FINAL REPORT OF THE
OTKA PROJEKT
REGIONAL FOOD SUPPLY SYSTMES-ROMANTIC VISION OR ECONOMIC REALITY?

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1.1. Introduction

During the last several decades, a large number of scenarios have been developed to predict the future state of the world or specific regions (Glenn et al., 2009; Kuhlmann and Edler 2003). Some of these scenarios are industry-specific, focusing, for example, on the future of transportation systems (Shiftan et al. 2003), while others couched their predictions in vague, ethereal terms (Raskin et al. 2002).

In recent years, we have seen increasing public and scientific attention toward the future of the agri-food sector. Numerous scenarios have been prepared focusing mainly on the effects of climate change on agricultural production. The changing ecological situation (Lorenzoni et al. 2000; Ericksen et al. 2009) and socio-economic environment (Schafer and Victor 2000) of agri-food systems make a compelling case for the application of scenario development and analysis to this sector. Our aim is to investigate the perspectives of food system experts on the future of the agri-food sector and to develop several scenarios that illustrate the future of the world's food system.

Understanding the possible paths for the development of the agri-food sector is important for several reasons. First, the sector is characterized by high human and physical capital requirements and a long time horizon for return on investment (Cristóbal 2008). Second, the agri-food complex exhibits strong linkages to other sectors of the economy for inputs and outputs and, therefore, the sector's accelerative and multiplicative effects have a considerable influence on the dynamics of national and regional economies. Moreover, governmental and managerial decisions affecting the agri-food sphere exert a considerable influence on the socio-economic structure and equilibrium of entire geographic regions (van Ittersum et al. 2007). Third, the development of the agri-food system has wide-ranging implications for the natural environment (Steenge 2004). Therefore, the identification of potential future scenarios may aid in better harmonizing the economic, social and natural consequences of food and fiber production.

The remainder of the paper is organized as follows. We first discuss scenario planning, it's development, and its application to business and the agri-food sector. We then discuss the methods used in this research, followed by a presentation of the results of a survey of an international group of agri-food specialists. Next, we report the results of exploratory factor analysis and identify and discuss the underlying constructs, which we evaluate using confirmatory factor analysis. We then develop several scenarios, which are assigned probabilities by a panel of industry experts. Finally, we conclude by presenting a summary and the implications of our findings.

1.2. Scenario Planning

Modern scenario planning may be traced to the first years of the cold-war era (Nye, 1994). Herman Kahn (1960), is generally credited with developing the methods for scenario development while working at Rand Corporation for the U.S. military (Fahey and Randall 1998). Kahn employed the term "scenario" to describe future states in relation to possibility of thermonuclear war.

The 1970's saw the application of scenario planning to the world of business. Pierre Wack, an executive with Royal Dutch/Shell developed "scenario planning" to create scenarios that did not rely on forecasts based on the assumption that "tomorrow's world will look much like today's" but rather considered the possibility of a major change in the business environment (Wack 1985). His work at Royal Dutch/Shell is credited with helping the company prepare foresee the energy crisis of 1973.

Huss and Honton (1987) characterize the value of scenario planning as providing a tool for the forecasting of long range, complex, and highly uncertain business environments. Wilkinson and Eidinow (2008) add that scenario planning aids decision-makers in identifying uncertainties and their potential effects so that they can formulate appropriate responses. In recent years, scenario planning has been studied and used by academia, business, consultants, policymakers, governments, and NGOs and many authors have published on the subject, including Godet and Roubelat (1994), Schoemaker (1995), Phelps et al. (2001), and Mietzner and Reger (2005), to name a few.

1.2.1. Global Food System Projections

McCalla and Revoredo (2010) note that there have been at least 30 quantitative studies projecting the global supply and demand of food. This number has grown over the last several years, and the number of studies that forecast various elements of the food system is extremely large when we consider research that is more narrowly focused on individual elements of the global food system. For the purpose of this literature review, we have chosen to focus on those studies that make future projections that address key elements of the global food system, such as energy, water, or global food supply and demand, regardless of whether the scenario analysis method was used, in order to provide a robust view of the projections using various forecasting techniques. We discuss some of the more comprehensive studies in the categories of natural resources, climate change, and global food supply and demand, below. Given the thousands of studies that have been published on forecasts concerning the global food system, this literature review is necessarily a small sample of the published works.

Natural Resources

Land. Most research focusing on natural resources addressed a single resource, such as land, energy, or water. Land use studies typically address the multiple demands for land, including urban, crop and pasture, forestry, and conservation uses. Lambin and Meyfroidt (2011) note that land is becoming increasingly scarce due to increased urbanization, greater demand for cropland, and deforestation. They estimate that the current land reserve could be exhausted by 2050. Seto et al. (2011) estimated that urban land cover will increase by 430,000 to 12,568,000 km^2 with the most likely estimate of 1,527,000 km^2. They note that increased urban development will put millions of people at risk to the effects of climate change and challenge conservation efforts.

Water. There is general agreement in the literature that water will be an increasingly scarce resource. Almaco et al. (2007) estimate that water stress will increase over approximately two-thirds of the world's total river basin area, with increasing stress being largely attributable to greater water withdrawals. Hejazi et al. (2014) develop socio-economic scenarios to evaluate future water demand. They develop six scenarios, with names such as, "Collapse," Muddling Through," and "Social Conservatism." They conclude that water is likely to be a limiting factor in the future with an increased reliance on groundwater, water reuse, and desalinization. They estimate that if a "business as usual" approach is taken that 52% of the world population and 49% of grain production will be at risk.

Energy. The World Energy Council (2013) developed two scenarios focusing on energy production an use through 2050. The "Jazz" scenario foresees a world driven by consumer demand, affordability, and quality with multi-national companies and price conscious consumers being the major players. Investments in nuclear energy and large hydro energy project would be limited but there would be better access to unconventional resources. The

“Symphony” scenario foresees an emphasis on sustainability and energy security with governments taking the leading role. Neither of the scenarios developed by the World Energy Council foresees a world where biomass utilization shows significant growth. Several studies examined the production of biofuels as a driver of agricultural prices. Trostle (2008) found that biofuel production led to short-term increases in food commodity prices, but that global demand would be the primary contributor to long-term increases in commodity prices. Both Ajanovic (2010) and Zhang et al. (2010) found no substantial relationship between the production of biofuels and long-term price increases in commodity prices.

Climate Change

The number of publications addressing climate change as well as those addressing climate change and agriculture number in the thousands. Probably the most widely cited research on climate change and its impact is the Intergovernmental Panel on Climate Change (IPCC). In a 2007 report, the IPCC predicted that global average temperatures will increase by 2 to 4^0C, that close to a third of global coastal wetlands will be in danger of being submerged, and that millions of people are likely to face food and water shortages. Parry et al. (2004) estimates that an additional 30 to 220 million people will be faced with the risk of hunger without taking into account the effect of CO_2 fertilization. When the CO_2 fertilization effect is considered, the risk falls to between 12 and 20 million people. Rosenzweig and Parry (1994) argue that a more nuanced approach is needed to consider the effects of climate change on regions and countries. They predict that disparities between the productive capacity of the developed and developing world will increase with climate change. Fischer et al. (2005) find that total cereal production will not be greatly impacted by climate change at the global level, but that there will be differential impacts on cereal production and hunger in various regions of the world with the tropical semi-arid regions and developing countries suffering the greatest impacts.

Global Food Supply and Demand

Research on the global supply and demand of food typically addresses factors such as population, agricultural production, food prices, calorie consumption, and malnutrition. Several comprehensive studies, including some that employ scenario analysis, are described here to provide some perspective on the breadth of the various global food system analyses. Chen and Kates (1994) examine factors including the number of undernourished people, population, dietary changes, income distribution, relative poverty, and economic integration. They develop scenarios for 2060 including "Food Secure" and "Basic Linked System," as well as 12 climate change scenarios. The European

Commission (2012) developed scenarios for Europe that addressed population demographics, renewable energy use, world population, food prices and malnutrition. The scenarios were entitled, "Nobody cares: Standstill in EU Integration," Fragmented Europe - EU under Threat," and "EU Renaissance." Nelson et al. (2010) developed three scenarios for 2050, "Optimistic," "Baseline," and "Pessimistic," that included population, GDP growth, price changes for maize, wheat, and rice, and child malnutrition. Pinstrup-Andersen et al. (1999) developed forecast demand for food, cereals, and meat, cereal imports, food prices, and malnutrition of children under 5 years of age for both developing and developed countries in 2030. The Institute for the Future (2011) developed four scenarios, for 2030 labeled, "Growth," "Constraint," "Collapse," " and "Transformation." They focus on issues such as calorie consumption, the food supply chain, food scarcity, and technology. Hoogwijk (2003) developed three scenarios based on the type of diet with scenarios called "Vegetarian Diet," "Moderate Diet," "and "Affluent Diet."

We cannot readily summarize the findings of the various studies, particularly those involving scenario analysis, as they do not lend themselves to calculating averages or even ranges. Rather, it is insightful to view the way that the authors characterize the future states and the factors that they include in the analyses. Many of the scenarios focus on whether the system will be in balance or out of control. Others describe the positive or negative nature of the outcomes. Still others, characterize the systems by describing key characteristics that describe key features, such as the type of diet that might predominate. It is also insightful to look at the variables included in the studies. Many of the variables, such as those mentioned above, including populations, agricultural production, food prices, calorie consumption, and malnutrition appear in many studies. However, other factors, such as water availability, dietary components, system of economic organization, and energy and other agricultural inputs, appear in relatively few studies. Of course, the real value of scenario development lies not in looking at the outcomes, but in understanding the complete story that the scenario describes, how the various factors influence the outcomes, and particularly how the factors work together, often leading to an outcome that may be far different than could be envisioned by examining the impact of any individual factor. McCalla and Revoredo (2001) argue that, notwithstanding the inaccuracies of forecasts, the models been able to focus the attention of policy makers on major issues that need attention.

1.3. Methods

In our research we have combined different methods, widely applied in future research and strategic planning. The collection of ideas on possible future ways of development has been carried out by brain storming (Collaros and Anderson, 1969), than we have screened the ideas, following the general guidelines of literature (Nunamaker et al. 1987). In phase of evaluation of probabilities we have applied the methodological approach of expert probability estimation (Hogarth, 1975). Result of survey have been evaluated by one-and multivariate statistical methods, generally applied in social research (Scandura and Williams, 2000). Scenarios have been generated by such a method, which offered a favorable possibility to combine the favorable aspects of qualitative and quantitative future research methods (Godet, 2000).

