Sur la durabilité du complexe agri-agroalimentaire français: une évaluation macroéconomique

Abstract:

The French farm and food sectors face increasing societal pressures to engage in sustainable transition. By defining ambitious environmental objectives and promising significant funds for green investment, the Green Deal roadmap of the European Union provides a unique opportunity to make this transition feasible. This paper assesses the current economic ability of the French food system to cope with some farm-related biodiversity objectives defined in this roadmap. Integrating the most recent statistical evidences on the behaviors of French farmers and consumers on an otherwise standard macroeconomic methodology, we find that these objectives are reachable without seriously hampering the incomes of active farmers and transferring the burden on foreign economies. This positive message may turn clearly negative, depending on the currently unknown definition of high biodiversity landscape features. The devils will be in the details once more.

Keywords: Green Deal, Farm income, Environmental impacts, Economic models

Introduction

With the Green Deal (GD) adopted in 2020, the European Union (EU) defines ambitious short term and long-term policy goals towards a more sustainable economy, targeting carbon neutrality by 2050. As regards the food system, these include significant reductions in the use of chemical pesticides, mineral fertilizers and antimicrobials by farmers. The GD also intends to improve the sustainability of food processing, distribution and consumption. Many policy actions are contemplated to reach these objectives, such as financial investments in green technologies, some land use restrictions for biodiversity objectives and information campaigns on sustainable food consumptions.

The GD is a comprehensive and ambitious roadmap for the EU, raising many questions on its global relevance, coherence of the different sub-objectives, the planned budget or precise actions. In particular, the European Commission claims that "*our transition towards a sustainable food system should preserve affordability of food while generating fairer economic returns, fostering competitiveness of the EU supply sector*". The general purpose of this paper is to quantitatively contribute to the ongoing debate on the macroeconomic income and trade effects of the GD. Indeed, several stakeholders and academics anticipate that, at least in the short to medium run, the GD will hurt the incomes of European farmers and will deteriorate food security in foreign countries, implying in turn that the GD is not sustainable (Guyomard et al., 2020 and references in this report). The underlying economic intuition is that, by restricting farmland and their usages of chemical inputs, European farmers will suffer from increased production costs by using more expensive inputs and will produce less, all other things being equal (in particular commodity prices). Depending on prevailing market conditions, this may increase commodity prices, which would temper farm income losses and production shortfalls. Beckman et al. (2020) provides one first study quantifying these effects at the 2030 horizon, confirming that the GD may lead to farm income losses despite increases in commodity price. This study also reports significant effects on the number of food insecure people in some African and Asian countries.

This ongoing debate shares some similarities with the previous debate on the relevance of the European biofuel policies. By supporting the demand of farm commodities, these policies also contribute to increase farm commodity prices and world food insecurity (IEEP, 2012). This debate lasts more than one decade, informed by continuously improved methodologies designed to measure many direct and indirect effects. As expected, the dedicated literature underlines that the extent of these effects critically depends on the behaviors of economic agents, as traditionally measured with (production/substitution/price/income) elasticities. Accordingly, we expect that the quantitative evaluation of some GD effects also hinges on the accurate representation of the behaviors of economic agents operating on the food system, prominently on the behavior of European farmers and their possibility to cope with their new technological restrictions. The methodology developed by Beckman et al. relies on the Arrow Debreu static Computable General Equilibrium (CGE) framework, implemented with the GTAP database. This database offers a detailed representation of many farm and food sectors, covering the main producing and consuming countries. However, this world database does not isolate mineral fertilizers from pesticides among chemical inputs used for crop productions, forcing these authors to approximate the combined effects of reductions on these two different inputs. We partially solve this issue by developing an original Arrow Debreu static CGE framework for the French economy where these two inputs are distinguished. We also make use of up-to-date econometric results obtained by Bareille and Gohin (2020) regarding the behavior of French farmers in terms of input uses and land allocation per main crop categories. This framework already allows us to quantify some effects of farm-related GD provisions at the French level, notably on the French farm income and food trade balance. This is the first main quantitative contribution of this paper.

The GD is not only about imposing new constraints on European farmers, nor is the sustainability of the food system only in the hands of those farmers. By altering their consumptions, European households can also contribute to a more sustainable food system. Many studies already quantify that some environmental damages can be reduced if food diets include less red meats and more fruits and vegetables (again Guyomard et al., 2020 and references in this report). The GD intends to promote the adoption of healthy and sustainable diets by consumers, mostly by improving consumer information and encouraging adoption of national fiscal measures. However, when it comes to define the content of a sustainable diet, significant issues arise. Let's illustrate with the case of red meat consumption. It is now widely recognized that cattle production contributes to GHG net emissions due to enteric fermentation. But, in addition to value non edible grasslands on carbon-storing permanent grasslands, cattle production also contributes to biodiversity. Indicators that measure some impacts while ignoring others are obviously criticized by many stakeholders, as well the potential labelling of food products with such indicators (Interbev, 2020). Without clear messages and/or price incentives directed to consumers, one can doubt about a rapid modification of food consumption. Still, food consumption is currently evolving. Recent consumer surveys in many developed countries indicate that consumers tend to value local foods at higher prices (for the French case, FAM, 2018). In France, consumers also care more and more about getting GM free products. Food processors and retailers invest in new product lines or/and distribution systems to fulfill these emerging demands. Policy makers (regional/national) also support information campaigns that promotes French GM free food production. One may conjecture that this trend towards French GM-free food will accelerate if French food is produced with less chemical inputs. To measure these effects, our French CGE framework also innovates by including new local/GM free sectors and markets. We then simulate the effects of preference changes towards these products, again on French farm income and food trade balance. This is the second main quantitative contribution of this paper.

