Deliverable 3.6

Forecast implications

SUFISA

Grant agreement 635577

Call: H2020-SFS-2014-2

Topic: SFS-19-2014

Deliverable number/Name: Deliverable 3.6 Forecasts implications

Dissemination level: public

Delivery date: February 2019

Authors: Davide Viaggi (UNIBO), Francesca Minarelli (UNIBO), Francesco Galioto (UNIBO), Meri Raggi (UNIBO)

Comments by Katharina Biely, Isabelle Bonjean and Sarah Creemers

Summary

1. Introduction on TASK 3.5

The SUFISA project focuses on the identification of sustainable business strategies of primary producers that are affected by market imperfections. It is known that market imperfections do not allow efficient market performance and resource allocation. As part of the SUFISA project, work package (WP) 3 aims to analyse the impact of market imperfections in the efficiency and performance of farmers (objective 3 of SUFISA project).

Task 3.5 focuses on implications for forecasting. The text of the task is as follows:

"A final step involves an analysis of what these findings imply for short-term forecasts and long-term foresights and particularly for the quantitative models underpinning these forecasts and foresights, as these insufficiently take into account challenges such as heterogeneous products (product differentiation), vertical relationships, market power and the changing nature of government support (Rude and Meilke, 2004)."

The task was originally intended as the final step of the WP3 and, in this light, the original text was basically aimed at providing a summary of implications. However, in the previous steps of the project and in the project review, the need for stronger linkages with the other work packages were highlighted. As a consequence, the task has been upgraded towards identifying wider insights for forecast also considering selected results of WP1, WP2 and WP4 and incorporating them in the reasoning stemming from WP3.

In line with this background, the objective of this deliverable is to illustrate implications of future scenarios developed in WP4 and of the main findings of the project (with special reference to WP3) pertaining to the forecasting ability. This pays specific attention to the implications for quantitative models usable for forecasting.

The next section focuses on recapping shortly scenarios and context variables followed by section 3 that focused on trends and issues in modelling tools. Section 4 addresses forecasting issues arising from the project, while section 5 provides an example based on applications of asymmetric information modelling in different scenarios. Section 6 concludes.

2. Scenarios, drivers and context variables

2.1 General

Scenario techniques are increasingly being used in order to analyse potential futures conditions under which economic systems are working and the actions to deal with them. The use of ad-hoc scenarios is now quite common in the literature (see below). In addition, wide-range institutional scenarios are used.

Scenarios are often coupled with modelling. Usually, scenarios are first described in qualitative terms (storylines), and then their features are specified into parameters that can be used as input

in modelling. Classical examples are different prices, different yields or other technical parameters. Further, scenarios can include different policy conditions. The choice depends obviously on the objectives of the scenario analysis, but also on the systems considered/modelled and on the border between what is endogenous and what is exogenous to the system.

Several recent scenario exercises are characterized by the need to consider broad worldwide conditions. One peculiarity of these scenarios is that considering the increasing number of interactions between globalised economy and the interconnected climate and environmental conditions makes these scenarios characterised by a wider and wider range of potential states and results. Meaningful examples are provided by the scenario simulations developed by Bauer et al. (2017), O'Neill et al. (2017), Popp et al. (2017), Riahi et al. (2017), van Vuuren et al. (2017). This is more important in the long term. Interestingly many of these conditions may lead to opposite effect in terms, for example, of prices or land allocation.

2.2 SUFISA scenarios

For the aim of the SUFUSA project a dedicated scenario exercise has been performed in WP4, identifying and describing four main scenarios and assessing the expected outcome of these scenarios through local workshops. The full account of the results is given in deliverable D 4.1 "First identification of solutions and first set of draft scenarios"." Four different scenarios have been developed: 1) International competition, 2) Europeanization, 3) Ecologization 4) High market segmentation.

The first scenario is called "international competition" and is mainly characterized by a global market totally liberalized. The access to the market is regulated by prices and standards. There is high competition between producers because of lack of differentiation between them. Consumers require cheap food and highly transformed products. There is poor attention for quality products and environmental issues. In this highly competitive market, the role of traders is pivotal within the food supply chain. Research and technology are developed through private funding and primarily focused on providing income, and secondarily to preserve environment and pursue quality.

The second scenario has been named "Europeanization" where consumers require a high level of food safety standards and, to a lesser extent, environmental sustainability. There is a strong commitment to environmental climate and ethical issues and the market is characterized by the presence of strong non-tariff barriers. Dietary preferences are functional food and ready-to-go meal, with high food safety standards. Consequently, technology is highly developed in order to meet market's requirements and the supply chain is mainly dominated by processors and retailers.

In the "Ecologization" scenario European consumers have a strong preference for high food food safety standards and food products with low environmental impact. The food market is dominated by organic and high quality certified food. Consequently, short supply chains are expanding with a decentralisation of activities and a reduction of the role of retailers and processors. NGOs are pivotal for issues like animal welfare, healthy diets and environmental preservation. To meet such requirements technology is oriented towards agroecology and farming system innovation.