Table 1. Scenario-Analysis Characteristic Descriptions

Overarching themes	Scenario Type	Characteristic Choice*
A. Project goal: exploration vs. decision support	I	Inclusion of norms: **descriptive** vs. normative
	II	Vantage point: **forecasting** vs. backcasting
	III	Subject: **issue-based**, area-based, or institution-based
	IV	Time scale: **long-term** vs. short-term
	V	Spatial scale: **global/supranational** vs. national/local
B. Process design: intuitive vs. formal	VI	Data**: qualitative** vs. quantitative
	VII	Method of data collection: **participatory** vs. desk research
	VIII	Resources: extensive vs. **limited**
	IX	Institutional conditions: **open** vs. constrained
C. Scenario content complex vs. simple	X	Temporal nature: **clean** vs. snapshot
	XI	Variables: **heterogeneous** vs. homogenous
	XII	Dynamics: peripheral vs. **trend**
	XIII	Level of deviation: alternative vs._**conventional**

Source: van Notten et al. (2003)

In order to identify possible future directions for the development of the food and agricultural sector, we began by holding two brain-storming sessions with the participation of industry experts. The goal of the brain-storming sessions were to identify the likely future trends in the agri-food system. Participants were encouraged to suggest trends without discussion or criticism. Nine experts participated in the first session and ten in the second. The two brainstorming sessions were held in two different locations. The first session was held in an agricultural region, Dusnok, Hungary, with support from the Regional Agricultural Chamber. The nine participants included six farmers, two owners of medium-sized food processing companies, and one representative of a nation-wide input-trading organization. Seven of the participants had degrees in higher education and four had substantial international experience. The second session was held at Corvinus University of Budapest in Budapest, Hungary. The ten participants consisted of three representatives of medium-sized food processing companies (two were owners), three representatives of the Hungarian Ministry of Rural Development), four agricultural researchers. Four of these participants were members of the Hungarian Association of Food Science and Technology, a scientific NGO.

The brainstorming sessions led to a total of 63 different ideas concerning the future development of the agri-food chain. This large number of items required consolidation so that a manageable number of potential events could be presented to the expert panels for evaluation. Parenté and Andersen-Parenté (1987) indicate that in the case of the Delphi-method the upper limit of is 25 items. We sought to limit the number of future state statements to 25 or less.

Three experts evaluated each of the 63 statements based on three criteria: global character, importance and relevance from the point of view of food industry, and specificity from the point of view of the actual research. One expert was a professor emeritus from Serbia with considerable international experience gained as a consultant of FAO and UNIDO. Another expert was been an international lawyer from Nigeria, with considerable experience in the field of rural development in northern (Sub-Saharan) Nigeria. The third expert was a professor at Corvinus University in Hungary and an expert in food security and the impact of climate change on agriculture.

The process of reducing the number of statements resulted in the initial elimination of 27 statements. Additionally, seven statements were eliminated because they reflected processes of local importance, three were eliminated because they were unimportant from a practical perspective, another three were omitted because they were irrelevant from the point of view of the development of the agri-food sector, and fourteen were eliminated because they did not reflect directly on the development of agri-food sector. The remaining 36 statements were reformulated and consolidated into 20 future state statements.

The final version of the questionnaire was prepared with the assistance of members of the Program Planning Committee of 19th Annual World Forum and Symposium of the International Conference of the International Food and Agribusiness Management Association (IFAMA). The full questionnaire is presented in Appendix I. This committee had a broad representation of international experts from many different fields, was geographically diverse, and included members from both industry and academia.

Respondents were asked to estimate the probability of occurrence of the 20 different states using a seven-point probability scale. The scale described the probability of an event occurring as 0 to 5% at one extreme and 96 to 100% at the other extreme. The seven-point scale was utilized in order to simplify the task for respondents and maximize the response rate. To avoid the possibility of bias based on the order in which the possible events were presented, the order was determined by a random-number generator.

The sample was drawn from two sources. All registered participants of the annual IFAMA conference. Experts from Central Europe were selected from participants in several scientific conferences held in Hungary, Romania, and Serbia. The meetings included the 4th International Conference for Rural and Agricultural Development, at Debrecen University, Debrecen, Hungary and preparatory meetings of the Techfood project "Solutions and Interventions for the Technological Transfer and the Innovation of the Agro-food Sector in South East Regions" held at the Bucharest Academy of Economic Studies, Bucharest, Romania as well as the Faculty of Agriculture at Belgrade University and Serbian Scientific Research Institute of Economic Sciences, both in Belgrade, Serbia. IFAMA members and Central European experts were sent 350 and 280 questionnaires, respectively. The IFAMA group 109 completed questionnaires and the Central European group returned 97 questionnaires for response rates of 31% and 35%, respectively. The geographic distribution of all 206 respondents is summarized in table 3.

Table 3. Geographic distribution of respondents

International specialists	
North-America	51
South and Central America	22
European Union	22
South Africa, Australia, India	14
Total	109
Central-European Specialists (non-IFAMA members)	
Hungary	67
Serbia	8
Ukraine	9
Romania	13
Total	97

Grand total	206

The data from the 206 observations were recorded and summary statistics were calculated. We initially looked for those events that were deemed to have the highest probability of occurrence as well as differences based on the respondent's region. Ultimately, the preliminary analysis was used to develop a shortlist of the events to be used in the development of scenarios.

In opinion of Kaiser (1970) "in explanatory work… we know very little ahead of time; the best we can do is take observations on a whole pot-full of random variables which we suspect may be relevant, nad then see what happens"

In first phase of our research we have taken into consideration a relatively high number of events, which are supposedly capable influence the future states of agro-food sector. In this phase we had not formulated yet any concept on stochastic relations between the variables investigated, that's why this factor can be considered as an exploratory phase of the research (Stebbins, 2001). By definition of Stebbins (2001) the main goal of innovative exportation is to gain a "degree of familiarity with the properties of substances and procedures that is needed to manipulate them so as to achieve the desired effect or product".
The next step was to use exploratory factor analysis to identify underlying contructs associated with our relatively large number of events. Exploratory factor analysis is typically used to identify latent constructs in data matrices with correlated variables (Floyd and Keith 1995). This eigenvector–based, multivariate analysis is a theoretically optimal linear scheme, in terms of least mean square error, for compressing a set of high dimensional vectors into a set of lower dimensional vectors. Factor analysis is based on a correlation and covariance matrix, and assumes that the observed variables are measured continuously, are distributed normally, and that the associations among indicators are linear. Because our expert responses were measured on an interval scale, we used the mathematically more correct Categorical Principal Component Analysis (CATPCA) method to analyze the data (Linting et al. 2007). Based on CATPCA output there appeared to be some underlying factors, also known as background or latent variables that were not measured directly, but which may have determined respondents' expectations of future of agri-food chain events.

Next, we used the results of CATPCA to establish the relationship between the directly observed and latent variables. First, we used the information from CATPCA to construct a model of key agri-food chain events, which we tested using confirmatory factor analysis. In this phase we have formulated a conceptual model on relations of different variables, investigated by our questionnaire. This combination of exploratory and confirmatory factor analysis is in line with general logic of application of different types of factor analysis, reflecting the inherent, successive approximation approach of this method (Schriesheim and Eienach 1995; Anderson and Gerbing 1988). In contrast to exploratory factor analysis or principal component analysis, where all loadings are free to vary, confirmatory analysis tests hypotheses relative to theoretical underpinnings. This analysis can include both directly measurable and latent variables using the CATPCA as input. Second, we used the results of CATPCA to identify the most important future directions for the agri-food sector (which we have labeled as outcomes) and which served as input for second phase of the research.

Neither the number of respondnets (sample size) nor their geographical distribution (representativeness) allow a classic, hypothesis-testing procedure. Our results, obtained by survey method offer just a limited possibility for the generalization: it can not be declared, that "this is the expectation of learned, professional public on future of agro-food chain up to 2030", but our results seems to be capable to highlight the most important way of development in next one and a half decade.

In this second phase of the project, we developed scenarios based on the estimation by experts of the probability that the various outcomes would occur. While a simple questioning of the experts on the probability of the occurrence of future events would be the simplest method, such a process would imply that each event is independent of other events. To properly account for the interrelationships between events, it was necessary to use a method that accounts for the cross-impacts of different processes.

Several algorithms have been developed to account for the effect of one event on another. The goal of these different cross–impact algorithms is the manipulation and harmonization of probability estimates (Cho and Kwon 2004). We chose the Smic-Prob-Expert cross–impact analysis tool, developed by team a team led by Michael Godet (Godet and Roubelat, 1996; Bradfield et al. 2002).

According to the definition of Jarke et al. (1999) a scenario is a "description of a possible set of events that might reasonably take place." As a first step in the defining the scenarios, we determined a finite set of possible, separate events. This set is denoted by

$$\mathbf{H} = (e_1, e_{2,}. \ldots e_n),$$

where the events are denoted as e_i.

The probability that an event will occur is denoted by P(i). The conditional probability of event e_i when e_j event occurs is denoted by P(i/j) and the conditional probability of the occurrence of e_i if the e_j does not occurs is denoted by $P(i/\bar{j})$.

Duperrin and Godet (1975) state, “in practice, the opinions given in response to certain specific questions about non-independent events disclose some degree of inconsistency with the overall opinion (which is implicit although not expressed), revealed by the answers given to all the other questions.” These primary opinions must be corrected, is such a way as to conform to the following constraints. Their method is presented in Appendix II.

The Smic-Prob-Expert software is capable of generating a hierarchical rank of scenarios, based on their probabilities. The input contains three components: a vector of a-priori estimations of the probability of different processes, and two square matrices. The first matrix contains the experts’ estimation of the pairwise probability of the co-occurrence of events. The second matrix contains the estimated probabilities of the occurrence of processes in pairwise form, should the other process in the pair not occur.

Developing the input matrices for Smic-Prob-Expert analysis turned out to be extremely complicated. Originally, a Delphi–type questioning of experts had been planned. However, even after two rounds of the questioning there were still considerable differences. Subsequently, a two-hour workshop was organized, during which the needed probabilities were estimated by consensus. The probabilities were then used to develop the scenarios and their probability of occurrence.

1.4. Results

Descriptive analysis

In the first phase of the research, we attempted to characterize respondents' evaluation of the probability of the various events regarding the future state of the agri-food sector. In some cases response patterns could be described by Erlang or lognormal functions, but in most cases the distributions did not fit any common probability density functions.

The coefficient of variation varied significantly for the different events. For example, the coefficient of variation was very low for some events, such as those concerning agricultural prices and water, and high for other events, such as the future role of biotechnology. This indicates that there was agreement on the expectation for some events and a divergence of opinion for others.

