Integrating quantitative and qualitative research methods to foresee the transformations in the Finnish agrifood sector[1]

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1. Introduction

One interesting research design for futures studies is to integrate quantitative research method with qualitative research method. This type of design begins with a strong research methodology with quantitative method that is enhanced with a qualitative measure in formulating assumptions and describing key outcomes. Qualitative methods, such as the Delphi method, improve the research design by providing judgments on complex matters where precise information is unavailable, thus giving insights to the results provided by the quantitative method such as a computable general equilibrium (CGE) model. By itself, a CGE model such as the Global Trade Analysis Project (GTAP) model has limited explanatory power. Therefore, we can obtain a deeper understanding of the alternative futures for the Finnish agrifood sector by combining the GTAP model with the Delphi method.

In this paper, the focus is on the methodology approach of generating alternative futures for the Finnish agrifood sector by creating interactive models that can provide feedback to either method in order to further define the research results. The forecasted results and alternative futures can be further improved by combining the strengths of both methods and confronting the weaknesses of each method. Therefore, we will show that method integration can serve as a mutual validation of data and findings as well as for the production of a more coherent and complete picture of the alternative futures for the Finnish agrifood sector compared to the outcomes of a single research method.

2. The quantitative GTAP model and qualitative Delphi method

In this paper, the presented results are based on a research project which was conducted to foresee the future of the Finnish agrifood sector in the realm of the changing EU Common Agricultural Policy (CAP) in conjunction with the global agricultural, trade and climate policy. The goal is to support the process of policy planning and decision making in a rapidly changing environment. Two methods were utilised in this study – the Delphi method based on panels of expert opinions and quantitative method based on a computable general equilibrium model called Global Trade Analysis Project (GTAP).

2.1 The GTAP model and database

The standard GTAP model [1] is a comparative-static, multi-region, multi-sector, computable general equilibrium model, with perfect competition and constant returns to scale. Bilateral trade is handled via the Armington [2] assumption. Model results are derived from assumptions of firms and consumers optimising their behaviour within constraints given by endowments (land, labour, capital, natural resources) and policies (e.g. taxes). In the equilibrium solution, all markets are in equilibrium, i.e. demand equals supply.

The model utilised in this study is a recursive-dynamic applied general equilibrium model extended to better analyse energy and environment issues and take into account the various forms of agricultural subsidies. The model is modified based on the GTAP-Dyn model [3] and GTAP-E model [4]. The GTAP-Dyn model permits a recursive solution procedure, a feature that allows easy implementation of dynamics without imposing limitations on the model's size. Adding to the standard GTAP model, it incorporates international capital mobility, capital accumulation, and accounting that keep track of foreign capital ownership with an adaptive expectations theory of investment. The GTAP-E model includes energy substitution, which is absent from the standard GTAP model. It also incorporates carbon emissions (CO_2) from the combustion of fossil fuels and provides a mechanism to trade these emissions internationally. This allows the analysis of various climate policy measures.

Trade policy instruments are represented in the GTAP database as ad valorem taxes and subsidies. For agricultural commodities, domestic support levels are calculated from the OECD [5] Producer Support Estimate (PSE), and components for market price support are excluded to avoid double counting with the tariffs in the database. The total PSE of a country is translated into a form

that is compatible with the database and into four categories of subsidy payments: output payments, intermediate input payments, land based payments and capital based payments. In this study, the GTAP model has been modified to consider agricultural subsidy payments in a way that allows an easy manipulation of subsidy payments in monetary terms that correspond to the policy measures of the EU Common Agricultural Policy. This allows the analysis of subsidy payments to agricultural production and trade.