The last scenario is referred to as "High market segmentation." The global market is liberalised but with a moderate global demand for food. The high market segmentation corresponds to the highly fragmented consumers' demand. The European market includes a great variety of products, from discount to high quality certified food. Consequently, the number of standards to diversify products

are increasing. The Retailer is dominant within the food supply chain. There is a balance between public and private investments for research and innovation, which is mostly focused on improving products rather than bringing ground breaking innovation.

This deliverable will build on this scenario exercise to devise potential issues for forecasting and modelling.

2.3 Evidence from case studies

Evidence about trends are also availbale from case studies delevloped in WP2. In particular, SUFISA case studies provide examples of how certain scenarios may affect a) market power, b) asymmetric information, c) economic performance, and d) environmental performance. This insighst may be used based on the idea that dynamics that are found in the present can contribute to the understanding of the future. While the exact details may differ, certain patters may be similar.

As an example, we illustrate how sugar beet in Belgium may contribute a suitable example of international competition (see also the national report of Belgiumfor details) Market power was not an issue for the Belgian sugar beet farmers due to the protected market. The quota system counterbalanced the high concentration on refinery level. However, with the liberalization of the market the situation changed drastically. Due to international competition and the reduction of political support (the secure supply of sugar has been of political interest in earlier times) refineries had to close down. 174 sugar beet factories could be found in Belgium by 1872, while there are only three left in 2019. These three refineries belong to two companies. One of which is a subsidiary company from one of the largest sugar companies in Europe. Market concentration is not limited to the Belgian case study, with projected further concentration due to the quota termination. The market liberalization led to a drastic reduction of prices and an increased price volatility. Conditions which make it hard for Belgian sugar beet farmers to operate. As a reaction to changing conditions, some of the already organized sugar beet farmers found their own cooperative sugar refinery which should get in operation in 2021.

Though not only farmers are struggling with the increasing international competition. Despite the monopoly of the existing sugar refineries a co-dependency exists (this will be explained in the paper: Causal loop diagrams to systematically analyze market power in the Belgian sugar value chain Katharina Biely, Mag; Erik Mathijs, Dr.; Steven Van Passel, Dr. [forthcoming / planned]). The pressure on prices is transferred upstream the chain, but does not originate from the refineries in Belgium. Instead it comes from international competition, where different labour, social and environmental standards, different political support structures as well as differing purchasing power parity, mixed with changing demand and supply patterns cause a downward pressure on prices. As a result one of the largest sugar refineries in Europe openly considers the closure of productions sites.

3. Impact simulation and forecasting tools

Modelling has been widely used in recent decades to provide forecasts or, more appropriately, to provide the impact assessment of different context scenarios and policies. Several modelling approaches are available and used in order to address different problems. They range from farm-level models or even process models, up to models simulating the world economy. Intermediate scales envisage territorial models based on land allocation or interaction among agents (Reidsma *et al.*, 2018; Schroeder, Gocht and Britz, 2015; Espinosa *et al.*, 2016; Solazzo *et al.*, 2016; Louhichi *et al.*, 2017; Tziolas, Manos and Bournaris, 2017; Bertoni *et al.*, 2018).

The majority of these models are based on rational behaviour assumptions and are designed to provide adaptations to changes in market prices or other economic incentives. Risk behaviour is considered to some extent. Still, it is acknowledged that the ability of such models to represent more complex behavioural aspects is still limited and challenges remain for future improvements.

Techniques for calibration or estimation of these models are evolving over time due to the growing availability of data that can be used for this purpose.

Similarly the issue of interaction among farmers and other actors or among different farms accounting not just for land exchanges or market mechanism but for network behaviour or system behaviour remain rather challenging in spite of being a key for the understanding of future trends and strategies (see e.g. SUFISA report D3.3).

The use of integrated modelling has been promoted and used in an increasing way to deal with the complexity of issues related to farm decision-making. In particular the integration of models representing economic behaviour by farmers and models representing physiological and environmental processes are at the core of bio-economic modelling approaches. Environmental, sustainability and ecosystem services issues have been in the spotlight in assessing farm and farming systems performance (see e.g. SUFISA Refer to Deliverable 3.4. Sustainability Performance Analysis and Deliverable 3.5. Value-Based Sustainability Indicators). The integration of economic models with sustainability indicators in connection to modelling covering the full range of economic, social and environmental performance of firms is a solution increasingly used to account for the full range of farming roles in rural areas (Bartolini *et al.*, 2007; Gocht et al., 2016; Blanke et al., 2017).

4. Issues and challenges in forecasting

Table 1 reports a qualitative estimation of the different trends in relevance of the issues addressed in WP3 depending on the scenarios developed in WP4 (see description above).