In analyzing the responses, it became obvious that many of respondents believed that the agri-food complex will face significant new challenges over the coming decades (table 4). It was interesting that for many of the issues of local importance there was generally good agreement between the international and regional groups of experts. For example, both groups believed that water will become increasingly important for agricultural production, and that as a consequence of global warming, water will become one of the most important limiting production factors. The Central-European experts believed most strongly that this will be the case, perhaps because they have observed decreasing precipitation and many different adverse climate predictions possibly foreshadowing the increased frequency of severe droughts (Arnella 1999; Bartholy, Pongracz, and Gelybo 2007).

There was also agreement that we should expect increasing energy prices and the internalization of environmental externalities. This prediction is in line with the majority of forecasts from other sources (Yergin 2006). More than half of respondents also predicted a further increase in food imports by China and India. This reflects the generally accepted view of that incomes will continue to rise in these countries and result in shifting patterns of trade in food and agricultural products (Kaplinsky 2006; Trostle 2008). At the same time, the majority of respondents attached a low probability to finding a solution to the global malnutrition problem and for a decrease in the prices of agricultural commodities. These rather pessimistic expectations support the opinions of other experts who argue that if no corrective action is taken, the target set by the World Food Summit in 1996 (halving the number of undernourished people by 2015) will not be met (Rosegrandt and Cline 2003).

Based on these predictions, we may anticipate an agri-food sector that will play an even more important role in the world economy in the decades to come. The threat of global warming, increasing food demand in emerging economies, and the continuing need for food aid for the world's poorest countries highlight the significance of preserving the productive capacity of world food system.

Another important future tendency, as viewed by our expert respondents, will be the challenge of meeting the demands of diverse consumer segments. This phenomenon will manifest itself in increasing interest in organic products and tailor-made nutritional products. Moreover, an augmentation in demand for locally produced foods may be expected.

In some cases, there were widely divergent opinions among the experts. For example, they were not in agreement on the future of biotechnology. This may be explained by the great differences in the assessment of the potential of genetically modified agricultural products among different groups (Lusk and Rozan 2006). Approximately, one-quarter of the respondents estimated that increasing interest in biotechnology is rather improbable (probability below 25%) while roughly one-quarter of the respondents seemed confident in the increasing acceptance of biotechnology. Overall, more than half of respondents estimated that the probability of the general global proliferation of genetically modified agricultural products is above 70%.

There was a divergence of opinion on the future structure of agricultural and industrial food production throughout the world. Overall, respondents anticipated an increasing concentration in agricultural production, but only a small percentage of respondents accepted the opinion of some experts (Steiner 2000) that mergers and acquisitions in the food industry will lead to a small number of firms (30 to 40) that will produce the overwhelming majority of production of the world. However, more than half of the respondents forecast a further, drastic decrease in the number of small-scale, family-owned food shops. There were significant differences in the opinions of the "international" and Central-European experts. This may be due to the fact that the concentration of the food trade in Central and Eastern Europe is considerably lower than in Western Europe, where significant concentration in the food trade occurred in the 1980s and 1990s (Juhász, Seres, and Stauder 2008).

Table 4. Experts' Assessments of the Probability of Various Events through 2030[a]

State Variables	International Experts (percent)	Central-European Experts

		(percent)
1. Water becomes a limiting factor of production-output (WATER)*	82.8	94.5
2. Increasing interest in bio-products (BIOPROD)*	72.8	60.3
3. Increasing energy prices and environmental taxes considerably increase prices of food produced in distant regions (FOODPRICE)	72.4	69.8
4. Increasing interest in specific, tailor-made nutrition, supported by the latest methods of medical science (NUTRIFOODS)	68.7	66.2
5. Increasing trust in locally produced food products (TRUSTLOCAL)	68.6	69.7
6. Increased agricultural and food import in China and India (EMKTS)	68.4	64.2
7. General proliferation of genetically modified agricultural products globally (GM)	67.8	72.1
8. Increasing role of bio-mass in energy production (BIOMASS)	67.4	69.8
9. Further concentration of agricultural production (AGRCONC)	64.7	68.9
10. Increasing urbanization, some regions lose their population even in developed states (URBAN)	63.6	61.6
11. Further and increasing migration from third world to the developed states (MIGRATE)*	59.7	72.8
12. Increasing threat of agri and food terrorist attacks (BIOTERROR)	58.8	64.5
13. Increasing trust in biotechnology (ACCEPTGM)*	58.7	65.6
14. Drastic decreases in the number of small-scale, family-owned retail shops (TRADECONC)	54.4	58.8
15. Global warming considerably decreases production potential (LOWOUTPUT)*	53.4	68.4
16. Many high-tech agri production parks near big metropolitan areas (Metropolitan Agriculture) (METROPAGR)	38.7	36.8
17. Increased influence of religion and traditions on eating habits (TRAD)	23.2	25.4
18. Concentration of food production will narrow to 30-40 firms producing the overwhelming majority of the world's food (FOODCONC)*	18.6	29.4
19. The number of malnourished people decreases to at least one-quarter of the current number (MALNUTR)	17.6	16.8
20. Real price of agricultural commodities will decrease considerably (PRICEDECR)	15.1	16.7

Notes:
a. Data in the cells of the table represent the estimated average probability expectations of experts, calculated by replacing the interval ranges with mid-point values.
b. An asterisk (*) indicates a statistically significant difference between the two groups based on the results of the Mann-Whitney test.

Exploratory Factor Analysis

The input data obtained from the questionnaire is categorical (experts' estimation of ranges of probability of the occurrence of events, processes, or states) and we have therefore used categorical principal component analysis (CATPCA), as explained above. This method has proven to be an efficient method for analyzing the underlying constructs in which a large number of variables are involved, some of which may not be measurable. The principal component analysis yielded seven components with an eigenvalue of one or greater. However, the contribution of the seventh factor was marginal and the variable was omitted. The internal consistency of scales was evaluated by using Cronbach's apha. This statistic was greater than 0.65 for each of the remaining principal components. Because only two factors loaded on factor 4, Cronbach's apha was not calculated for this factor.

Because the factor analysis yielded results that were difficult to interpret we decided to employ factor rotation. We chose the most commonly-used method, Varimax rotation, developed by Kaiser (1970). A principal advantage of this method is that the variables tend to have either high or low loadings on the factors. Put another way, each state variable tends to be associated with a relatively small number of factors making the results more easily interpreted (Abdi, 2003). In opinion of Abdi (2003) "because the rotated axes are not defined according to a statistical criterion, their raison d'être is to facilitate the interpretation". While the application of other rotation methods may have led to slightly different results (Schmitt, 2011), the results obtained using the Varimax method were easily interpreted. The component-structure before and after rotation is summarized in table 5.

Table 5. Summary Results of the Categorical Principal Component Analysis

Principal Component	Extraction Sums of Squared Loadings	Rotation Sums of Squared Loadings	Chronbach's Alfa

Number	Total	Percent of variance	Cumulative Percentage	Total	Percent of variance	Cumulative Percentage	
1	5.744	28.718	28.718	2.625	13.123	13.123	0.826
2	2.209	11.046	39.764	2.542	12.710	25.833	0.799
3	1.802	9.009	48.773	2.418	12.092	37.925	0.789
4	1.523	7.617	56.390	2.333	11.663	49.588	-[a]
5	1.282	6.408	62.799	1.899	9.496	59.084	0.685
6	1.132	5.660	68.459	1.504	7.521	66.605	0.657
7	1.010	5.050	73.509	1.21	6.050	72.655	0.515

Notes:
a: Cronbach's alpha is not reported for principal component 4 since only two variables load on factor 4.

The results of the principal component analysis indicate the possibility that underlying the observed variables are some well-defined latent variables. These six, unobservable and unmeasurable latent variables, may be interpreted based on the variables that load on (or have the strongest relationships with) these factors (table 6). We identify the six principal components by giving them each a name that reflects the underlying processes.

Table 6. Principal Component Factor Loadings of State Variables on Outcome Variables

	Principal Component					
State variables	LOCAL	WARMING	CONCEN-TRATE	BIOTECH	INDIV	SUPPLY
WATER		0.790				
BIOPROD	0.570				0.416	
FOODPRICE	0.473					0.477
NUTRIFOODS					0.784	
TRUSTLOCAL	0.648		-0.346			
EMKTS						0.784
GM			0.456			
BIOMASS				0.351		0.739
AGRCONC			0.683			
URBAN	0.443				0.355	0.462
MIGRATE		0.708				

BIOTERROR	0.593					0.456
ACCEPTGM				0.706	0.304	
TRADECONC			0.707			
LOWOUTPUT		0.641				0.424
METROPAGR	0.701					
TRAD					0.811	
FOODCONC*		0.656				-0.405
MALNUTR	0.532					-0.627
PRICEDECR						-0.766

Notes:
a: The numbering of the principal components is the same as in table 6, where the first principal component is named LOCAL, the second, WARMING, and so on.
b: Only values above 0.3 are presented.

The majority of variables that have a significant loading on the first principal component, LOCAL, are related to the development of local food production systems. These include variables related to metropolitan and urban agriculture, trust in local products, and increases in prices of food from distant regions. Likewise, the variables related to the second principal component, WARMING, are generally related to the phenomenon of global warming. For the third factor, CONCENTRATE, the highest loading factors pertain to the concentration of firms within the global food system. All three areas of possible concentration, including concentration in the agricultural, food processing, and trade sectors, load on this component. This suggests that the experts believe that concentration will occur across all levels of the food system. The variable concerning trust in locally produced food products has a significant negative loading on CONCENTRATE. For the fourth component, which we named BIOTECH, the highest loading factors are related to statements regarding the acceptance and use of biotechnology and the use of biological products in energy production (biomass). Paradoxically, the loading of another item, GM, the global proliferation of genetically modified agricultural products, received a loading value less than 0.3 and was not included in the table. This result may be due to the divergence of opinion among the experts regarding the prospects for GM products. The highest loading factors for the fifth factor, INDIV, pertained to the increasing importance of individualization in food consumption patterns. The sixth principal component, SUPPLY, had positive loadings related to the problems of global food supply and malnutrition.

Confirmatory Factor Analysis

To better understand the structure of respondents' future expectations, we formulated a conceptual model to describe the relationship between the observed variables and their underlying latent constructs. The directly observed variables are analogous to independent (exogenous) variables, whereas the non-observable (latent or background) variables are analogous to dependent (endogenous) variables in regression analysis (Derksen and Keselman, 1992).

Based on the results of exploratory factor analysis, we developed hypotheses regarding the relationships between the observed measures and the underlying latent variables. As is general practice, the directly observed variables are portrayed as squares, circles represent the unobservable, latent variables, single–headed arrows represent the impact of one variable on another, and double-headed arrows represent relationships between pairs of variables that both impact each other (Byrne, 2009).