Methodology

We develop an original CGE model for the French economy, starting from the USDA-ERS single country CGE model (Robinson et al., 1990). It is thus static, assuming perfect competition in all markets (except land, see below). By default, firms maximize their profit subject to constant returns to scale technology and a representative French household maximizes utility subject to budget constraint. We do not include non-market considerations in the utility function and concentrate our analysis on the market and income effects (for an analysis with externalities specified in the utility function, see Vissers et al., 2021). Thus we do not offer normative evaluation, avoiding us to weight potentially conflicting market and non market issues. We rely on the traditional Armington specification at both the export and import side, adopting significant elasticities (10) consistent with the GTAP parameter choices for detailed farm commodities. We also specify iso-elastic import supply and export demand function, again with significant own price elasticities (respectively +10 and -10). These elasticities are also consistent with the former Armington elasticities due to the limited shares of French trade flows on world food markets.

We gather many official French data to build our Social Accounting Matrix. Some data are not yearly published, we choose the 2011 as the base year. This is a compromise between the 2010 agricultural census and the 2012 survey on GM free food products conducted by Tillie and Rodriguez-Cereso (2015). Indeed, the French food sectors produce an increasing variety of food products with different practices and public/private labelling, targeting different externalities[1]. But national public statistics on the size of these differentiated markets, the production costs, the prices and premiums for the different economic actors involved in these markets are currently lagging. Tillie and Rodrigue-Cerezo (2015) provide precious national figures for animal feed and animal products produced with GM free soybeans. We use these figures to split many products between GM-free and other products (that we hereafter label conventional products) in our database. Roughly 20% (respectively 10%) of dairy and red (respectively white) meat production are GM free and price premiums average around 15% (exact figures are provided in Tables 3 and 4). We also split many farm and food processing activities into two different technological process. This starts with the soybean crushing sector producing GM free soymeal (vs conventional soymeal) from domestic and imported GM free soybeans (vs imported conventional soybeans). Then the activity of the compound feed industry is dividing between the GM-free feed formulation for different animals, using only GM free soymeal, and the conventional feed using conventional raw materials. We pursue similar distinctions at the livestock production stage, then the food processing (slaughterhouse/dairy), food retailing and finally the consumption stage by our French household. By default, we make two critical but usual assumptions when making all these distinctions. First, all price premiums cover only additional production costs (like certification costs), meaning that producers do not make additional profit or losses from engaging in GM-free production. Second, all GM-free production volumes are sold on the GM free markets with price premiums, meaning that there are not sold at discounted values on the conventional corresponding markets.

Naturally some modelling assumptions are also required to represent the behavior of economic agents towards these different products in our CGE framework. Let's start with the consuming stage, then the food retailing and processing stage and closing with the farm

[1] See for instance https://yuka.io/decryptage-labels-alimentaires/

production stage. Many studies report willingness to pay for some attributes on some food products, controlling for socio economic characteristics of survey participants (Balcombe et al., 2020, Marette et al., 2021). But these studies generally do not cover many food products and/or have difficulties in converting stated in revealing preferences and/or do not report the impacts of price variations on consumption volumes. We thus guess some price and income effects and borrow the others from the econometric results of Caillavet et al. (2016). More specifically, we develop a standard nested structure of CES-LES functions. For each individual food product, the bottom nest models the substitution between the conventional and GM free varieties. The calibration of this bottom CES-LES function assumes a higher income elasticity for the GM free variety (1.5) and that the minimal consumption of the conventional variety amounts to 20% of initial consumptions. The Marshallian elasticity matrix reported in Table 1 resumes our modelling choices of the behavior of French household towards food products. For instance, the demand of conventional beef has a lower income elasticity (0.34) compared to GM free beef (0.65). A one per cent increase of conventional beef price reduces its own demand by 0.72 per cent and mostly stimulates GM free beef consumption by 0.21 per cent.

The French households can source GM free products from domestic producers or foreign ones. We assume strong preferences for French products, that we control with low price elasticities of import supply (0.1 compared to 10 for conventional products). The 0.1 choice acknowledges France contiguity with other European countries (for instance, households in the Grand Est region purchasing some German GM free food products).

The GM-free products are distributed by French retailers who incur additional retailing costs for these products. We assume that the marginal retailing costs are constant, meaning in particular the absence of scale economies. Food processors also incur additional variable costs to produce GM free varieties. Contrary to the retailing stage, we assume that in the short/medium run, food processing plants (slaughterhouse, dairy) cannot freely switch from conventional to GM free processing and vice versa (for instance, due to cleaning, management of storage capacities, …). In a given sector, a logit specification (with an elasticity 3) governs the arbitrage between GM free vs conventional processing.

