Pay as you eat dairy, eggs and meat

External cost estimates and policy options to internalise them in France

CE Delft

Committed to the Environment

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Summary

The production and consumption of animal products is associated with a wide range of environmental problems that create 'external costs' for society. In this study, we estimated the external environmental costs of animal products: meat (from beef, veal and dairy cows), pork, chicken, eggs and cheese, including cheese.

The results are shown in Table 1. The impact associated with ammonia emissions (PM, marine and terrestrial eutrophication, and terrestrial acidification) dominate the total external costs, followed by climate change, toxicity categories and agricultural land occupation. The latter three impacts are strongly related to feed production for all animal systems, in addition to methane emissions in cattle systems.

Our analysis shows that external costs are substantial, ranging between € 0.35 for a litre of milk to almost € 10 per kg for meat from beef cows. Pork has an external cost of € 1.77 per kg, chicken € 1.50 per kg, eggs € 0.93 per kg and (hard) cheese € 2.75 per kg. These external costs are primarily caused by emissions of greenhouse gasses plus ammonia from manure handling and its application as a fertiliser (plus artificial fertilizer) for growing crops for feed. Ammonia has many health related impacts and places stress on the environment in the form of eutrophication and terrestrial acidification. It is therefore no surprise that cattle systems, which produce high ammonia emissions, also have the highest external costs.

Table 1 - External cost estimates for meat, eggs, milk and cheese in France (€/kg, conventional farming)

Impact category	Unit	Beef Beef cattle (incl. veal)	Beef Dairy cattle	Pork	Chicken	Eggs	Milk	Cheese (Gouda)
Particulate matter formation	€/kg	3.78	0.75	0.51	0.47	0.28	0.12	0.91
Climate change	€/kg	2.05	0.58	0.42	0.42	0.22	0.09	0.71
Marine eutrophication	€/kg	1.59	0.34	0.13	0.08	0.06	0.05	0.40
Terrestrial acidification + terrestrial eutrophication	€/kg	1.23	0.24	0.16	0.12	0.07	0.04	0.29
Agricultural land occupation	€/kg	0.63	0.15	0.15	0.10	0.07	0.02	0.18
Terrestrial ecotoxicity	€/kg	0.42	0.16	0.35	0.29	0.21	0.03	0.19
Human toxicity	€/kg	0.11	0.03	0.03	0.02	0.01	0.00	0.03
Photochemical oxidant formation	€/kg	0.04	0.01	0.01	0.01	0.00	0.00	0.01
Freshwater eutrophication	€/kg	0.02	0.02	0.01	0.01	0.01	0.00	0.02
Ionising radiation	€/kg	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Freshwater ecotoxicity	€/kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Marine ecotoxicity	€/kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ozone depletion	€/kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Urban land occupation	€/kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**€/kg**	**9.89**	**2.28**	**1.77**	**1.50**	**0.93**	**0.35**	**2.75**

These external costs comprise the unpaid bill of consuming animal products. The fact that current meat and dairy prices do not cover substantial external costs in France, leads to prices that are low enough to incentivise overconsumption. In total we estimate the external costs of environmental pollution of livestock for the whole of France to be as high as € 18.9 bln. per year. In this study, we only focused on the environmental impact as part of the unpaid bills. It is very likely that the 'real' unpaid bills are higher for several reasons. The sector receives considerable subsidies that are not being paid by the consumer of animal products. Besides, the sector is the cause of numerous outbreaks of animal diseases (which are paid for by taxpayers in many countries). Moreover, the animal production sector has a severe impact on human health, zoonoses and resistance to antibiotics and it has poor standards for animal welfare that can only persist by hiding them from the general public. However, we have not derived external cost estimates for these non-environmental categories in this study.

External costs of consumption of animal products can be most effectively combatted by making the consumers pay for these costs. Only then will consumers take the environmental impact into account when deciding to consume animal products or one of the plant-based alternatives and the sector can be steered towards cleaner production methods and alternatives for animal products. Pricing instruments are therefore most effective when addressing the issue of unpaid bills in the animal products sector.

In this study, we have investigated an excise levy for French consumption of meat and the removal of the lower VAT tariff on animal products. Both schemes are feasible from a legal perspective and can be implemented, although the levy needs more scrutiny with regard to practical design questions such as where the taxation point should be and whether imports/exports should be addressed in the scheme. The easiest measure to implement would be the removal of the lower VAT tariff for animal products in France. The lower VAT tariff for meat can be labelled as an 'environmentally harmful subsidy'. Phasing out environmentally harmful subsidies is a commitment of the EU Roadmap for Resource Efficiency. Various EU MS, such as Bulgaria, Denmark and the three Baltic States, have not granted lower VAT tariffs for meat or dairy. France could follow their lead. This would reduce meat consumption by about 11% for beef and about 8% for other animal products. Government revenues would be around € 6.3 billion. In France, a high VAT rate on meat, dairy and eggs would reduce GHG-emissions by 5.5 Mton CO_2-eq./year.

Although easy to implement, a higher VAT rate for animal products would have the drawback that it does not fully cover the external costs of meat consumption. For that, additional measures could be considered, either on top of the VAT increase or as a substitute. In this study, we have investigated the option of a levy equivalent to the external costs of meat. The levy would raise € 11.5 billion in government revenues per year and reduce GHG emissions annually by about 18.5 Mt CO_2-eq. over the value chain.
The most straightforward way of introducing a levy would be to implement an excise levy on meat sold to consumers by retail companies (supermarkets) and food services (catering, restaurants, etc.), irrespective of whether this meat is being produced in France or in another country.

Higher VAT rates and/or a levy would imply that costs of consumers still wanting to consume meat will increase, which would reduce their purchasing power. Consumers can be compensated by recycling government revenues from a VAT increase on meat products to distribute the revenues evenly over the population through a 0% VAT on vegetables and fruit, bread, cereals, coffee, tea, organic food and meat/dairy alternatives or a (free food) voucher or healthy food gift card to be spent in supermarkets on fruit or vegetables, for example. If a single voucher is issued per inhabitant, this voucher would amount to € 94 per

person from the VAT increase or € 171 per person from the government revenues in a system with a levy. Alternatively, consumers could be (partly) compensated by VAT relief (to 0%) for fruit and vegetables and the remaining money could be spent on VAT relief to 0% for other food products such as meat/dairy alternatives, organic food products, bread and grain products. In this way, the price of a supermarket shopping trolley for an average French consumer will not increase or might even decrease.

1 Introduction

1.1 Background

The livestock sector contributes significantly to global anthropogenic greenhouse gas (GHG) emissions. Direct emissions from the sector contribute to 11% of total anthropogenic GHG emissions (Llonch, 2017) - beef and dairy production account for the majority of these GHG emissions followed by pork and poultry. There are also considerable GHG emissions involved in the value chain. Twine (2021) estimates that in total at least 16.5% of GHG emissions can be attributed to livestock farming. Numerous other environmental problems exist in which animal production is plays an important role, such as eutrophication and acidification of soils, human health issues due to air pollution and loss of biodiversity due to monocrops grown for feed. These problems create costs for society.

Yet animal products form an important element of European diets. From an economic point of view, the problem is in essence that animal products are priced too low because a large part of the total associated 'social' costs are not included in the price. Since a 'full' or 'fair' price is not paid for these products or services, the decision-making process about the way of producing or whether or not purchasing them is not optimal and results in more production and consumption of environmentally harmful goods than optimal. The costs to society are considered as 'external costs' by producers and consumers: yet society pays a price through the decrease in the overall level of welfare.

There are various government policies aimed at internalising these external costs, such as the European Emissions Trading System (EU ETS), a CO_2-eq. tax for industry and energy taxes. Companies covered by these schemes pay for their greenhouse gas emissions and try to pass them on to their customers. As a result, the external costs are (partly) internalised. However, there are still many economic activities where an 'internalization deficit' occurs. For example, the difference between the consumer price and the 'real price' for animal products tends to be relatively large, as for example (CE Delft, 2018a) and (Funke, et al., 2022) have shown. Several policy options can be implemented to increase consumer prices so that they better reflect actual costs to society. Ideally, this will take place on a European scale, as there will be a wider range and a level playing field for all farmers and consumers within the EU.

1.2 Project aim and approach

The aim of the project is to provide policy proposals that can be used to pass on the external costs via the price of meat, dairy and eggs. The overall project covers the following three parts:

- Calculate average external costs for meat, dairy and eggs in France. It indicates what price increase would be needed to cover the external costs.
- Identify policy options to increase the price of meat, dairy and eggs and estimate the expected impact of two selected financial policy options on the environment.
- Describe what can be done with French government revenue to create political and social support, including some quantitative examples.

A Supervisory Committee provided us with useful insights and feedback on the analyses. The members were:

- Pierre Marie Aubert and Nathalie Bolduc (L'Institut du développement durable et des relations internationales, IDDRI, France).
- Reinhild Benning (Deutsche Umwelthilfe e.V., DUH, Germany).
- Élodie Vieille Blanchard, Pauline Abela and Anna Labarre (Association végétarienne de France, AVF, France).
- Joey Cramer (ProVeg, Netherlands).
- Siska Pottie (European Alliance for Plant-based Foods, EAPF, Belgium).
- Jan Paul van Soest (Food Transition Coalition, TCV, and De Gemeynt, Netherlands).
- Jeroom Remmers (TAPP Coalition, Netherlands).

In this study, we have produced a main report with extensive technical details on the calculation of the external costs for animal products in the EU27, Germany and France. The present report contains an analysis of the results for France only. The other reports are available on the website of TAPP and CE Delft.

1.3 Scope and research boundaries

In this study, we have estimated the external costs associated with the following animal products: meat (chicken, pork and beef), dairy (standardised milk and cheese) and eggs. The environmental impact of those products has been estimated over the value chain of production and cover cradle to gate: the whole production chain up to the moment that the meat is sold to retail.

