

The organisation of transactions: studying supply networks using gaming simulation

Summary of the thesis

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This book studies the organisation of transactions in supply networks. More specifically it investigates the influence of social structure on the mode of organisation in supply networks. To gain new insights, the results in this book have been gathered using gaming simulation as a research method. As this is a new application of gaming simulation, special attention is paid to the methodological implications.

Food supply chains and networks span a whole series of firms from grower to consumer. Depending on the product traded and the market in which it is consumed the grower and consumer can be located in countries thousands of kilometres apart. However, the food still needs to arrive in a perfect condition at the consumer, passing through several companies in the supply network. Transactions need to be made between the subsequent companies that trade the product. The way in which the transactions are organised can be any mix of three modes of organisation, namely market, network and hierarchy. This book concentrates on market and network. The market mechanism uses the price as a control mechanism. Network uses trust and reputation for this.

Transactions are made by people. People who trade with each other may have known one another for a long time. Their companies may have business ties. And the traders will have certain norms and values about what is appropriate behaviour in trade. The interpersonal relations, business ties and norms and values influence trade behaviour in a supply network. This behaviour will influence the mode of organisation of the network. Lazzarini et al (2001) call this **social structure**, as a bucket category of variables from the social sciences that explain interpersonal and business relations and the norms and values of the supply network as a whole. Trust between traders is the most prominent interpersonal variable. Business relations are expressed in a level of embeddedness as a measure of the density and the strength of ties between businesses. Norms and values in a network can be related to the culture traders come from. **Social structure** covers a broad range of concepts from sociology to social psychology and network theory. This book focuses on the major variables trust and embeddedness, with norms and values as an important context.

Gaming simulation is commonly used as a training or learning tool. This book, however, uses gaming simulation as a research method. The methodological contribution of this book is to use gaming simulation as a lab environment to generate and test hypotheses using both qualitative and quantitative data in the domain of supply chains and networks. Chapter 2 discusses the methodological issues of gaming simulation as a research method. The first section (2.1) describes what gaming simulation is and gives 6 inputs for a session with a gaming simulation. Section 2.2 argues that by using gaming simulation, researchers can study the behaviour of real people playing a role of interest for research in a simulated environment, based upon the characteristics of gaming simulation. Research purposes are less common among gamers. Section 2.3 first describes the non-research purposes, while Section 2.4 discusses the purposes for research. Three types of research purpose are distinguished, namely hypothesis generation, hypothesis testing and sensitivity analysis when combined with multi-agent simulation. Research with gaming simulation is often positioned in the design sciences, which means that the effect of the gaming simulation as a design on changes in the real world is tested. This book positions gaming simulation in the analytical sciences, to study phenomena in the real world.

Section 2.5 positions gaming simulation among other research methods common in the domain of supply chains and networks. The influence of social structure on the organisation of transactions can be studied in a single or small set of supply networks using case studies, to provide in-depth observations of actions and the surrounding context. The generalisability of detailed case studies is a complicated matter. Furthermore, it is hard to observe the actual actions in a case study research. Questionnaire research overcomes the generalisability issue of case studies, though lacks the in-depth knowledge of a subject within its contextual variables. Surveys do not observe actual actions either.

The validity and reliability of gaming simulation is discussed in Section 2.6 and is based on the work of Raser (1969) who identified four criteria for validity: psychological reality, process, structural and predictive validity. Each of the four criteria has been used in this book.

Chapter 3 presents the research method used in this study. It consists of four interconnected cycles. The first is the design cycle in which the gaming simulation is developed and tested. The test sessions provide insight into the structure and important variables of the problem studied. The hypothesis generation function can be done using the design cycle. The outcomes of the design cycle are induced hypotheses (based upon the test sessions) and the gaming simulation. Both are inputs for the empirical cycle in which a structured experimental set-up results in game sessions, which provide the data to be analysed.

The other two cycles are support cycles. The first is the multi-agent design cycle in which a multi-agent version of the gaming simulation is built. The second one is the multi-agent simulation cycle in which experiments can be conducted to verify the multi-agent model or to draw conclusions. Multi-agent simulation could in the future provide ways to select interesting variable settings to play with human participants. The multi-agent simulation is validated against conclusions from the empirical cycle.