Finally our farm supply specification departs from the traditional specification adopted in CGE framework in two important ways. First, the standard specification relies on nested Constant Elasticity of Substitution (CES) functions. This specification is theoretically sound but its full statistical calibration on historical data for crop activities is impractical in the French case. In particular, chemical input allocations per crop are generally unavailable for different years. Moreover, the French farmland price regulation prevents us to know the economic value (or returns) that farmers annually give to their farmland. Hence the substitution between chemical products and land per crop categories cannot be statistically estimated with a CES approach. Bareille and Gohin (2020) circumvent this difficulty by applying a micro econometric specification on French regional data covering last 25 years. In this specification, the crop yield per hectare only depends on applications of fertilizers and pesticides and land is measured physically. We implement this approach at the French regional level, to account for the different climatic or soil conditions. A similar approach is developed for animal activities where yields (per cow for livestock) only depend on the different feed ingredients provided to animals. A distinction is made between animals fed with only GM free feed ingredients and other animals fed with conventional feed ingredients. Second, the standard specification assumes the availability of full accounting costs per activity (for instance, the number of accounting hours or maintenance of equipment, spent on wheat production or rapeseed) and that the substitution between say farm equipment and farm labor is also measured per farm activity. We depart from this specification on other farm inputs which is very intensive in parameters. We adopt a more parsimonious one close to the one implemented by Peterson et al (1994) for the same reasons. The specification considers mixed farms that arbitrate between activities according to their margins. The arbitrage is modelled with nested Constant Elasticity of Transformation functions with elasticities calibrated to target hicksian (conditional to the level of some farm primary factors) farm supply elasticities. These elasticities are provided in the upper part Table 2 where total farmland, farm capital and family owned labor are fixed (hired farm labor is endogenous). The lower part of Table 2 reports acreage and input use effects for crop activities. For instance, a one per cent increase of wheat price favors the expansion of wheat acreage (by 0.1 per cent) and wheat yield (by 0.05 per cent) thanks to higher fertilizer and pesticide applications. This price increase has a negative influence on other crop productions due to the acreage effects. It also has a negative effect on animal production due to an increase of feed prices and a reallocation of the bundle of farm labor/capital to the detriment of animal activities. We consider these elasticities as short run ones because the amount of the family labor/capital bundle is fixed. In the medium run, we allow the amount of this bundle to change (to capture real increasing/decreasing investments, entry/exit from the farm sector) in response to its own return.

Before turning to the simulations, we warn that our original farm supply specification does not include a direct substitution between chemical inputs and labor/capital in crop activities. For instance, we do not capture the fact that when the nitrogen price increases, farmers may spend more time/effort to measure the nitrogen requirement of their crops during the growing season. We have no statistical evidence to calibrate this substitution.

Scenarios

The GD includes many objectives affecting directly and indirectly the food system. We consider two main scenarios. The first one focuses on some quantitative targets as defined in the biodiversity strategy. We explicit simulate a decrease by 50 per cent of pesticide uses, by 20 per cent of mineral fertilizers use and an increase to 10 per cent of agricultural area dedicated to high diversity landscape features. As regards the first two objectives, we assume that the French government imposes ad valorem taxes, by 60 per cent on pesticide uses and 50 per cent on mineral fertilizer uses. These levels of taxes are calibrated using our calibrated total own price elasticity (see Table 2). We choose the tax instrument even if France has not yet introduced such significant taxes. Many academics (Zilberman et al., 1991, Litchtenberg, 2004 or Aubertot et al., 2005) have long argued that the tax instrument is the most efficient one among all potential instruments. In the simulation results below, we do not redistribute the tax receipts to farmers but will discuss later this possibility. A redistribution increases the acceptability of policy reforms by economic agents and is usual practice in France (Bontems, 2019). As regards the 10 per cent objective of high diversity landscape features, there is not yet a formal definition of this objective. We consider two alternatives. The first one, that we hereafter label the unproductive biodiversity scenario, assumes that no production is possible on 10 per cent of the total agricultural area (similar to the Beckman et al study). In our database, voluntary set aside amounts to 1.5 of agricultural areas. This means that we further reduce the agricultural area available for farming by 8.5 per cent (both arable land and pasture land, as we make no distinction between the different pasture lands). The second one, that we hereafter label the productive biodiversity scenario, assumes that the commons (covered by permanent grassland, mostly located in mountain areas and valued by livestock grazing) are considered as high diversity landscape. These commons currently cover 6.2 per cent of the total agricultural area. Accordingly, we reduce the total agricultural area available for farming by 2 per cent in this second alternative. We warn that with our static CGE framework, we are not able to go deeper in the analysis of the uses of new idle areas (such as planting trees, management of crop rotations). The biodiversity strategy also includes two other major quantitative objectives on organic farming and antimicrobial uses that we are not able to analyze due to data issues. However Guyomard et al. (2020) show that the last constraint may be not binding in the future. As regards the objective on organic farming, we presume that the 50 per cent reduction of pesticides contributes to this objective.

Our second scenario, hereafter labelled sustainable demand, focuses on the consumer side and is more tricky to motivate. The Farm to Fork strategy does not include quantitative objectives for food consumption, probably due to the lack of official definition of the content of a sustainable diet. Key elements of this strategy include improving consumer information, strengthening sustainable food procurement and encouraging adoption of fiscal measures that support sustainable food consumption. These elements are not really new and thus one may doubt that some significant changes can occur from the demand side. Without much scientific evidence, one may still conjecture that if French households perceive real significant changes from the French farming system towards sustainability (and not hypothetical as assumed in most WTP studies), they may consume more French products. The reverse can also be true: if the French farmers perceive significant changes from the French households with real willingness to pay for their differentiated products, they may adapt their production systems. By promising significant funds, the external GD roadmap may be a useful opportunity to break the long lasting internal French debates on the individual responsibility concerning the sustainability of the food chain.