GTAP model applications are widely used particularly in research concerning international trade. The GTAP 7 Database [6] has been used in this study, representing the world economy for a given reference year -- 2004. The database comprises several types of data: behavioural parameters that include elasticities of substitution between domestic and imported goods, and elasticities of substitution between sources of imports (Armington [2] elasticities). The main data file is derived from regional input-output tables, bilateral trade flows and protection data (taxes and subsidies). The database represents the world economy as flows of goods and services measured in millions of 2004 US dollars. Additional data is provided for capital stocks, population and savings. The database includes five endowments (i.e. production factors) -- land, skilled labour, unskilled labour, natural resources, and capital -- with 113 countries/regions and 57 commodities/sectors. In this research project, the database is aggregated into 11 countries/regions and 20 commodities/sectors, including 12 agricultural commodities/food sectors.

2.1.1. Using the GTAP model to assess alternative futures

The future of the Finnish agrifood sector is faced with uncertainty due to changing situations and policies driven by internal and external forces. The GTAP model was used to assess the impact of four alternative policy scenarios on agricultural production in Finland. The policy scenarios present the question of "what if" a radical policy is implemented, what would be the forecasted impact on food production in Finland. The four alternative policy scenarios are presented below:

i) Climate change mitigation policy:

A more ambitious climate policy will take over from the Kyoto Protocol after 2012. The EU-27 emission target is to reduce CO_2 emission by 40% in 2030 from the 1990 emission levels. The model does not take into account improvement in technology through global funding allocated to the development of clean technologies, thus the predictions may be overestimated.

ii) Economic crisis:

During the 5-year period from 2009 to 2014, worldwide unemployment grows by 2% annually and worldwide investments are reduced by half. In the subsequent 5 years from 2015 to 2019, unemployment is decreased back to the original levels and investments are increased back to the initial levels.

iii) Unilateral removal of domestic subsidy in the EU:

Removal of all agricultural subsidies in the EU-27 region, implemented in 3 years from 2018 to 2020 and structured as domestic agricultural policy reform.

iv) Multilateral removal of tariff and subsidy for agriculture globally:

Removal of all import duties for agricultural products and agricultural subsidies in all regions, implemented in 3 years from 2018 to 2020 and structured as global trade liberalisation for agriculture.

2.1.2. Results from the GTAP model

According to the results of the GTAP model simulations, a significant reduction of global economic growth in the long term would have only temporary impact on the primary agricultural production in Finland, whereas the impact on the production of processed food would be more significant in the long term. The assumed extension of the global economic crisis would have an impact on the global demand for European food. In particular, the demand for processed milk and meat products would halt due to a decrease in the purchasing power in emerging economies. This would reduce the global market prices for milk and meat products and increase the competition within the EU's internal market, thus affecting the Finnish processed food market as well.

Additional restriction on greenhouse gas emissions, namely carbon dioxide (CO_2) emission allocations, would also decrease primary agricultural production in Finland by 6 per cent and the production of processed food by nearly 3 per cent. Additional carbon emission restriction would decrease particularly cereal and milk production in Finland, whereas their impact on meat products would be quite insignificant. This can be explained with the proportionally high transportation and packaging costs in cereal and especially milk production, 17 to 22 per cent (compared to meat products 9–11 per cent).

According to the model simulations, abolishing agricultural subsidies in the EU would decrease primary agricultural production in Finland by nearly 7 per cent and the production of processed food by about 3 per cent. The removal of agricultural subsidies would not, however, significantly affect the total volume of the agricultural production in the EU. The production would centralize into areas with more beneficial production possibilities. Therefore, the competitiveness of Finnish agricultural production in the EU market would suffer due to high production cost; hence agricultural production in Finland would decrease, particularly in cereal production.

Global liberalization of agricultural trade would mean a decline in the production of almost every food commodity in Finland. Primary agricultural production in Finland would decrease by 12 per cent and the production of processed food would decrease by nearly 18 per cent in the long-term. Sugar and meat production would face the most drastic decrease in production, as these sectors are highly sensitive to the elimination of import duties. The current prohibitively high import duties of the EU efficiently prevent competing food products from third countries entering the common EU market as the global market prices of most food products, with import duties added, are essentially much higher than the market prices for EU's domestic food products.

