

Revising Network Pictures

- An Agent Based Modeling Approach

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ABSTRACT

Industrial marketing research has recently focused on the manager's "network pictures". Network pictures are a manager's subjective mental representations of their relevant business environment. However, while the concept is found to be at the core of networking and thus impacts network outcomes, longitudinal research on changes in network pictures is scarce. Constant change in a network places a high emphasis on a manager's ability to make sense of changes in the network and revise the network picture. This study contributes to the discussion on the relation between network pictures, networking, and network outcomes, by investigating the relation between a manager's ability to revise the network picture and the resulting decision quality. The issue is approached through simulation, and more specifically using agent based modeling. We propose that a manager with a fast ability to revise network pictures benefits more in a dynamic business environment than a manager with a slower ability in this context. However, in a business environment where the trend of change is low, the difference between a fast and a slow reviser is diminished. Thus, in a turbulent business environment, the significance of a manager's ability to revise the network picture is decreased.

Keywords – Network Pictures, Business Networks, Simulation, Agent Based Modeling

INTRODUCTION

In today's world, business is increasingly networked. This has led to the ability to understand business networks and relationships in the business-to-business context becoming an important part of everyday business life, which has resulted in an extensive quantity of academic literature on the topic during the past decades (e.g. Ford, 1980; Gadde, Huemer, and Håkansson, 2003). The Industrial Marketing and Purchasing (IMP) research group has been leading this discussion. The actors in the network are not considered to exist in isolation, but as interdependently interacting actors forming the network. Operating in these business networks is fundamentally based on a person's subjective perceptions of the network. Thus, all persons in the network have their own different, subjective "picture" of the network (Ford, Gadde, Håkansson, and Snehota, 2003). These pictures are formed on the basis of the person's perceptions, experiences and presumptions. Nevertheless, these mental structures are the foundation for managers' understanding of relationships, interaction and interdependencies, and thus are also fundamental to the actor's decision-making process (Henneberg, Mouzas, and Naudé, 2006). According to Gary and Wood (2011), the more accurate mental models of the causal relationships in the business environment are linked to higher performance outcomes. Therefore, these subjective mental structures are a central concept to managing in networks, and thus a relevant issue for study. This perspective has attracted growing interest in the academic literature (e.g. Fiol and Huff, 1992, Ford, Gadde, Håkansson, and Snehota, 2003; Henneberg, Mouzas, and Naudé, 2006; Colville and Pye, 2010; Gary, and Wood, 2011).

Authors in the IMP group have developed the network picture concept to describe these mental models, which is defined as "the different understanding that players have of the business network in which their focal company is operating" (Henneberg, Mouzas, and Naudé, 2009). According to Henneberg, Mouzas, and Naudé (2006), these network pictures are produced by "subjective, idiosyncratic sense-making with regard to the main constituting characteristics of the network in which their company is operating." The existing literature discussing the network picture concept focuses on defining the dimensions of the network picture (e.g. Henneberg, Mouzas, and Naudé, 2006; Leek and Mason, 2010), discussing its nature (e.g. Colville and Pye, 2010; Geiger and Finch 2010), and creating a model to study network pictures academically and managerially (Leek and Mason, 2009; Leek and Mason, 2010; Ramos and Ford, 2011). The network picture discussion has thus far addressed the development of the concept at the theoretical level, offering some empirical evidence (Henneberg, Mouzas and Naudé, 2006; Öberg, Henneberg, and Mouzas, 2007; Leek and Mason, 2009; Leek and Mason, 2010).

There still seems to be a dearth of longitudinal studies on network picture changes, with some exceptions (e.g. Ford and Redwood, 2005; Öberg, Henneberg, and Mouzas, 2007). The constantly changing network emphasizes an actor's ability to make sense of changes and revise the network picture. Thus, understanding the dynamic nature of the network picture is essential in constructing theory around it (Colville and Pye, 2010). The purpose of this study is to increase understanding of the dynamic nature of network pictures. This is approached through a longitudinal examination of the relation between a change in the network and a person's ability to revise the network picture. The research question is phrased *How does a manager's ability to revise the network picture affect the quality of decisions in a dynamic business environment?* It is presupposed that if the network picture corresponds broadly to the network conditions at a certain moment in time, the quality of decisions is high. And vice

versa, if the network picture does not correspond to the network conditions at a certain moment in time, the quality of decisions is poor. High quality decisions are supposed to lead to positive network outcomes.