By how much French households can change their preferences and food behaviors? This is another tricky question. In our second scenario, we simply assume that French households want to consume more GM-free French food products and less conventional products. Concretely we assume that their preference changes are such that, before price adjustments, the food budget is the same. In our initial database, GM free white meat represents around 10 per cent of white meat consumption (in volume, 11.5 per cent in value due to higher prices).

We suppose that the volume of the GM free variety doubles, and the corresponding volume of conventional white meat decreases to maintain the initial food budget (by 12.8 per cent)[2]. This assumption leads to a small decline of total white meat consumption (again before price changes) by around 1.5 per cent. In real life, this change may come from effective consumption reduction or from reduced food waste, a dimension that we do not factor in our analysis (Philippidis et al., 2019). As regards the dairy and red meat consumptions, we assume a 50 per cent increase of the volumes of GM free varieties as they initially represent higher shares (20 per cent).

We implement our two scenarios on our CGE framework calibrated on 2011 economic data. It is standard practice to first define a baseline and then implement scenarios. The construction of baseline is another tricky exercise that we avoid because the macroeconomic French food system has not dramatically changed over the last ten years (see Agreste, 2020). In particular, the removal of milk and sugar quotas has not so far conducted to significant changes in these productions. More importantly, the fertilizer and pesticide farm uses have been quite stable over the last decade. We also note that the 2011 commodity prices are in the range of commodity prices observed over the same decade (the main exception is sugar, see below). The main changes concern the enduring decrease of beef consumption towards poultry and a likely (but not precisely measured) increase of some GM free volumes (in particular organic ones).

Results

Of the biodiversity scenario

[2] If the consumption of GM free (respectively conventional) product amounts to 10 (resp. 90) and the price premium for GM free product is 15 per cent, then the initial budget is 10*1.15+90=101.5. We assume that preferences change such the consumption of GM free becomes 20. Hence the consumption of conventional variety decreases to 101.5-20*1.15=78.5. This represents a 12.8 per cent decrease of conventional consumption.

Our main results of the first scenario are qualitatively similar to those obtained by Beckman et al. but quantitatively different but directly not comparable (we only focus on the French case). The reductions of fertilizer and pesticide farm uses are close to the objectives fixed in the GD (Table 5). Both the introduction of input taxes and the reduction of cultivated farmland contributes to decrease these uses but the two effects are partially dampened by the commodity price increases (Table 3). As expected, the constraints imposed on the French farmers reduce the farm commodity productions. The ensuing disequilibrium on commodity markets is solved by some commodity price increases, tempering the initial production decreases. The effects are more severe for the rapeseed sector than the cereal ones, as the former relies more on chemical inputs and is more sensitive to price changes (Table 2). The reduction of rapeseed production is close to one fourth. While the sugar beet production also depends significantly on chemical inputs, the production of this sector declines more modestly. In fact the price of sugar beet increases considerably because this commodity is not traded on the world market. And we assume that, in the short run, the sugar industry does not close sugar plants, hence the need to pay higher prices of sugar beet to induce farmers to grow this crop. Accordingly this sugar industry suffers from a huge decrease of capital return (by one third). The capital return in the oilseed crushing industry decreases in the same proportion because initial margins are lower in this industry and foreign competition more intense. Indeed the reduction of protein-rich crop productions stimulates additional imports of conventional soybean and soy meals from foreign countries, limiting the price effects on the French protein crops. The French deficit in protein-rich crops aggravates by around 0.6 billion euros.

Another demand-side effect participates to this deficit. Both the taxes on chemical inputs and the reduction of cultivated farmland negatively impact the production of fodder (corn silage and grass-related products) by around 12 per cent. Feed rations of dairy cows then include a greater share of imported soymeal and domestic cereals. The effects of this scenario on the animal sectors are more muted. We note a slight increase of pig and poultry production (both conventional and GM free), mostly through a farm labor/capital effect. The reduction of cultivated farmland frees up farmers' working time towards animal activities. The production impacts are negative for the conventional dairy and cattle sectors, because they suffer from reduced fodder availability. The production impacts are positive for the GM free dairy and cattle sectors, because their technology depends relatively more on labor.

All these effects concur to reduce considerably the French food trade balance, by close to 50 per cent or 5 billion euros. Most significant absolute reductions concern the cereal sector (by a decrease of domestic production and an increase of domestic feed consumption, by 400 thousand tons) and the beverage sector (by a decrease of domestic production). Net exports of animal products (meat and dairy) are virtually unchanged, with the additional GM free livestock production mostly sold on the French market.

The income effects of this first scenario are considerable, with a decrease of farm gross value added by 14.8 per cent (5.6 billion euros, an amount equivalent to the direct payment of the first pillar of the Common Agricultural Policy (CAP)). Farmers are constrained to reduce hired labor by as much as 25.5 per cent (26000 persons, full time equivalent). Farm wages (and social contributions) decrease by 1.7 billion euros. Without farmland rental regulations, the farmland return would increase considerably as this factor becomes highly limiting (by close to 300 per cent according to our simulation). The French farmland regulations intend to protect active farmers and so far prevent full capitalization of direct payments in land values (Gohin, 2006). Each year, the farmland rental rates are partly determined by the evolution over the previous years of the farm gross value added per hectare. When we acknowledge this regulation, the farmland return no longer increases ; it even decreases by 0.4 billion euros[3]. The residual part of the gross farm value added is perceived by the family farm labor and farm capital, whose return decreases by 12.3 per cent, representing 3.5 billion euros. This is considerably much more than the input taxes collected by the French government (2.4 billion euros) and full compensation of this income loss is impossible. This scenario leads to limited income effects on the French food processing industry. The economic losses supported by the sugar and oilseed crushing industries are roughly compensated by the gains in the compound feed industry and the meat and dairy product industries. The activities in the two latter industries increase, explaining the small increase of hired labor by food processing (close to 3000 persons full time equivalent). Finally the food expenditures by our French household slightly decrease, thanks to the reduced prices of GM free varieties of animal products.