2.2 The Delphi method

One of the most common futures studies methods is the Delphi method. The Delphi method aims to identify and explore alternative future possibilities, their probabilities of occurrence, and their desirability by tapping into the expertise of respondents [7]. The Delphi method consists of the judgement of experts by means of successive iterations of a given questionnaire, to show possible convergence of opinions and to identify dissent or non-convergence. The Delphi method is considered as one of the most used scenario planning method in the field of futures studies, especially for long-range studies (20 to 30 years). For the long range evaluation, expert opinions are usually the only source of information available [8, 9].

Delphi, as it originally was introduced and practiced, tended to deal with technical topics in order to anticipate the technology change in society. It was also used to seek a consensus among homogeneous groups of experts. The results of the traditional Delphi usually included the forecast time of realization and an evaluation of importance for different technological topics. Usually, these Delphi studies for technology forecasting were nationwide surveys. Fundamentally, the Delphi method was considered as a version of a survey analysis [14]. With the development of the Delphi method, the use of the technique has many variations (for example see chapter 2.2.1).

Based on the views of agricultural and food-chain experts, the Delphi approach was used to detect what type of policy challenges, key driving forces and other indicators of change pose to the Finnish agriculture and food sector and its further development. The first objective is to assess which driving forces the experts consider to be the most important and influential. The second objective is to develop an analytical framework which would make it possible to detect the type of policy challenges that a certain driving force represents. The third objective is to classify driving forces according to the developed policy challenge typology and, based on this classification, to identify likely pitfalls and drawbacks that the agricultural sector is going to face in the future.

2.2.1. The Delphi process

The Delphi method concentrates on assessing development in the future. Linstone and Turoff ([7], p. 3) characterize Delphi as a method for structuring a group communication process in such a way that the process is effective in allowing a group of individuals, as a whole, to deal with a

complex problem [10-13]. The Delphi method consists of experts' judgement by means of successive iterations of a given questionnaire, to show convergence of opinions and to identify dissent or non-convergence. Anonymity and feedback can be considered as two irreducible elements of a Delphi technique. Traditionally, a third feature, a consensus seeking, has been one element. However, nowadays consensus seeking is not a primary goal in Delphi applications.

In this study, empirical data was gathered following the principles of a Policy Delphi method and its latter variant Argument Delphi [8 and 11] because of their benefits in the use of long-range planning (20 to 30 years). The Policy Delphi represented a significant departure from the understanding and application of the Delphi technique as practiced in 1950–70 ([8], p. 80). Conventional Delphi as it originally was introduced and practiced tended to deal with technical topics and seek a consensus among homogeneous groups of experts. The Policy Delphi, on the other hand, seeks to generate the strongest possible opposing views on the potential resolutions of a major policy issue. A Policy Delphi should be able to serve any one or any combination of the following three objectives: (1) to ensure that all possible options have been put on the table for consideration, (2) to estimate the impact and consequences of any particular option and (3) to examine and estimate the acceptability of any particular option.

The selection of the panel is a critical phase in using methods like Delphi technique [11]. In the research project, the selection process was the following. First, the criteria and classification for choosing the expert panel were prepared. The needed expertise was determined to cover the studied themes (substance) together with the stakeholders of the agricultural sector. The aim was to achieve a well-balanced representation of the themes and stakeholders. Also, at this phase, the preliminary panellists were listed. The expert panellists list was considered complete when there was a sufficient amount of expertise in the dimensions according to the specified criteria for the expert panel. After circulating the list of preliminary panellists, the coordinator of the Delphi process personally called the chosen experts that were selected to be interviewed. The interviewed experts represented 26 out of the total 248 respondents and they were selected in such a way that they represented the expertise coverage of the studied themes and stakeholders in the agricultural sector.

The studied themes in the Delphi questionnaires were defined according to their policy relevancy. The themes were 1) primary production and entrepreneurship 2) food market 3) institutions and policy making 4) energy and the environment. These themes interact closely with each other, and therefore they are interpreted as a whole to capture a holistic view on the agricultural production in Finland. The themes themselves can be seen as a framework to assess strategic decision-making challenges to be taken into account in the future policy design of agricultural policy agenda. The derived future images will give an overview about policy choices and alternative development paths that the agricultural sector as well as the EU Common Agricultural Policy has to be prepared to cope with by the year 2030. The time frame of producing alternative future images for the agricultural sector in Finland was defined until 2030.

