H2020 VALUMICS Project

Conceptual system model and operationalisation of fairness in food value chains

VALUMICS Food Systems Dynamics

Research Findings Brief
September 2021

Content

This brief summarises the VALUMICS developments of a conceptual food system model with the objective to assess the impact of interventions influencing fairness in food value chains (FVCs).

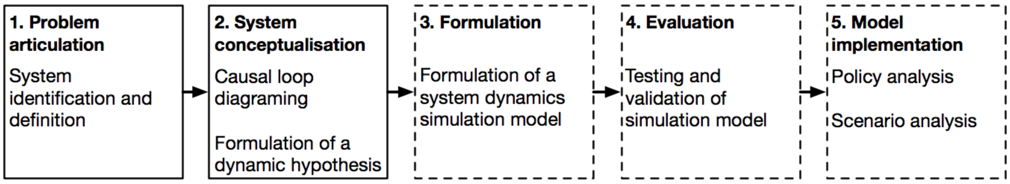
System behaviour

System conceptualization, entails analysing the underlying feedback structure of the system in an effort to formulate a dynamic hypothesis concerning the system's behaviour.

Simulation modelling is one of the tools developed in the VALUMICS project to enhance the understanding of the functioning of food value chains (FVCs) with the aim to facilitate decision makers to evaluate the impact of different interventions in future scenarios towards fairer and sustainable food supply chains.

Steps in the modelling work

A system thinking approach was applied for the conceptualisation of the simulation model developed in the VALUMICS project. System dynamics modelling approach is useful for studying changes over time in complex supply systems with the aim to build both the understanding of complexity needed to find effective policies and the confidence to use that understanding to take action[1].



The steps in the modelling are based on traditional system dynamics research design. The first step involves clearly defining the problematic or rather undesirable behavior of the system that is to be addressed and specify its boundaries. The second step, the system conceptualization, entails analyzing the underlying feedback structure of the system in an effort to formulate a dynamic hypothesis concerning the system's behavior. This causal theory of how behavior is generated in the system is presented as a mental model in the form of a Causal Loop Diagram (CLD). The system conceptualization is induced through system analysis. The resulting dynamic hypothesis is subsequently used to recreate the dynamics of the system using a mathematical simulation model in the following steps.

Conceptual framework

Supply systems are viewed as integrated downstream physical flows, upstream financial flows and decision chains that link these flows. Central to this idea is that supply systems are driven by profit and regulated by market dynamics[2]. The qualitative conceptual VALUMICS model was initially presented as a simplified causal loop diagram (CLD) based on supply, demand and

[1] Sterman, J. (2000). *Business dynamics: Systems thinking and modeling for a complex world*: Irwin/McGraw-Hill.
[2] Gudbrandsdottir I.Y., Olafsdottir A.H., Sverdrup, H.U., Olafsdottir, G., Bogason, S.G. Stefansson, G. (2018) Modelling of integrated supply-, value- and decision chains within food systems. Proceedings in System Dynamics and Innovation in Food Networks 2018, p. 341-348, DOI: http://dx.doi.org/10.18461/pfsd.2018.1827

Multidimensional feedback structure

The multidimensional feedback structure of food supply chains, driven by profit and regulated by market dynamics, results in nonlinear behaviour that calls for a modelling approach, like system dynamics, that can capture the dynamics of systems with inherent feedbacks and delays.

price. Each step in the supply chain (e.g. farming, processing and retail) is presented as a part of a food supply chain feedback structure describing the relationship between a supplier and a customer. The chain of agents, each aiming at maximizing profit and minimizing costs, therefore, adds up to a reinforcing supply system.