Chapter 4 discusses the reference theories on which this book is based. Section 4.1 presents theories on supply chains and networks needed for the domain of study. Section 4.2 discusses new institutional economics used as the main theoretical framework for analysis of the results of the two gaming simulations. Central elements are the four-level framework by Williamson (2000) that links levels of analysis from culture to day-to-day operations, and the modes of organisation, namely network, market and hierarchy. Section 4.3 discusses the fact that there are other explanatory theories used for the two specific gaming simulations. These theories are discussed in the subsequent chapters.

Two custom-built gaming simulations each study an aspect of the influence of social structure on the mode of organisation of transactions. Chapter 5 presents the first one, called the Trust and Tracing Game (TTG). The TTG assessed the influence of trust and embeddedness on the choice between the network and the market mode of organisation. The TTG is a paper-based gaming simulation of a supply network of a product with a hidden quality attribute. Participants face the dilemma of whether to rely on trust or tracing when confronted with a possible cheat. Section 5.1 describes the

fact that the TTG was originally designed to be a learning tool by the researchers who started this project. The TTG operationalised an abstract supply network of a good with a hidden quality attribute. Hypotheses were generated during the last series of test sessions in the design cycle. From observations of 15 test sessions, intended to identify the learning effect, conclusions about the participants' behaviour in the sessions were drawn. The results showed that participants used the two modes of organisation, both the network and the market mechanism.

Section 5.2 uses the observations and variables identified in 5.1 as inputs to the empirical cycle for the quantitative analysis of 27 additional sessions as induced hypotheses and list of variables to be collected. The quantitative analysis proved that the mode of organisation in the Trust and Tracing Game was **network** for the financially well-performing traders and **market** for the well-performing consumers. Social structure manifested itself in trust and embeddedness influencing the organisation of transactions. Generally trust and embeddedness were detrimental to the (financial) performance in the setting of the Trust and Tracing Game, as the traders who benefitted from the use of **network** exploited their trusting clients. There was no evidence that trust affected the measurable transaction costs. Additional analyses showed that buyers detected cheats with other mechanisms than tracing. The traces showed more cheats than statistically possible when the envelopes were a random sample.

Section 5.3 presents the multi-agent model developed for the Trust and Tracing Game. This model has been tested and validated. It has been possible to validate the multi-agent simulation on an aggregate level against sessions with human participants. Hypotheses were formulated based upon observations of sessions. Each hypothesis could be confirmed in model runs.

Chapter 6 presents research with the second gaming simulation, called the Mango Chain Game (MCG). It was developed to study the bargaining power and revenue distribution among traders in the Costa Rican mango export chain. The MCG assessed what factors, including social structure, determined the bargaining power, what mode of organisation was used and how this influenced the revenue distribution between traders. The data collection combined data from a questionnaire among the participants with the actual behaviour in the game session. Five sessions were conducted with smallholders in the Costa Rica lowlands, resulting in 82 contracts. The results show that the bargaining power in the sessions was isomorphic to the real-world bargaining power of smallholders, multinationals and independent exporters. As expected, lower bargaining power on the part of the buyer (seller) resulted in higher revenue for the seller (buyer). In general, stakeholders with more bargaining power were able to take advantage of the other agents. Higher risk-aversion of the buyers and/or the sellers led to higher revenues for the other agents involved in the exchange relationship. In the same vein, long-term contracts in the buyer-seller relationship led to lower revenues (but also reduced risk) for sellers. The latter result was surprising, since contract choice appeared only to be significant for the seller's and not for the buyer's revenue equation. Mango producers turned out to be well aware of the fact that the type of markets in which they operate is mainly based on short-terms contracts. Not working with long-term contracts gave them the opportunity to remain flexible towards changes in demand and supply that they cannot control. Producers were trying to establish long-term relationships, but they could equally rely on repeat short-term contracts with the same partner. The latter type of contract tends to rely on trust or friendship, thus the network mode of organisation is at play here. Finally, real-world wealth appeared to have a significant impact on bargaining power.