The first round of questionnaire was developed and pre-tested by the research group that implemented the project and also with a few outside experts in the agricultural field. The first round of the Delphi study was carried out by structured questionnaire (internet survey for 248 respondents) including 26 face-to-face interviews. Response rate in the first round was 44. The second round with feedback followed the same procedure. Before the second round, a feed-back report that included the first round results was send to the respondents.

Generally, the Delphi method process can involve from less than ten to several hundreds or even thousands of respondents in the panel [14]. The number of panellists is dependent on the context of the defined research questions. Applying the Policy Delphi approach means that the collected opinions among panel should converge during the process. The expert coverage is sufficient when new included respondent emerges no new views anymore. The Policy Delphi approach emphasises expert quality over quantity. The panel size is bigger in conventional Delphi studies, thus emphasising more on the quantity of experts in the panel [11, 14, 15, 16].

2.2.2. Results from the Delphi method

The panel of experts' views on 86 driving forces and trends in the Finnish food supply chain were determined in the first round of questionnaire. Due to the length limitation for this paper, the actual results for questions concerning only climate change are used as examples for this paper (Appendix 1). The results concerning climate change are shown below:

Table 1. The first round of expert panel evaluations for the questions concerning climate change

Change factor	1. Desirable change	2. Probable change	3. Certainty of the probable change	4. Importance of change factor
Greenhouse gas emissions from agriculture in Finland	-1.17 ⇩	-0.30 ⇩	3.55 ?	3.97 *
Mitigations measures of climate change in Finnish agriculture	0.99 ⇧	0.73 ⇧	3.78 ≈	3.99 *
Adaptation measures of climate change in Finnish agriculture	1.09 ⇧	0.84 ⇧	3.82 ≈	4.11 **

Likert scale was used in the questionnaire (scales: -2…2 and 1…5)

The results from the first round of questionnaire with questions concerning climate change are illustrated in Table 1. The Likert scale was used in the questionnaire: scales of -2 to 2 for category (1) & (2) and scales of 1 to 5 for category (3) & (4). Overall, the expert panel considered that these climate change topics were important (value 3.97 to 4.11) among the evaluated 86 driving forces. They hope that the greenhouse gas emissions from agriculture in Finland would reduce significantly (value -1.17), but they don't see a probable change in the emission levels (value -0.30). However, they are not certain (value 3.55) that emissions will stay at the current level in Finland. Furthermore, they consider equally desirable and probable that both mitigation and adaptation measures will increase in the future (values close to 1). They are also quite certain (values close to 4) of a probable change in mitigation and adaptation measures for climate change in Finland within a 20-year perspective.

3. Strengths and weaknesses of the quantitative and qualitative methods

3.1. Strengths and weaknesses of the GTAP model and economic modelling in general

Economic models like GTAP are an invaluable tool for exploring alternative policy choices and for generating insights about how the economy might respond to different types and forms of policy interventions. The strength of the GTAP and other economic modelling is that they can provide a relatively rigorous and transparent mechanism for describing the likely outcomes of hand-picked scenarios. A well designed model can make a significant contribution to policy debates and decision making if it is used by skilled practitioners to shed light on issues that the model was designed to illuminate [21]. The utilised GTAP model has geographically global coverage and sufficient coverage of agricultural and food commodities. In fact, the GTAP includes different sectors for agricultural products. Although each separate agricultural sector is in aggregated form, encompassing several individual products, the detailed specification of agriculture is much beyond what is normally done in more general economy wide applied general equilibrium (AGE) models [22]. Furthermore, the GTAP is a versatile tool that is adaptable to reflect the main policy issues connected with agricultural policy and trade policy reforms. Therefore, the GTAP model is able to provide important insights into the consequences of agricultural policy and agrifood market changes in particular. The GTAP work also provides a framework of data collection and organization that makes the estimation and use of the model relatively easy.