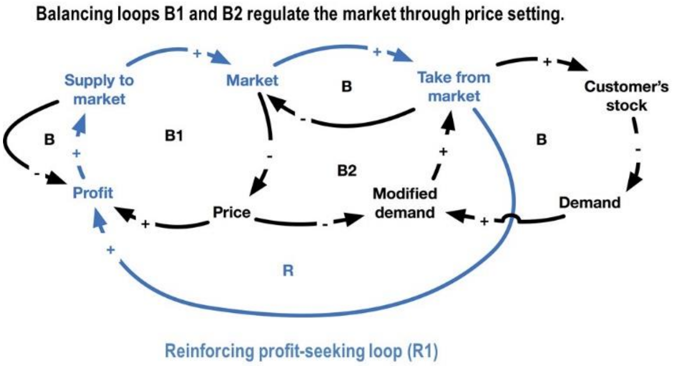


Figure 1 A simplified model of the main drivers of the integrated supply system. (From: Gudbrandsdottir et al.,2018[2]).

Studying the structure and dynamics of food chain systems in VALUMICS as integrated supply-, value- and decision chains, however, underscored the complexity of such systems[2]. Further analyses on governance, market power and trade relations in the VALUMICS case studies provided a more in-depth understanding of the behaviours of actors that influence decisions and external factors such as regulations and policy influencing the functioning on system.

Problem description - Fairness in FVCs

Unfair Trading Practices in FVCs

Unfair Trading Practices (UTPs) are of concern in food value chains, as producers may be placed under pressure and have limited bargaining power

Unfair trading practices within food supply chains are of increasing concern to European Union (EU) and member states' policy makers [3]. Findings indicate that their negative impact on SMEs in the EU food sector is affecting the competitiveness of the industry as a whole[4]. Although UTPs can arise in any market or sector of an economy, they have the potential to be especially problematic in food supply chains, as agricultural producers may be placed under pressure and have limited bargaining power in negotiations with larger purchasers, such as supermarkets or retailers[5]. As a counter measure, the EU Directive (2019/633) on UTPs aims at protecting weaker 'suppliers', primarily farmers, including their organisations (e.g. cooperatives) against their buyers, as well as suppliers of agri-food products which are further downstream. The Directive addresses aspects of procedural fairness which have a direct effect on distributive fairness as the fairness of procedures influence the resulting outcomes. The definition of UTPs in food supply chains emphasises the links between bad commercial conduct and imbalances in market power, which can lead to the imposition of additional risk, an extra cost burden and obligations on one actor or group of actors. Supply chains are made up of a series of actors performing activities involved in bringing products from primary production, through processing and distribution, to the final consumer. Products move through the system by way of business transactions between sellers and buyers. The **price** negotiated in each transaction is therefore the central mechanism by which the different echelons of the supply chain are interlinked. When examining quantitative metrics for distributive fairness, the importance of price for agents in the FVC is acknowledged as part of their effort to maximize profit. Furthermore, the influence of market power with respect to creating opportunities for misuse of power in the form of UTPs is a topic of concern. Simulation modelling has been successfully used to develop and test policy interventions. However, the subjectivity and intangibleness of fairness perceptions make them difficult to operationalize in a quantitative model[6]

Indicators of fairness

The degree of fairness in inter-firm relations is a perception and therefore it is necessary to define quantifiable indicators for the simulation model.

[3] DG IPOL (2015) Directorate-General for Internal Policies, Policy Department C, Citizens' Rights and Constitutional Affairs (2015) The general principles of EU administrative procedural law (PE 519.224), European Parliament.
[4] Wijnands, J. H., van der Meulen, B. M., & Poppe, K. J. (2007). Competitiveness of the European food industry: An economic and legal assessment 2007: Office for Official Publications of the European Communities.
[5] Fałkowski, J., C. Ménard, R.J. Sexton, J. Swinnen and S. Vandevelde (Authors), Marcantonio, F. Di and P. Ciaian (Editors) (2017), Unfair trading practices in the food supply chain: A literature review on methodologies, impacts and regulatory aspects, European Commission, Joint Research Centre.
[6] Gudbrandsdóttir et al., 2019.

Procedural fairness

Power asymmetries and environmental uncertainty pose challenges on actors´ decision making. Controls, collaboration, and information sharing, are factors which can be facilitated through strategic horizontal coordination (cooperatives, producer organisations PO) or vertical integration.