Table 1 - Trends in relevance of issues addressed in WP3 as a function of WP4 scenarios

	International competition	High market segmentation	Europeanization	Ecologization
Market power	++	+++	++	++
Asymmetric information	-	+++	-	++
Economic performance	+++	-	+	+
Sustainability performance	-	++	++	+++

Market power

Market power may be more related to local structures and supply chain arrangements than to variables in macro scale scenarios. However, market segmentation can encourage lock-in that ends up in asymmetric market power disadvantaging farmers. On the other hand, international competition can lead to downstream concentration and hence to stronger market power issues related to structural difference between farms and down/upstream agents. High market segmentation and ecologization seem to strengthen tendencies towards chain organisation based on vertical integration or networking. This brings to the fore the trade-offs between benefits of horizontal and / or vertical integration and distortion to competition, which may affect market power.

Asymmetric information

Asymmetric information is particularly relevant in the case of market segmentation, in which case the correct flow of information is a guarantee for the expression of the "right" value by the right consumer group. In addition, intermediary structure has a role guaranteeing and designing segmentation (see among others SUFISA report D3.2). In this case asymmetric information problems can affect the possibility to segment markets and so have an impact on the possibility of segmentation itself. In terms of forecasting, a correct accounting for asymmetric information may indeed allow to detect the feasibility of new segments and product differentiation, or the actual price that a market can express.

Economic performance

Economic performance is part of the understanding of the future in relation to any scenarios, though with different declination. The most straightforward case is that of international competition, in which indeed production costs are the key to understand the ability to stay on the market and ensure sales and profits. In high market segmentation and ecologization, the key issues are related to understanding the trade-offs between: a) product quality and production efficiency (costs), and; b) sustainability and efficiency. These may be interpreted respectively as the costs of higher differentiation and the cost of higher sustainability. Indeed, in particular ecologization, may require an expansion of the concept of productivity and efficiency towards measures accounting for environmental performances. A practical example of connected measurement issues is provide by SUFISA report D3.3: If a market is assumed to be characterized by some form of imperfect competition in the output and/or input market, this assumption should also be reflected in the construction of a Total Factor Productivity (i.e., technical efficiency) measure to take into account possible biases; the main aim is to solve for firm's efficiency under different parameter assumptions of the output markup and the input markup to the model.

A major topic especially in a competitive market is dynamic efficiency and the impact of innovation on technologies and costs. This is transversal to all scenarios as innovation will be anyway a key feature of the future, however may be more important in the liberalisation scenario in which competition will put higher pressure in the short term. Clearly this is also important for the other scenarios, but more focused on the ability of innovation to meet specific requirements than on the pace of increase of efficiency per se.

A component of performance at system level is also related to transaction costs. This may be expected to be higher and have a higher weight in decision making in a market segmentation scenario, both because of higher need of labels and signalling, on the one hand, and because the higher potential for moral hazard and hence result-based components of contract design. This potentially also creates transaction costs linked to the transfer of risk towards the farmers (assuming they are more risk averse). Also, a sustainability scenario may have fairly high transaction costs, as shown by the explicit transaction costs of measuring environmental performance or of related certification. These transaction costs may offset or not benefits from higher sustainability which measure is discussed below.

Sustainability performance

Sustainability performance is relevant in all scenarios, especially considering growing awareness of resources constraints and unprecedented climate change issues. However, it takes more importance in the ecologization scenario, due to the higher focus of the whole system on ecological performances. A major topic here is not only the ability to measure sustainability performance in general, but specifically to identify suitable proxies that can connect sustainability performance to premium prices and market or policy remuneration.

Here issues are rather different depending on the type of players whose action is connected to sustainability. In case of pure public goods in which impacts are on society as a whole, sustainability performance is relevant to support policy design and implementation. A huge literature already addresses this issue (see e.g. the PROVIDE project on this topic.

A growing focus of attention are cases in which sustainability rests on consumers' perceptions that are partially expressed by markets. Here, first there are issues with the fact that these preferences can be more uncertain and less stable. In addition, they can be affected by policies and information, so that individual behaviour actually changes with policy.

Finally, the process of model integration with sustainability indicators, that is already advocated and more and more widely used would need to become more prominent in the ecologisation scenario due to the wider set of relevant dimensions to consider.

5. An example based on Asymmetric information modelling

5.1 Introduction

In this section we provide an exercise in which scenarios developed within WP4 are adopted as references for the analysis of asymmetric information implications under different external conditions. The nature of the asymmetric information is described as a Principal Agent (PA) problem in which the principal (buyer or cooperative) cannot have complete information on the actions/practices adopted by an agent (farmer).

The solution is sought in the appropriate design of contracts between the Principal and the Agent. Experts involved in WP4 scenario analysis for the fruit sector in Italy have stressed the importance of system organization. In this respect, contracts within the supply chain are a fundamental tool to control bargaining power and imperfect information between the contracting parties (buyers and suppliers).