In fact, economic models like GTAP can be such powerful tools in understanding some economic relationships, that it is easy to ignore their limitations. Economic models are often complex mathematical representations of the economy, and they are relatively accurate in describing the link between a 'dependent variable' like greenhouse gas emissions and an 'independent variable' like GDP or policy intervention, but that does not mean that they are at all accurate in guessing how the 'independent variables' will behave. Therefore, it is very important to remember that models cannot predict future events, nor can they produce precise projections of the consequences of specific policy [23]. Economic models are, for example, virtually useless for making long run predictions about likely impact of structural or technological changes that have yet to occur. They are, however, good at predicting what the likely consequences of repeating a similar event to one that has happened previously.

According to Hertel [24] "models are just models; in the end, expert use and judgment are required to get sensible outcomes". The fact that modelling requires subjective judgment does not diminish the value of economic modelling but rather reinforces the idea that models are not perfect predictors of the future. Model results are also strongly dependent on input assumptions and on the structure of the model itself. Every model uses its own set of assumptions, definitions, structure and data – its results ultimately depend on these attributes and choices. What is left out of a model can be as important as what goes in. Critical assumptions and structural biases are not always readily apparent to the outside observer. A proper understanding of economic models, their uses and limitations, is therefore critical in a constructive debate about options for reasonable policy interventions.

3.2. Strengths and weaknesses of the Delphi method

As mentioned earlier, the Delphi method is useful for long-range forecasting (20-30 years), as expert opinions are the only source of information available [12]. It is particularly useful when the research question does not lend itself to precise analytical techniques, but can benefit from subjective judgments on a collective basis.

The basic principle of a Delphi study is structuring an iterative survey rounds in which the argumentation of future views is closely related. Compared to a traditional survey design, several survey rounds are seldom the case; survey is a one-time measurement. In futures studies and in a strategic planning point of view, an iterative Delphi is more well-grounded, because it enables the panellists to challenge the argumentation of a differing view in an anonymous manner. Furthermore, the presentation of new topics or approaches to the study process is much easier.

Recently, the design of a Delphi process is concentrated more on expert interviews and smaller top expert panels in which the role of general experts is to challenge the arguments presented by the top expertise [11, 25]. This kind of process allows the deeper opinions and reasons that experts have on specific questions, to see the light of the day. The role of the general experts is also to influence the information policy of the top experts in the field, and therefore it is more probable that they will reveal all of the key information they possess. This kind of pressure on panellists enables the key factual arguments to enter the Delphi results.

For successful argumentation, anonymity is one of the basic principles in the use of the Delphi method. Turoff [8] lists several problems associated with committee processes in which the appointed group works face to face. These are (i) the domineering personality, or outspoken individual that takes over the committee process, (ii) the unwillingness of individuals to take a position on an issue before all the facts are in or before it is known which way the majority is headed (iii) the difficulty of publicly contradicting individuals in higher positions, (iv) the unwillingness to abandon a position once it is publicly taken and (v) the fear of bringing up an uncertain idea that might turn out to be idiotic and result in a loss of face. Delphi, however, cannot be seen as a committee process. The proposition made by Turoff [8] is that a Delphi process can be organised as a precursor to committee activity. Its goal in this function is not so much to obtain a consensus as to expose all the differing positions advocated and the principal pros and cons for those positions.

The origins of critique of the conventional Delphi were presented by Harold Sackman [10]. He recommended in 1975 that conventional Delphi should be dropped from institutional, corporate and government use until its principles, methods, and fundamental applications can be experimentally established as scientifically tenable. Many of the points of critique have been sharpened during the decades through the progress of the latter versions of Delphi, namely the Policy Delphi [8] and the Argument Delphi [11].