There are recurring debates in France and Europe about the appropriate level of farm income, hence their capacity to support an eventual 15 per cent reduction of gross value added obtained in our first scenario (Rocci et al., 2020). While French farmers experience greater yearly variation in the last decade, they do not suffer from sustained farm income drops, so it is difficult to know if our first scenario is economically sustainable. To inform the policy debates on the GD effects, we simulate our first scenario in the medium run, where we allow farm exit (both family farm labor and capital). We take the other extreme where we assume an infinite own price elasticity supply of farm labor/capital (on the other hand, we still assume that the capital in food processing industry remains fixed). The medium run results of our first scenario are reported in the second columns of Table 3 to 7. The impacts on crop markets are roughly similar while the impacts on animal product markets are now negative. For instance, the French global milk production decreases by 3.1 per cent (compared to a decrease of 0.1 per cent in the short run). This comes from the farm exit (by 7.5 per cent). Focusing on the

[3] We assume that landowners no longer receive returns for idle land by farmers and that unitary return on cultivated farmland decreases by 6.3 per cent (the difference between 14.8 and 8.5 per cent).

trade and income effects, we find larger negative effects on the French food trade balance, mostly due to a reduction of exports of dairy products. The gross farm value added decreases less (by 6.5 per cent, compared to 14.8 per cent in the short run), thanks to higher prices for animal products. The value added drop is roughly equally shared across all factors once farmland rental regulations are taken into account. The hired farm labor decreases less but some family farms do exit, such that total farm labor decreases by 7.5 per cent (56 000 persons, full time equivalent). The effects are also more negative for the food processing industry, where total employment decreases by 1 per cent (close to 6000 persons, full time equivalent). The food expenditure of the French household slightly increases due to the increased prices of animal products.

By considerably reducing the food trade balance and the farm and food value added, our first scenario departs further from the GD objectives to generate fairer farm economic returns and foster competitiveness of the EU supply sector. As expected, the outcomes are less negative if farm production is possible on high diversity landscape features (columns 3 of Table 3 to 7). In this variant, the reductions of mineral fertilizer and pesticide uses are still close to the GD objectives. Compared to our first variant, the expanded cultivated farmland increases the farm uses of these inputs but the crop price effects are less important (for instance, from 4.9 percent to 2.1 per cent for soft wheat in the short run). The French food trade balance deteriorate less (from 4.9 to 3.0 billion euros) and farm income effects are less dramatic. In particular it appears that the input tax slightly increases (mostly on fertilizers) from 2.4 to 2.5 billion euros and the full compensation of the drop of farm capital return (by 2.4) appears feasible.

Overall these results highlight that the most critical element of the biodiversity strategy for the French food chain is not the reduction of mineral and pesticide uses, but the possibility to maintain production on high diversity areas.

Of the sustainable demand scenario

Our second scenario leads, as expected, to a significant evolution of the animal production towards more GM free products. The preference changes by the French household towards GM free products increase the corresponding prices by up to 10 per cent, with the notable exception of beef (decrease by 1.3 per cent). The main reason is that the demand for GM free white meat increases relatively more than the GM free beef demand. Another reason is the additional supply of beef from the expanded dairy herd. This scenario has limited impacts on the crop markets and hence on the farm uses of pesticides and mineral fertilizers (as we do not model the production, crop use and multiple losses of organic manure, which is one direction of model improvement critical for a real analysis of the Greenhouse Gas dimension). The conventional soymeal consumption decreases in animal feeding but the French deficit on protein-rich crop only slightly ameliorates (export of field peas decreases). The French food trade balance increases only due to the additional animal productions. These sectors also contribute to the expansion of hired labor in farms and food industries. The value added of the food industry increases significantly (by 2.0 per cent or 0.6 billion euros) as they process more high value products. The farm sector also benefits from the change of consumer preferences by a lesser extent (by 0.8 per cent or 0.3 billion euros). The food expenditure slightly increases (by 0.2 per cent or 0.4 billion euros) due to the aforementioned price effects.

Of the combined scenarios

We finally combine our two scenarios that we hereafter label “farm to fork” where we assume that farm production is allowed on high diversity areas by including the commons. The market impacts of this combined scenario are roughly the sum of the market impacts of the individual scenarios because our simulated price effects are limited. Overall our farm to fork scenario is close to reach the GD objectives that we consider, even in the short run and without additional investment in green technologies. The farm uses of mineral fertilizers (respectively pesticides) decrease by 18.1 (47.5) per cent, the 10 per cent of land is devoted high biodiversity features (with 3.8 per cent of set aside land, 6.2 per cent of commons). The French food trade balance decreases by 1.4 billion euros, mostly by a reduction of beverage products exports. Hence this may not significantly increase the number of food insecure people in foreign countries. While the employment opportunities decrease in the farm sectors (by 6.7 per cent), workers may find jobs in the food processing industries (increase by 1.7 per cent). The return to landowners from the farm sector decreases by 7.4 per cent (0.2 billion euros) but 2 per cent of their land asset is now available for alternatives, provided that these areas fulfill the conditions for high diversity landscape features. The landowners may not lose if these alternatives deliver yearly around 400€/ha of net returns. The French farm household, by providing his labor force, human capital and owning almost completely the physical farm capital, is the main looser of this scenario (by 2.2 billion euros). But the French government collects 2.5 billion euros of additional taxes that can be used to facilitate the acceptation of our farm to fork scenario (as in the history of CAP where the intervention price decreases were compensated by direct payments). A redistribution from the food industry is less feasible as the owners of the capital invested in food industry slightly gain (by 0.1 billion euros). Finally the French household spends more on food products (by 0.3 billions euros) but eat more GM free products and may value that French farmers spread less pesticides on their crop fields.