In this analysis, we attempted to describe the relationships between the observed variables and the latent variables, as expressed in the exploratory factor analysis. We used confirmatory factor analysis to test the adequacy of this conceptual model. The approach of this method is similar to regression analysis. However, contrary to simple regression analysis, we estimate not a single equation, but a system of regression equations. There are two types or such equations in the model: equations describing relations between the directly observed and the latent variables as well as equations describing relations between latent variables. The analysis was conducted by employing structural equation modeling, based on the Analysis of Moment Structure method (Arbuckle and Wothke 2004). The Chi-square of the model was 0.12, possibly a consequence of non-normality of the data. The Sttorra-Bentner scaled chi-square was 0.071 which may be considered acceptable. The adjusted goodness-of-fit index was 0.89 and the Browne-Cudeck criterion was 0.86. In summary, the model appears to have an acceptable fit.

Note: The values in the figure represent the standardized regression coefficients between the state variables and latent variables

The results of the confirmatory factor analysis generally support our conceptual model; however, we were not been able to determine a statistically significant model that included the latent variable, CONCENTRATE. Therefore, this variable was omitted, leaving five latent variables. Some of the key findings and our interpretations are discussed in the following paragraphs.

There was a strong, significant relationship between two variables, the expectation of decreasing agricultural production due to global warming

(LOWOUTPUT) and the expectation of the increasing importance of water in agricultural production (WATER) and the latent variable (WARMING), which we have so named to represent the prospect of global warming. We believe that the expectation of decreased production potential and water scarcity becoming an increasingly limiting factor to agricultural output may both be interpreted as a consequence of global warming.

The latent variable BIOTECH has only a weak association with the observed variables, ACCEPTGM, which measures the social acceptance of genetically modified foods, and GM, which measures the proliferation of biotechnology. This result may be explained by the wide divergence of opinions regarding the acceptance and use of biotechnology and the growth in the production of biological products. As we have seen, there are considerable differences among respondents concerning the future place and role of biotechnology in global agricultural development. Omitting this factor could improve the fitting parameters of the model considerably, but-on the another hand- the negligation of this factor could lead to a simplification of future development trends.

There was a high level of agreement that agricultural prices will not decrease (PRICEDECR), which may also be interpreted as the belief that prices will rise, or at least remain stable. In our model this was expressed as a negative relationship between the PRICEDECR variable and the latent variable, SUPPLY. We interpret this as an expectation that there will be increasing concerns and tensions surrounding the global food supply, which is expected to lead to stable or rising food prices, increased malnutrition (MALNUTR), the increased importance of agricultural production in emerging markets (EMKTS), and the possibility of bioterrorism (BIOTERROR).

The expectation of the increasing importance of bioproducts (BIOPROD) as well as metropolitan agricultural production systems (METROPAGR) both support the growing importance of local food supplies as expressed in the latent variable LOCAL. The importance of local food supplies is also supported by the expectation that foods produced in distant regions will experience rising prices (FOODPRICE).

Finally, the expectation of the increasing importance of specific nutritional food products (NUTRIFOODS) as well as the consequences of migration (MIGRATE) highlight the potential for a food system focused on personal preferences as represented by the latent variable INDIV.

Event Probabilities

The input-data for the scenario analyses were based on the results of the expert workshop. Six experts, a moderator, and one of the authors of this article participated in the workshop. All of the experts had at least ten years of international experience in agri-food research in a variety of geographical locations, under different socio-cultural conditions (Africa, China, Serbia, Northern Cyprus, Hungary). The workshop was held in July, 2009. We drew on six basic outcomes, which correspond to the six principal components of the categorical principal component analysis. These were as follows:

- As a consequence of global warming, agri-food production capacity will decrease throughout the world (WARMING);
- Further concentration of the agri-food industry, including agriculture, the food industry, and trade (CONCENTRATE);
- Increasing importance of local food supply systems (LOCAL);
- Increasing acceptance and use of biotechnology in agricultural production (BIOTECH);
- Increasing importance of satisfying individual food demands (INDIV); and
- Increasing global food supply issues (SUPPLY).

The input matrices were developed as follows. The experts were given information on the survey results and, based on this input, they were asked to estimate the probabilities and conditional probabilities of the six outcomes described above. The participants were asked to estimate three different probabilities for each of the outcomes: 1) the probability of occurrence of a given outcome without taking into consideration the other outcomes (a-priori probability); 2) pairwise estimation of the probability of each event occurring given that the other event in the pair occurs (Appendix II, equation 8); and 3) pairwise estimation of the probability of each event occurring given that the other event in the pair does not occur (Appendix II, equation 9). In this way, we obtain a vector of a-priori probabilities consisting of six elements and two matrices of conditional probabilities. We then calculated simple averages of all of the individual estimations. Finally, the final estimates were determined by group discussion until a consensus was reached. The vector of a-priori probabilities and the two matrices of conditional probabilities served as the input to the Smic-Prob-Expert software for the generation of the scenarios. The *a priori* and conditional estimates of probabilities are presented in tables 7, 8, and 9.

Table 7. *A-priori* Probabilities of Events

Outcome	Probability of Occurrence
LOCAL	0.81

WARMING	0.87
CONCENTRATE	0.65
BIOTECH	0.82
INDIV	0.85
SUPPLY	0.78

Table 8. Conditional Probabilities of Different Processes Based on the Occurrence of Conditional Events

	Probability Event					
Conditional Event (Event Occurs)	LOCAL	WARMING	CONCEN-TRATE	BIOTECH	INDIV	SUPPLY
LOCAL	-	0.87	0.55	0.72	0.85	0.69
WARMING	0.92	-	0.74	0.90	0.82	0.95
CONCENTRATE	0.60	0.87	-	0.92	0.81	0.77
BIOTECH	0.71	0.87	0.70	-	0.87	0.72
INDIV	0.90	0.87	0.65	0.88	-	0.78
SUPPLY	0.92	0.87	0.77	0.90	0.75	-

Table 9. Conditional Probabilities of Different Processes Based on the Non-Occurrence of Conditional Events

Conditional Event (Event Does Not Occur)	Probability Event					
	LOCAL	WARMING	CONCEN-TRATE	BIOTECH	INDIV	SUPPLY
LOCAL	-	0.84	0.78	0.91	0.58	0.72
WARMING	0.68	-	0.57	0.64	0.70	0.57
CONCENTRATE	0.84	0.54	-	0.65	0.85	0.59
BIOTECH	0.75	0.92	0.60	-	0.61	0.84
INDIV	0.62	0.84	0.87	0.73	-	0.82
SUPPLY	0.54	0.67	0.51	0.54	0.82	-

In the following discussion, we examine how the expert panel viewed the likelihood of each of the six events both independently and in relation to the other events. When addressing the global warming and supply issue variables we discuss how these expert assessments compare with those from other forecasting and scenario analysis studies as well as the assessments of other experts. Because the number of studies relating to these events is extremely large we have chosen to include in our discussion only those studies that we deem most relevant based on the extent to which the studies addressed global agriculture and food systems.

The subject of global warming and climate change has received a great amount of attention by politicians, scientists, activist groups, and the public in general. Moreover, a great deal of research has been devoted to the topic. Among our experts, there is a strong consensus that the negative consequences of global warming on agri-food productivity are practically unavoidable. This is our strongest and most consistent finding with an estimated likelihood of 0.87. Interestingly, the pairwise probability estimates indicate that the negative impacts of global warming are perceived to be generally independent of the occurrence or non-occurrence of other events (tables 7 and 8). Only when the CONCENTRTATE or SUPPLY events are not expected to occur is the probability of WARMING deemed to be substantially less. One interpretation is that supply issues and further concentration may be seen as indicators of more rapid development and that the absence of these events may be interpreted as an indicator of slower development which in turn may make severe climate change less likely.

Our results are highly consistent with the results of many recent studies and reflect converging agreement in the scientific community not only that global warming will occur but also that there will be negative consequences for food production. Perhaps the largest and most widely respected effort to understand climate change and its impacts is the Intergovernmental Panel on Climate Change (IPCC). The IPCC estimates various scenarios for climate change with projected increases varying between 1.8 to 4 ^{0}C for the period of 2000 to 2100 (IPCC 2007). In another study, Rogelj et al. (2012) estimate global temperature increases of 2.3 to 4.6 ^{0}C above the pre-industrial level by 2090-99.

The impact of global warming on agriculture is less certain. For example, Gornall et al. (2010) argue that climate change will have both positive and negative impacts on agriculture and that the result is location dependent. However, Jaggard et al. (2010) note that the increased prevalence of extreme events, including heavy rainfall, flooding, extreme heat, and droughts will negatively affect food production. The IPCC (2007) also predicts a reduction in crop yield and lower livestock productivity as a result of climate change.

We view the possibility of supply issues (SUPPLY) as closely related to that of climate change. This is supported by our expert panel’s evaluations. While the independent probability expectation of supply issues is 0.78, this increases to 0.95 should WARMING occur. Indeed many of the potential supply issues could be triggered global warming, including water availability and plant and animal productivity, and the susceptibility of agricultural production to extreme events such as droughts and floods.

Supply issues, particularly those focusing on specific resources, such as land, energy, and water, have been the focus of a great many studies. Lambin and Meyfroidt (2011) note that the supply of land not currently in production is expected to be exhausted by 2050. Energy is a cornerstone of modern agriculture and supply restrictions or higher prices would have a major impact on agricultural systems. Aleklett et al. (2010) conclude that peak oil production has already occurred and that there will be a "gentle" decline between 2008 and 2030 in production in their "Uppsala" scenario. Water has been the focus of a great deal of research and there is a high level of agreement that water will become increasingly scarce. Almaco et al. (2007) predict that water stress will increase in the majority of river basins (62 to 76 percent) and that the principal cause will be increasing water withdrawals. Hejazi et al. (2014) foresee a growing demand for water will result in low to severe water scarcity in most regions of the world by 2050, with the severest scarcities occurring in the Middle East, India, and China.

The increasing acceptance and use of biotechnology in agricultural production (BIOTECH) had a likelihood of 0.78. In contrast some of the other factors, particularly global warming, the BIOTECH factor is not expected to have a large impact on the occurrence of other events. That is the occurrence or non-occurrence of this event does not generally influence that experts' assessment of the likelihood of other events. Given the divergence of opinions regarding the factors associated with BIOTECH, it is hard to draw any conclusions other than that this factor is seemingly viewed as independent from the other factors.