Kuusi [11] argues that the method for selecting the Delphi panel is one of the most critical phases of a Delphi study. The Delphi facilitator should consider in his/her actor analysis the most important stakeholders, the most important area of expertise (the competence of the experts) as well as the terms of delivering information in a Delphi process (information policy). The selection process of an expert panel should be done as overtly as possible. An objective actor analysis should deliver not just all the key informants in the focus group of the Agri-food sector but also the most significant stakeholders in the active agricultural field. The results of the Delphi study are only as valid as the opinions of the experts who made up the panel, whereas the panel viewpoints are summarized statistically rather than in terms of a majority vote. The information obtained by the Delphi study is only as good as the experts who participate on the panel [26]. A great deal of attention must be given to the choice of participants; the questionnaires must be meticulously prepared and tested to avoid ambiguity. Multi-round studies require a great deal of time; inevitably, some participants will drop out during the process.

It can be said that in the planning of the questionnaire a survey-based Delphi calls for more attention in the question formulation compared to the more interview-based Argument Delphi. Delphi literature is full of warnings and descriptions of poorly formed questionnaires [10, 27]. If the starting point of a Delphi process is based on a survey, the handwork of generating a questionnaire must be done in such a way that double-barrelled questions, biased questions, halo effect questions or loaded questions can be avoided. This is because the measurement (survey) is usually done just by one time [25].

4. Combining the quantitative GTAP model with the qualitative Delphi method

In this paper, an interesting aspect is to scrutinise an interactive way of combining model-based and expert-based methods. Expert-based and more qualitative information can complement the information provided by the quantitative model-based approach and vice versa [25]. In the literature of futures studies, qualitative methods have repeatedly been related to heuristic reasoning, whereas quantitative methods are understood as formal methods, typically mathematical modelling [17-20].

Our approach is to contribute to the discussion on how these qualitative and quantitative methods can be used in parallel:

1) How could the combination of these methodological approaches be done by integrating model simulations with the future views of an expert panel?
2) Do the evaluations by the expert panel (Delphi results) improve the assumptions behind the model simulations (GTAP model) by delivering relevant policy scenarios?
3) Can model simulations deliver projections to serve as benchmarks to help the expert panel to foresee the future?
4) What kind of value added is to be gained by combining these methods?
5) What would be the drawback of combining these methods?

In theory, the expert panel can be used to deliver or evaluate assumptions for the alternative scenarios used in the model simulations. In addition, the expert panel can also be used to gain feedback on the results generated by model simulations in several dimensions [for example: 1) desirability, 2) probability, 3) certainty, & 4) importance of the policy scenarios]. In the following chapters (4.1 and 4.2), examples are given to describe the interaction between model simulations and expert views.

4.1. Using the Delphi method to deliver relevant policy scenarios for the GTAP model

The first round of questionnaire is usually concentrating on major guidelines for future development. This is done to get a comprehensive picture of the studied field in question. As the Delphi process continues, more in-depth questions will be involved. In this paper, a set of questions concerning greenhouse gases emissions is used as an example in combining both methods. In the first round of questionnaire for the Delphi study, experts can be used to deliver their subjective opinion for an example of the overall target percent to reduce CO_2 emissions. The results of the expert panel evaluation can be part of the alternative scenarios in the GTAP model simulations. Thus, the assumptions for model simulations can be retrieved from expert panel estimations by using the Delphi method. Appendix 2A will show the example questions to be given to the expert panel; and the results from this questionnaire can be used as assumptions for the model simulations.

4.2. Using the projections from the GTAP model to serve as benchmarks for the expert panel to foresee the future

In the second round of questionnaire, the model results can be exposed to the expert panel evaluation in order to validate the results generated by the model. Confirmation can be attained from the expert panel in order to gain feedback on the implementation of the climate policy in several dimensions: 1) desirability, 2) probability, 3) certainty, & 4) importance of the climate policy. An example is presented in Appendix 2B where the expert panel is asked about the impact of more stringent climate policy on agricultural production (the GTAP model results are given). The second round of Delphi questionnaire can be used to gain feedback on the implementation of the climate policy in several dimensions: 1) desirability, 2) probability, 3) certainty, & 4) importance of the climate policy. Also, if the expert does not agree with the projected results, he/she can give his/her own opinion. In this case, it is important that the key arguments supporting the future view are presented.

