease in emissions. This figure is too low to be fully significant given the

[16] Types PA and Rum+Four Grand Ouest in Section 3.3.1

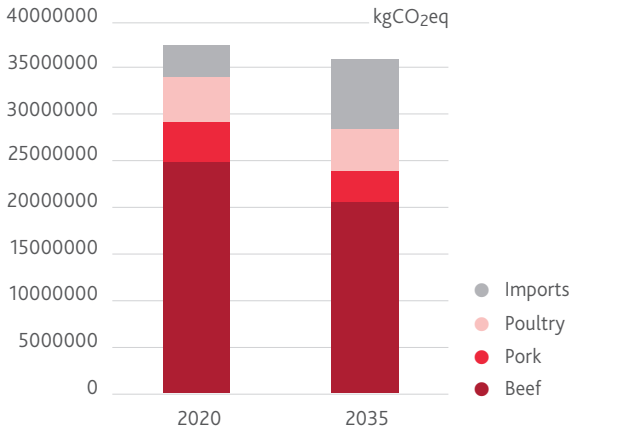
[17] Type E_Conc of lowland regions and hillsides suiTable for cultivation. These areas are transitioning to type PV "crop production"

[18] E_Four_montagnes and grassland hills and E_Conc marginal areas.

rather rough assumptions made. This does not take into account the emissions associated with the likely conversion of grassland, which could be substantial, though we have not attempted to quantify this here (Figure 35).

In addition, the need for concentrates remains high in this scenario, notably due to the development of fattening cattle. Assuming yields remain constant, more than 4.5 million hectares (Mha) of arable land will be required to feed French livestock, down 12% compared to 2020. This includes 2.5 Mha of imported soya (a 13% decrease from 2020), on which chicken production entirely depends, as does milk production (from which some beef is derived), although to a lesser extent. Although France's share of imported deforestation associated with soya is decreasing, demand for soya continues to be part of a global context where deforestation pressure is increasing (Karlsson *et al.*, 2021), particularly as poultry imports generate a "soya footprint" that must be taken into account (Caro *et al.*, 2018).

FIGURE 35. Changes in GHG emissions expressed in kg CO2eq/year



Source: authors.

Vulnerabilities of the BAU scenario and agri-environmental implications

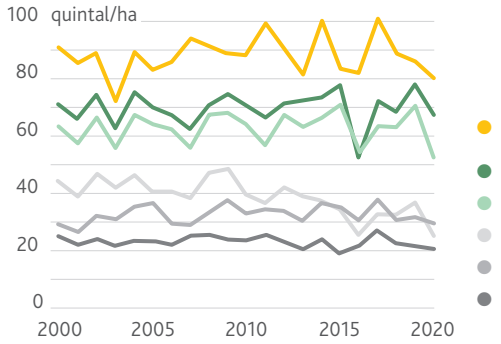
Overall, the BAU scenario does not lead to any significant environmental improvements, especially when considering the imported impacts, and nor does it appear particularly resilient to future shocks. In terms of environmental impacts, the implications for biodiversity in France are mediocre to negative, regardless of the area considered: slight improvements in the nitrogen balance in western regions, a loss of agroecological infrastructure across the country, and a continued high demand for arable land and irrigation, with some of this demand (soya) outsourced to other regions of the world. When factoring in the impact of climate change on yields, the BAU scenario could maintain the same level of pressure on arable land in mainland France. Indeed, given the increasing variability of cereal yields, the 13% decline in food demand by 2035 could be almost entirely offset by lower yields, depending on the year. While this outcome is clearly undesirable, it nevertheless needs careful consideration, as shown in Figure 36.

Furthermore, emission reductions in France are largely offset by imports from regions where production methods are probably no more sustainable. In addition to its environmental impact, which exacerbates the pressure on ecological systems, the BAU scenario fails to address the social and economic vulnerabilities of the French meat sector: dependence on soya imports and reliance on import markets remain high, and the increasing capital intensity of farms makes succession increasingly difficult. Therefore, it seems urgent to bring a positive answer to the question, "can we shift away from the BAU scenario?".

Figure 37 summarizes all the assumptions made for the BAU scenario and presents the main results, following the analytical framework proposed in Section 2.