The research question is approached by means of simulation, a form that has been used since the 1950s to understand dynamic behavior (Forrester, 1958). Recent papers (Warren, 2005; Gary, Kunc, Morecroft, and Rockard, 2008; Gary and Wood, 2011) have recognized simulation as a suitable tool for management research. Its particular strength is that simple models can be used to support research on abstract phenomena that are hard to study quantitatively with traditional research methods, especially when a longitudinal research approach is needed. Both of these elements are central to our research focus, as we are interested in the effect of revising the network picture on the quality of decision-making. First, the network picture idea is inherently abstract, making its measurement empirically challenging. Secondly, the interest in the change process requires a longitudinal approach, as change occurs over time. Since the research focuses on individual entities, agent based modeling was perceived to be a good approach to modeling the problem (Schelling, 1969; Macal and North, 2006; Gilbert, 2008). Agent based modeling concentrates on individual decision makers, who employ local information and make local decisions to reach their desired goal (Wooldridge and Jennings 1995).

We develop a simulation model of a changing network between firms and the perceived network picture of different decision makers who are assumed to have different abilities in renewing their network picture. The primary testing variables are endogenous variables that control the process of change, such as interval time, amplitude, or trend intensity of change. The simulation is executed using agent based modeling, which enables the creation of freely forming and developing network structures. The developed model describes how the relationships in a network created by three different levels of a firm develop over time. The simulation results show that decision quality is tied to the decision maker's ability to revise its network picture. The selected testing variables are shown to control the value of being able to update the network picture quickly.

COGNITIVE PERSPECTIVE ON THE RESEARCH OF BUSINESS NETWORKS

Network research has a long tradition, being the object of interest in several disciplines (e.g. sociology, social-psychology, computer sciences, and business studies). A collective feature of these disciplines is that an actor is perceived to be related to a theoretically unlimited number of other actors forming a network, wherein individual actors' actions are perceived to affect other actors and their actions. Thus, the object of interest is usually the network itself rather than a single actor. In the business studies domain, networks are discussed in several forms (e.g. supply networks, communication networks, relationship networks). A study on business networks can be grounded on several perspectives, such as organizational networks (Wasserman and Faust, 1994), social networks (Laumann, Galaskiewicz, and Marsden, 1978), and egocentric organizational networks (Gulati, 1998). In addition, among the Industrial Marketing and Purchasing (IMP) research group, the network perspective has evolved (Ford, 1980; Ford, Håkansson and Johanson, 1986; Håkansson and Johanson, 1992). This perspective is based on the ontological view that markets are interconnected webs of dependent exchange relationships (Anderson, Håkansson and Johansson, 1994; Easton and Håkansson, 1996). Furthermore, according to the IMP

perspective, a core requirement to understanding networks is to understand the interactions of the parties within that network (Ford and Håkansson, 2006). These networks are perceived as relativistic in nature and it is said that there is no single, objective network. The network is not owned by any company, nor can it be centrally managed, although all firms try to manage in it. Also, no company is the hub of the network as there is no “centre”, although many companies may believe that they are at the centre. (Ford, Gadde, Håkansson, and Snehota, 2003).

The interactions in the network take many forms and one of the main challenges for a manager in business-to-business markets is to understand these multiform interactions. In recent years, the academic interest in business studies has emphasized the manager’s ability to operate in the network environment. In addressing one aspect of this issue, research examining the role of managerial cognition has shown that understanding managers’ cognitive mental structures is focal in studying successful network operations (Simon, 1991; Henneberg, Naudé and Mouzas, 2010; Gary and Wood, 2011). Research on a person’s cognitive mental structures is not a novel area. Prior research offers several disciplines to study a person’s mental model, such as managerial and organizational cognition (Huff, 1992; Huff and Eden, 2009), the sense-making literature (Louis, 1980; Weick, 1995), psychology including social psychology (Markus and Zajonc, 1985; Markus, 2005), and cognitive psychology (Eysenck and Keane, 2010; Manktelow, 2008). These disciplines offer concepts, such as cognitive maps (Ring and Rands, 1989; Fiol and Huff, 1992), schemas (Markus and Zajonc, 1985; Harris, 1994), mental models (Hodgkinson and Johnson, 1994; Osborne, Stubbart and Ramaprasad, 2001), heuristics (Eysenck and Keane, 2010), dominant logic (Bettis and Prahalad, 1995), and belief systems (Rokeach, 1968; Grube, Mayton and Ball-Rokeach, 1994). Generally, the mental structures can be understood as a person’s simplified knowledge structures or cognitive representation of how the business environment works. The focus in these concepts typically lies in the entire business environment, including for example human resource policies, earning logics, and existing business relationships. However, the IMP research group’s focus remains trained on the interaction of the parties in the network. In addition, dissimilar ontological assumptions or alternative viewpoints to sense-making differentiate the IMP research group’s perspective from that of the existing literature (Henneberg, Naudé and Mouzas, 2010). Thus, a discussion concerning cognitive mental structures has evolved among the IMP research group.