This section builds on the principal-agent model developed in D3.2 (Asymmetric information assessment on a selected value chain). The model is here applied to simulate how incentives (and optimal contract design) change based due to the variation of price and production costs that could occur in different forecast scenario. For these purposes, we are referring to information provided by experts invited to participate in a WP4 workshop. The workshop was held in Bologna on 3 October 2018 and involved 8 participants. Details are provided in WP4 reports. During the scenario workshop, specific information was required from experts regarding potential variation in prices and production costs that could occur in relation to each scenario.

The model previously developed in D3.2 considers the relationship between primary producers and intermediate buyers in the (Italian) fruit supply chain. Therefore, the sensitivity analysis exercise is applied for this specific case study.

The rest of the section is organized as follows: First the scenario analysis is presented, where we provide a short description of strategies adopted by chain actors in the Italian fruit sector for the scenarios elaborated in WP4. Then a numerical example, where the parametrization of the model and the data used for the analysis and the results obtained by the analysis are described. These results feed the general discussion and conclusions of this document.

5.2 Scenario Analysis

The organization of the supply chain is a key issue for all the scenarios described in WP4, as it affects capacity of the food supply chain to meet demand. A key instrument is represented by contracts. These instruments are fundamental to secure farmers' investments and revenues on the one hand and the achievement of the quality standards and quantities required by the market on the other hand. Labelling and transparency are also considered strategic prerequisites to adapt to each of the four scenarios addressing the need for traceability. Training is, finally, a key aspect to minimize possible unintentional hazards along the food supply chain.

Table 2 - Supply costs and market price variations among the different competitive scenarios developed in WP4.

EUROPEANIZATION

COSTS	PRICES
+	+ + +

MARKET SEGMENTATION

COSTS	PRICES
-	+

INTERNATIONAL COMPETITION

COSTS	PRICES
-	- - -

ECOLOGIZATION

COSTS	PRICES
+ +	+ +

Table 2 offers a picture of the difference in supply costs and market prices under the different scenarios. Below we provide some descriptions of the motivations behind the scores provided by experts.

5.2.1 Europeanization

In this scenario, experts addressed the need for training at all stages of the supply chain and they foresee a substantial increase of supply costs also in terms of efforts spent by farmers and other chain actors to acquire the necessary knowledge to face new market challenges. Thus, in a first period, costs are foreseen to be very high, calling for the necessity of public incentives supporting investments and training. In a second period, supply costs are foreseen to be slightly higher than current ones, but these will be offset by higher output prices.

5.2.2 International competition

In this scenario experts addressed the need for organizing and aggregating primary production in order to increase the bargaining power, reduce production costs and achieve economies of scale to face low prices. However, few producers will have the financial capacity to renew their productions and tackle market challenges. Hence, the reduction of costs will not offset the reduction in prices for most producers.

5.2.3 Ecologization

In this scenario, experts addressed the need for improving their ability to enter niche markets and improve horizontal integration. The absence of economies of scales and more restrictive practices would force farmers to increase costs. This condition would advantage only some farmers.

5.2.4 High market segmentation

In this scenario, experts addressed the necessity for improving coordination and seeking solutions related to different market segments, including direct sales. Public incentives must be designed and delivered on the basis of the potentialities of each territory through a bottom-up approach, rather than imposing standard practices. Costs are assumed to be quite affordable and prices to be slightly higher for high quality standards.

5.3 A numerical example

In this present section, we provide a numerical example of the interpretative model developed in D3.2 applied to the case of Italian pear producers for the strategies that are most likely to be implemented by chain actors under the four different scenarios developed in WP4 and which implications are described above.

The numerical example is based on the following assumptions about the functional form of the variables described in D6.3. The price function of a unit of product is assumed to be linear in quality, such that: $p(q) = a * q,\ where\ q \in \{\underline{q}, \overline{q}\}$ is the level of quality. The cost function of both farm types is assumed to be quadratic in quality, such that $c_1(\overline{q}) = \overline{d} * \overline{q}^2 and\ c_2\left(\underline{q}\right) = \underline{d} * \underline{q}^2$. The quality level is assumed to be between 0 and 1, $q \subset \{0,1\}$. Consequently, the optimal quality level solution for the two farm types is:

$$\overline{q}^* = \frac{a}{2\overline{d}}$$
$$\underline{q}^* = \frac{a}{2(\frac{\underline{d}}{1-\beta} - \overline{d})} \qquad (1)$$

Where: a and $d \in \{\underline{d}, \overline{d}\}$ are respectively the parameters of the price and the cost functions and β is the probability that the buyer receives a unit of product from the efficient supplier. From equation 1 it is possible to calculate the corresponding prices for the two equilibrium quality levels and the supply costs for the two equilibrium quality levels for each farm type.