4.3. Value added in combining the GTAP model with the Delphi method

In the literature, there are examples of combining qualitative and quantitative methodological approaches in Delphi studies [20]. The qualitative approach refers to the analysis of qualitative (i.e. non-numeric, oral, textual or visual research material. The quantitative approach, in turn, refers to the gathering and analysis of quantitative, i.e. numeric, countable, research material [20]. Examples of combining economic modelling (e.g. a recursive-dynamic applied general equilibrium model GTAP) with the Delphi method are rare, as they are seen to lean fundamentally on different sources of knowledge source, statistical and judgemental information [20]. However, combining these methods can provoke new ideas and increase the depth of the knowledge base needed in decision making.

For example, if we want to forecast the impacts of climate change on agriculture, a Delphi study can involve experts in the field of agriculture and climate change. These experts can be asked for a direct estimate of the impact of climate change on agricultural production volumes in different production lines. In order to accomplish this would require integration of the answers from the expert panel on all factors and driving forces affecting the operational environment (i.e. political, ecological, social, technological, economical, and value change factors). This kind of questions would miss the determinants behind the given answers. Therefore, a better technique in this case would be to use a model-based tool, such as the GTAP model to project the future alternatives, and the expert panel's role is to evaluate the driving forces, their desirable and probable development and the relative importance between different emerging driving forces and trends. By this combined scrutiny, impacts of climate change can be estimated in quantitative terms, but not only in view of the past development (statistical information), but also in consideration of changing driving forces evaluated by the Delphi expert panel (input to the model simulations by expert information).

As mentioned earlier, future research questions can be studied base on both policy modelling (e.g. GTAP model) and expert panel views (e.g. Delphi technique). Both of the methods must produce policy relevant information as a base for decision-making in order to be useful. The

research methodology should improve in order to better serve the decision making process. Therefore, research results can be utilised, for example, in the policy dialogue phase. An organised policy dialogue forum requires that the results of both approaches are exposed to the evaluation of planners and decision-makers within the agricultural field. In addition to going through the actual results, it can also raise questions on the basic assumptions of both methods. In this way, the methodology can be improved with the help of information acquired from this kind of feedback.

It is very important to remember that models cannot predict future events, nor can they produce precise projections of the consequences of specific policy. Economic models are virtually useless for making long run predictions about likely impact of structural or technological changes that have yet to occur. The Delphi method can counter this major weakness by bringing to the table an expert panel view on the forecasted time of the realization of a certain non existing technology. The panel can provide a road map for the emergence and how important would be the different technological developments in the future.

5. Conclusion and implications for future research

There is growing recognition of the benefits to be gained from combining quantitative and qualitative methods in socio-economic research. This paper contends that the interaction between the GTAP model (a quantitative method) with the Delphi method (a qualitative expert-based method) can improve the understanding of the alternative futures for the agrifood sector in Finland.

By combining model-based and expert-based methods, a degree of comprehensiveness may be achieved that neither approach, if used alone, can achieve. The expert panel (Delphi results) can improve the assumptions behind the model simulations (GTAP model) by delivering relevant policy scenarios, whereas model simulations can deliver projections to serve as benchmarks to help the experts to foresee the future. Furthermore, the expert panel may be able to explain or give the reasons behind the projected results simulated by model. Lastly, model-based and expert-based methods can be combined to enhance the validity and reliability of the results by using both approaches interactively by combining their strengths to confront the weaknesses of each method. Hence, the combination of these methods is able to produce a more coherent and complete picture of the investigated domain compared to a single method.

If the projected results from the GTAP model converges with the evaluations of the Delphi expert panel, our confidence in the projected results will be strengthen considerably, and also our confidence in the methods used is increased. However, if the projected results from the quantitative model diverge from the qualitative expert panel evaluations significantly, we do not know which method is producing the realistic results, hence forcing us to check the basis and process of both methods for possible mistakes or misrepresentations in the research procedures. In the quantitative method, we have to check whether the assumptions and baseline for the GTAP model are incorrect or underestimated. In the qualitative method, we have to check whether the expert panel is bias, and thus the bias can be amended by adding new experts in the second round of the Delphi study.