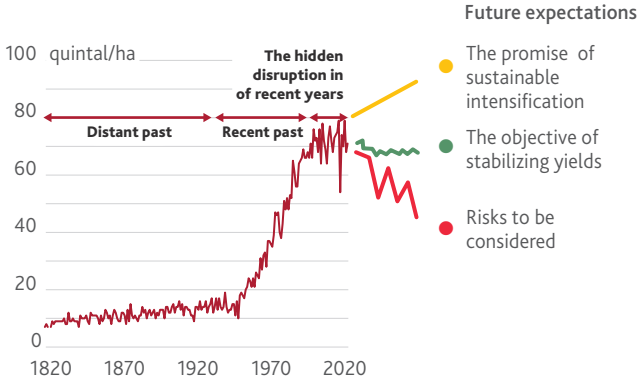
FIGURE 36. A levelling off and increased variability in grain yields over the past 30 years

Change in cereal and protein and oilseed yields (quintal/ha)



Source: authors, based on FAOSTAT data.

Change in average annual wheat yield across France (1815 to 2018)



https://www.academie-agriculture.fr/publications/encyclopedie/reperes/0102r02-evolution-du-rendement-moyen-annuel-du-ble-france-entiere

FIGURE 37. Summary of assumptions and results for the BAU scenario

DRIVING FACTORS 2020-2035

Demand:

- France: change in individual consumption 7% C; -3% P; -7% B
- Europe: aggregated demand for V increases, while P & B decrease
- World: aggregated demand increases for all meats, with C contributing the most

Competition between sectors: chicken continues to dominate due to its advantages

International competition: European and global production regions continue to hold competitive advantages over French producers

Public policies: No strong measures targeting demand, with reduced support for ruminants

DEVELOPMENTS IN THE MEAT INDUSTRY 2020-2035

Flow structure: supply-demand gap and decline in coverage rate from 98% to 88%:

- **C:** from 93% to 84% (increased demand, supply unchanged)
- **P:** from 103% to 98% (supply decreasing faster than demand)
- **B:** 96% to 80% (supply decreasing faster than demand)

Livestock systems: maintaining production in the Grand Ouest, increasing farm concentration, and efficiency and productivity gains

- **C:** 2.3% decline in farms per year (compared to 11% fall from 2000 to 2020) and an 8% reduction in average consumption index
- **P:** 4.9% decline in farms per year (compared to a 7% fall from 2000-2020) and a 10% reduction in average consumption index, 20% of manure used for anaerobic digestion (20% more covered manure storage)
- **B:** 2.6% decline in farms per year (compared to 2.9% fall from 2000-2020) and 10% of manure used for anaerobic digestion, 4% of fattening calves with enteric fermentation inhibitors

Slaughtering and cutting industry: maintaining processing facilities in western France, increased labour productivity (9% increase on average) and concentration of facilities (20% average increase in tonnes processed per site)

SOCIO-ENVIRONMENTAL IMPLICATIONS

Socio-economic aspects

- 4% fewer farms 30% reduction in agricultural employment
- 20% decline in slaughtering and cutting sites and 14.5% decline in jobs, (especially in the beef industry with 26%, compared to a 7% decline in poultry)
- €400 million in stranded assets in the industrial sector

Environmental aspects

- Loss of 18% of grassland, generating losses in organic carbon emissions and nitrogen losses
- 15% decline in emissions on French soil, partly offset by an increase in imported emissions: overall balance of -3%
- Nitrogen surplus down 9% in the Grand Ouest, but remains at a high level
- Concentrate requirements down by 13.5% due to reductions in livestock and efficiency gains

Source: authors.

5. CONCLUSION: EXPLORING ALTERNATIVES TO THE BAU SCENARIO

The proposed BAU scenario is, by design, a continuation of the trends that have been underway for decades, in which economic, social and environmental performance have not, and still do not, offer an overall favourable outlook for the French meat industry. In this business-as-usual projection, we see that the negative dynamics of the past are amplified by demographic and economic threshold effects, accelerating the sector's transformations in a negative direction. The outlook for 2035 appears bleak, and prompts further discussion around two crucial questions:

— If this outcome is undesirable for the meat sector, and for French livestock farming more broadly, what future should we work towards?
— Who can take action, and in what ways, to support a transition towards a more desirable future?

Answering these questions requires other scenarios to be explored. However, the retrospective analysis and the BAU scenario provide an essential first lesson: the scope of possibilities is severely limited by the major trends shaping production and consumption. In this context, exploring the future is less about promoting an unlikely "great leap forward" for the meat industry, and more about identifying desirable changes that can happen in the short term. It must also account for the diverse issues associated with meat production and consumption, as explored in this *Study*. This diversity refers to the wide range of stakeholders: firstly those directly involved in the value chain, but also all those "impacted" by changes in the meat sector. This considerably broadens the scope to include stakeholders involved in human health, regional actors, the environment, animal welfare and public policy. The future of the meat sector is therefore a collective and inherently complex issue, and therefore a deeply political one. This leads us to clarify the notion of "desirable" in the questions posed above. While each stakeholder naturally brings their own issues and interests to the table, in working towards a collective future, it is necessary to broaden the analytical framework. The impact of this framing–defining not only what should be discussed, but also, and just as significantly, what should be left out–must be better acknowledged.