Table 2 - Environmental impacts covered

Environmental impact categories	
Climate change	Freshwater eutrophication
Ozone depletion	Marine eutrophication
Human toxicity	Land use - urban
Photochemical oxidant formation	Land use - agricultural
Particulate matter formation	Terrestrial ecotoxicity
Ionising radiation	Freshwater ecotoxicity
Acidification	Marine ecotoxicity

In addition, the following research boundaries have been defined:

- External cost estimates will cover the environmental impact of the current production characteristics in livestock farming and product industries only. Besides the environmental impact, animal production is associated with a wide range of societal problems: animal diseases (zoonoses), health damage caused by the consumption of meat, issues with animal welfare. desiccation, depletion of the soil or antibiotic resistance. We also did not calculate possible positive 'external' effects of meat, dairy and eggs (e.g. nice landscape for recreation purposes). Although relevant, these impacts are outside of the scope of the present study and could be investigated in future research.
- The analysis will consider the situation 'today' of conventional (non-organic) farming and information to date on policy initiatives and existing policy framework in the countries/regions under consideration.

- The environmental impact is assessed for its damage to human health, natural capital (ecosystems) and man-made capital (buildings/materials) by applying a valuation scheme used in EU policy appraisals. The valuation is based on average prices for the EU27 (see Annex C.1 in the main report).
- When figures are expressed in €/kg meat, we mean kilograms of meat sold (and thus excluding carcases unless they are part of the sold products), unless explicitly stated that it is in 'carcass weight'.

1.4 Methodological introduction

This paragraph gives a brief methodological introduction to the methods employed in this research. Full details of our methods are given in the main report of this series.

The environmental impact of animal products in the 14 impact categories in Table 2 have been determined using life cycle assessment (LCA). The analysis covers direct emissions at the farm level and indirect emissions in the chain, related to animal feed, energy mix and transport in the production chain. Transport to retail and transport to consumer are out of scope of the present analysis. The LCA models are based on LCA models of animal products in the Agri-footprint LCA database (v5.0), with specific adjustments for France provided by I4CE. Annex A.1 of the main report shows in detail the methods employed in this research.

The external costs have be calculated by the following formula:

$$EC_j = \sum_{i=1}^{14} I_{i,j} * EP_i$$

Where *EC*=external costs of one kg of animal product *j*, $I_{i,j}$ is the environmental impacts on environmental theme*i*associated with one kg of animal products *j* and EP_i are the environmental prices for environmental theme *i*. There are in total 14 environmental themes (see Table 2). The external costs of one kg of animal product j is then the sum of impacts multiplied by their environmental price for all themes.

Environmental prices for each theme have been taken from the Handbook of Environmental Prices (EU28 version) by CE Delft (CE Delft, 2018b). The values from this Handbook have frequently been used to determine the external costs from LCA-analysis (see e.g. (Costantini, et al., 2020), in cost-benefit analysis or by companies in reporting about their Environmental Profit and Losses (see e.g. (Philips, 2018). The environmental prices also form the basis of the European Handbook of valuing external costs of Transport for DG Move (CE Delft et al., 2019) and are frequently used in European policy analysis.

Although France has its own valuation framework for, e.g., CO_2 emissions (Quinet, 2019) or the reduction in life expectancy due to air pollution (see (Commissariat général à la stratégie et à la prospective, 2013)), we do not know if environmental impacts occur within the French borders or in other countries and we do not know French prices for other pollutants. That is one of the reasons why we have used European prices where external costs have been harmonised over the various environmental themes (see Table 2).

1.5 Reading guide

This report contains analysis and results for France. In Chapter 2 we present our results of the analysis of the external costs in France from consumption of animal products. We express the external costs both in per kg consumed product and as total for France and compare our estimates with others in the literature. Then in Chapter 3 we analyse pricing instruments that can be used to internalise these external costs and discuss their design, impacts and revenues that they generate and how these revenues can be recycled back to consumers. Chapter 4 concludes.

1.6 Relation to the main report

In the main report on the EU27 (CE Delft, 2022a) all assumptions and data sources of the method have been listed in Annex A. The reader is referred to this main report for further explanation on how the environmental impacts have been modelled and what environmental prices have been taken to value the environmental impacts.

2 External costs of meat

2.1 Introduction

External costs of animal products are costs that matter to society but are not paid by those that produce and consume animal products. In economic terms this implies that total welfare is lower. In more popular terms, the external costs can be described as the unpaid bill from producing and consuming animal products.

In this chapter, we present our calculation of the external costs from animal products for food in France. In Section 2.2 we discuss the scope. Section 2.3. reveals the results for France and in Section 2.3 we discuss the implications and compare our results with results found elsewhere in the literature. Readers interested in the methodologies that have been used in deriving those figures are referred to the main report that contains a detailed account of the methodologies applied to derive these external cost estimates.

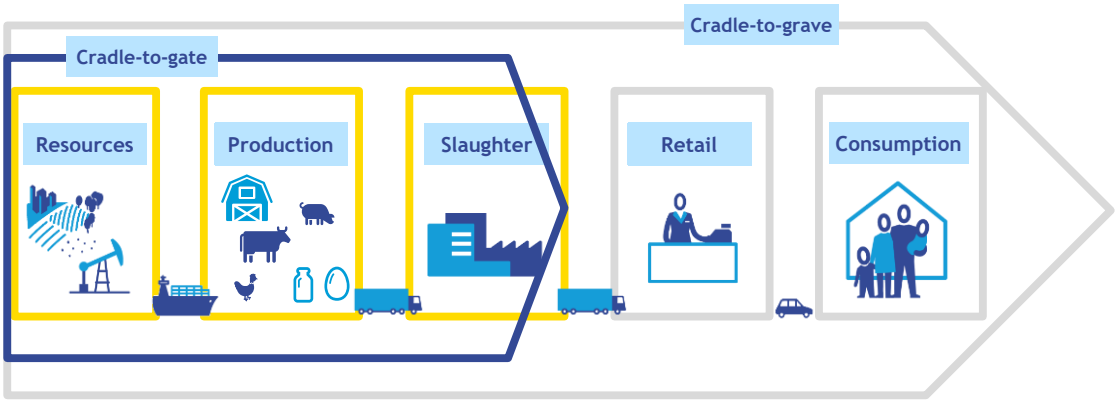
2.2 Scope

Our analysis contains all the external costs that occur in the cradle to gate route in the value chain. Figure 1 gives a graphic representation. The analysis covers direct emissions at farm level and indirect emissions in the chain, related to animal feed, energy mix and transport in the production chain. These aspects have an influence on the impact of (the production of) the products on nature and the environment. Transport to retail and transport to consumer are out of scope (grey rectangles in Figure 2). These cover a very small share of total environmental impacts only.[1]

The environmental impact estimates have been based on current average emissions for farming systems in France. This means that we implicitly take into account the fact that livestock farming production systems differ per region. More details about the way we have modelled environmental impacts can be found in Annex A of the main report.

[1] E.g. (Poore & Nemecek, 2018) report that the sum of emissions from packaging, transport, and retail contributes to 1 to 9% of total emissions. However, they do not provide details on each individual chain so their results cannot be used in the present analysis. Transport required to take feed to livestock is included in our analysis.

Figure 1 - LCA scope



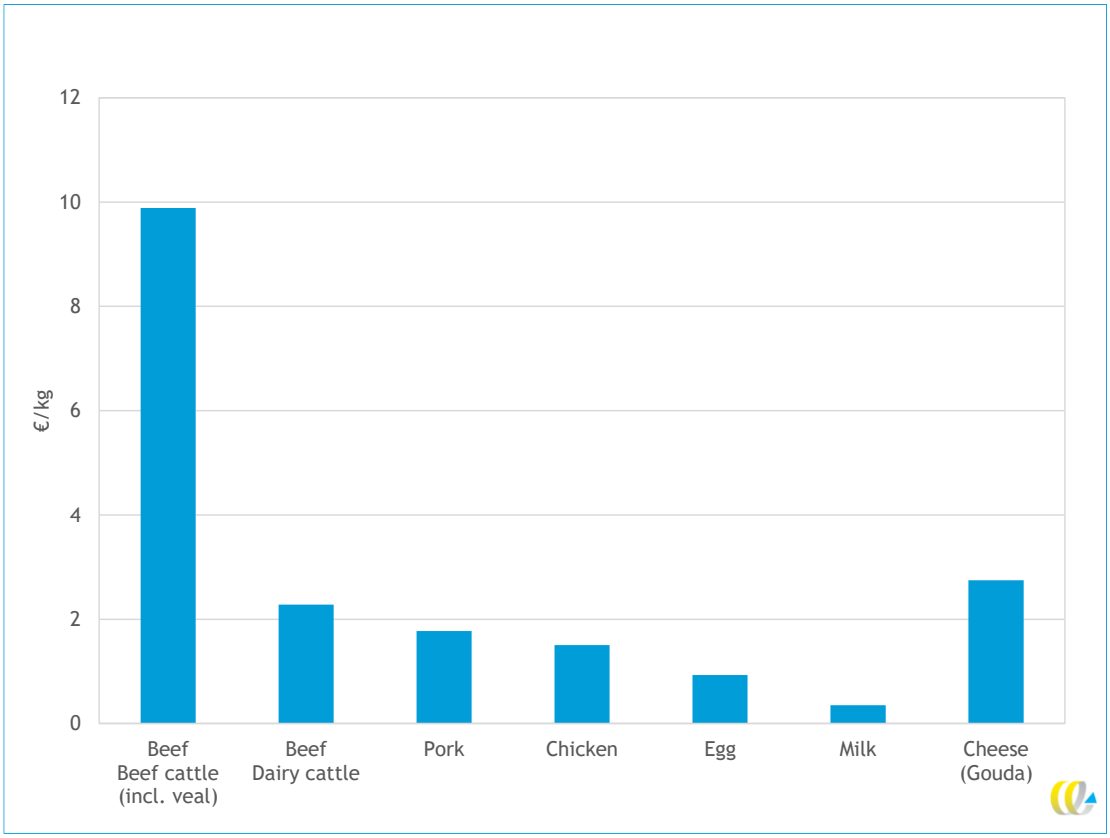
The LCA models applied have been made specific for France by focussing on emissions of NH_3, CH_4, N_2O, CO_2 and NO_3. Initial analysis revealed that over 75% of external costs in the various animal products are caused by these emissions. Inventory data on farm level emissions of NH_3, CH_4, N_2O was acquired from the EU National Inventory Report and Informative Inventory reports (European Environment Agency, 2021). When emission data could not be divided between animal product group, the most conservative data from France, Germany or the original Agri footprint process card were used as proxy, in order to avoid underestimation of emissions. Other (indirect) emissions were made country-specific by adapting inputs of the production system. As such, manure application rates and composition of feed was made country-specific where possible. For soy-based feed, dLUC (direct land use, was adjusted for the share of certified 'deforestation-free soy'. Finally, ammonia emissions from crop residues in grass and maize cultivation were recalculated according to the recent NEMA method (RIVM, 2021), which resulted in different (lower) emission values of feed throughout cattle production models than what is normally included in Agri-footprint. In Annex A of the main report, all details of the method have been given.