Ford, Gadde, Håkansson, and Snehota (2003) developed a notion that all persons in the network have their own different, subjective “picture” of the network. These pictures are based on the person’s perceptions, experiences and presumptions. Nevertheless, these mental structures are the foundation for managers’ understanding of relationships, interaction and interdependencies, and thus are also fundamental to the actor’s decision-making process (Henneberg, Mouzas, and Naudé, 2006). Therefore, these subjective mental representations of the surrounding network are a central concept to managing in networks, and thus a relevant issue for study. IMP group research has proposed the network picture concept to describe “the different understanding that players have of the business network in which their focal company is operating” (Henneberg, Mouzas, and Naudé, 2009). These network pictures are argued to be the result of the “subjective, idiosyncratic sense-making with regard to the main constituting characteristics of the network in which their company is operating” (Henneberg, Mouzas, and Naudé, 2006). Thus, the network pictures are retrospective in nature, constructed of past events. However, the pictures form a basis for prospective decisions and thus shape organizations’ future options (Weick, 1979).

The network pictures are an individual's interpretation of the surrounding network, and thus the foundation for decision-making (Ford, Gadde, Håkansson, and Snehota, 2003; Henneberg, Mouzas, and Naudé, 2006; Colville and Pye, 2010). The relation between network pictures and operations in the network is therefore evident. Ford, Gadde, Håkansson, and Snehota (2003) have suggested a model that grasps the composition and they offer a model of managing in networks, depicted in the Figure 1. The model comprises the interconnected elements of network pictures, networking, and network outcomes.

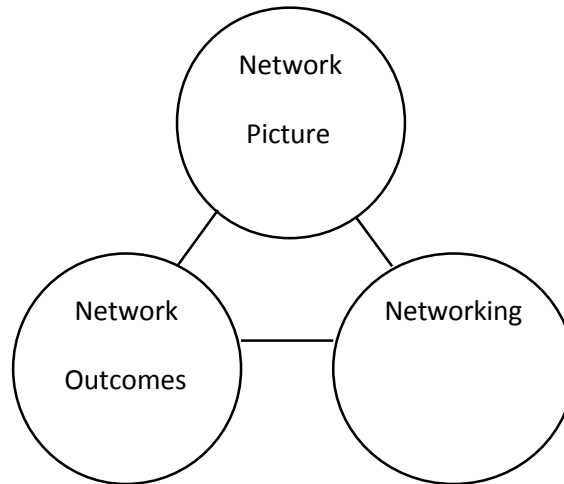


Figure 1. Model of managing in networks (Ford, Gadde, Håkansson, and Snehota, 2003).

The networking element comprises all the interactions of a company or an individual. Networking is an ongoing process in which all actors are networking simultaneously. The essential feature is that networking is affected by the network pictures, and thus the pictures ultimately impact the network outcomes (Ford, Gadde, Håkansson, and Snehota, 2003). Conversely, the network outcomes affect the actor's network pictures and thus also networking. If the network outcomes are in line with the present network picture, the outcomes validate the picture. On the other hand, if the outcomes are not in line with the network picture, it will most likely be revised (Ford, Gadde, Håkansson, and Snehota, 2003). Thus, these three elements are at the heart of an ongoing process, in which an actor's network picture is revised by the network outcomes as well as by networking itself.

An understanding of the network management process requires an understanding of the nature of the network pictures, and perceptions of that nature vary. The existing network pictures literature offers two levels of analysis: narrow and broad (Henneberg, Naudé and Mouzas, 2010). The narrow perspective suggests that network pictures collected from managers can provide an insight into the individual's frame of mind (Henneberg, Mouzas and Naudé, 2006; Öberg, Henneberg and Mouzas, 2007). The broad perspective advocates that network pictures can be integrated and abstracted from the specific managerial network pictures to broad network pictures as part of a research tool (Ford, Gadde, Håkansson, and Snehota, 2003; Ramos, Ford and Naudé, 2005). The narrow perspective offers a suitable level of analysis for the present study, whose purpose is to understand the dynamic nature of network pictures, approaching it from an individual's frame of mind and characteristics.

The existing literature on the network picture concept focuses on defining the dimensions of the network picture (e.g. Henneberg, Mouzas, and Naudé, 2006; Leek and Mason, 2010), discussing its nature (e.g. Colville and Pye, 2010; Geiger and Finch 2010), and

creating a model to study network pictures academically and managerially (Leek and Mason, 2009; Leek and Mason, 2010; Ramos and Ford, 2011). The network picture discussion has thus far addressed the development of the concept at the theoretical level, offering some empirical evidence (Henneberg, Mouzas and Naudé, 2006; Öberg, Henneberg, and Mouzas, 2007; Kragh and Andersen, 2009; Leek and Mason, 2009; Leek and Mason, 2010). Meanwhile, Henneberg, Naudé and Mouzas (2010) note that research on the relation between networking and revising network pictures remains sparse, although the impact on the outcomes and positioning in the network has been recognized. In addition, there still seems to be a dearth of longitudinal studies on network picture changes, with some exceptions adopting a well framed perspective (e.g. Ford and Redwood, 2005; Öberg, Henneberg, and Mouzas, 2007). The constantly changing network emphasizes an actor's ability to make sense of changes and revise the network picture. Thus, understanding the dynamic nature of the network picture is essential in constructing the theory around it (Colville and Pye, 2010).