Quantitative indicators

Outcomes in terms of the simulation modelling of distributive fairness in FVCs are the results of operational efforts and can be measured as gross profit margin. Degree of market power (a proxy for procedural fairness) can be assessed using the Lerner Index

Simulation model to test policy interventions with a focus on fairness

The mental model for a generic food supply system served as a basis for the further development of the simulation model used to test policy intervention opportunities, specifically focusing on fairness.

Operationalisation of fairness

In an effort to measure fairness as a quantifiable output of a simulation model the factors related to interorganisational fairness (IOF) which contribute to procedural and distribute fairness were explored, drawing on fairness theory and related literature on governance and market power in FVCs (Gudbrandsdottir et al., 2021). The factors identified associated with interorganisational relationships were explained in the context of decision making (Figure 2). Power asymmetries and environmental uncertainty pose challenges on actors' decision making. Strategic coordination such as horizontal collaboration, producer organization and vertical integration can strengthen the bargaining power of e.g., farmers against their buyers.

Environmental uncertainty, the regulatory framework and market dynamics are factors of external constraints while internal constraints are associated with, for example, the firms' technology and knowhow. Outcomes in terms of the simulation modelling of distributive fairness in FVCs are the results of operational efforts and profit which can be measured by quantitative indicators.

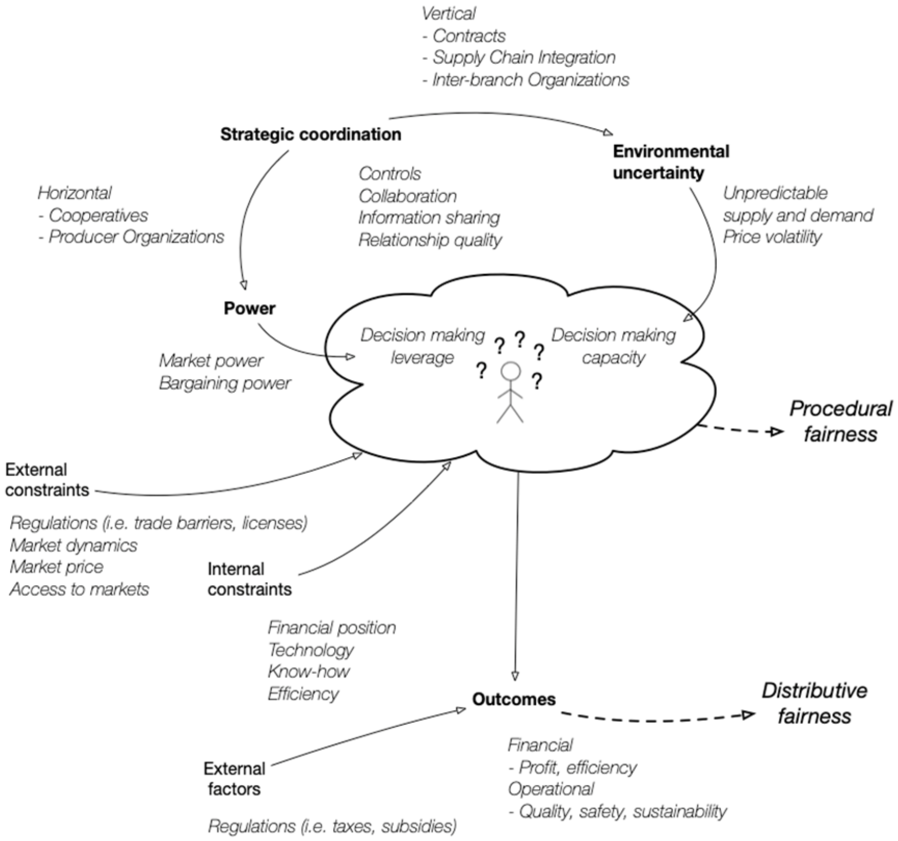


Figure 2 Factors viewed in the context of organizational decision making (Source: Gudbrandsdottir et al., 2021)

The operationalisation of distributive fairness through economic indicators in the simulation modelling was defined as the *gross profit margin* obtained by the various actors across the FVCs. The degree of market power (a proxy for procedural fairness) can be assessed using the *Lerner Index (*an estimate of market power measuring the price-cost margin through the difference between the output price of a firm and the marginal cost divided by the output price). The aim was not to determine an absolute measure of fairness using these indicators, but rather to ascertain transitions towards fairer outcomes.