2.3 External costs estimates

Valuing the quantified environmental impacts from LCA with the environmental prices provides an estimate of the external cost for the various animal products. These are shown in Figure 2. Beef (from beef cattle, incl. veal) production causes the highest external costs (9.89 €/kg), followed by cheese (Gouda, 2.75 €/kg)[2], beef (from dairy cattle, 2.28 €/kg), pork (1.77 €/kg), chicken meat (1.50 €/kg), eggs (0.93 €/kg) and milk (0.35 €/kg).

[2] These results are for Gouda cheese, which is a hard cheese. For softer cheeses, such as are common in France, less milk is needed per kg (because of the higher moisture content). The amount of milk needed for 1 kg cheese caries considerably, from around 4 l (very fresh and soft cheese) to 12 l (very old and hard cheese) per kg cheese. For the Gouda cheese in this study, 7.8 l milk is needed. For an average softer cheese, such as St. Paulin, around 5.5 l milk is needed (Kosikowski, 1985) . To calculate the external costs of soft cheeses we therefore recommend to multiply the value for Gouda cheese with a conversion factor of 5.5/7.8 = 0.7.

Figure 2 - Total external costs of conventional meat, eggs, milk and cheese in France (€/kg)



The comparatively high external costs of beef from beef cattle result for the largest part from high particulate matter (PM) emissions, followed by climate change impact, marine eutrophication, and terrestrial eutrophication and terrestrial acidification (Table 3). These are in turn mostly caused by ammonia from manure handling and application, and artificial fertilizer application for feed. Ammonia has many effects on human health (PM) and the environment (eutrophication and terrestrial acidification) and it is therefore no surprise that cattle systems, which have high ammonia emissions, have high external costs.[3]

Next to PM, beef from beef cattle has a relatively high climate impact due to methane emissions during its lifetime, and impact related to feed production (beef cattle needs a lot of feed to produce 1 kg of meat, much more so than pigs or chickens).

Beef from dairy cattle has a significantly lower impact than beef from beef cattle because most of the impact related to the lifetime of a dairy cow is allocated to the milk, and not the meat.[4] Milk has a relatively low impact as a cow produces a lot of milk over a lifetime,

[3] Please recall that environmental prices are averages for an average emission at an average location. However, particulate matter emissions in agriculture are usually in rural areas, so with a much lower population density. This is partly blown into the city (see e.g. IIASA, 2009), but not entirely. This means that the cost figures include an upper limit for the harmfulness of particulate matter emissions.

[4] The impact has been allocated using an economic allocation mechanism where the total economic value over the lifetime of the cow has been used to attribute the impacts to the various product categories. See Annex A of the main report.

which causes less impact per kg product. The external costs of 1 kg (Gouda) cheese are relatively high; almost as high as beef from dairy cattle. This is due to the fact that around 8 kg of milk is needed to produce 1 kg of cheese.

The external costs of pork and chicken meat are lower than beef meat and cheese. Chickens have the best feed conversion efficiency of all animals in this study and therefore the external costs associated with chicken products are relatively low. Pigs have a more diverse diet with less soy (which has high associated external costs) and therefore the impact per kg of pig feed are lower than a kg of chicken feed. The net external costs of chicken meat however are still lower due to more efficient feed conversion.

Table 3 shows the external costs of the animal products, attributed to the different environmental impacts and as totals. The importance of the environmental impact categories in the total external costs are quite similar for most animal products. Impact categories associated with ammonia emissions (PM, marine and terrestrial eutrophication, and terrestrial acidification) are dominant in the total external costs, followed by climate change, toxicity categories and agricultural land occupation. These latter three impacts are strongly related to feed production for all animal systems (in addition to methane emissions in cattle systems).

Table 3 - External cost estimates for meat, eggs, milk and cheese in France (€/kg, conventional farming)

Impact category	Unit	Beef Beef cattle (incl. veal)	Beef Dairy cattle	Pork	Chicken	Eggs	Milk	Cheese (Gouda)
Particulate matter formation	€/kg	3.78	0.75	0.51	0.47	0.28	0.12	0.91
Climate change	€/kg	2.05	0.58	0.42	0.42	0.22	0.09	0.71
Marine eutrophication	€/kg	1.59	0.34	0.13	0.08	0.06	0.05	0.40
Terrestrial acidification + terrestrial eutrophication	€/kg	1.23	0.24	0.16	0.12	0.07	0.04	0.29
Agricultural land occupation	€/kg	0.63	0.15	0.15	0.10	0.07	0.02	0.18
Terrestrial ecotoxicity	€/kg	0.42	0.16	0.35	0.29	0.21	0.03	0.19
Human toxicity	€/kg	0.11	0.03	0.03	0.02	0.01	0.00	0.03
Photochemical oxidant formation	€/kg	0.04	0.01	0.01	0.01	0.00	0.00	0.01
Freshwater eutrophication	€/kg	0.02	0.02	0.01	0.01	0.01	0.00	0.02
Ionising radiation	€/kg	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Freshwater ecotoxicity	€/kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Marine ecotoxicity	€/kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ozone depletion	€/kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Urban land occupation	€/kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**€/kg**	**9.89**	**2.28**	**1.77**	**1.50**	**0.93**	**0.35**	**2.75**

2.4 Interpretation

The environmental impact of livestock farming is currently not taken into account by both the producers and consumers of animal products. They sell and buy products at prices that do not include these costs and environmental impact, which therefore barely play a role in decisions about investments or purchases. The fact that meat and dairy prices are currently not covering substantial external costs in Germany leads to prices that are low enough to incentivise overconsumption. In total we estimate the external costs (for the whole of France) as high as € 18.9 bln.

Table 4 - Total external costs from meat and dairy product consumption in France, 2020

	Beef*	Pork	Chicken	Milk	Eggs	Gouda Cheese	Total
Consumption (mln tonnes)	1.17	1.55	1.40	2.31	0.97	0.76	8.16
External costs (bln €)	9.5	2.8	2.1	2.2	0.3	2.1	18.9

* Assuming 77% beef from beef cattle and 23% beef from dairy cattle.

These external costs form the unpaid bill of consuming animal products in France. However, this should be regarded as a lower estimate for various reasons. First, not all meat products have been included in our analysis: meat from sheep and goats have not been included in our analysis. Moreover, in this study we have only focussed on the environmental impact as part of the unpaid bills. Most likely the 'true' unpaid bills are higher because the sector receives considerable subsidies (that are not being paid by the consumer of animal products), is the cause of numerous outbreaks of animal diseases (paid in many countries by taxpayers), has a severe impact on human health through zoonoses and resistance to antibiotics and has poor standards for animal welfare that can only persist by hiding them from the general public. However, we have not derived external cost estimates for those categories in this research.

There are, to our knowledge, also no external cost estimates in the literature that include all of these categories. There are a number of studies that have undertaken a similar type of analysis, and our results are in the range of what can be expected. Compared to an earlier study by CE Delft on this subject ((CE Delft, 2018a); (CE Delft, 2020)), the external costs for the products are different. This is both due to the different approach followed for the LCA models (see Annex A in the main report) and due to different external costs for impact categories. The previous study used environmental prices for direct emissions in the Netherlands and the present study uses such prices at the level of the EU27 + UK. As the Netherlands is much more densely populated than the European average, air pollutants cause much more damage to human health.

When comparing the results with the previous analysis, we observe that especially the external costs of pork are much lower. This is mainly because this study uses more recent data from efficient pig production systems, which are more representative of average large-scale pork production. To a lesser extent the differences are explained by differences in external costs.

When compared to other literature on this subject, external costs are more or less in line. (Funke, et al., 2022) calculated, on the basis of data from (Poore & Nemecek, 2018), the external costs for beef between US$5.75–US$9.17 per kilogram (the higher range for beef from meat cows and the lower range for beef from dairy cows), US$1.94 per kilogram for pork, and US$1.50 per kilogram for poultry. These estimates are slightly lower than our

results. However, they state that they did not include a valuation for biodiversity loss or the health effects from livestock-related air pollution. The latter impact is, in our estimate, the largest category of external costs through the impact in the particulate matter formation. So all in all the costs estimated by us and (Funke, et al., 2022) are probably in line.

Older research on valuation of external costs of meat exist (see e.g. (IVM, 2010)), but these studies used older data on the impact and valuations that the results are hardly comparable.

3 Policy instruments

3.1 Pricing instruments

Many economists are in favour of pricing mechanisms to stimulate behavioural change of both consumers and producers. Pricing instruments have important advantages over other forms of climate and environmental policies, such as setting standards or granting subsidies. Pricing systems, especially when adopted on a larger scale, have the advantage that they are:

- Effective: increased prices for non-sustainable goods ensure that producers and consumers consider the effects on the climate/environment in their decisions so that the composition of the consumption package or the production structure is directed towards a more sustainable, low-carbon economy.
- Efficient: higher cost prices drive innovations and investments in energy-efficient and low-emission technologies, making the transition to a more sustainable economy cheaper.
- Fair: higher prices create a sense of justice in society whereby the polluter pays for environmental damage that is caused and no longer passes it on to others or future generations.

While the advantages of pricing instruments have long been recognised in (environmental) economics see e.g. (Baumol, 1988); (OECD, 1989), it has taken some decades before pricing instruments for environmental pollution have become widespread. Nowadays, pricing environmental pollution has become more common for politicians and consumers.
For example, 68 carbon pricing schemes have been counted at the moment in the World (World Bank, 2022), among which the European Emissions Trading Scheme (EU ETS) and national carbon taxes in the Netherlands, France, Spain, etc.

In general, pricing instruments can be classified into two categories:

1. (Behavioural) taxation based on a fixed charge.
   Unlike other taxes, the main aim of a behavioural tax is not to generate government revenues, but to reduce consumption of particular products or lessen their environmental impact by making it more expensive. The amount of environmental impact is uncertain; it depends on the behavioural response to raising (cost) prices.
2. The taxation rate can be based on a politically agreed decision, like a VAT increase, or based on the actual external costs per kg of product.
   Trading systems in which the maximum environmental impact is fixed by an annual ceiling (the cap) and permits are traded on the market. This means that the permit price is not fixed. A well-known example is the current European Emissions Trading System (ETS) system for greenhouse gas emissions. The CO_2(eq.) price that must be paid for emissions depends on the supply and demand on the market for emission rights.