Little has been written on the issue most germane to this discussion, i.e. the future prospects for the acceptance and adoption of biotechnology. However, much has been published on the potential, impact, and politics of biotechnology. From a scientific perspective, the issue is largely settled. An overwhelming majority of the scientific community throughout the world supports the application of modern biotechnology (Varshney et al., 2010; Ahmad et al., 2012). However, the political debate is far from over. While biotechnology is largely accepted in many regions of the world, particularly in the United States and much of the Americas, there has been great resistance to the use of biotechnology in Europe. John Davison (2010), of the Institut National de la Recherche Agronomique in France, writes that, "Europe has probably the strictest GMO regulations in the world, though these derive rather from political considerations, rather than being based on upon scientific principles. The European anti-science attitude reaches the highest levels of the EU bureaucracy...” The widespread acceptance of biotechnology in the Americas, particularly the United States and the political aversion to biotechnology in Europe highlight the stark choices facing policymakers throughout the world. However, these two perspectives offer little insight as to the direction the world will take regarding the application of biotechnology to agriculture.

The further concentration of businesses in the agri-food chain (CONCENTRATE) seems likely with an estimated probability of 0.65. As previously discussed, the different perspectives on concentration in the agri-food chain may reflect the differing experiences with and widespread debate over the role of small-and medium-size enterprises (SMEs) in the agri-food sector in many regions throughout the world (Kadocsa 2006; Husti 2009).

In contrast to the WARMING variable, the concentration of firms in the agri-food sector (CONCENTRATE) is viewed as being dependent on other factors. In the opinion of the experts, the concentration of agri-food firms is more likely in the event that the consequences of global warming (WARMING) or global supply issues (SUPPLY) become significant. This can be seen by comparing the relatively high probability assigned to firm concentration should global warming or supply issues develop as compared to the a-priori estimation of the probability of agri-food firm concentration. On the other hand, the expert assessment of the probability of further industry concentration drops when it is assumed that global warming or supply issues do not develop. We believe that this assessment is due to the presence of scale effects associated with issues that might accompany global warming or supply problems. In other words larger firms may be better equipped to deal with issues related to global warming and supply.

The experts also assigned a high probability (0.81) estimate to the increasing importance of local food production systems (LOCAL). This variable is associated with the development of metropolitan agriculture (METROAGR) and higher food prices in distant regions (FOODPRICE), as well as increasing interest in bio-products (BIOPROD). The likelihood that local food systems will be increasingly important is estimated to be higher than the *a priori* estimate given increasing individualization in food demand (INDIV), increasing food supply issues (SUPPLY) and increased global warming (WARMING) is higher than its a-priori probability. Our interpretation is that some of the same demand factors may affect consumer preferences for locally-produced food as well as food that meets their individual preferences. Furthermore, it appears that the our panel sees issues associated with supply and global warming as creating an environment that supports demand for locally produced food.

The importance of satisfying individual food demands (INDIV) had an *a priori* estimate of 0.85. It was strongly associated with consumer increasing interest in tailor-made nutrition (NUTRIFOODS) and increasing migration from developing countries to the developed world (MIGRATE). The results of the pairwise, conditional probabilities indicated that the INDIV variable did not vary much with the occurrence of other events. However, the demand for individualized foods was perceived as much less likely should the increased importance of local food systems or the increased acceptance and use of biotechnology not occur. Again, it would seem that the experts see that the demand for local and individualized food may share some common demand factors. We interpret the importance of biotechnology as being key to the development of specific products, such as nutraceuticals that will enable the production of individualized food products.

Scenario Analysis

Based on expert-estimations of a-priori as well as conditional probabilities of different processes we have generated a set of scenarios using the Smic-Prob-Expert algorithm. The output of the Smic-Prob-Expert algorithm is a set of scenarios with different combinations of the six basic outcomes. Although 38 scenarios were generated, only the three scenarios with a probability of greater than 10% are presented and discussed below. The three scenarios along with a descriptive name and the probability of the scenario's occurrence are presented in table 10.

Table 10. Three Most Likely Scenarios for the Agri-Food Industry

Scenario Name	Scenario Characteristics	Probability (%)
PANTA RHEI (Everything Moves)	Includes… - increasing effects of global warming - increasing concentration of agricultural, food industry & trade - increasing importance of local food production systems - increasing application of biotechnology - increasing individualization in food consumption - increasing food supply problems	26

DISTRIBUTED FOOD SYSTEMS	Includes… - increasing effects of global warming - increasing importance of local food production systems - increasing application of biotechnology - increasing individualization in food consumption Without - increasing concentration of agricultural, food industry processing & trade - increasing food supply problems	19
CONCENTRATED SUPPLY SYSTEMS	Includes - increasing effects of global warming - increasing further concentration of agricultural, food processing & trade - increasing application of biotechnology - individualization in food consumption Without... - increasing importance of local food production systems - increasing food supply problems	12
All other scenarios		43

The highest probability scenario (26%) is characterized by presence of all of the principal variables. We call this scenario PANTA RHEI[1] or Everything Moves. PANTA RHEI forecasts a future of concentrated agri-food systems, characterized by considerable changes in the conditions of agricultural production (supply issues and global warming), increased application of biotechnology and consumer preferences for local and individualized foods.

[1] Πάντα ῥεῖ (*panta rhei*) "everything flows", or "all things are in flux"–a Greek philosophical statement, falsely attributed to Heracleitos. This phrase is attributed to Theodorus, an associate of Protagoras (Chappel, 2004)

In this scenario there will be parallel processes of concentration and development of local production capacities as described by Watts and Goodman (1997). Both of these processes are supported by previous research. For example, Hawkes and Murphy (2010) discuss increased foreign direct investment as a driver of further concentration within the agri-food sector and Feagan (2007) discusses the growing importance of local production systems. This scenario also emphasizes the importance of the application of the latest methods of biotechnology in developing agricultural production, which may support increased demand for individualized food products

The second scenario, with a probability of 19%, is labeled DISTRIBUTED SYSTEMS because it does not forecast the further concentration of production capacities, but rather a focus on distributed, local production systems. One way to interpret this scenario is that food production would be supported through the application of biotechnology and would occur in the presence of the effects of global warming, but without severe global food supply issues.

The third scenario, CONCENTRATED SUPPLY SYSTEMS, has a probability of 12%. Our interpretation of this scenario is that consumer demand will be met through the development of concentrated food production systems with increased application of biotechnology. This scenario envisions decreased food production capacity as a result of global warming without severe global supply issues.

The three scenarios presented above provide alternative visions as to how the world, and, specifically the global agri-food system may look in 2030. In our view, scenarios are most useful in examining different ways that events or combinations of events may unfold. While the probabilities associated with each of the scenarios give us some indication of the perceived likelihood of each scenario, we should note that the likelihood of “all other scenarios” at 43 percent, is greater than that of our “most likely” scenario with a likelihood of 26 percent. The subsequent discussion will focus on how the various events within the three listed scenarios relate to each other and add “color” to the main features of each of the scenarios.

The scenario PANTHA RHEI may seem somewhat contradictory. In our analysis, we have seen that some variables are perceived as more or less likely depending on the occurrence or nonoccurrence of other variables. However, under PANTHA RHEI all of the events are expected to occur. This begs the question of how all events might occur simultaneously despite the apparent contradictions between events. For example, increased concentration in the agri-food chain is in apparent conflict with the growing importance of local food systems. Of course, there are multiple pathways whereby the events might occur and in fact relate to each other. We can envision a world wherein increased concentration in the food system may be a viable way to confront the challenges of global warming and supply issues. Moreover, increasing firm concentration does not necessarily imply increasing geographical concentration. It is entirely possible, if not likely, that demand for locally produced food may be met by large firms with sophisticated production and operation systems that focus on regionally- or locally-appropriate production systems. The apparent inconsistencies in the PANTHA RHEI scenario serve as a reminder that the scenarios represent events, but not the pathways underlying the events. We can see how the events relate to each other but not what drive these events and lead to a particular configuration.

It is interesting to note that increasing global food supply issues are not projected to occur in the latter two scenarios. In our view, the absence of such pressures highlights the adaptability of the global food system to meet the many challenges that are projected to occur over the next several decades. The alternative scenarios underscore the various ways that the future may unfold. Furthermore, we believe that the absence of severe supply pressures and the consequent increased food insecurity and higher prices that would likely accompany such pressures may make it more likely that diverse scenarios may occur. Put another way, severe global food supply issues may constrain governments and other key actors to address the issues in the most expedient way possible and constrain choice in important areas such as firm concentration and local food production.

The DISTRIBUTED SYSTEMS scenario provides insight into how an unexpected configuration of events might occur based on adaptation within the global food system in response to external events. One factor that could give rise to this scenario is rising energy prices, which would lead to considerable increases in the relative transportation costs (Egger et al. 2013). Higher energy prices would make food produced in distant locations relatively more expensive than that produced locally, other things equal. This scenario highlights the increasing tendency to internalize the full cost of energy, which could lead to a shift to more local food production systems (Fouquet 2011). Moreover, it is consistent with the local food movements' emphasis on reducing "food miles." This scenario, with the absence of increased supply pressures, is supported by results of Parry et al. (2004). According to their simulation results, a more concentrated food production system would result in greater yield reductions than with a more regionalized system. Such a system would meet Dahlberg's (1992) vision of a food system that achieves a global balance between food, population, resources, and the conservation of genetic and biological diversity by emphazing the importance of local and regional markets, maintaining farm and regional diversity, rural revival, decentralization, and utilizing local species.

The CONCENTRATED SUPPLY SYSTEMS scenario foresees a world without increasing supply pressures and is in some ways the opposite of the DISTRIBUTED SYSTEMS scenario. It portrays a world with more concentrated production, processing, and distribution systems without an increased emphasis on local production. As we discussed previously, expert opinion was split on the likelihood of increased concentration in the agri-food sector, which may in part explain the two contradictory visions of how the global food system will evolve. The impacts of increased firm concentration in economic systems in general (Daughety 1990; Brock and Obst 2009), and on the agri-food chain in particular (Sexton 2000), have been heavily debated issues with strong arguments on both sides of the issue. Apart from the academic debate, it is clear that numerous forces support continued concentration of firms in food production processes. One such force is a persistent tendency towards concentration in the agricultural inputs industry (King, 2001). Another force is regional economic integration that promotes geographical concentration, a phenomenon that has been demonstrated in the case of the European Union (Krieger-Boden et al. 2008), and ASEAN countries (Kuroiwa 2012). Yet, a third force is the increasing activity of multinational companies in agri-food sphere (Rama, 2005). This scenario may be viewed as an alternative whereby gains in the form of efficiency from concentration in agricultural production, food processing, and distribution

We can also envision how the second key aspect of the CONCENTRATED SUPPLY SYSTEMS scenario may unfold. Consumers throughout much of the industrialized world Despite the strong consumer and environmental arguments for local food production, evidence has begun to emerge that indicates the emphasis on food-miles may have unintended consequences. Ballingall and Winchester (2010) have shown that decreasing the number of miles that food travels could actually have a negative effect on world's poorest economies without yielding a significant reduction in environmental damage. Weber and Matthews (2008) show that the greenhouse gas emission associated with food are dominated by the production phase (83%) and that long-distance transportation and the final delivery from producer to retail contributes to only 15% of life-cycle emissions. Thus, producing food closer to home might actually harm local consumers, particularly if the production costs were substantially higher than that of food produced in distant regions thereby reducing the impetus behind the preference for local foods.