Simulation of agent decisions: what-if scenarios

A hybrid of system dynamics and agent-based modelling (ABM) is the approach for the simulation model. The main advantage of ABM is its ability to model the behaviour of agents

What if

- ***Volumes decrease /increase***
- ***Trade barriers: low /high /removed***
- ***CAP subsidies: low /high /removed***

in terms of decision rules, executed when special events occur, and in interactions with other agents. The aim is to use the model to identify the level of fairness within the system which emerges from the concurrent execution of these decision rules on behalf of multiple independent agents in the FVC. The decision-making and agents' behaviours were explored through the VALUMICS case studies. The agents can be e.g. producers, collectors, processors, retailers and their attributes include for example production capacity, cost and number of suppliers and buyers. The decisions of the agents revolve around investments, capacity planning, sourcing raw material, price setting and price negotiations and transactions. External factors such as taxes and subsides are typical policy related interventions which influence the profitability of firms and can be tested in a simulation model as experimental factors. The aim is to use the model to identify the level of fairness within the system in future scenarios and assess the impacts of various "what if" policy interventions to transition the food system towards sustainability.

Key sources for further information

To discuss the research presented in this brief, please email: go@hi.is or iyg1@hi.is

Deliverables

Ólafsdottir, A.H., Sverdrup, H.U., Gudbrandsdóttir, I.Y., Ólafsdóttir, G., Bogason S.G. (2018). Summary report for all first year's WP2 workshops The VALUMICS project "Understanding Food Value Chains and Network Dynamics" funded by EU Horizon 2020 G.A. No 727243. **Deliverable D2.3**, University of Iceland, Reykjavik, 19 pages.

Olafsdottir G., Gudbrandsdottir I. Y., Bogason S. (2018) Integration report for qualitative model and initial designs for the qualitative model delivered to WP7. The VALUMICS project "Understanding Food Value Chains and Network Dynamics" funded by EU Horizon 2020 G.A. No 727243. **Deliverable D2.5**, University of Iceland, Reykjavik, 40 pages

Olafsdottir, G, McGarraghy, S, Kazakov, R., Gudbrandsdottir, I.Y., Aubert, P.M., Cook, D., Cechura, L., Bogason, S.G. (2019). Functional specifications and design parameters for the implementation of the quantitative modelling. VALUMICS project "Understanding Food Value Chains and Network Dynamics" funded by European Union's Horizon 2020 research and innovation programme GA No 727243. **Deliverable 5.2,** University of Iceland, Reykjavik, 47p https://doi.org/10.5281/zenodo.5106551

Published scientific papers and conference proceedings

Gudbrandsdottir IY, Olafsdottir G, Oddsson GV, Stefansson H, Bogason SG. (2021). Operationalization of Interorganizational. Fairness in Food Systems: From a Social Construct to Quantitative Indicators. *Agriculture*.; 11(1):36. https://doi.org/10.3390/agriculture11010036

Gudbrandsdottir I.Y., Olafsdottir A.H., Sverdrup, H.U., Olafsdottir, G., Bogason, S.G. Stefansson, G. (2018) Modelling of integrated supply-, value- and decision chains within food systems. Proceedings in System Dynamics and Innovation in Food Networks 2018, p. 341-348, DOI: http://dx.doi.org/10.18461/pfsd.2018.1827

Gudbrandsdottir I. Y., Cook D., Olafsdottir G., Oddsson G., Bogason S., Stefansson H., McGarraghy S. (2019) Modelling fairness in FVCs: developing quantitative indicators. Presented at the EU Conference on Modelling for Policy Support 2019 in Brussel on November 26-27. Available in Book of Abstracts p.101-103, https://ec.europa.eu/knowledge4policy/event/eu-conference-modelling-policy-support-experiences-challenges-way-ahead-0_en

H2020 VALUMICS – Understanding Food Value Chains and Network Dynamics

University of Iceland, Dunhagi 5, Reykjavik, Iceland – https://www.valumics.eu

"This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727243"