Discussion

The French farm and food sectors face increasing societal pressures to engage in sustainable transition. Despite three decades of CAP reforms aimed to green the farm policy support and successive national plans to reduce chemical input uses (in particular the Ecophyto plans focused on pesticides), the environmental impacts of these sectors remain highly controversial (in particular with no significant reductions of agricultural pesticide uses). In 2017 with the "Etats Généraux de l'Alimentation", the newly elected French government gathered all stakeholders to find solutions to overcome the tensions between the economic and environmental dimensions of this transition. Four years later, first results appear globally disappointing for most stakeholders.

Just before the coronavirus pandemic, the van der Leyen European Commission launched the GD roadmap targeting ambitious environmental objectives and, different from the French strategy, promising significant public funds to foster innovation and investment in green technologies. So far the GD has been globally well received by farm/food stakeholders. Without surprise, debates immediately follow on the most relevant uses of the promised funds. This paper contributes to this debate by assessing the current capacity of the French economy to cope with some farm-related environmental objectives of the GD. We focus on the reduction of mineral fertilizer and pesticide uses and on the biodiversity delivery, leaving aside the objectives on greenhouse gas emissions, antimicrobials (which are currently less pressing issues, Guyomard et al., 2020).

Integrating the most recent statistical evidences on the behaviors of French farmers and consumers on an otherwise standard methodology, we find that these objectives are reachable without seriously hampering active farmers' incomes or transferring the burden on foreign economies. This positive message may turn to be much more negative, depending on the features of the so-called high biodiversity landscapes in the GD. If this definition ends up into mandatory set aside for all individual farmers, then the GD objectives are clearly not sustainable given current farm and food processing technologies. This positive message also depends on the attitude of French household in favor of GM free French food products.

All empirical results reported in this paper are obviously contingent on our definition of scenarios, on the exclusion of some effects in our CGE framework (such as scale technological effects or organic fertilizers) or on our parameter calibration based on past behaviors of French farmers. From an academic perspective, the ambitious GD objectives question the validity domain of our elasticities of farm fertilizer and pesticide uses. On the one hand, French farmers experienced in the past significant yearly variations of fertilizer and commodity prices but prices of pesticides remained relatively steady. On the other hand, our model does not account for the substitution possibilities of farm labor and equipment (for instance, precision farming) for chemical inputs, nor for the potential adoption and/or development of new production technologies (for instance, new breeding technologies). Historical evidence supports induced technical change and long adoption lags (Manuelli and Seshadri, 2014). Further researches on the long run effects of the GD must complement medium run estimates provided in this paper and inform policy debates on the relevant use of public funds promised in the GD.

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Table 1. Calibrated Marshallian demand elasticities

	Conv beef	GM free beef	Conv pork	GM free pork	Conv poultry	GM free poultry	Conv dairy	GM free dairy	Ready meals	Income
Conv beef	-0,719	0,075	0,030	0,004	0,021	0,004	0,002	0,002	0,100	0,360
GM free beef	0,208	-1,384	0,055	0,008	0,038	0,008	0,003	0,004	0,183	0,650
Conv pork	0,016	0,011	-0,570	0,033	0,017	0,004	0,001	0,002	0,083	0,300
GM free pork	0,025	0,017	0,372	-1,211	0,027	0,006	0,002	0,003	0,131	0,470
Conv poultry	0,024	0,026	0,037	0,005	-0,882	0,079	0,002	0,002	0,123	0,440
GM free poultry	0,038	0,026	0,060	0,009	0,600	-1,884	0,003	0,004	0,198	0,710
Conv dairy	0,002	0,001	0,002	0,000	0,002	0,000	-0,212	0,020	0,032	0,110
GM free dairy	0,003	0,002	0,004	0,001	0,003	0,001	0,054	-0,406	0,059	0,210
Ready meals	0,010	0,007	0,015	0,002	0,011	0,003	0,003	0,004	-0,897	0,720

Table 2. Calibrated conditional farm elasticities

Price	Soft wheat	Rapeseed	Sugarbeet	Pig	Pig GM free	Milk	Milk GM free	Fertilizers	Pesticides
Production elasticities									
Soft wheat	0,155	-0,007	-0,004	0,001	0	-0,007	-0,004	-0,03	-0,028
Rapeseed	-0,018	0,425	-0,003	0,001	0	-0,006	-0,003	-0,105	-0,238
Sugarbeet	-0,037	-0,013	0,395	0,002	0	-0,011	-0,005	-0,036	-0,088
Pig	-0,122	0	0	2,491	-0,938	-0,105	-0,149	0,007	0,005
Pig GM free	-0,491	0	0	-10,045	15,806	-0,105	-0,149	0,007	0,005
Milk	0,012	-0,003	-0,001	-0,069	-0,008	1,352	-0,187	-0,041	-0,028
Milk GM free	-0,008	0,004	0,002	-0,242	-0,029	-2,439	3,09	0,094	0,064
Input elasticities	Soft wheat	Rapeseed	Sugarbeet					Total	
Acreage	0,104	0,12	0,275						
Fertilisers	0,238	0,436	0,436					-0,391	0,002
Pesticides	0,337	1,287	1,287					0,005	-0,863
Input initial values									
Fertilisers (€/ha)	150	270	250						
Pesticides (€/ha)	100	230	200						