1.5. Concluding Remarks

The scenarios developed in this study foretell a world in which the global food system will face substantial new challenges, many of which will occur concurrently. One of the principal predicted events, global warming and its impact on food production, is viewed by the great majority of experts as inevitable. However, even in the case of global warming, which has the potential to impact many aspects of the global food system, the dynamic nature of the agri-food system offers many possibilities to mitigate global warming's negative effects. In particular, the opportunity for increased efficiency through greater industry concentration, the wide-ranging application use of biotechnology, and the judicious use of local food production offer the prospect of offsetting the possible adverse effects of climate change in an era when food demand is expected to increase substantially. The challenges and opportunities highlighted in this research underscore the importance of preserving the agri-ecologic production potential and the development of knowledge and human resources to meet the needs of global food demand.

The projected scenarios, which paint sometimes contradictory visions of the future, remind us that the future is not deterministic and that a multitude of factors will determine how events unfold and interact. We conclude by suggesting that there is great opportunity to influence the outcome of the global food system by the many actors who work within the system, shepherd its resources, consume its products, and shape its structure.

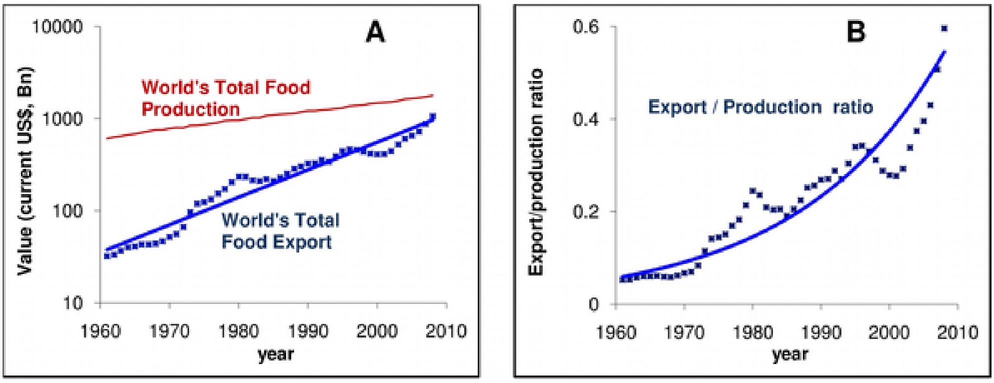
Methodically, an important lesson of our research, that in organisatinon of such collective estimations, we should more intensive utilize the rapidly developing tools of computer-based simulations to study some future events and their consequences. Such easy manageable tools, like e.g. climate wizard (Girvetz et al., 2009; www.climatewizzard.org) offer a unique possibility to quantify possible climate changes under different initial conditions. Similarly, the identification and analysis of different position of socio-economic actors, shaping the landscape of regulation of genetically modifies agricultural materials could had been an important step towards the better understanding of current contradictory situation. These effort can be easily supported by MACTOR model, developed by the same team, as SMIC-PROB-EXPERT (Godet and Roubelat, 1996). A third, important tool could be at organization and management of similar workshops the system dynamic software (e.g. the freely available Insight maker). Application of these tools would be a great help in studying highly complex processes with positive and negative feedbacks. However the establishment of differential equations and their correct parameterization (determination of different initial values as well as constants) of a system dynamic model is extremely time-consuming process, running of such models could help the panel-members to grasp the consequences of some changes in model-parameters.

2. THE GLOBAL FOOD TRADE NETWORK

By 2030, food demand is expected to increase by 50% and thus the global food supply is playing an increasingly critical role in the economical and political landscape,. The latest deadly food poisoning outbreaks in 2011 (*Escherichia coli* in Germany], *Listeria monocytogenes* in the US) and their economic, political and social effects clearly illustrated the importance of prompt tracing of the origin of specific food ingredients. This task is placing a huge pressure on regulation and surveillance.

Since the 1960-s, global food transport has been increasing at an exponential rate, faster than food production itself, as illustrated in Fig. , which was generated using ComTrade, an agro-food import-export database of the United Nations (UN). The picture becomes even more complex if we factor in the growing number of countries relying on international food trade and, additionally, the fact that the traded food types have been increasingly moving from agricultural raw materials and staples towards processed and branded products. As a consequence, food fluxes between countries form a complex, dynamic web of interactions referred here as the International Agro-Food Trade Network (IFTN). For several countries, this web ensures access to any food item regardless of season and location. However, it may also present serious vulnerabilities. As we show here, the IFTN has become a densely interwoven complex network, creating a perfect platform to spread potential contaminants with practically untraceable origins.

- **Figure 1. The world's food trade grows faster than the food production.**



Ercsey-Ravasz M, Toroczkai Z, Lakner Z, Baranyi J (2012) Complexity of the International Agro-Food Trade Network and Its Impact on Food Safety. PLOS ONE 7(5): e37810. doi:10.1371/journal.pone.0037810
http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0037810

PLOS | ONE

Figure 1. The world's food trade grows faster than the food production.

(**A**) (Log-linear scale). The world's food production (thin red line), measured in current Billion US$, doubles in ca. 30 years, while the amount of food transported on the IFTN (linearly fitted small squares, blue) increases by ca. 10-fold in the same time. (**B**) (Linear scale). Food ingredients flow at an increasing rate from countries to countries, as shown by the exponentially increasing [world export]/[world production] ratio calculated from the above data (small squares fitted by an exponential curve). Note that this ratio is unaffected by the US$ inflation rate. Data obtained from UN databases [6], [23].

http://dx.doi.org/10.1371/journal.pone.0037810.g001

Using the ComTrade database [6], we constructed the IFTN and analyzed its structure and dynamics during the last ten years. Fig. 2, based on the 1998 data, shows a typical picture of the IFTN.

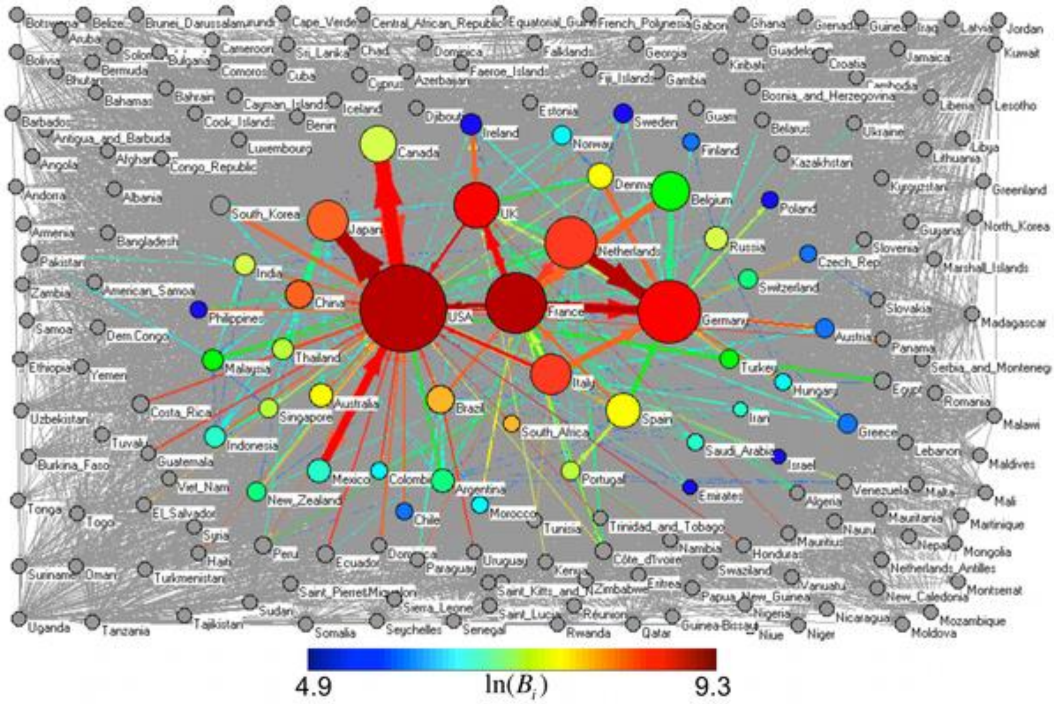


Fig. 2

Teh compelete international Agro-food trade network

The nodes of the network represent the countries, while the directed and weighted edges indicate the food trade fluxes between the countries. The magnitude of a flux (edge weight) represents the total value of the annual agro-food trade expressed in current US dollars (US$) from one country to the other. The size of a node is drawn proportional to the total import-export value of the country, while the thickness of an edge is proportional to the log-value of the food-flux it represents. Colors indicate the betweenness-centrality values of the nodes and edges.

2.1. General Trends and Structure of the IFTN

The total amount of food-flux in the IFTN grew from 438Billion (B) US$ in 1998 to 1060B US$ in 2008; a 2.3-fold increase, while the total food production grew only 1.4-fold in the same period (from 1,400B US$ to 1,780B US$). The density of the IFTN increased from 25% in 1998 to 33% in 2008. Unlike homogeneous random graphs, the IFTN has a broad degree distribution, indicating a heterogeneous network structure. The distribution of fluxes (number of edges with flux values within a given range) can be approximated by a lognormal distribution, implying that this distribution is also broad, with a fat tail.

The IFTN is based on reported export, involving N=207 countries (nodes) drawn as disks and M = 10645 trade fluxes (those worth more than 1 million US$), drawn as directed edges/links. The top 44 countries with the largest total trade activity (import+export) and the top 300 largest food-trade fluxes were colored according to their betweenness values. The rest of the countries and edges are drawn with gray. The sizes of the colored disks are proportional to the logarithm of their total trade activity, $\ln(E_i+I_i)$. The thickness of the directed links is proportional to the log value of the trade flux in that direction, $\ln(\Phi_{ij})$. The structure of the IFTN was similar throughout 1998–2008.