Application of the polluter pays principle in animal products is still very limited, despite the academic world considering that the application of taxes is much more effective than labels or giving information (Katare, et al., 2020), for example. Recently, there have been initiatives to introduce economic pricing instruments in both categories with respect to food products. New Zealand is likely to be the first country to bring agriculture under an ETS system and Germany is currently considering a consumer tax on animal products. In other countries, including the UK, US and Finland, Sweden and Denmark, 'meat taxes' are

currently being considered. Also at the EU level it is starting to attract political attention (FAIRR collective, 2020). Some countries, such as the Netherlands, consider a meat tax part of a broader policy package to encourage consumers to buy affordable, and more healthy and sustainable food. A tax on meat could then, for example, be combined with a tax increase on soft drinks and recycling revenues by lowering (or scrapping) the value added tax on fruit and vegetables and a sugar tax. This is by no means a hypothetical situation. In 2020, at least 40 countries have some form of sugar tax in place, including France, the UK and Mexico (FAIRR collective, 2020). A number of European countries have an (extra) reduced VAT rate on fruit and vegetables, including Ireland (0%), Spain and Italy (4%) (European Public Health Alliance, 2019). Such initiatives increases the price difference between animal based food products and vegetables and fruits.

The details of policy design are crucial to ensure public and political support for price instruments. They are related to the treatment of imports and export (level playing field for companies and avoiding carbon leakage) and the earmarking of government revenue (subsidise 'healthy food', support lower income groups and/or help companies to invest in sustainability). Limiting undesirable (income) effects and conducting careful communication is crucial. Otherwise, social resistance might cause an absence of political will to actually implement 'unpopular' financial policy measures.

3.2 Policy context

In France, there is a lot of political discussion on the reduction of livestock, and industrial farming in particular. A left-wing political coalition intends to close industrial farms, with a focus on organic farming and plant-based food instead.

So far, no taxation schemes exist or are proposed for the French agricultural sector[5] or for French food products, although the government implemented a tax on sugary drinks and levies a carbon tax on energy products (I4CE, 2022).[6] The absence of such mechanisms might be explained by the following:

- Taxation measures are politically sensitive in France. Tax paid by consumers for environmental reasons were at the origin of the 2018 '*gilets jaunes*' movements. Hence, any additional environmental tax is currently politically very difficult to support. At the moment, the window of opportunity is even lower, given the COVID-19 pandemic, food price inflation and the war in Ukraine. Yet, since farmers are having a hard time in France, a VAT-increase combined with financial support to the sector (earmarking revenues) might be the most promising option from a political point of view.
- Apparently, there is no (political) majority that considers tax mechanisms at consumer or producer level as an accurate and effective way to internalise the external costs.[7] A homogenous tariff is considered to be ineffective as the environmental footprint of livestock products are tremendously dependent on the production system of the farm. No farmer is stimulated to commit as they face the same tariff anyway. Tariff differentiation resolves this issue, but such a system requires Monitoring, Reporting and Verification (MRV) mechanisms, which take time to develop (I4CE, 2022).

[5] Except for a pesticide tax since 2018 (PAN website) and a nitrogen fertiliser tax proposal in 2021.

[6] The tax serves as a complementary policy measure to the EU ETS.

[7] Although some do believe that such taxes can be good ways to internalised negative externalities, E.g., in October 2021 a large majority in EU parliament (including French politicians from social democrat, liberals and Christian democrats) supported an amendment to the Farm to Fork strategy to 'increase VAT tariffs on food products that have negative impacts on health or sustainability.

Since 2018, France has a '*Label bas carbone*' (Low Carbon Standard). In order to stimulate sustainable development in the sectors, GHG emissions reductions and sequestrations in agricultural and forestry projects can be certified. The original target of this scheme was to stimulate voluntary carbon markets, but it may be used for other purposes such as the earmarking of public subsidies. Several GHG reduction projects in livestock farms have been have already begun in France and a second set of projects is starting. Furthermore, such a carbon certification framework is considered to be a first step towards establishing a relevant carbon market for the agricultural sector or other binding policies on agricultural emissions (I4CE, 2022).

As the French and EU livestock sectors are important sources of (greenhouse gas) emissions, integrating it in EU ETS (as a separate system for livestock in the EU) would increase the coverage of the system. It is also possible to set up a national system first. New Zealand plans to integrate livestock in its national ETS scheme by 2025 (see Section 1.5). Alternatively, a national trading system might cap the total *number* of animals at the level of slaughterhouses and meat importers (instead of emissions).
On the other hand, there might be (more) limitations in the agricultural sector to implement such a trading scheme at the national or European level. Some of them are:

- Levelling the playing field through an ETS would be a challenge, given the subsidies that are provided to the agricultural sector under the Common Agricultural Policy (CAP). It is crucial to correct the existing incentive structures, by shifting potentially environmentally harmful agricultural support towards targeted environmental payments. Such CAP reforms might be more effective than adding another mechanism. However, those reforms might be difficult to realise and can only be proposed every 7 years (next option for change is 2028).
- Emission markets have long lead times until they become effective. The history of the ETS teaches us that while it started in 2005, it took until 2018 until it finally started to work.
- A national ETS or ETS extension requires solving some serious issues with respect to accurate Monitoring, Reporting, Verification (MRV) and rigid enforcement. The fear of the carbon pricing/ETS community is that inclusion of agricultural activities and food consumption into the EU system might water down the high standards achieved thus far (Ecologic, 2022). For taxation, MRV systems must also be in place, but the required level of detail depends on the exact design (see Section 3.2) and it is easier to include a development path to a differentiated system over time.

Therefore, it has been decided in this research to focus for France on the implementation of an excise levy on meat, dairy and eggs or a VAT increase for animal protein products for France – even though such schemes have their complications as well. In the next paragraphs, an excise levy and VAT increase will be described in more detail.

3.3 Excise levy

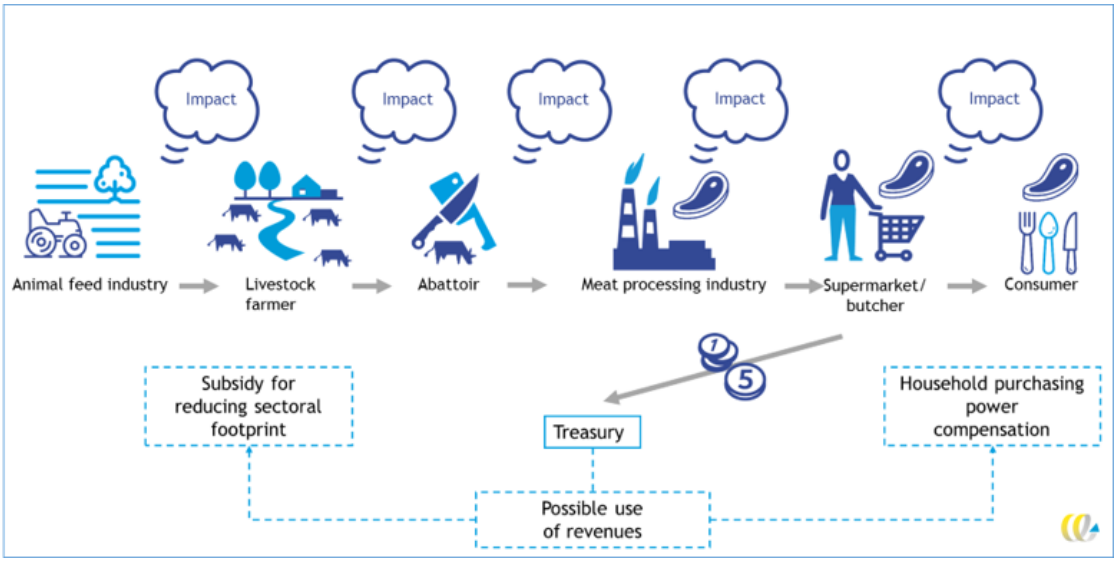
3.3.1 Types of levy

We distinguish here a generic levy from an value chain levy. A generic levy will only differentiate towards the type of meat. In this sense the levy very much works likes an excise duty, similar to duties on alcohol or cigarettes. The tax is levied on the amount of meat, dairy and eggs (tax base) that is sold to end consumers. The advantage of this levy is that it is relatively straightforward and that similar levies have successfully been implemented in many countries worldwide. The disadvantage of this levy is that it

stimulates less consumption of meat but does not necessarily stimulate cleaner production techniques in the value chain.

Another type of levy would be to base the levy on the external costs added in each production step. This is the basis of the External Cost Charge in which the added external costs in each production step are being taxed (CE Delft, 2020). The ECC aims to include the environmental impact during the entire supply chain up to the end consumer in the product prices. In each production step, ECC taxes the added external costs. Figure 3 provides an example for the meat production chain. Such approach would create the optimal price incentives for both producers and consumers to avoid/reduce the external effects. Hence, meat from livestock farmers who cause few external costs, a lower taxation rate is paid per kg of meat than when it comes from livestock farmers who cause high external costs.

Figure 3 - Ideal picture of excise levy based on ECC



This requires an extensive monitoring and reporting system on the external costs that are being added in each production step ((CE Delft, 2018c). If only GHG is being monitored, it works like a Carbon (eq.) Added Tax (CAT). While such schemes do have great benefits in combining incentives for farmers with incentives for consumers, they are complex in monitoring and reporting regulations and so far they have not been implemented in any country in the world.

A simplified scheme in the end will boil down in an external cost charge for end consumers, which is similar to the excise duty above based on external costs. We will use this in this study: the level of the levy is then similar to the external costs and the unit of charge is the mass of meat, dairy and eggs sold (all converted into kg). This requires producers of products containing meat, dairy and/or eggs to register the amount of processed animal products. Either they pay taxes based on this information or they have to inform the next actors in the supply chain, so that the levy is paid at the final consumer level.