This study aims to address these gaps in the network pictures research. First, the study contributes to the discussion on the relation between network pictures, networking, and network outcomes (Ford, Gadde, Håkansson, and Snehota, 2003; Henneberg, Naudé and Mouzas, 2010), investigating the relation between decision quality and an individual's ability to revise the network picture. Secondly, the study offers a dynamic and longitudinal perspective on network pictures research, employing simulation and, to be more precise, agent based modeling (Schelling, 1969; Macal and North, 2006; Gilbert, 2008).

Simulation has been put forward as a suitable management research tool (Warren, 2005; Gary, 2005), and has attracted growing interest among the IMP group (Wilkinson and Young, 2011). Its particular strength is that simple models can be used to support research on abstract topics that are hard to study quantitatively using traditional research methods, especially when a longitudinal research approach is needed. Both of these elements are central to the research focus here, given our interest in the effect of revising network pictures on decision-making quality. The network picture idea is inherently abstract so its measurement is empirically challenging, and research on the change process requires a longitudinal view as change happens over time. Simulation was therefore selected as the research approach for this paper.

SIMULATION MODEL

Model structure

The objective is to simulate two distinctively different tasks: the dynamics of relationships between different firms in a supplier network, and how a manager understands those relationships. The simulation of relationships between firms concretizes how the dynamics in a networked business environment are implemented in the model. The focus of our research is the manager's network picture, which represents a single manager's understanding of the network between the companies. This picture changes over time as the manager makes increasing sense of the business environment, but it can never be perfect. The focus of the model lies in the disparity between the simulated business environment and the manager's network picture. The following section provides a more thorough description of how the parts of the model were executed and combined.

Business environment

The business environment is simulated as a network comprising three different types of company (A, B, C). Each company describes a link in a supply chain and all are needed to produce a service. The simulated network describes how effectively an individual company is able to work with another that sits either before or after it in the supply chain. The network is simplified so that only connections between A to B and B to C are simulated (Figure 2). The structure of the simulated network is presumed to be static, but each link is dynamic. In practice, this means that the number of firms at different levels does not change, but a firm's ability to work in a network changes over time.

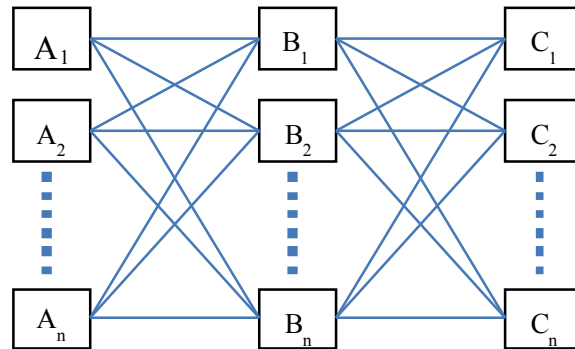


Figure 2. Structure of the network.

The dynamics of the firm's co-operation linkages are controlled for using a set of control variables that describe different types of dynamic in the network. The first variable is the interval time of change. The network change is implemented as a discrete event causing the co-operation connections to change between static intervals. The control for the length of this interval is interval time. The second variable is amplitude which controls the average size of a change in the co-operation network, but the actual size is implemented randomly. The final variable of change is trend, which controls for the randomness of the change. When the trend is high, the co-operation change is more likely to develop in a similar direction as during previous change. If the trend is low, both the change and the development of the network are more random. Each actor in the model has a specific cost associated with its component. At the initialization of each simulation run, each actor is assigned a cost between 50 and 150, uniformly distributed. While looking for a potential combination of actors, whether or not the aggregated cost of all actors is below the selected price cap will be checked. If the total cost is higher than the price cap, the combination is seen as infeasible. The lower the price cap, the fewer possible combinations exist.