A frequently used measure in the structural analysis of complex networks is the node- or edge-betweenness centrality. It quantifies how "central" is the position of the node/edge in the network, in the sense that high centrality nodes/edges collect large portions of the traffic through the network. For this reason, they also present the Achilles' heel of a network as changes in the status of these nodes and edges will have the largest effect on the whole system, both in connectivity and transport properties. Nodes with top centrality values play a critical role in the IFTN because any food-born substance (e.g. chemical or microbiological contamination) will spread most efficiently through them into the rest of the network, while tracing the source of such a substance is difficult due to the large number of network paths running through these nodes. Fast spread is also facilitated by the small value of the average shortest path (measured in hop-counts) of the IFTN, which is $L = 1.52$. That is, on average, one can reach any node in less than 2 hops from any other node along shortest trade routes. Though a single, specific food ingredient may not necessarily follow the shortest paths in the IFTN (e.g., it could be included into more complex foods and sent on various routes), the small value of the average shortest path length is still an indicator of the close proximity of almost all the nodes, guaranteeing fast spread on the network.

(**A**) Histogram of fluxes (blue bars) fitted by a lognormal distribution (solid continuous line). The parameters of the fitted distribution for $\ln\Phi$ are $\mu=7.68$ (mean) and $\sigma=3.42$ (standard deviation). The flux Φ is expressed in thousand US$ units. (**B**) Histogram of the betweenness centrality values of nodes and (**C**) edges. (**D**) A scatter-plot of degree *vs.* betweenness for every country. The figures represent the 2007 dataset. These distributions show that the network is dominated by a centrally positioned small set of countries (shown with their 3-letter codes on the figures) and their trade relationships. Interestingly, despite its relatively small size (compared to other high betweenness countries such as USA or Germany), The Netherlands, with trades totaling 50B US$ in imports and 79B US$ in exports in 2008, has assumed a top centrality position over the years.

Countries with high betweenness also tend to be *network hubs* in the IFTN, *i.e.* they tend to have the largest degrees. However, there are also high degree countries that do not have high betweenness centrality values (*e.g.* Belgium). Note the role of Russia as a “bridge”-node, with a relatively high centrality, but a lower degree. A core group of 7 nodes (within the oval in the picture), each engaging in trade relations with at least 77% of all the world’s countries. When combined, they are responsible for 30% of the total trade flux. These 7 nodes present hotspots for the whole of the IFTN, as changes in their status would generate the largest global impacts.

Although USA has the largest betweenness value, the per-capita trade activity is largest for The Netherlands. Therefore, combining this with the fact that it has the 4-th largest betweenness, the food traders of The Netherlands have probably made their country into the most critical hub of the IFTN. Assuming that this overall picture of the network is sufficiently representative for food products that may act as suitable vectors for microbiological or chemical contaminations, the products that start from or go through The Netherlands would most efficiently affect the whole system.

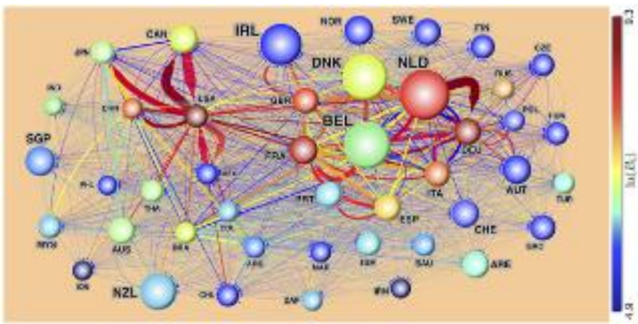


Figure 4. The backbone of the IFTN based on the 2007 dataset.

The backbone is formed by the top 44 nodes (countries) with the largest total trade activity (import+export). Nodes and edges are both colored by their betweenness values; the thickness of the directed edges is proportional to the natural logarithm of the trade value in that direction, as in Fig. 2. The size of a node, in this figure, is proportional to the logarithm of the *per capita* trade activity, *i.e.* $\ln[(E_i+I_i)/\Pi_i]$ where Π_i is the population size of the country *i*. Countries are labeled by their 3-letter ISO 3166 codes.

2.2. Spread and Tracing on the IFTN

The above observations made about vulnerabilities are based on graph-theoretical properties of the IFTN. Next, we develop a dynamic model, by tracking the food fluxes between the countries (Food Flux Model, or FFM), which will further underscore the potential of the IFTN to efficiently spread contaminants, and the poor outlook for their traceability. For brevity, in what follows, by “contaminated food” we mean a food item that contains some specific substance (such as chemical or microbiological contamination but it could also be common additives, or a subset of ingredients) to be followed or traced along the food trade pathways.

The total import (export) into (from) a country i can be written as: $I_i = \sum_{j,j \neq i} \Phi_{ji}$ and $E_i = \sum_{j,j \neq i} \Phi_{ij}$ respectively. Suppose that a country i produces an amount of P_i of a certain food, out of which $P_i^{(in)}$ is consumed there, while the rest $P_i^{(out)}$ is exported (Fig. 5), and thus $P_i = P_i^{(in)} + P_i^{(out)}$. Let r_i denote the fraction of the imported food, which is passed on to other countries (via resale, repackaging, or after processing it into more complex food items). We can estimate the r_i fractions as follows. The fraction of imported and produced food that is locally consumed (obtainable from the FAOSTAT food balance sheets) can be written as $\alpha_i = (1-r_i)I_i/P_i^{(in)}$. If we assume that consumption is proportional to the size of the population of a country (at least for the highest trade activity countries shown in Fig. 5), we can write: $(1-r_i)I_i + P_i^{(in)} = c\Pi_i$, where c is the typical value (in US$) of food consumed by a person in a year in the country i with a population of Π_i.

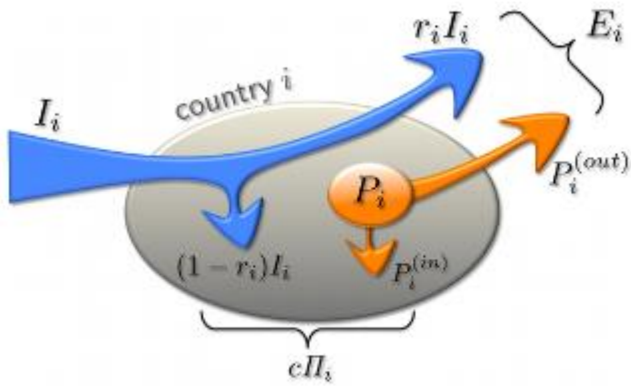


Figure 5. Schematics for the Food Flux Model.

Country i with population of P_i has a total yearly agro-food import I_i , out of which $r_i I_i$ is exported, and $(1-r_i)I_i$ is consumed locally. A specific food ingredient to be tracked is produced in this country in the value of P_i from which $P_i^{(out)}$ will be included into its total export E_i , while $P_i^{(in)}$ is consumed locally. The parameter c represents the average value (in US$) of the food consumed by a person in a year.

We estimated the value of c, for the backbone of the IFTN, to be at around 10^4 US$. This value is fairly constant over the backbone-countries. The reason is that these countries are approximately on the same level of economic development, and there is a low degree of variance between the shares of foods. (The analysis can, of course, readily be repeated with country-specific c values). From the above two equations it follows that. $r_i = 1\ [c a_i 1 \Pi_i/(1+a_i)I_i]$.

Suppose that a country s produces an amount of D_s from a specific food ingredient and passes it to its neighbors in the IFTN at rates proportional to the food-fluxes (Φ_{sj}) towards those neighbors. A fraction r_j of that "contaminated" food, namely $r_j D_s \Phi_{sj}/E_s$ is then exported towards the neighbor j, while the rest, $(1–r_j)D_s\Phi_{sj}/E_s$ is consumed locally. The following recursion then describes the way food ingredients spread on the IFTN: $D_{i|s}(n+1) = \sum_{j,j\neq i} r_j D_{j|s}(n)\frac{\Phi_{ji}}{E_j}$, (1)where n denotes the number of export steps, $D_{i|s}(n)$ the amount (in dollar value) of food containing the ingredient in question, arriving into country i on the n-th step (this also allows for re-appearance in the same country), given it started from country s, and the summation is over all the neighbors j of i in the IFTN. The amount of food $D_{i|s}^{(in)}(n)$consumed in country i that contain the tracked ingredient can be obtained from the recursion

$D_{i|s}^{(in)}(n+1) = D_{i|s}^{(in)}(n) + (1-r_i)D_{i|s}(n+1)$(2)The initial conditions for (2) are given as $D_{i|s}(0)=0$ if $i\neq s$ and $D_{s|s}(0)=\beta E_s$, where β represents the contaminated fraction of the export from country s. We chose $D_{i|s}^{(in)}(0)=0$ for all i.

We simulated and recorded the contamination spread for $n=5$ steps, from every one of the top 44 countries with the largest trade activity as shown in Fig. 4. After the simulations, we selected the top ten (s,t) source-target pairs with the largest contamination $D_{t|s}(n)$ at the target country; see Table 1. Germany came out with the largest potential for contaminated food import with The Netherlands as the source of the contamination.

SOURCE	TARGET	$D_{t|s}(n)$ (Million US$)
The Netherlands	**Germany**	**6.48**
USA	**Japan**	**6.46**
Canada	**USA**	**6.05**
USA	Canada	5.24
USA	USA	4.97
France	Germany	4.93
The Netherlands	UK	4.63
Germany	Germany	4.24
The Netherlands	France	4.40
The Netherlands	USA	4.02

Parameters used for the simulation: $\beta=0.001$ and $n=3$.
doi:10.1371/journal.pone.0037810.t001

Table 1. Largest $D_{t|s}(n)$ contamination values and the respective source-target pairs using the 2007 dataset in the Food Flux Model.

Considering the above mechanism as a *worst-case scenario*, we may assess how a contamination starting from a source country *s* affects the *global population*. This can be quantified via $R_s(n) = \sum_i D_{i|s}^{(in)}(n)$, which we call the contamination impact.

(A) Evolution of the contamination impact $R_s(n)$ and **(B)** vulnerability $V_i(n)$, for the top 14 countries as function of the export steps, *n*. **(C)** "Vulnerability *vs.* betweenness" scatter plot for the 44 countries with the largest trade activity. Countries with significant food poisoning cases in the last 15 years are indicated by encircled symbols. In particular: the 2011 *Listeria* outbreak in the USA, from produce, causing 29 deaths; the 2011 *E. coli* outbreak in ermany, from red beet sprout, with 46 deaths and 4000 diagnosed cases; the *Salmonella* outbreak in 2005 in The Netherlands with 165 diagnosed cases; the 1996 *E. coli* outbreak in the UK with 512 confirmed cases, 17 deaths; the 2008 *Listeria* outbreak in Canada with 57 diagnosed cases and 27 deaths; the 1996 *E. coli* outbreak in Japan, from radish sprout, with 2 infant deaths and more than 5000 hospitalized.