Table 5 shows the excise levies for the various animal products when they reflect the external costs estimates (see Chapter 2), with the highest costs for beef and lowest for milk.[8]

Table 5 - Excise levy on meat, dairy and eggs, internalising external costs (€/unit of product, conventional farming, 2021)

	Levy (€/kg product)
Beef (beef cattle incl. veal)	9.89
Beef (dairy cattle)	2.28
Average beef	8.14*
Pork	1.77
Chicken	1.50
Milk	0.35
Eggs	0.93
Cheese	2.75

* Average based on 23% and 77% share of meat from dairy and beef cattle respectively (see Annex A.1.3. in main report).

3.3.2 Taxpayers and taxation point

An excise-like levy means that a given amount must be paid to the national government per kg of meat, dairy and eggs. The levy is added to the retail price. The taxation point can be placed at three levels.

The first option is to introduce the levy when the product is sold to the consumer (retail and food services like restaurants, catering companies). The seller then pays a rate based on the amount and type of product sold (beef, pork, chicken, dairy or eggs). This means that sellers have to report the amount of meat, dairy and eggs sold to end consumers and the meat, dairy, egg processing industries. The advantage of this approach is that a significant amount of sales are covered by the excise levy. For example, about 85% of the sales of meat (products) are to consumers (CE Delft, 2018a). The levy thus provides an incentive for consumers to switch to products with less meat, dairy and egg ingredients or animal products with lower environmental impact as they pay the levy.

If the levy would also apply to composite products containing animal products, food manufacturers may change their product compositions (less animal ingredients) to limit price increases. In addition, no import or export corrections are necessary as the tax is levied on products sold to consumers. Imports are then treated the same as domestically produced goods. A disadvantage is that the cost increase associated with environmental pressure is only 'visible' when sold to consumers. The price impact must be passed on in the chain, so the incentive for the livestock farmers to shift their production towards less animal products is only indirect. Where markets work efficiently, this should not be a problem. However, existing distortions in the market on e.g. land ownership, subsidies through the CAP and monopsony in retail may distort the price signal to producers.

[8] Since circumstances might change, both within the sector (sustainability of farming) of outside (environmental prices reflecting the welfare loss due to production and consumption of animal products), the levy should be reviewed periodically

With a levy at the point of consumption, farmers have no incentive to use cleaner production methods as these will not be 'rewarded' with a lower levy. This could partially be circumvented by introducing labels or categories that would apply for a lower levy. Then, tariff differentiation is possible instead of an average tariff for each product category (see Section 3.2.3), information requirements are high as reliable registration of environmental impacts in the product chain is needed and the risk of failing Monitoring, Reporting and Verification (MRV) is high.

A second option is to choose a taxation point more downstream in the chain. In that case, slaughterhouses, dairy and egg producers and meat, dairy and egg importers (mainly processing industries) are liable to pay the levy. Although it can be assumed that the tax will be (partly) passed on in consumer prices, it limits the number of actors directly under the scheme. Since the tax is levied on all products manufactured or imported into the country, exports would also be covered by the scheme. To maintain an international level playing field, a refund must be made for exports which makes administrative costs higher.

A third option is to place the taxation point at the livestock farmer level. As they are directly confronted with the taxation bill, it would give farmers the most direct incentive to use (new) techniques or methods that reduce external effects in the production of the good, or to switch on the production of other goods that have fewer externalities. This particularly holds when the tariff is differentiated towards production methods. There is also a more direct incentive for the buyer of the meat to purchase meat from livestock farmers whose production causes less environmental impacts.

Under this latter option there is a potential risk of relocation of polluting activities abroad (leakage) due to a competitive disadvantage since only meat from French livestock farmers is taxed. To correct for this, cross-border adjustments for both imports and exports need to be made which may be difficult to monitor, inflict on existing trading agreements, run the risk of retaliation and be perceived as unfair towards developing countries. Especially, since France is leading a discussion at the European level about mirror clauses (and the Carbon Border Adjustment Mechanism), i.e. including clauses in trade agreements to prevent unfair competition from products with lower environmental standards (I4CE, 2022). Although this discussion leading to strong measures is yet far to be guaranteed, such mirror clauses would resolve the dilemma and allow polluters-payers schemes on the production side without risking carbon leaks (which is an important cause for the current reluctance to implement pricing instruments) (I4CE, 2022).

3.3.3 Environmental impact

Based on the levies in Table 5, we roughly estimate the price increase, the expected reduction in French consumption of animal products, associated reduction in environmental impacts and related welfare gains (based on environmental prices).

Price increase

Table 6 shows the price details of the animal products and the impact of a levy on the average product price. In this analysis, the levy accounts for 100% of the external cost estimate. In practice a growth patch might be chosen, due to political reasons or to allow parties to get used to the system, starting for example with 20% of external costs, increasing over the years to 50 and ultimately 100%. Subsequently, the estimates presented in this paragraph show the *maximum* impact levy. In the analysis, we used average prices per product category.

Table 6 - Price details excise levy, internalising external costs of conventional farming in meat/dairy/eggs

	Beef	Pork	Chicken	Milk	Eggs	Gouda Cheese
Current average retail price (€/kg excl. VAT, 2020)*	€ 13.65	€ 7.49	€ 6.82	€ 0.88	€ 3.77	€ 9.34
Levy (€ per kg)	€ 8.14**	€ 1.77	€ 1.50	€ 0.35	€ 0.93	€ 2.75
Price increase (%)	60%	24%	22%	40%	25%	29%

* Based on average TTC prices (*toutes taxes comprises*) in product category from all retailers (FranceAgriMer, 2021a) (FranceAgriMer, 2021b) (RNM, 2022).

** Weighted average of beef from beef cattle incl. veal (77%) and beef from dairy cattle (23%).

Consumption decrease

Due to the introduction of the excise levy, consumer will pay more for their animal-based products than before. Based on average consumption levels per head before introducing the levy (see Table 7), an inhabitant would spend almost € 140 a year more on beef, about € 30 to 40 more on pork, on chicken and on cheese and around € 10 more on milk and on eggs. In practice, the increase in expenses will be lower because consumers will buy less of these products.

The impact on the quantities of animal products consumed and related expenditure on these products are determined on the basis of price elasticities. The values in Table 7 are average values used to show midterm price elasticities based on meta-analysis of international literature (see (CE Delft, 2019). They reflect the general view that food products on average show a rather inelastic demand (<1 own price elasticity), especially in the short-medium run. A French-oriented study on the impact of carbon taxation (Caillaveta, et al., 2019) presents higher elasticities ranging from 0.8 (cheese) to 1.1 (beef) and 1.4 (other meats). According to these figures, the demand for most animal products would be elastic (>1 own price elasticity). They are at the upper range of (CE Delft, 2019), indicating the impact in the much longer run, when people have more opportunity/are more eager to change their consumer behaviour. Therefore we decided to use the lower price elasticities, meaning -0.8 for beef and -0.6 for the other products (see Annex C.2. in the main report for details).

Lower consumption of the taxed products, creates additional demand for alternative products. This will be partly a desired effect when people switch to plant-based protein food products. Hence, it is also possible that they shift to other animal based products as become relatively cheaper as they face lower tax tariffs[9]. This would be an undesired effect when demand increases for products that are worse for animal welfare, as the aim is fostering the transition towards the consumption and production of less and 'better' animal products.[10] An undesired shift would occur when a lower rate on chicken compared to beef causes a consumption shift towards chicken. However, earlier research of research of (CE Delft, 2018c) and (CE Delft, 2020) indicates that a ECC-based levy would cause a net

[9] Tariffs are highest for beef, followed by pork and chicken, in accordance with the environmental impact.

[10] Beef might be a worse product for environmental reasons, but better for animal welfare. Animal welfare is not included in the analysis, see Section 1.3.

reduction in chicken meat consumption, even when the tax level would be lower than beef. Substitution effects (from beef to pork to chicken) are taken into account.[11]

A second impact path involves food manufacturers reformulating product compositions in order to keep the price increase as low as possible. The fewer animal products that are included (e.g. on a pizza or in a meal), the lower the price increase due to the excise-like levy. This impact is not quantitively included in the analysis.

Table 7 and Figure 4 reveal the decrease in consumption due to the introduction of an excise levy covering the full external costs estimated in Chapter 2. Depending on the type of animal product, consumption will drop between 14 (chicken) and 48% (beef).

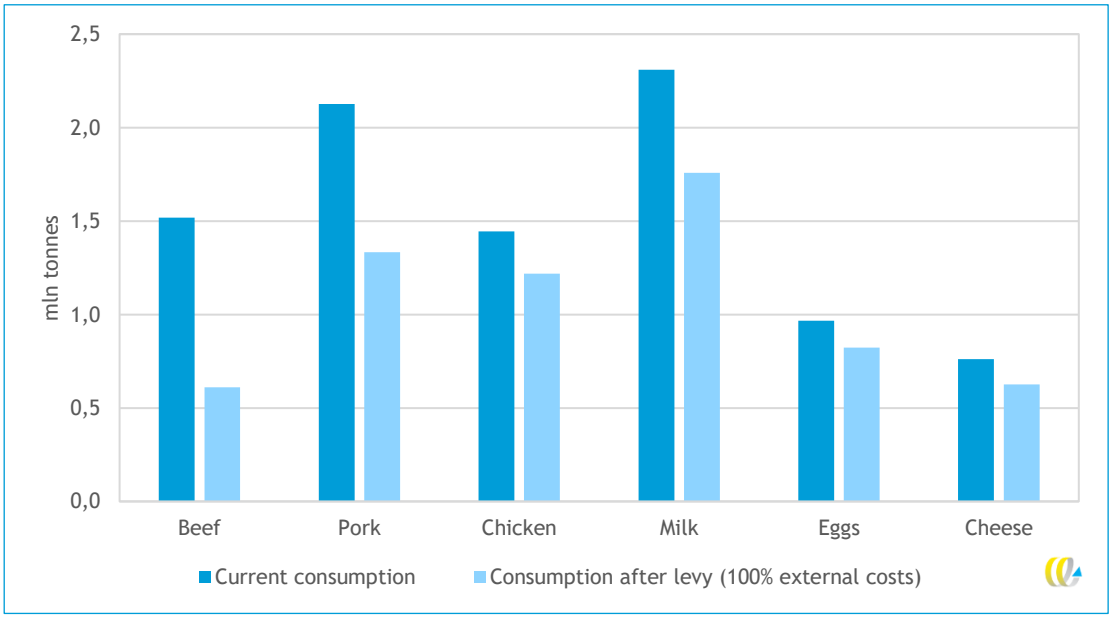
Table 7 - Annual consumption figures of animal products before and after introducing a levy

	Beef	Pork	Chicken	Milk	Eggs	Gouda Cheese
Current situation						
Consumption level (million tonnes, carcass weight, 2020)	1.52	2.13	1.44	2.31	0.97	0.76
Consumption level (million tonnes, product weight, 2020)	1.17	1.55	1.40	2.31	0.97	0.76
Consumption per head (product kg/year, 2020)	17.29	23.02	20.79	34.20	14.3	11.3
After introduction of levy						
Price increase	60%	24%	22%	40%	25%	29%
Price elasticities	-0.8	-0.6	-0.6	-0.6	-0.6	-0.6
Consumption reduction (%)	-48%	-14%	-13%	-24%	-15%	-18%
New consumption level (million tonnes, product weight)	0.6	1.3	1.2	1.8	0.8	0.6

Sources: Current national consumption figures: (FranceAgriMer, 2021b) (FranceAgriMer, 2021a) (FranceAgriMer, 2021c).