Manager's network picture

The manager's network picture is implemented as a simple system dynamic model. The model contains system dynamic stocks that describe the manager's vision of the quality of connections between different companies. When the manager's view is compared to the simulated 'true network', a gap can be calculated which represents the discrepancy in the manager's network picture. The gap also represents how much more accurate the manager's network picture could be. Revision is implemented as a continuous change for which the control is both the size of the gap, and the manager's ability to revise the network picture which is used to separate fast and slow revisers; the fast reviser will revise a higher relational

share of the gap than the slow reviser. This implementation method results that the manager's network picture closes asymptomatic the simulated network, but it can never be exactly right. The presupposition is that if the network picture corresponds broadly to the network conditions at a certain moment in time, decision quality is high, and vice versa. High quality decisions are supposed to lead to positive network outcomes. In addition, it is presupposed that the revision of the network picture is always enacted towards the existing network conditions at a certain moment in time.

The manager's network decision is also implemented using the system dynamic model, the selection enacted using brute force. The function travels through the whole network in each simulation round, searching for the best possible connections between the firms. This kind of approach provides an accurate optimization algorithm, but from a technical perspective makes the model difficult to simulate.

Setting up the simulation

The simulation model is tested with parameter variation. Table 1 below shows each variable and the range of values used in the simulation. The results are also analyzed using Monte-Carlo methodology as the model contains a stochastic element; each variable combination is replicated 100 times, and the mean value for each is employed in the analysis. Simulation was executed using Anylogic and simulation time set to 520 rounds.

Table 1. Parameter variation in the simulation model.

Variable	Description	Values	Increment
Interval time	Interval time of the change	10-100	15
Amplitude	Average size of change in the real network	0-0.2	0.04
Trend	Trend dependency in development	0-1	0.2
Price cap	Limits the maximum price of actor combinatio	250 or no price cap	

The true link values change according to interval time, amplitude, and trend. Interval time represents the change interval; the lower the value, the more frequent the changes. At an interval time of ten, the true link values change every tenth time step. Amplitude shows the maximum size of change. Change is uniformly distributed with a minimum value of 0% and a maximum value of amplitude. If amplitude is 0.1, the largest possible change is 10%. Trend represents the impact of previous change on current change; with the value set at 0, each change has a 50% chance of increasing or decreasing, while at 1 the change depends totally on the previous value. The only exception is when the link has reached a value of 0 or 1, at which trend has no impact on chance.

The continuous revision was dependent on the difference between the simulated and perceived values, and on revision efficiency. The slow reviser has an efficiency of 0.3 and the fast reviser 1. This change in perceived links is presented in equation (1).

$$\frac{\text{True links} - \text{Perceived links}}{60} \times \text{Revision Efficiency (1)}$$

The value of 60 was chosen by experimenting with the model. If the denominator is too low, all persons will revise fast and no true differences exist in the results. If the value is too high, even the fast reviser will not revise the network picture fast enough.

SIMULATION RESULTS

The simulation model results are analyzed using linear regression. We analyze how different environmental aspects impact a person's ability to revise the network picture. In the following analysis, the dependent variable is the relative performance of the slow reviser against the fast reviser. The potential variables impacting revision are: interval time of changes, amplitude of changes, trend of change, and the potential price cap for the chosen network. We first created a regression model using only price cap as an explanatory factor, in which the R Square value was 10.0, serving as a baseline to estimate environmental factors.

Since the potential exists for interaction between interval time, amplitude and trend, the interactions between these variables are also analyzed. This creates three different interactions: interval time and amplitude, interval time and trend, and amplitude and trend. The variables were standardized and then multiplied together to create the interaction terms. As the dependent variable has non-linear connections with the independent variables, the independent variables were square rooted. This was chosen instead of a logarithmic value as zeros existed in the data. For the price cap, a dummy variable was created where the value 1 represented the situation where no price cap exists. We first present the results without using the interaction terms and the results for the first regression model are shown in Table 2.

Table 2. Regression model without interaction. The dependent factor is the relative performance of the slow reviser compared to the fast reviser. Interval time, amplitude, and trend have been square rooted.

Term	Unstandardized Coefficient	t-value	Significance
Constant	75.173	982.953	0.000
Interval time	1.127	151.026	0.000
Amplitude	0.547	44.363	0.000
Trend	-0.292	-52.891	0.000
No price cap	5.490	173.083	0.000

As can be seen in Table 2, all of the terms are statistically significant. However, the impact on performance difference is quite small. The constant has the highest impact, followed by the price cap. The R square is 19.2, Durbin-Watson 1.963, and the Variance Inflation Factor for all variables is 1. There are no problems with autocorrelation or multicollinearity. Table 3 shows the results for the model using the interaction terms.

Table 3. Regression model with interaction. The dependent factor is the relative performance of the slow reviser compared to the fast reviser. Interval time, amplitude and trend have been square rooted.