Chapter 7 discusses the experiences with gaming simulation as a research method and draws conclusions from the combined results of the TTG and MCG. Section 7.1 discusses the experiences with gaming simulation to generate and test hypotheses. Methodologically there were some differences. Research with the TTG took more time than that with the MCG. The reasons for this difference can be found in the functions used and the number of variables. The TTG started with a broad scope, where the important variables coming from all four levels of the Williamson framework had yet to be found in the design cycle. In contrast to this, the MCG used an analytical model with fewer and theory-based variables.

Attention is paid to validity and reliability. In summary, the process validity of both gaming simulations was the most important aspect, and psychological reality was required to get the process going. Both the TTG and MCG met these criteria in different ways. The MCG scored more positively on both the structural and predictive validity because of the closer resemblance of the supply network modelled with the real world and the use of real smallholders versus students. Care should be taken regarding claims about what is modelled.

The multi-agent simulation has been developed to perform sensitivity analyses of variable settings (loads). This project has not reached the point where variable settings selected with the MAS have been tested in a human session. Future research should make clear whether MAS really helps to increase efficiency by reducing the number of sessions needed through selection of interesting loads. This project has proven, however, that it is possible to develop and validate a multi-agent model of a gaming simulation.

The different types of data that the TTG and MCG can generate are hard to obtain using other methods. Gaming simulation is special in that the participants are exposed to a laboratory-like situation that isolates them from the real-world (trading) environment. In this laboratory environment, the attention of the participants can be focused on a particular problem, while retaining the full richness of human behaviour. Based upon the experiences presented in this book, gaming simulation can be positioned as a research method that facilitates a whole range of data collections. It is possible to acquire data before, during and after a session, enabling the coupling with questionnaires and interviews and actual observation of actions. It can analyse differences between participants in one session, testing for differences in backgrounds, or between session, testing for the effects of varying the load and situation in a session, or even the rules, roles, objectives and constraints of the gaming simulation itself. The combination of qualitative and quantitative analyses that is possible using gaming simulations makes the method a good candidate for research that requires both. In the methodology used in the MCG and TTG the first cycle (design cycle) was based upon a qualitative approach, while the hypotheses were tested in a quantitative empirical cycle.

Section 7.2 compares the theoretical conclusions of the Trust and Tracing Game with those of the Mango Chain Game and relates them to the main research question. The conclusions of the MCG are in line with the TTG conclusions insofar as the variables of social structure used in this book (trust, embeddedness, norms and values) clearly shape the organisation of the transactions. Both the TTG and MCG show that trust and embeddedness lead to the use of the network mode of organisation, but also to less revenue in the setting of these two gaming simulations. It seems that the network mechanism is essential in supply networks with independent traders but not in a way that directly leads to more revenues. The conclusions from the two gaming simulations are at odds with the leading paradigm in the literature on supply networks which says that trust and relationships are important for successful business. The conclusions are more in line with neo-classical economic theory, where companies use transactions as the rational result of considering price and product.

Section 7.3 presents ideas for future research divided into ideas for the domain and ideas for methodological improvements. Next, Section 7.4 presents the implications of the research for the domain of food supply chains and networks. The application of gaming simulation as (one of the) research method(s) can be of value for gathering data about the real behaviour of real participants in a simplified 'surrogate' environment, determined by the gaming simulation. In this book a laboratory for chain and network studies has been built. Section 7.5 looks at the implications for other domains and argues that the issues about trust, embeddedness and other variables from social structure can be found in most other business domains, thus providing opportunities for research with this method.

The chapter ends with some concluding remarks in Section 7.6, stating that this book showed as a proof-of-principle that gaming simulation is an excellent additional research method for controlled analysis of complex social systems. It also showed that the possibility to have a repeatable experiment within a controlled contextual setting provides insight into socio-economic behaviour in a way that can be approached from multiple bodies of theory. Staying within the framework of one body of theory cannot explain the full richness of human behaviour, thus links have to be made. In the current book the theoretical framework from new institutional economics has been used and some first attempts have been made to link up with theory on culture, psychology and other theories in the social sciences. Future research could use gaming simulation as the research method of choice for true interdisciplinary research.