Therefore, combining these methods is a long process and also very time consuming since this approach has not been done previously, and there is no guidance to show the most efficient way to accomplish the tasks involved. This integrated approach requires a multidisciplinary research team with expertise in both types of methods, thus may be labour-intensive and expensive. These are the potential drawbacks in attempting to combine such divergent research methods. Some of these drawbacks can be countered by applying this integrated approach more often in research projects that anticipates the futures in order to enhance the learning curve. A check-list or simple manual for the approach to combine these methods can be drawn up to improve efficiency in the implementation process.

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Appendix 1: The approach of the questions asked in the first round of the Delphi study

The panel of experts' views on 86 driving forces and trends in the Finnish food supply chain were determined. Each question is divided into four dimensions:

(1) The desirable change of a driving force
(2) The probable change of a driving force
(3) The certainty of a probable change
(4) How important the driving force is for the future of Finnish agriculture and food economy

An example question with a driving force concerning climate change:

Change factor	(1) Desirable change	(2) Probable change	(3) Certainty of the probable change	(4) Importance of change factor
	-2=decreases considerably -1=decreases 0=stays unchanged 1=increases 2=increases considerably		1=extremely uncertain 2=uncertain 3=fifty-fifty chance 4=quite certain 5=extremely certain	1=not important at all 5=extremely important
Reduction in greenhouse gas emissions from agriculture in Finland	-2 -1 0 (1) 2	-2 -1 (0) 1 2	1 2 3 (4) 5	1 2 3 4 (5)

Explanation on the answers provided by a panel member concerning greenhouse gas emissions from agriculture in Finland:

Dimension(1) means that you hope (value 1 circled) for more reduction of greenhouse gas emissions from agriculture in Finland from the current level, but dimension(2) means that you do not consider the reduction in greenhouse gas emissions from agriculture in Finland probable (value 0 circled). Dimension(3) means that you think it is quite certain (value 4 circled) that greenhouse gas emissions from agriculture in Finland will not decrease. Finally, dimension(4) means you think the reduction in greenhouse gas emissions from agriculture in Finland (driving force) to be very important (value 5 circled) for Finnish agriculture in a 20-year perspective.

Appendix 2: Examples in combining the quantitative method with the qualitative method

Appendix 2A: example questions to be given to the expert panel concerning CO_2 emissions

As part of the alternative scenarios building, assumptions can be retrieved from expert panel estimations by using the Delphi method. Below are example questions to be given to the expert panel and the results can be used as assumptions for the alternative scenarios of the GTAP model.

Question: A more ambitious climate policy will take over from the Kyoto Protocol after 2012. The EU-27 emission target is to reduce CO_2 emissions by _____% in 2030 from the 1990 emission levels.

Or

Question: A more ambitious climate policy will take over from the Kyoto Protocol after 2012. The EU-27 emission target is to reduce CO_2 emissions in 2030 from the 1990 emission levels by (circle or specify your estimate) a) 20% b) 40% c) 60% d) other _____%

Appendix 2B: the GTAP model result is exposed to the expert panel evaluation

How do you see the target for CO_2 reduction affects Finnish total agricultural production?

Change factor	**1. Desirable change**	**2. Probable change**	**3. Certainty of the probable change**	**4. Importance of change factor**
	1= not desirable or probable at all 2 3 4 5= very desirable or probable		1= extremely uncertain 2 3 4 5= extremely certain	1= not important at all 2 3 4 5= extremely important
1. A more ambitious climate policy for EU-27 after 2012 to reduce CO_2 emission by 40% from the 1990 emission levels in 2030 will decrease Finnish total agricultural production by 5%.	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
2. I disagree: In my opinion the total agricultural production will decrease _____% or increase _____%				
3. My argument for this future view is (open phrase question):				