Term	Unstandardized Coefficient	t-value	Significance
Constant	75.173	997.329	0.000
Interval time	1.127	153.235	0.000
Amplitude	0.547	45.011	0.000
Trend	-0.292	-53.664	0.000
No price cap	5.490	175.604	0.000
Interval time and amplitude	1.021	65.289	0.000
Interval time and trend	0.835	53.425	0.000
Amplitude and trend	0.063	4.035	0.000

The results for the second regression model are similar. All terms are statistically significant, R Square increases to 21.5, Durbin-Watson is 2.022, and the Variance Inflation Factor for all variables is 1. The increase in the R Square is directly attributed to the interaction between the independent variables. In order to grasp a better understanding of the interaction, Figures 3 to 5 present surface plot between the mean relative performances of the slow reviser against the independent factors.

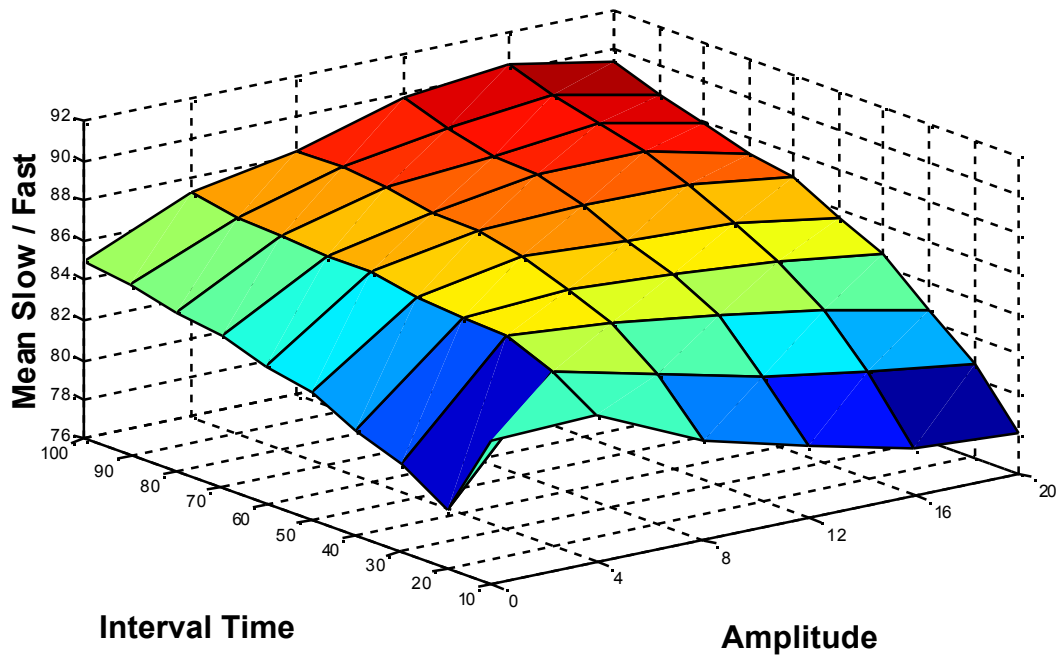


Figure 3. Surface plot between interval time, amplitude, and relative performance of the slow against the fast reviser