Table 1 - parameters used for the scenario analysis

Parameters	**Values**
β (probability that the buyer receives a unit of product from the efficient supplier)	0.3*
a (quality function parameter)	0.8**
$\underline{d}$ (cost parametr for the efficient farmer)	0.75*
$\overline{d}$ (cost parametr for the less efficient farmer)	0.65*
+ (percent change of each plus in the qualitative table)	+ 10%***
– (percent change of each minus in the qualitative table)	-10%***

Sources: * Organizzazione interprofessionale pera (2015) related to the production of Abate Fétel in the district of Ferrara; **Camera di commercio di Ferrara (2017) related to the production of Abate Fétel, in the district of Ferrara; ***assumptions made on the basis of private information provided by experts participating to the WP4 workshop in Italy.

The scenarios define by themselves the characteristics of the market including both the level of market segmentation and price levels, but do not provide any information about the magnitude of these effects and the impact on the level of supply costs. The missing information were provided by experts during the WP4 workshop in Italy mentioned above. The level of the market segmentation determined by the scenarios influence the differences between the equilibrium quality levels. For both, the Europeanization and the International competition scenarios, there is no market for high quality products and high quality is assumed to collapse to low quality. For the High market segmentation scenario both equilibrium quality levels hold, as it is for the current scenario. For the Ecologization scenario low quality levels are assumed to converge to high quality because of the presence of very restrictive Minimum Quality Standards (MQS). Figure 1 shows the effect of the WP4 scenarios on the quality levels marketed. Figure 2 shows the effect of the WP4 scenarios on the profit generated by the buyer. As illustrated in Figure 1, the quality level on average increases with respect to the current scenario only for the Ecologization scenario. This is also the scenario that generates higher surplus for suppliers (at least for the most efficient ones). However, the Europeanization and the High segmentation scenarios are the ones guaranteeing higher surplus for buyers. Among the scenarios analysed the main differences between quality and impacts on the private surplus are between the High segmentation scenarios and the International competition scenarios. These two scenarios were considered to be the most likely to occur in the near future by experts.

Figure 1 – Quality level scenarios for the Pear sector in Italy (€/kg)

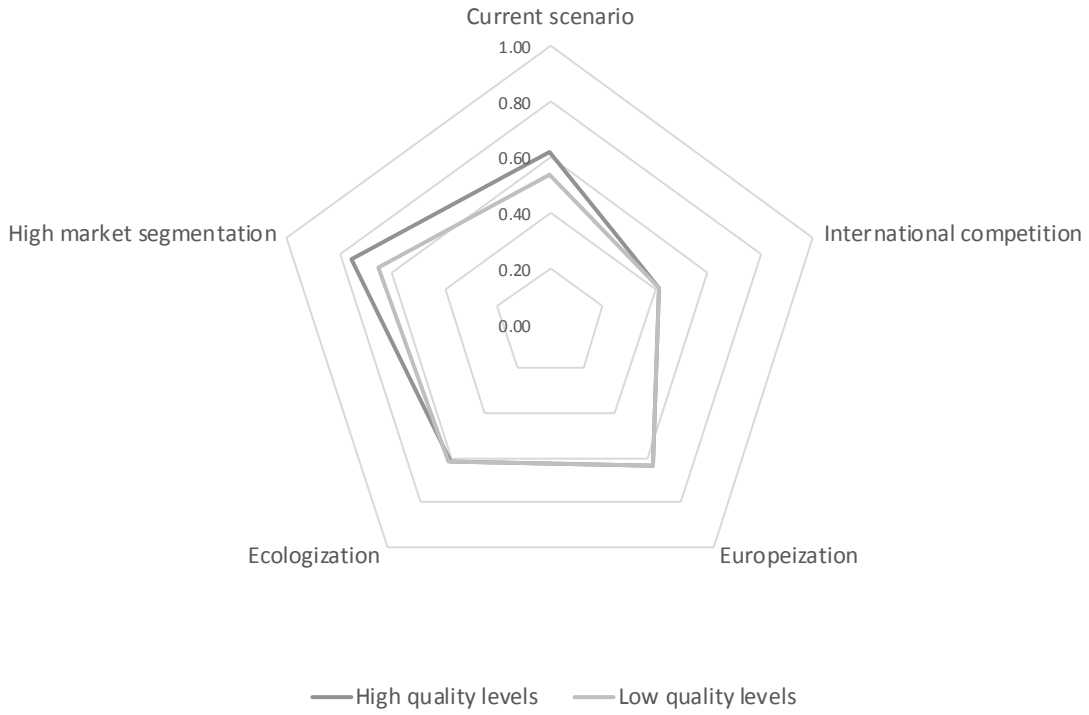
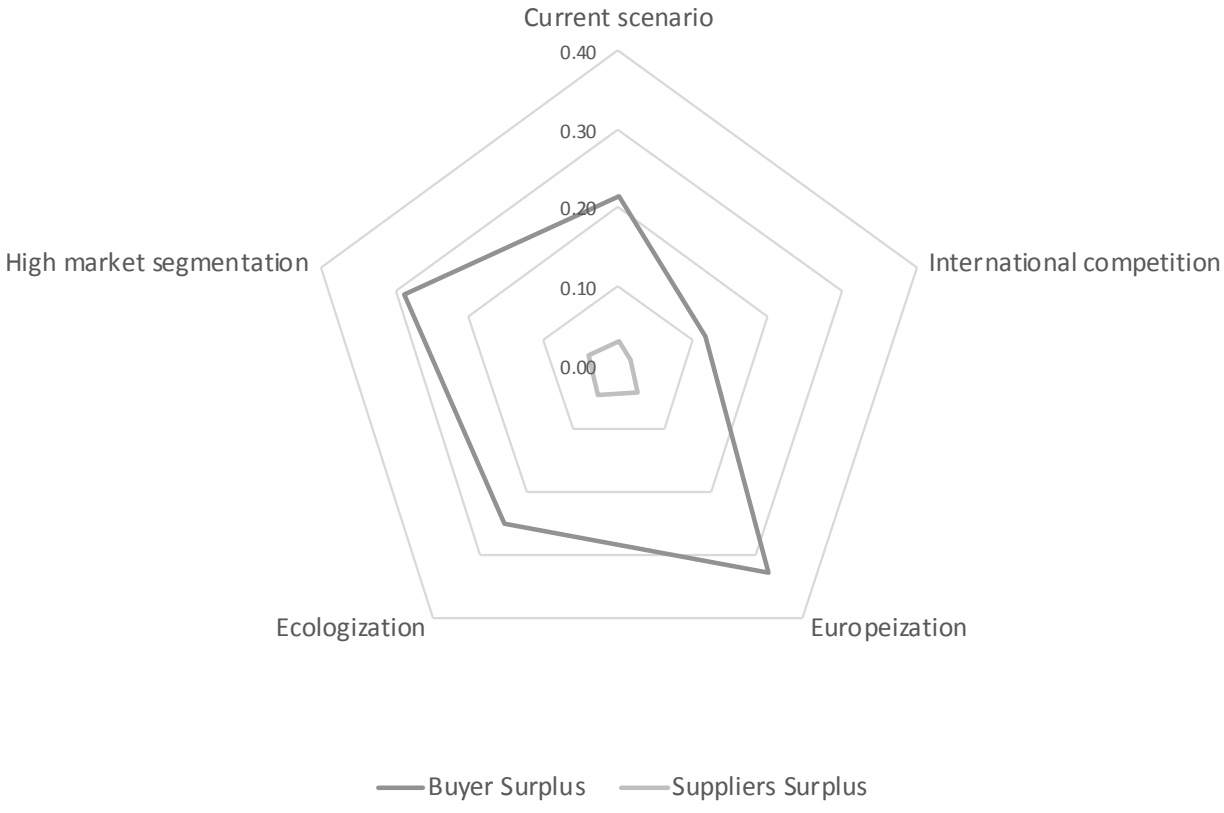