In this context, the *Study* also offers methodological proposals that we consider essential for future debates. Addressing a diversity of issues in scenario-building requires a modelling framework that meets three requirements: first, it must be open and transparent, ensuring that the links between hypotheses, normative objectives and results are clear; second, it must integrate both socio-economic dimensions (employment, investment, and income if possible) and biophysical aspects (production volumes, nitrogen balance, GHG emissions, agro-ecological infrastructure); and third, it must provide a coherent understanding of developments at the farm level, within the agro-industry and in dietary habits, while reflecting as much as possible the heterogeneity that exists at each level.

More specifically, while an oversimplification of the debate along the lines of "for or against meat" reduces the complexity of the issues at stake to a search for a compromise between competitiveness and climate, based on technical and economic efficiency per tonne of product that reaches the market, a broader consideration of other environmental, socio-economic, and territorial issues significantly shifts the scope of what can be considered "desirable". Furthermore, widening the range of stakeholders reveals that what may be considered a challenge for the meat sector and livestock farming more broadly, could be an opportunity for plant-based sectors, both food and non-food. Even at the farm level, transitioning away from livestock farming has been and will continue to be a liberation for some, sometimes economically viable, sometimes not. Our approach leads to an important project: that of identifying the losers–who are clearly visible in our BAU scenario, which is why we mention them first–but also the winners, whose presence is crucial in understanding why such a future can be envisaged. This work is essential if we are to provide political support for any change of direction that we would collectively wish to see.

This broadening of focus and political analysis becomes particularly relevant in the geopolitical, demographic and environmental context we have outlined. We have chosen a BAU scenario that continues the major trends, viewing crises as isolated events. However, another interpretation of the present could be that crises are becoming structural and should no longer be labelled as such. This introduces another challenge for the exploration of different futures: assessing the sustainability and robustness of the alternative scenarios we envisage. Again, this *Study* does not provide definitive answers, but a broader framework to explore a diversity of futures–including their associated risks. These may be linked to increased variability in plant production, which as we have seen is still largely directed towards animal feed; the cost or availability of production inputs–consider for example the recent fertilizer supply *challenges–; epizootic* diseases; funding issues; societal trends; functional disruption of agrosystems, etc. This list is potentially endless and no one will be able to fully integrate this risk analysis on their own. Progress in collective future-oriented debates will come from comparing partial analyses, while hopefully also adopting a broader perspective on the issues, and gaining a better understanding of the disruptions currently underway. Ultimately, this is the goal that we have aimed to achieve through this *Study*.

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APPENDIX. BRIEF PRESENTATION OF THE MODELLING TOOLS USED

SPCalc: production systems

The SPCalc tool assesses the impacts of the scenario on the number of farms, the number of jobs, livestock density and physical labour productivity. The implications in terms of farm income were not analysed in detail in this *Study*, and remain a particularly complex aspect to address (see Aubert *et al.*, 2021 for a discussion on how farm incomes could remain stable under varying subsidy conditions and/or market prices, depending on the transitions made).

IAACalc: cutting and processing industries

The IAACalc tool assesses the effects of the scenario on the number of units, their geographical distribution, associated jobs, investment requirements and stranded assets. The analysis is also based on assumptions concerning the product mix (e.g. share of processed products compared to products sold whole or in pieces for poultry), which are linked to changes in demand and have significant effects on employment and industry profits.

MOSUT: the biomass balance of the French agriculture sector

MOSUT is a biomass equilibrium model that can be used to assess total emissions from the animal production sector (animal waste, enteric fermentation, livestock buildings, and emissions associated with feed production), nitrogen pressure (estimate of the annual nitrogen surplus per hectare of UAA), land requirements for feed (distinguishing between forage and concentrates), and changes in permanent grassland area. By cross-referencing with SPCalc, MOSUT can determine detailed changes in the unit performance of livestock farms across France (such as the consumption index). Furthermore, MOSUT can represent changes at a sub-national scale, by focusing on two regions: the Grand Ouest (including Brittany, Pays de la Loire and Normandy), where most animal production is concentrated; and the rest of France. Although the level of detail is less precise, particularly when compared to the more granular analysis made possible retrospectively by data at the level of the small agricultural region (see 3.3), it still allows us to examine the changes in the crop-livestock balance within the scenario.

French meat sectors under pressure: facing competition and feed supply challenges

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