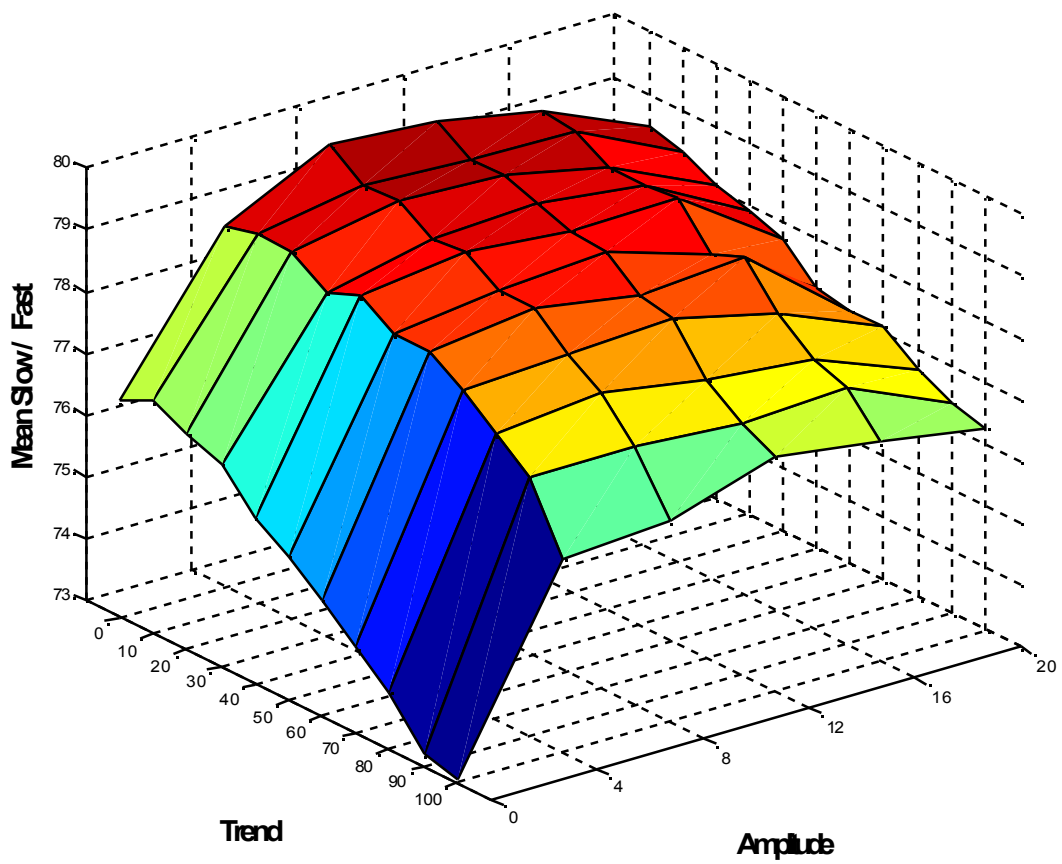


Figure 4. Surface plot between trend, amplitude, and relative performance of the slow against the fast reviser

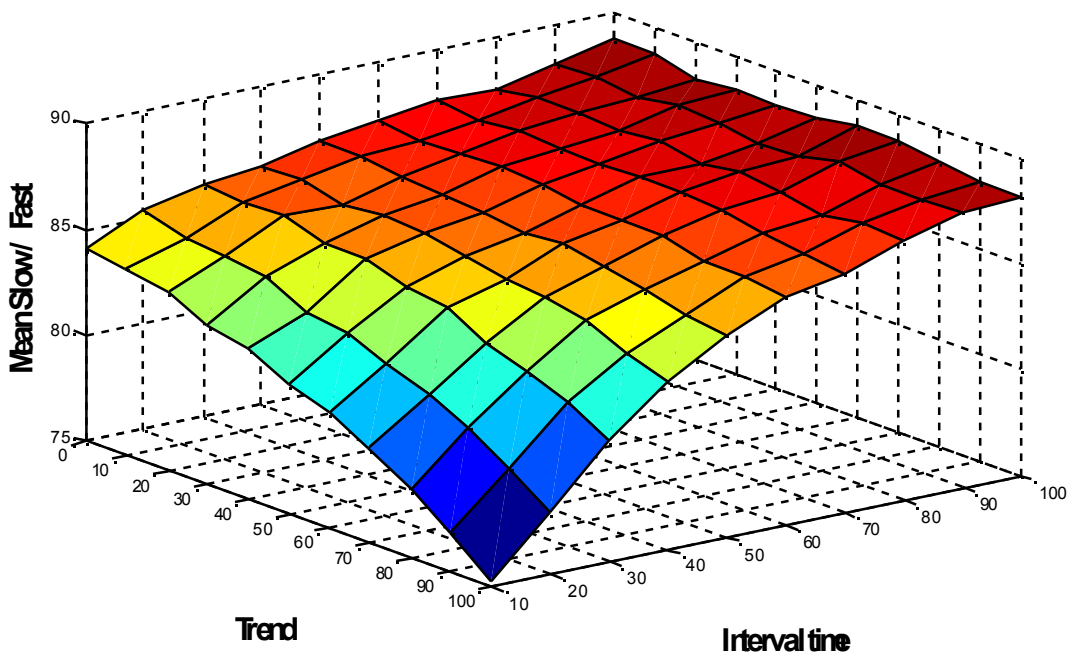


Figure 5. Surface plot between interval time, trend, and relative performance of the slow against the fast reviser

As can be seen in Figures 3 to 5, most of the difference between the slow and fast reviser can be explained without the interaction between the environmental factors.

DISCUSSION

The relative performance of the slow reviser compared to the fast reviser depends on various environmental factors (trend, amplitude, and interval time of change), but overall the revision efficiency has a higher impact. According to the regression analysis, most of the performance was explained by the constant term and the lack of a price cap. Including the interactions between the environmental factors increases the R square from 19.2 to 21.5, which indicates that interaction has only a minor impact on the results. On the other hand, the R Square of the regression model with and without environmental factors was 10.0 and 19.2 respectively. Including the environmental factors in the analysis enables better predictions concerning relative performance.

The general finding from the simulation results is that a manager with a faster ability to revise his or her network picture will make better decisions than one with a slower ability to revise. With regard to external parameters, the interval time between changes in the network is the most significant individual variable influencing network picture quality. These results should not be considered surprising as a fast ability to revise a network picture is likely to be valuable in a more dynamic business environment.