[11] Cross price elasticities are expected to be low. By deliberately estimating one's own price elasticities lower, the substitution effects can be met without having to use cross elasticities (see (CE Delft, 2018a).

Figure 4 - Consumption levels before and after introduction of a levy (million tonnes/year, 2020)



Environmental impact and welfare gains

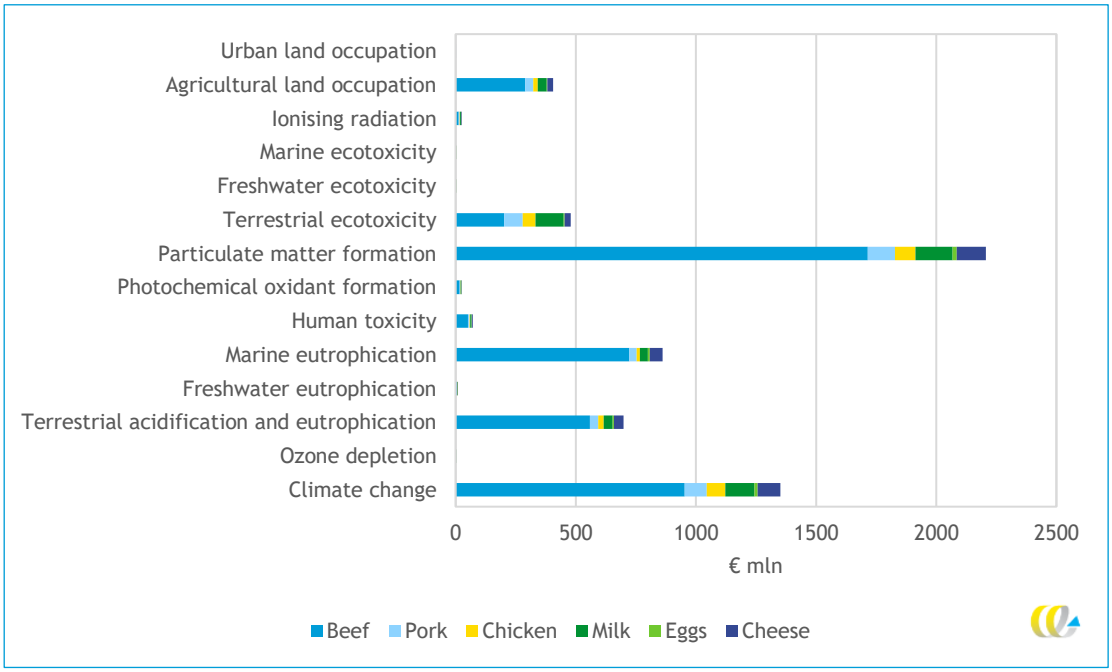
As a result of the consumption decrease, pressure on the environment decreases as well. For calculating the environmental gains, the simplifying assumption is made that all French consumption is covered by domestic production.[12] With respect to climate change, the reduction in CO_2-eq. emissions would be around 17.1 Mton (indicative estimate).
The total welfare gain due to less environmental effects would be about € 6,100 million per year of which € 1,350 million is related to climate change benefits and € 4,750 million to other environmental impacts.[13] Most welfare gains arise due to the reduction in PM formation and land occupation, as Figure 5 shows.[14] Per inhabitant, the annual welfare gain is € 90 on average, of which € 20 relates to climate-related issues and € 70 is related to other environmental themes. These are substantive impacts, but also related to significant price increases.

12 Similar as in (CE Delft, 2018a). Within the context of this study, it was not possible to conduct import/export analysis.

13 In addition to those welfare gains from less environmental pollution there are (smaller) welfare losses from foregone consumer surplus from consumption of meat (so-called deadweight losses).

14 Impacts not corrected for increased CO_2 emissions, etc. due to greater consumption of meat substitutes. In (CE Delft, 2018a) it is estimated that this will offset 15-25% of the welfare gains.

Figure 5 - Total welfare gains due to reduced environmental impacts after introducing a levy (million €/year)



3.3.4 Administrative and regulatory issues

Administration and implementation costs can be expected to be high as the system has to be newly developed. When the levy is paid when the product is sold to the consumer, retailers need to report the amount of meat, dairy and eggs sold to end consumers and/or the processing industry. The regulatory government organisation needs to process and check these declarations. If slaughterhouses and importers pay the tax, they need to report their sales (excluding exports) and import of meat, dairy, eggs and products that contain them. This increases the implementation costs, as governments also have to check imports and export corrections. If taxes are implemented at the farm level, farmers may have to register their emissions. As insight in the supply chain is needed, it would be best to develop/use existing MRV system that comply with EU regulations. Especially when the levy is differentiated, it is crucial that registration is reliable. This will be a challenge, not to be solved in the shorter run.

With respect to legal feasibility, a German evaluation by (Karpenstein, et al., 2021) reveals that implementation of an excise levy seems to be possible. Such taxes have the additional advantage that they may reduce other distortionary market signals, such as given subsidies to the agricultural sector.

3.3.5 Government revenues

Government revenues amount to € 11.5 billion, based on a levy that fully covers the external cost estimates. These revenues can be recycled to compensate low and middle-income households for purchasing power losses and/or subsidise the livestock sector to further reduce its environmental footprint (see Section 3.5).

3.4 VAT increase in retail

3.4.1 Taxpayers, taxation point and tariff

A Value Added Tax (VAT) means in this research that a percentage is added to the retail.[15] It is paid when products are sold to the customer. For retail, in France, there are two VAT-rates, 5.5% (reduced rate) and 20% (standard rate). Generally, the basic food needs have the reduced VAT-rates of 5.5%. This includes animal-based food products such as fresh meat, dairy and eggs. The policy measure to internalise external costs here is to make animal products in retail subject to the highest VAT rate of 20%.

3.4.2 Environmental impact

Based on a VAT increase from 5.5 to 20%, we roughly estimate the expected reduction in French consumption of those products, associated reduction in environmental impact and related welfare gains (based on environmental prices).

Price increase

Table 8 reveals the current annual consumption levels of animal products, based on (BMEL, 2021) and the impact of a VAT increase with 14.5%. Per product category, we used average retail prices. These prices raise with 13.7% due to the VAT increase.
The VAT increase covers only part of the total external costs: ranging from only 21% for beef (average) to 66% for chicken.

Table 8 - Price details VAT increase

	Beef	Pork	Chicken	Milk	Eggs	Cheese
Current retail price (€/kg incl. 5.5% VAT, 2020)*	€ 14.40	€ 7.90	€ 7.20	€ 0.93	€ 3.98	€ 9.85
Retail price high VAT rate (€/kg incl. 20% VAT, 2020)*	€ 16.38	€ 8.99	€ 8.19	€ 1.06	€ 4.52	€ 11.20
Price increase	€ 1.98	€ 1.09	€ 0.99	€ 0.13	€ 0.55	€ 1.35
External costs (conventional farming)	€ 8.14	€ 1.77	€ 1.50	€ 0.35	€ 0.93	€ 2.75
Part of external costs covered by VAT increase	21%	61%	66%	36%	59%	49%

* Average TTC prices (toutes taxes comprises) in product category from all retailers (FranceAgriMer, 2021a) (FranceAgriMer, 2021b) (RNM, 2022).

Consumption decrease

As a result of the VAT increase, consumers have to pay more for their animal-based food products as before. Based on average consumption levels per head before the VAT increase

[15] In addition to VAT rates applying for retail, there are also VAT rates applicable in the French agricultural system with specific rules of VAT related to agricultural inputs (reduced VAT rates for e.g. limestone and organic fertilizers), or outputs to persons not registered for VAT and farmers subject to the reimbursement forfaitaire (RFA). These have not been considered in this study. Also the specific VAT regimes for agriculture (the reimbursement forfaitaire (RFA) and the régime simplifié agricole (RSA)) have not been considered here as the VAT change only focusses on VAT paid at retail.

(see Table 9), an inhabitant would spend about € 35 a year more on beef, about € 20-25 more on both pork as well as chicken and around € 5-15 more on milk products and eggs. In practice, the increase in expenses will be lower because consumers can be expected to buy less of these products in response to the price increase.

The impact on the quantities of animal products consumed and related expenditure on these products are determined on the basis of price elasticities, as discussed in Section 3.3. Again, lower consumption of the taxed products, creates additional demand for alternative products. This will be partly a desired effect when people switch to plant-based products. Hence, it is also possible that they shift to other animal based products as become relatively cheaper as they face lower tax tariffs[16]. This would be an undesired effect when demand increases for products that are worse for animal welfare, as the aim is fostering the transition towards the consumption and production of less and 'better' animal products.[17] An undesired shift would occur when a lower rate on chicken compared to beef causes a consumption shift towards chicken. However, earlier research of CE Delft (2018) indicates that a ECC-based levy would cause a net reduction in chicken meat consumption, even when the tax level would be lower than beef. Ecologic (2022) also expects only a small substitution effect, if any. Substitution effects (from beef to pork to chicken) are taken into account.[18]

A second impact path leads through reformulation of product compositions by food manufacturers in order to keep the price increase as low as possible. The less animal products are included, the lower the price increase due to the excise-like levy. This impact is not quantitively included in the analysis.