The upper part of the table provides the supply elasticities with respect to output and input prices. The left hand side of the lower part of the table first provides the crop specific input elasticities. The right hand side provides the total input demand elasticities (a weighted sum of per crop elasticities).

Table 3. Simulated Price effects

Scenario		Unproductive biodiversity		Unproductive biodiversity		Productive biodiversity		Sustainable demand		Farm to Fork	
Time frame		Short run		Medium run		Short run		Short run		Short run	
€/ton	initial value	Var abs	Var relat	Var abs	Var relat	Var abs	Var relat	Var abs	Var relat	Var abs	Var relat
Soft wheat	183	8,91	4,87%	7,75	4,23%	3,89	2,13%	0,23	0,12%	4,15	2,27%
Corn	269	13,22	4,92%	11,51	4,28%	4,44	1,65%	0,14	0,05%	4,59	1,71%
Rapeseed	438	35,14	8,02%	34,26	7,82%	27,90	6,37%	0,43	0,10%	28,38	6,48%
Sugarbeet	37	8,96	24,22%	8,88	23,99%	5,36	14,48%	-0,02	-0,04%	5,34	14,44%
Fodder (index)	100	17,91	17,91%	14,16	14,16%	9,79	9,79%	-1,54	-1,54%	8,10	8,10%
Pig	1539	-59,84	-3,89%	48,33	3,14%	-15,50	-1,01%	-4,84	-0,31%	-21,06	-1,37%
Pig GM free	1696	-50,58	-2,98%	57,57	3,39%	-9,37	-0,55%	119,97	7,07%	105,11	6,20%
Poultry	1883	-29,13	-1,55%	50,92	2,70%	-5,39	-0,29%	-5,00	-0,27%	-10,88	-0,58%
Poultry GM free	2140	33,84	1,58%	68,18	3,19%	22,63	1,06%	218,32	10,20%	234,75	10,97%
Milk	360	5,03	1,40%	27,36	7,60%	7,34	2,04%	-19,48	-5,41%	-11,93	-3,31%
Milk GM free	364	-30,15	-8,28%	17,73	4,87%	-8,56	-2,35%	25,62	7,04%	15,30	4,20%
Cattle	3388	31,32	0,92%	192,71	5,69%	49,46	1,46%	-104,86	-3,09%	-55,60	-1,64%
Cattle GM free	4136	-372,17	-9,00%	176,70	4,27%	-113,22	-2,74%	-54,79	-1,32%	-175,60	-4,25%

Table 4. Simulated production effects

Scenario		Unproductive biodiversity		Unproductive biodiversity		Productive biodiversity		Sustainable demand		Farm to Fork	
Time frame		Short run		Medium run		Short run		Short run		Short run	
000 tons	Initial value	Var abs	Var relat	Var abs	Var relat	Var abs	Var relat	Var abs	Var relat	Var abs	Var relat
Soft wheat	36236	-4 226,78	-11,66%	-4 241,27	-11,70%	-2 055,57	-5,67%	16,60	0,05%	-2 035,27	-5,62%
Corn	15514	-1 477,07	-9,52%	-1 480,31	-9,54%	-514,65	-3,32%	8,71	0,06%	-505,15	-3,26%
Rapeseed	4812	-1 187,96	-24,69%	-1 190,21	-24,73%	-977,52	-20,31%	2,65	0,06%	-973,80	-20,24%
Sugarbeet	31838	-2 261,28	-7,10%	-2 230,88	-7,01%	-1 273,62	-4,00%	5,55	0,02%	-1 267,03	-3,98%
Fodder (index)	100	-11,75	-11,75%	-12,43	-12,43%	-7,16	-7,16%	-0,24	-0,24%	-7,57	-7,57%
Pig	1895	40,06	2,11%	-25,17	-1,33%	11,31	0,60%	-92,52	-4,88%	-80,93	-4,27%
Pig GM free	148	0,69	0,46%	-0,35	-0,24%	0,24	0,16%	108,21	73,11%	108,50	73,31%
Poultry	1678	33,94	2,02%	-45,75	-2,73%	8,11	0,48%	-108,97	-6,49%	-100,50	-5,99%
Poultry GM free	186	-1,44	-0,77%	-1,73	-0,93%	-0,73	-0,39%	113,89	61,23%	113,44	60,99%
Milk	19226	-93,97	-0,49%	-753,65	-3,92%	-187,31	-0,97%	-1 410,09	-7,33%	-1 600,17	-8,32%
Milk GM free	5880	49,17	0,84%	-22,51	-0,38%	15,60	0,27%	2 136,17	36,33%	2 153,50	36,62%
Cattle	1204	-14,05	-1,17%	-87,24	-7,25%	-23,44	-1,95%	-48,07	-3,99%	-73,85	-6,13%
Cattle GM free	368	9,24	2,51%	-2,88	-0,78%	3,10	0,84%	84,67	23,01%	87,97	23,90%