Figure 2 – Buyer and Supplier profit level scenarios for the Pear sector in Italy (€/kg)



A more comprehensive overview of the existing market condition and the four prospective market scenarios for the pear sector in the Italian case study is provided in Table 3.

Table 3 – Problem parameters and Equilibrium solution under the existing Market condition and under the 4 Market scenarios

Problem parameters	Current scenario	International competition	Europeanization	Ecologization	High market segmentation
b	0.3	0.3	0.3	0.3	0.3
a	0.80	0.56	1.04	0.96	0.88
d+	0.65	0.585	0.715	0.78	0.585
d-	0.75	0.675	0.825	0.9	0.675
Equilibrium solutions					
High quality levels ($\overline{q}^*$)	0.62	0.42	0.63	0.62	0.75
Low quality levels ($\underline{q}^*$)	0.54	0.42	0.63	0.62	0.65
Market prices for high quality levels ($\overline{a}^*$)	0.49	0.23	0.66	0.59	0.66
Market prices for low quality levels ($\underline{a}^*$)	0.43	0.23	0.66	0.60	0.58
Premium prices for high quality levels ($v(\overline{q}^*)$)	0.03	0.02	0.04	0.05	0.04
Costs faced by efficient producers ($c_1(\overline{q}^*)$)	0.25	0.10	0.29	0.30	0.33
Costs faced by inefficient producers ($c_2(\underline{q}^*)$)	0.22	0.12	0.33	0.35	0.29
Buyer Surplus	0.21	0.12	0.33	0.25	0.29
Suppliers Surplus	0.01	0.00	0.01	0.01	0.01

The equilibrium quality levels provided in table 2 are calculated by assuming that the quality is a continuous function of market prices and that there are no market restrictions. Under such assumption efficient suppliers under the existing market condition, on average, are found to be far to reach the maximum quality level required by the market (that equal 1). The equilibrium quality level reached by efficient suppliers under no market restrictions reveal that the market is far to offer the prices needed to incentivize the production of high quality pears in the Italian case study sector. All Market scenarios are better off than the existing market condition except for the International competition scenario. Buyers surplus is maximized under the Europeanization scenario, while suppliers surplus is maximized under the Ecologization scenario. Both buyers and surpluses are minimized under the International competition scenario. Finally, the quality level is maximized under the High market segmentation scenario and minimized under the International competition scenario for both low quality and high quality levels pears.