Table 9 reveals the decrease in consumption due to the VAT-increase. Consumption levels will drop with 11% (beef) or 8% (other products).

Table 9 - Annual consumption figures of animal products before and after the VAT increase

	Beef	Pork	Chicken	Milk	Eggs	Cheese
Current situation						
Consumption level (million tonnes, carcass weight, 2020)	1.52	2.13	1.44	2.31	0.97	0.76
Consumption level (million tonnes, product weight, 2020)	1.17	1.55	1.40	2.31	0.97	0.76
Consumption per head (product kg/year, 2020)	17.29	23.02	20.79	34.2	14.3	11.3
Introduction of levy						
Price increase	13.7%	13.7%	13.7%	13.7%	13.7%	13.7%
Price elasticities	-0.8	-0.6	-0.6	-0.6	-0.6	-0.6
Consumption reduction (%)	-11%	-8%	-8%	-8%	-8%	-8%
New consumption level (million tonnes, product weight)	1.0	1.4	1.3	2.1	0.9	0.7

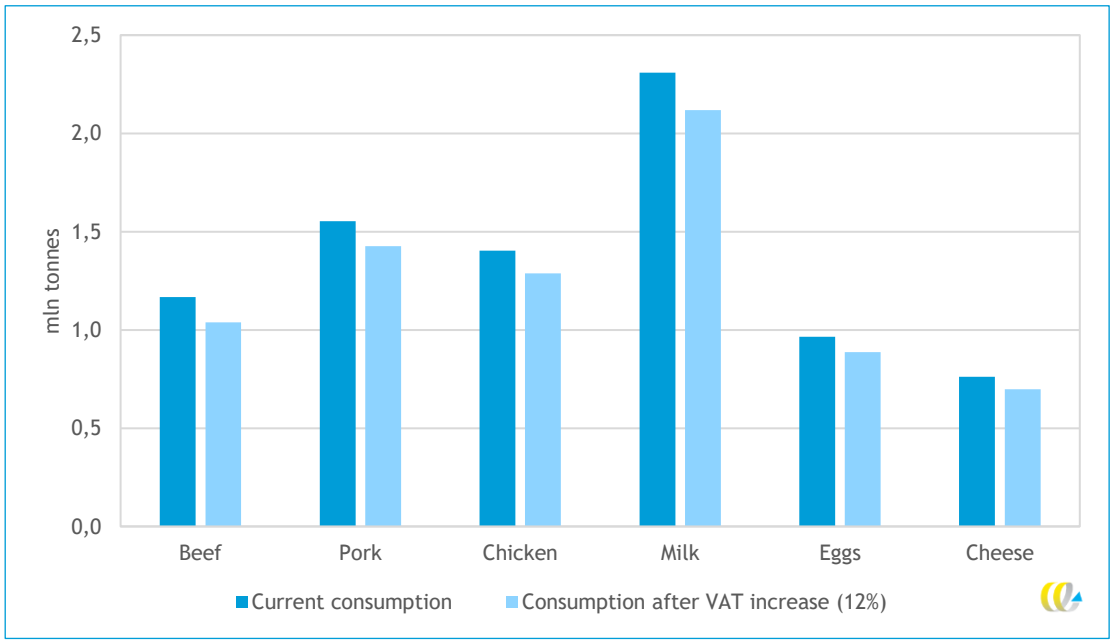
Sources: current consumption figures: (FranceAgriMer, 2021a) (FranceAgriMer, 2021b) (RNM, 2022). Latter reports in 2022 prices, translated to 2020 price level by 6% inflation correction (Eurostat).

[16] Tariffs are highest for beef, followed by pork and chicken, in accordance with the environmental impact.

[17] Beef might be a worse product for environmental reasons, but better for animal welfare. Animal welfare is not included in the analysis, see Section 1.3.

[18] Cross price elasticities are expected to be low. By deliberately estimating one's own price elasticities lower, the substitution effects can be met without having to use cross elasticities (see (CE Delft, 2018a).

Figure 6 - Consumption levels before and after a 14.5% VAT increase (million tonnes/year, 2020)

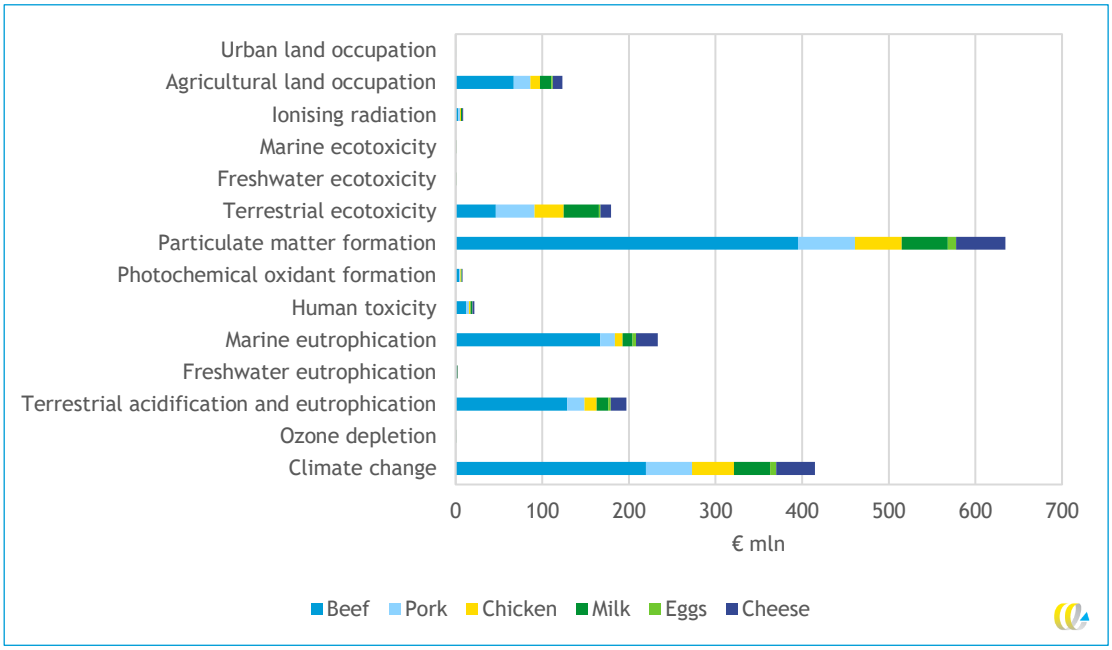


Environmental impact and welfare gains

As a result of the consumption decrease, pressure on the environmental lowers as well. For the environmental impacts we made the simplifying assumption that all French consumption is covered by domestic production. The reduction in CO_2-eq. emissions would be about 5.3 Mton (indicative estimate). The total welfare gain due to less environmental effects would be around € 1,800 million per year of which € 400 million is related to climate change benefits and € 1,400 million to other environmental impacts. Most welfare gains arise due to the reduction in Particulate matter formation and land occupation, as Figure 7 shows.[19] Per inhabitant, the annual total welfare gain is € 27 on average, which involves € 6 on climate-related issues and € 21 related to other environmental themes.

[19] Impacts not corrected for increased CO_2 emissions, etc. due to greater consumption of meat substitutes. In (CE Delft, 2018a) it is estimated that this will offset 15-25% of the welfare gains.

Figure 7 - Total welfare gains due to reduced environmental impacts due to VAT increase (million €/year)



3.4.3 Government revenues

The VAT revenues of the French government increases with € 6.3 billion.
These additional revenues can be used for various purposed, among which compensating low and middle-income households for higher prices and/or stimulate measures in the livestock sector to further reduce its environmental footprint (see Section 3.5 on earmarking).

3.4.4 Administrative and regulatory issues

Administrative and implementation costs are rather low as the measure relies on an already established VAT-system. For combined food products including meat, dairy and eggs (e.g. pizza's, bread with a hamburger) a decision has to be made in what kind of VAT tariff the product should have: the reduced or standard VAT-rate?

With respect to legal issues, particularly the principle of fiscal neutrality would have to be observed. According to a legal feasibility study for Germany (Karpenstein, et al., 2021), VAT measures are feasible.

3.5 Recycling of revenues through earmarking

The excise levy and VAT-increase yield government revenues of € 11.5 and € 6.3 billion respectively. These revenues can be used to stimulate the consumption of 'healthy food', compensate households for higher prices and/or stimulate sustainable livestock farming through subsidies.

On the one hand, the revenues can be used to compensate for a loss of purchasing power for certain groups. This may concern the sector itself, as it is confronted with a cost increase that can lead to a reduction of the profit margin (if the costs are not passed on

one-to-one) and a loss of turnover (if demand decreases when costs are passed on). Famers could be compensated by providing subsidies from the revenues for, e.g., investments in products and methods of production that allow for lower environmental impacts. Such measures have not been investigated further in this research, as a compensating mechanism should carefully consider the amount of pass through of the costs to end consumers, and such lays outside the scope of the present research.

If all costs are passed through to end consumers, or the pricing instruments directly target end consumers, they can be compensated for their loss in purchasing power because of the higher prices. This is especially problematic for low income households as a larger share of their incomes is spent on food products.

There are several ways to compensate consumers:

1. Through a VAT relief for fruit, vegetables and other products (e.g. bread, cereals, organic food, meat/dairy alternatives). In 2019, the Romanian government has decided to promote the consumption of healthy and traditional foodstuffs by cutting their VAT rate from 9% to 5% (Euractiv, 2019). In April 2022, Greenpeace Germany (Wiegmann, 2022) presented a report on VAT-increase on meat, dairy and eggs in different EU countries, and proposed at the same time to reduce VAT rates to 0% on vegetables, fruit, cereals and bread, allowing consumers a net benefit of about € 50 per capita per year (based on average diets). The advantage of a VAT relief is that it does not discriminate towards household income. Every household will benefit equally from this.
2. Through a reduction in other taxes, e.g. income taxes. Taxing environmental impacts and recycling money back to lower labour taxes has often been considered giving double dividends: lower pollution and lower unemployment (see e.g. (Topal, 2017)). Reduction of labour taxes could thus be a good idea, especially in countries that have a relatively high unvoluntary unemployment. On the other hand, the reduction in labour taxes will only benefit those who have a (paid) job while pensioners and unemployed people will pay for higher taxes but not reap any benefits. Therefore, this measure has distributional consequences which would have to be addressed through other policy measures. Distributional consequences will also appear if other taxes are being lowered such as profit or energy taxes.
3. Through providing a free voucher to citizens to spend on specific food product categories (e.g. vegetables and fruits). France is proposing such food vouchers for low income groups in 2023, to compensate for food inflation.