Table 5. Simulated technological effects

Scenario		Unproductive biodiversity		Unproductive biodiversity		Productive biodiversity		Sustainable demand		Farm to Fork	
Time frame		Short run		Medium run		Short run		Short run		Short run	
000 ha/tons/head	Initial value	Var abs	Var relat	Var abs	Var relat	Var abs	Var relat	Var abs	Var relat	Var abs	Var relat
Fertilizer (index)	100	-21,94	-21,94%	-22,22	-22,22%	-18,03	-18,03%	-0,09	-0,09%	-18,17	-18,17%
Pesticides (index)	100	-47,85	-47,85%	-48,35	-48,35%	-47,33	-47,33%	-0,05	-0,05%	-47,47	-47,47%
Wheat acreage	4990	-446,67	-8,95%	-445,68	-8,93%	-121,89	-2,44%	2,03	0,04%	-119,70	-2,40%
Rapeseed acreage	1560	-146,86	-9,41%	-146,03	-9,36%	-44,83	-2,87%	0,50	0,03%	-44,35	-2,84%
Sugarbeet acreage	383	-14,25	-3,72%	-13,76	-3,59%	5,02	1,31%	0,10	0,03%	5,16	1,35%
Wheat feed use	11328	406,05	3,58%	-59,97	-0,53%	146,75	1,30%	65,00	0,57%	212,41	1,88%
Soymeal	3416	377,53	11,05%	176,24	5,16%	199,34	5,84%	-150,43	-4,40%	40,10	1,17%
Soymeal GM Free	452	-22,44	-4,97%	-23,32	-5,16%	-21,07	-4,66%	12,62	2,79%	-6,01	-1,33%
Cows	6327	57,57	0,91%	-355,84	-5,62%	-55,12	-0,87%	-335,55	-5,30%	-397,79	-6,29%
Cows GM Free	1482	77,25	5,21%	-0,49	-0,03%	27,86	1,88%	462,76	31,23%	494,53	33,37%

Table 6. Simulated trade effects

Scenario		Unproductive biodiversity		Unproductive biodiversity		Productive biodiversity		Sustainable demand		Farm to Fork	
Time frame		Short run		Medium run		Short run		Short run		Short run	
000 000€	Initial value	Var abs	Var relat	Var abs	Var relat	Var abs	Var relat	Var abs	Var relat	Var abs	Var relat
cereals	6706	-1 507,59	-22,48%	-1 356,92	-20,23%	-682,22	-10,17%	-33,59	-0,50%	-715,68	-10,67%
protein rich crops	-897	-635,79	70,88%	-522,21	58,22%	-454,76	50,70%	7,53	-0,84%	-444,22	49,52%
vegetable oils	-778	-120,38	15,47%	-136,84	17,59%	-101,69	13,07%	-8,99	1,16%	-110,35	14,18%
sugar	1026	-203,89	-19,87%	-198,15	-19,31%	-114,30	-11,14%	-2,30	-0,22%	-116,59	-11,36%
beverage	7905	-1 690,84	-21,39%	-1 680,01	-21,25%	-936,51	-11,85%	7,90	0,10%	-928,20	-11,74%
animal products	4482	40,32	0,90%	-1 448,25	-32,31%	-265,83	-5,93%	1 588,36	35,44%	1 323,17	29,52%
all food products	10843	-4 887,83	-45,08%	-6 136,52	-56,59%	-2 990,01	-27,58%	1 541,34	14,22%	-1 442,60	-13,30%

Table 7. Simulated income effects

Scenario		Unproductive biodiversity		Unproductive biodiversity		Productive biodiversity		Sustainable demand		Farm to Fork	
Time frame		Short run		Medium run		Short run		Short run		Short run	
000 000€	Initial value	Var abs	Var relat	Var abs	Var relat	Var abs	Var relat	Var abs	Var relat	Var abs	Var relat
farm value added	38114	-5 653,32	-14,83%	-2 491,22	-6,54%	-3 126,50	-8,20%	320,60	0,84%	-2 875,54	-7,54%
farm wages	6779	-1 728,37	-25,50%	-507,73	-7,49%	-526,08	-7,76%	81,94	1,21%	-455,78	-6,72%
land returns	3022	8 660,63	286,59%	132,54	4,39%	1 625,06	53,77%	-453,20	-15,00%	1 259,89	41,69%
capital returns	28312	-12 588,50	-44,46%	-2 116,08	-7,47%	-4 226,03	-14,93%	692,01	2,44%	-3 680,08	-13,00%
With land regulations											
land returns	3022	-431,98	-14,29%	-202,57	-6,70%	-244,15	-8,08%	25,42	0,84%	-224,65	-7,43%
capital returns	28312	-3 492,98	-12,34%	-1 780,92	-6,29%	-2 356,28	-8,32%	213,24	0,75%	-2 195,12	-7,75%
tax receipts	0	2 418,61		2 403,80		2 512,10		0,00		2 507,35	
food value added	29814	-10,77	-0,04%	-552,04	-1,85%	-135,45	-0,45%	589,41	1,98%	456,04	1,53%
food wages	20780	117,44	0,57%	-215,24	-1,04%	2,39	0,01%	357,22	1,72%	361,28	1,74%
food bill	197930	-366,13	-0,18%	307,64	0,16%	-54,80	-0,03%	423,88	0,21%	304,00	0,15%