6. Main conclusions and implications

Current modelling and simulation tools, largely built on a standard neoclassical paradigm, are struggling to meet new challenges due to current trends in agricultural and food systems. This is already evident in the difficulty to properly account for issues such as market organisation, sustainability performance, policies based on voluntary instruments and innovation.

This is matched in the analysis of farm behaviour by the shift from a view of mechanistic adaptation of context parameters, to a more analytical and qualitative understanding of the matching between farm competences, strategies and enabling factors. At the aggregate level, system thinking adds insights and may be suitable for the description of a number of problems. The current literature however highlights that there are trade-offs in model complexity and is using more complex behavioural assumptions, as well as in considering a wider range of output indicators (i.e. environmental and social ones).

These trends and difficulties are likely made more evident by future scenarios though with a different degree depending on the feature of the actual scenario considered. In any case, local experts have highlighted that contracting, networking and chain coordination are key aspects that are common to all scenarios, as well as sustainability concerns. This interact also with behaviour, as, for example, the farmers' attitude towards sustainability affect intentions to implement specific farming strategies (D3.4).

This concerns all the four main topics addressed in this report: Market power, Asymmetric information, Economic performance and Sustainability performance. What is more important, especially the segmentation and the sustainability scenarios attract attention on the interplay among them. This is a challenge in itself, as it requires both innovative conceptual frameworks and tools allowing for this integration.

Though devising future instruments to address these issues is beyond the scope of this deliverable, however, some considerations can be made.

Modelling farming systems is an evolving field, already taking the route of more and more integrated modelling tools, covering a wide variety of scales from farm to global. Integrated modelling has been further boosted by the emergence of the concept of bioeconomy as a comprehensive point of view on these issues. Issues related to organisation and contracting have increasingly developed families of modelling approaches with analytical solutions applied to simplified problems. An example is that of asymmetric information. A key challenge for the future is the ability to integrate these topics into more complex simulations models and to explicitly consider contracting constraints, transaction costs and market power in market and land allocation models.

Another relevant route is that of more qualitative means of understanding of the future based on experts or stakeholder expertise. This should be viewed more and more as a way to identify possible routes and pathways.

A clear option is that of integration of qualitative and quantitative methods, into comprehensive assessments to understand the future. This is already done in several research projects using qualitative input from experts to the aim of model development and, on the other hand, using experts to interpret model results and to translate them into meaningful policy implications.

This work overall, also questions the concept of forecast as an approach to addressing the future (reinforcing a trend already well established in the literature). Indeed, in spite of modelling efforts, the future will remain rather uncertain and difficult to predict. So, the focus should be more and more in elaborating ideas about how to take actions rather than expecting to elaborate statements about future happenings.

7. References

Bartolini, F., Bazzani, G. M., Gallerani, V., Raggi, M. and Viaggi, D. (2007) 'The impact of water and agriculture policy scenarios on irrigated farming systems in Italy: An analysis based on farm level multi-attribute linear programming models', *Agricultural Systems*, 93(1–3), pp. 90–114. doi: 10.1016/j.agsy.2006.04.006.

Bauer, N., Calvin, K., Emmerling, J., Fricko, O., Fujimori, S., Hilaire, J., Eom, J., Krey, V., Kriegler, E., Mouratiadou, I., Sytze de Boer, H., van den Berg, M., Carrara, S., Daioglou, V., Drouet, L., Edmonds, J. E., Gernaat, D., Havlik, P., Johnson, N., Klein, D., Kyle, P., Marangoni, G., Masui, T., Pietzcker, R. C., Strubegger, M., Wise, M., Riahi, K. and van Vuuren, D. P. (2017) 'Shared Socio-Economic Pathways of the Energy Sector – Quantifying the Narratives', *Global Environmental Change*, 42, pp. 316–330. doi: 10.1016/j.gloenvcha.2016.07.006.

Bertoni, D., Aletti, G., Ferrandi, G., Micheletti, A., Cavicchioli, D. and Pretolani, R. (2018) 'Farmland Use Transitions After the CAP Greening: a Preliminary Analysis Using Markov Chains Approach', *Land Use Policy*, 79, pp. 789–800. doi: 10.1016/j.landusepol.2018.09.012.

Blanke, J. H., Olin, S., Stürck, J., Sahlin, U., Lindeskog, M., Helming, J. and Lehsten, V. (2017) 'Assessing the impact of changes in land-use intensity and climate on simulated trade-offs between crop yield and nitrogen leaching', *Agriculture, Ecosystems and Environment*, 239, pp. 385–398. doi: 10.1016/j.agee.2017.01.038.