In this research we will investigate options 1 and 3 which are believed to be the most favorable options for low income households and also discuss options to use the money to introduce more sustainability measures in the sector.

3.5.1 VAT relief for vegetables and fruits

The higher VAT tax revenues or revenues from a levy could be used for a tax relief for fruit and vegetables. In France, household expenditure on fruit and vegetables totals € 33 billion in 2018 (Statista, 2022). With a VAT of 5.5%, this yields a VAT revenue of € 1.72 billion for the French government. This is far less than the potential VAT revenues from a higher tax on meat and dairy products of € 11.5 billion for the levy and € 6.3 billion for the VAT increase on meat and dairy. This indicates that for either option, the VAT on fruit and vegetables could be reduced to zero, and more measures should be taken to fully recirculate the levy/VAT increase to consumers. One way this could be done, is to hand out vouchers for the remaining VAT revenues.

This could, for example, be done in various ways:
- by also providing VAT relief for other basic necessities such as bread, cereals, tea, coffee, but also organic food and local products and meat/dairy alternatives;
- by using the remaining revenues to hand out vouchers (see Section 3.5.2);
- by using the revenues for taking stimulating measures in agriculture for sustainability (see Section 3.5.3).

The VAT relief will have no additional administrative burdens compared to the present system.

3.5.2 Providing food vouchers

Alternatively, the revenues could be used to issue (free) food vouchers (healthy food gift cards) that can be used by consumers. A voucher system has recently been introduced in many countries (e.g. UK, Greece) to support struggling households with inflation and help them getting the basic necessities in home. In France and Belgium, a meal voucher system already exists since the late 1960s (EC, 2020). The higher revenues from a levy or VAT increase could be used to set up such an (extended) voucher system in France. We would propose here to earmark the vouchers only for healthy and sustainable food products, such as vegetables, fruit and organic food.

In the most simple form every citizen would get a voucher. If a single voucher per inhabitant would be issued, this would mount to € 94 per person from the VAT increase, or € 171 per person from the government revenues in a system with a levy. The vouchers would be higher if certain groups would be excluded from receiving a voucher, such as wealthy persons or children under the age of 1.

The voucher system would imply additional administrative efforts. Administrative costs will highly depend on the type of system that will be set up and will also depend on the number of people that can participate. An evaluation of the Italian scheme of a payment card for free purchases for poor people showed that the administrative costs can be expected to be around € 20 per card (EC, 2020). Other sources estimate that administration costs for food related vouchers can be between the 3 and 37% (United Nations, 2007).

Administrative costs can be substantially lower if no voucher for specific purposes is given, but rather a per capita lumpsum money refund that can be freely spent on anything the people want. The lower administrative costs can be achieved because it can connect to existing schemes (e.g. labour taxes, social security support, child benefits). On the downside, the money could also be spent on environmentally unfriendly products, such as airline tickets or meat.

3.5.3 Stimulating sustainability measures in agriculture

Finally, the proceeds can be used to further stimulate the taking of sustainability measures (influencing behaviour). Various target groups are possible for this. When the proceeds are used to stimulate further sustainability in the agricultural sector, the sector is supported to reduce the harmful effects to which the sustainability contribution applies. However, the potential of technical measures is limited. In particular, the currently available technical measures are not sufficient to solve two problems: the large amount of land required in France and abroad for the cultivation of feed, and the amount of greenhouse gases produced by livestock farming. For Germany (UBA, 2021) concluded that even if production were optimised through technical measures and an improved spatial distribution, the climate targets of agriculture would probably not be achieved and the global load limits would be exceeded. So a payment scheme for livestock farmers reducing livestock numbers,

can be considered too (like implemented in the Netherlands and Belgium), or giving subsidies to livestock farmers who improve animal welfare standards by adapting stables (government proposal in Germany).

In order for the food system in France to become more environmentally and climate-friendly, livestock farming and human diet have to be changed significantly: This means using both effective technical and distribution measures that can be implemented at short notice to reduce environmental impacts, and the level of production and consumption of animal foods to decrease.

3.6 Conclusion

Given the characteristics of the excise levy and VAT increase, Table 10 shows the evaluation of the two policy instruments. A VAT approach scores high on administrative, regulatory and legislative issues, mainly due to the fact that a VAT system is already in place in France. In principle, the VAT increase measure is also effective in providing financial incentives for more sustainable consumption and production. However, the ultimate impact depends on the VAT rate. The evaluated VAT increase from 5.5 to 20% only covers a relatively small part of the total external costs; coverage ranges from 23% for beef (average) to 66% for chicken. Therefore, its score on effectiveness (meaning generating a significant positive impact), would be lower than the score of an excise levy that covers 100% of the external costs. However, tariff rates are a political choice instead of characteristics of the policy measures in themselves. Hence, both policy instruments are given a + score as they both provide financial incentives.

When designing an excise levy, the choice of taxation point and taxpayer has a significant impact on the mechanism. It determines the number of actors that are covered by the scheme (and thus administrative and implementation costs), the effectiveness (which actor faces the main financial incentive) and the need to correct for cross border effects (to avoid relocation of polluting activities abroad).

Table 10 - Scores of policy instruments to increase the prices of meat, dairy and eggs

Aspect	Excise levy	Excise levy	(Differentiated) excise levy	VAT increase
Taxation point	Consumer level	Slaughterhouses and importers	Farm level	Consumer level
Effectiveness – Positive impact on 'greening' consumption and production	++	+	+/++	+
Low administrative burdens for producers	+	+	-	++
Low implementation costs of governments	+	-/0	-	+/++
Legal feasibility	+	+	+	++

Note: Scores indicate the performance of the policy instrument, so - = bad performance, 0 = modest, += good, ++=very good.

4 Conclusions

Animal products are a substantial ingredient of current French diets. Yet, the production and consumption of animal products is associated with a wide range of environmental problems: global warming, eutrophication of soils and waters that lower biodiversity, emissions of ammonium that are formed into secondary aerosols harming human health and extensive land use that comes at the expense of nature and biodiversity.

In this study, we estimated the external environmental costs of animal products: beef (both from beef, veal and dairy cows), pork, chicken, eggs and (hard) cheese. Our analysis shows that external costs are substantial, ranging between the € 0.35 for a liter of milk to almost € 10 per kg of meat from beef cows. Pork has an external cost of € 1.77 per kg, chicken € 1.50 per kg, eggs € 0.93 per kg and (hard) cheese € 2.75 per kg.
These external costs are primarily caused by emissions of greenhouse gasses plus ammonia from manure handling and application as fertiliser (plus artificial fertiliser) for growing crops for feed. Ammonia has many health related impacts and puts the environment under stress (eutrophication and terrestrial acidification). It is therefore no surprise that cattle systems, which have high ammonia emissions, also have the highest external costs.

These external costs comprise the unpaid bill of consuming animal products. In this study we have only focused on the environmental impact as part of the unpaid bills. It is very likely taht the 'real' unpaid bills are higher for several reasons. The sector receives considerable subsidies that are not being paid by the consumer of animal products. Besides, the sector is the cause of numerous outbreaks of animal diseases (which are paid for by taxpayers in many countries). Moreover, the animal production sector has a severe impact on human health, zoonoses and resistance to antibiotics and it has poor standards for animal welfare that can only persist by hiding them from the general public. However, we have not derived external cost estimates for those non-environmental categories in this research.

External costs of consumption of animal products can be most effectively combatted by making consumers pay for those costs. Only then will consumers take the environmental impact into account when deciding to consume animal products or one of the plant-based alternatives, and the sector can be steered towards cleaner production methods and alternatives for animal products. Pricing instruments are therefore most effective when addressing the issue of unpaid bills in the animal products sector.

In this study, we have investigated introducing an excise levy for French consumption of meat and removing the lower VAT tariff on animal products. Both schemes are feasible from a legal perspective and can be implemented, although the levy needs more scrutiny with regard to practical design questions such as where the taxation point should be and whether imports/exports should be included in the scheme. The easiest measure to implement would be removal of the lower VAT tariff for animal products in France. The lower VAT tariff for meat can be labelled as an 'environmental harmful subsidy'. Phasing out environmentally harmful subsidies is a commitment of the EU Roadmap for Resource Efficiency. Various EU Member States, such as Bulgaria, Denmark and the three Baltic States, have not granted lower VAT tariffs for meat or dairy. France could follow their lead. This would reduce meat consumption by about 11% for beef and about 8% for the other animal products. Government revenues would be around € 6.3 billion. In France, a high VAT rate for meat, dairy and eggs would reduce GHG-emissions by 5.5 Mton CO_2-eq./year.

Although easy to implement, a higher VAT rate for animal products would have the drawback that it does not fully cover the external costs of meat consumption. For that, additional measures could be considered, either on top of the VAT increase or as a substitute. In this study, we have investigated the possibilities of a levy equivalent to the external costs of meat. The levy would raise € 11.5 billion of government revenues per year and reduce GHG emissions annually by about 18.5 Mt CO_2-eq. over the value chain.
The most straightforward way of introducing a levy would be to implement an excise levy on meat sold to consumers by retail companies (supermarkets) and food services (catering, restaurants, etc.), irrespective of whether this meat is being produced in France or in another country.

Higher VAT rates and/or a levy would imply that costs of consumers still wanting to consume meat will increase which would lower their purchasing power. Consumers can be compensated by the recycling of government revenues from a VAT increase on meat products, to evenly distribute the revenues over the population through a 0% VAT on vegetables and fruit, bread, cereals, coffee, tea, organic food and meat/dairy alternatives or a (free food) voucher or a healthy food gift card to be spent in supermarkets on fruit or vegetables, for example. If a single voucher per inhabitant is issued, this voucher would amount to € 94 per person from the VAT increase, or € 171 per person from the government revenues in a system with a levy. Alternatively, consumers could be (partly) compensated by VAT relief (to 0%) for fruit and vegetables and the remaining money could be spent on VAT relief to 0% for other food products such as meat/dairy alternatives, organic food products, bread and grain products. In this way, the price of a supermarket shopping trolley of an average French consumer will not increase or might even decrease.

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