We can also define a vulnerability measure $V_i(n)$ for a country *i*, as the *average impact* generated by other countries as if the contamination started from there, where the average is taken over all sources. The ranking for the countries with the highest impact and vulnerability values is practically independent of *n*, the number of export steps. As the diameter of the IFTN is small, contamination can spread very efficiently, and thus already modest values of *n* will start capturing the effects on the whole network.

2.3. Discussion

The World Trade Web (WTW) has been extensively analyzed by network methods, for example in and. Our aim was not to repeat it for a subset of the WTW, but to demonstrate that the trends cannot be sustained if both free trade and the demand for biotracing are to be met. During a food poisoning outbreak the first and most important task is to identify the origin of the contamination. Delays in this task can have severe consequences for the health of the population and incur social, political and economical damages with international repercussions. A case in point is the consequences of the three weeks delay in identifying the origin of the *E. coli* contamination in Germany in June 2011.

Note that our study *does not predict* an increase in the number of food poisoning cases but that, when it happens, there will be inevitable delays in identifying the sources due to the increasingly interwoven nature of the IFTN. That is, even if food contamination was less frequent, for example due to better local control of production, its dispersion/spread is becoming more efficient. In particular, our study identifies critical spots in the network that may seriously hamper future biotracing efforts. Although the analysis presented here is based on coarse data representing aggregated food fluxes, it can also aid with biotracing, in a “Bayesian approach” sense by providing a list of *most probable* sources and pathways to be used as starting points.

Recently there have been calls for an interdisciplinary approach to monitor, understand, and control food trade flows as it becomes an issue no longer affecting just single countries, but the global livelihood of the human population. Such an approach would facilitate a better understanding of the IFTN, especially if it is broken down into time-scales, food types and their interdependencies. This would: 1) contribute to protection against outbreaks and intentional attacks; 2) help devise better traceability methods and thus increase consumer confidence; 3) allow for a better distribution of food and thus reduction of wastage, estimated to be about 30 – 40% globally; 4) increase the reliability and stability of supply systems; and 5) help decrease the environmental burden of food production and distribution logistics. Such an interdisciplinary approach is entirely within the means of the state-of-the art of science and technology, if supported by detailed and systematic data collection. The role of state and interstate organizations (e.g. EU, UN) is essential in this. Although much of the food commerce and trade happens through the private sector, information collection and sharing should be incentivized to generate the data needed for an in-depth knowledge of the structure and dynamics of the IFTN, to ensure the safety and security of the global food system.

3. REGIO-AND ETHNO-CENTRISM IN HUNGARIAN FOOD ECONOMY

Through perusing and analysing the relevant literature, we have sought answers to the following hypotheses:
H1 : ethnocentrism is on the rise among Hungarian consumers;
H2 : in parallel with ethnocentrism, there is a growing interest in regional products;
H3: the various consumer groups may also be segmented on the basis of their ethnocentrism / preference of regional products;
H4 : there is a correlation between ethnocentrism / preference of regional products and certain properties of consumers' socio-demographic situation;
H5 : selling local products is gaining importance for small food stores, and it provides a key chance for survival by implementing focusing strategies;
H6: the logistic models can verify that regional food production has less additional costs in terms of systems operation.

We endeavoured to combine diverse procedures to underpin my research. The key methods include the complex processing of the relevant technical literature (research in Hungary until now have mainly focused on the analysis of Hungarian publications, therefore, we also undertake to present and carry out the critical analysis of English and German sources) and an online survey series with 1,000 respondents.

3.1. RESEARCH OBJECTIVES

The study of the correlations of ethno- and regiocentrism and environmentally conscious consumer behaviour have a long history in both international and Hungarian research activities. Nevertheless, we have no complex and comprehensive concept that could serve as a comp assor clue for professionals involved in preparing governmental decision-making in this field, as well as for the specialists of professional and advocacy organisations, and the corporate sector, presenting the opinion and attitude of the Hungarian public towards these matters. The past years have witnessed several factors that affected the theme under review one way or another. Some highlights:

- Hungary has been the member of the European Union for more than ten years. One may have reason to presume that the trends the population and economy of the EU represent have spread among a wide range of the population (Horváth et al. 2012);
- Hungary has had a flat economic performance for a long time: economic growth practically stopped in 2006, followed by a last upswing in 2007, then the economic crisis broke in 2008 with its lingering impacts still perceptible until now; in such an event economic isolation obviously emerges;
- the political force that gained majority in 2010 considers one of its key duties to renew Hungarian agriculture and food industry based on local markets and regional food supply systems.

This work cannot set out to decide the adequacy of that goal, it is nevertheless obvious that the government's intention, together with its associated intensive law-making efforts and communication considerably influence the thinking and attitude of respondents.

In this work, we aim to discuss the practical dimensions of ethnocentrism from three aspects: • first, how system dynamics studies help to describe cooperation between producer and dealer,

• second, how the price transmission processes of food production and food trad.2systems between the individual players of the food supply chain can be described, and

• third, the products consumers seek, when it comes to local products.

We have analysed a representative sample of nearly one thousand respondents (N=951) in my research. The primary analysis of the data indicates that the respondents give a statistical representation of Hungarian population. As a first step in my research work, we used a simple descriptive statistical approach to find the indicators that may best represent respondents' thinking concerning the statements presented to them. In summary, the descriptive statistical analyses lead to show that this method can reveal numerous trends in the respondent consumers' thinking. The most important of these are: □a significant level of ethnocentrism □regiocentrism has clearly decreased compared to previous researches environmental awareness has increased, while at the same time □interest in food security and origin was relatively low in contrast to our expectations. This stage of the research also underlined several contradictions. The most important of these are: although a considerable part of Hungarian consumers accept the majority of statements on national identity when discussing it, however, their motivation level drops remarkably when it comes to specific action, the relative strength of national identity is not accompanied by regional attachment; although respondents find Hungarian food important, but they admittedly often fail to check the country of origin on the packaging, although they emphasise the importance of buying Hungarian products, but in practice only a few of them opt for shopping in retail chains with Hungarian owners, although environmental awareness has appeared among customers, and the concern about the condition of the environment is still present in the public consciousness, it is still not associated with environmentally conscious practices in the vast majority of cases. In the second part of my research, we aim to find the wider correlations and trends consumers thinking and values may be arranged and grouped into. For that purpose, we carried out a categorical principal component analysis. It was reasonable to separate altogether three principal components in the study. Applying variance analysis to the average values the respondents within the individual clusters shows that: Respondents in the first cluster are characterised by strong ethno- and regiocentrism. This attitude also manifests in specific behaviour. It is clearly encouraging that these respondents have a positive consumer opinion about Hungarian food products.

Commitment to environmental protection in this group shows a high value, however, no active practices are always associated to it. In summary, we can state that this consumer group with its strong ethno- and regiocentric attitude may be one of the key target for regional food supply chains. For the sake of simplicity, we will henceforth refer to the respondents in this group as ethno- and regiocentric respondents. Respondents in the second cluster are similar to those in the first group in many respects. A significant difference, however, is that they are less receptive to radical statements, and they are more tolerant and open to the world. Members of this cluster showed a significantly lower level of acceptance of statements on the outstanding quality of Hungarian products, but a higher level of acceptance of and interest in foreign products. This group displayed a lower level of ethnoand regiocentrism in their shopping habits, as expected. It is remarkable that respondents in the first and second cluster had approximately the same level of sensitivity to environmental protection matters as respondents in the first cluster. Members of this cluster showed a particularly high readiness to try new products, which may create a favourable opportunity for us to develop further marketing efforts. Actual consumer behaviour in terms of environmental protection was less intensive in this respondent group – save for selective waste collection – than in the first cluster. The third group agreed and disagreed with the individual statements to somewhat less extent. There were only two statements where agreement on average exceeded 4. Consequently, this group will be referred to as uncertain consumers. The next part of the research seeks to identify the socio-demographic characteristics to describe respondents in the individual clusters. we made contingency tables featuring the composition of the various socio-demographic groups in view of the previously presented cluster system. we basically intended to find out the relation between various socio-demographic characteristics and cluster grouping. In the following part of the research, wevalidated the clusters presented above by applying data mining procedures to analyse the role of individual factors in the course of clustering. This clearly shows that the key factor of clustering was age. Next, we used a multivariate set of equations to reveal a structure among the various attitudes towards regional products. The coefficients of the equations were determined according to the algorithms of the Amos program. This clearly shows that multiple factors influences customers when they select regional products. These factors include national identity, provincialism, pursuit to promote local economy and environmental attitude. It follows from the above that all of the above must get appropriate emphasis in the communications to consumers, presenting the positive properties of domestic produce.

3.2. CONCLUSIONS AND RECOMMENDATIONS OF SYSTEM DYNAMICS STUDIES

we ran the model for a dealer and a producer.we used the model created in view of the parameters presented to determine the stock levels of the producer and the dealer. The so-called “bullwhip” effect, as referred in technical literature is clearly visible here. The effect reflects the fact that the producer accumulates substantially larger stocks than the dealer, which wrecks the system and leads to imbalance. Obviously, any change in the parameters may result in even higher values, which are unrealistic in practice. In reality, producers and dealers have tried for several decades to cooperate for providing the highest possible service levels to customers so that all stakeholders may benefit from the maximum achievable efficiency. This requires sharing diverse information, cooperation in logistics and the joint application of product placement opportunities. This partnership is coordinated by ECR (Efficient Consumer Response – www.ecr.hu).

3.3. CONCLUSIONS AND RECOMMENDATIONS ON CONSUMER RESEARCH

The greatest lesson in my consumer research is that although many respondents stated to search for local products, their behaviour when facing the store shelves and other sociological attitudes fail to fully confirm this. Perhaps, the good news for the economic players is that we successfully identified some factors that after all lead to the shopping act: • strengthening the national identity and national attitude • environmental friendly message • efforts to develop local economy This process must also be boosted on the customer side to increase the leverage and role of local food products and the Hungarian food economy. No matter how good Hungarian regional producers are at production if customers do not see the products, or if they do, they select others. Obviously, further studies could and should be conducted on what makes local products competitive for customers on the shelves or outside the stores. As a matter of fact, if customers are not even aware that the products exist or are available, the support of producers will be of no avail. Major food brands have several decades of development and communication, and a vast amount of invested capital behind them. Small producers can hardly be in the same league, but – in sports terms – one should not play on the ground that offers no hope to win. The stakeholders must find the alternative opportunities and partnerships that make the benefits and advantages of local products clear to consumers who, in turn, get to know and like them.