Espinosa, M., Gocht, A., Heckelei, T. and Paloma, S. G. Y. (2016) 'Incorporating farm structural change in models assessing the Common Agricultural Policy: An application in the CAPRI farm type model', *Journal of Policy Modeling*, 38(6), pp. 1040–1059. doi: 10.1016/j.jpolmod.2016.03.005.

Gocht, A., Espinosa, M., Leip, A., Lugato, E., Schroeder, L. A., Van Doorslaer, B. and Paloma, S. G. Y. (2016) 'A grassland strategy for farming systems in Europe to mitigate GHG emissions—An integrated spatially differentiated modelling approach', *Land Use Policy*, 58, pp. 318–334. doi: 10.1016/j.landusepol.2016.07.024.

Louhichi, K., Ciaian, P., Espinosa, M., Colen, L., Perni, A. and Paloma, S. G. Y. (2017) 'Does the crop diversification measure impact EU farmers' decisions? An assessment using an Individual Farm Model for CAP Analysis (IFM-CAP)', *Land Use Policy*, 66, pp. 250–264. doi: 10.1016/j.landusepol.2017.04.010.

O'Neill, B. C., Kriegler, E., Ebi, K. L., Kemp-Benedict, E., Riahi, K., Rothman, D. S., van Ruijven, B. J., van Vuuren, D. P., Birkmann, J., Kok, K., Levy, M. and Solecki, W. (2017) 'The roads ahead: Narratives for shared socioeconomic pathways describing world futures in the 21st century', *Global Environmental Change*, 42, pp. 169–180. doi: 10.1016/j.gloenvcha.2015.01.004.

Popp, A., Calvin, K., Fujimori, S., Havlik, P., Humpenöder, F., Stehfest, E., Bodirsky, B. L., Dietrich, J. P., Doelmann, J. C., Gusti, M., Hasegawa, T., Kyle, P., Obersteiner, M., Tabeau, A., Takahashi, K., Valin, H., Waldhoff, S., Weindl, I., Wise, M., Kriegler, E., Lotze-Campen, H., Fricko, O., Riahi, K. and Vuuren, D. P. van (2017) 'Land-use futures in the shared socio-economic pathways', *Global Environmental Change*, 42, pp. 331–345. doi: 10.1016/j.gloenvcha.2016.10.002.

Reidsma, P., Janssen, S., Jansen, J. and van Ittersum, M. K. (2018) 'On the development and use of farm models for policy impact assessment in the European Union – A review', *Agricultural Systems*, 159, pp. 111–125. doi: 10.1016/j.agsy.2017.10.012.

Riahi, K., van Vuuren, D. P., Kriegler, E., Edmonds, J., O'Neill, B. C., Fujimori, S., Bauer, N., Calvin, K., Dellink, R., Fricko, O., Lutz, W., Popp, A., Cuaresma, J. C., KC, S., Leimbach, M., Jiang, L., Kram, T., Rao, S., Emmerling, J., Ebi, K., Hasegawa, T., Havlik, P., Humpenöder, F., Da Silva, L. A., Smith, S., Stehfest, E., Bosetti, V., Eom, J., Gernaat, D., Masui, T., Rogelj, J., Strefler, J., Drouet, L., Krey, V., Luderer, G., Harmsen, M., Takahashi, K., Baumstark, L., Doelman, J. C., Kainuma, M., Klimont, Z., Marangoni, G., Lotze-Campen, H., Obersteiner, M., Tabeau, A. and Tavoni, M. (2017) 'The Shared Socioeconomic Pathways and their energy, land use, and greenhouse gas emissions implications: An overview', *Global Environmental Change*, 42, pp. 153–168. doi: 10.1016/j.gloenvcha.2016.05.009.

Schroeder, L. A., Gocht, A. and Britz, W. (2015) 'The Impact of Pillar II funding: Validation from a Modelling and Evaluation Perspective', *Journal of Agricultural Economics*, 66(2), pp. 415–441. doi: 10.1111/1477-9552.12091.

Solazzo, R., Donati, M., Tomasi, L. and Arfini, F. (2016) 'How effective is greening policy in reducing GHG emissions from agriculture? Evidence from Italy', *Science of the Total Environment*, 573, pp. 1115–1124. doi: 10.1016/j.scitotenv.2016.08.066.

Tziolas, E., Manos, B. and Bournaris, T. (2017) 'Planning of agro-energy districts for optimum farm income and biomass energy from crops residues', *Operational Research*, 17(2), pp. 535–546. doi: 10.1007/s12351-016-0236-y.

van Vuuren, D. P., Riahi, K., Calvin, K., Dellink, R., Emmerling, J., Fujimori, S., KC, S., Kriegler, E. and O'Neill, B. (2017) 'The Shared Socio-economic Pathways: Trajectories for human development and global environmental change', *Global Environmental Change*, pp. 148–152. doi: 10.1016/j.gloenvcha.2016.10.009.