More interesting findings are revealed on inspection of the combination effects of variables. Both the amplitude and trend dependence of network change positively correlate with the relative decision quality of the fast network reviser. The effect of amplitude is logical as higher amplitude implies high dynamics in the business environment. The importance of trends in network development leads to some interesting findings. Where network development trend is low, network change is practically random. In such a situation, the likelihood of success for a manager with a slow ability to revise the network picture increases. This effectively means that a manager with a fast network revision ability sometimes needs to unlearn the previous network picture, whereas the lagging slower manager can be in an advantageous position in the short run. Thus, the results indicate that the benefit of having a fast reviser diminishes when network turbulence is increasing. This phenomenon is explained in Figure 6 below that demonstrates the logic of how the trend of change affects the network picture error in the two scenarios. If the amplitude of network change either grows or decreases, it affects the importance of development. The situation is best for the manager with a fast ability to revise the network picture when trend and amplitude are high.

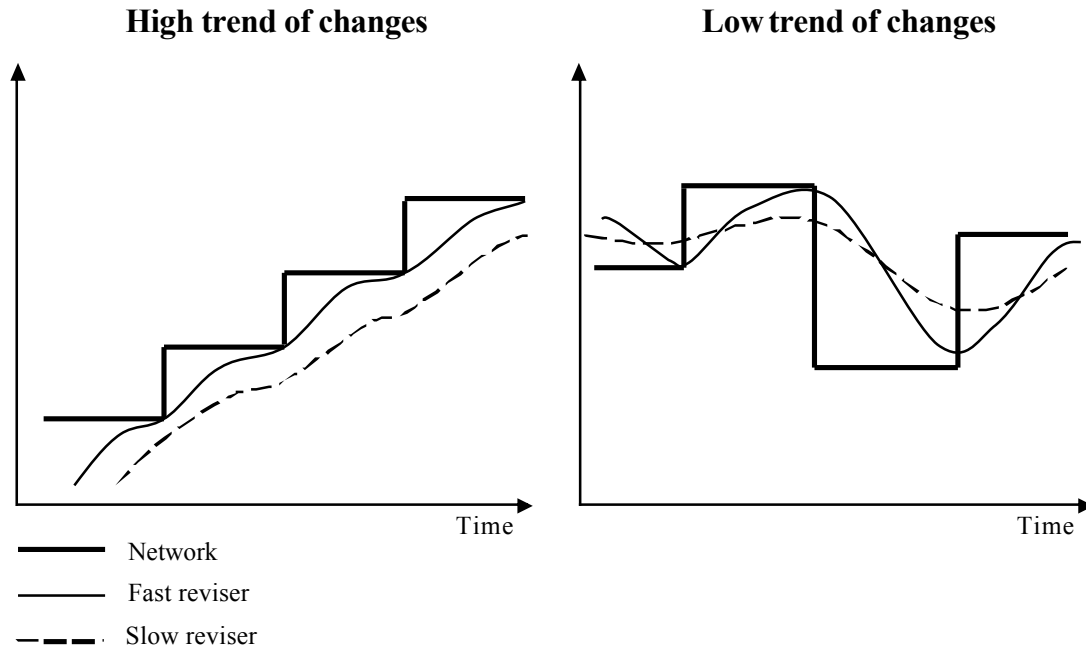


Figure 6. Effect of the trend of change on network picture error.

There are diverse factors affecting a manager’s ability to revise the network picture, such as network picture inertia (Öberg, Henneber, and Mouzas, 2007). This refers to drag on the revision of network pictures deriving from pre-existing pictures, which have usually been found to be functional and thus there is opposition to changing them. However, in changed network conditions, these pre-existing network pictures can be severely obsolete and thus distort decisions. Especially the role of network picture inertia in substantial network changes can be significant (Öberg, Henneber, and Mouzas, 2007).

Our findings suggest that a manager with a faster ability to revise the network picture will make better decisions. However, prior studies have shown that managers do not necessarily need an accurate understanding of the entire business environment (Gary and Wood, 2011). Denrell, Fang, and Levinthal (2004), and Gavetti and Levinthal (2000), have provided evidence that not all partial knowledge is equally valuable. Managers should focus on identifying the essential knowledge, instead of trying to make sense of the entire business network (Gary and Wood, 2011). Thus, besides being able to revise the network picture fast, a manager should be able to discern the essential information.

CONCLUSIONS

The purpose of this paper has been to increase understanding of the dynamic nature of network pictures. This has been realized by studying the relation between a manager’s ability to revise the network picture and decision quality in a dynamic business environment. In approaching this purpose with agent based modeling, we propose that a manager with a fast ability to revise the network picture benefits more in a dynamic business environment than a manager with a slow ability to revise the picture. Thus, the manager with the fast ability makes more accurate decisions. However, in a business environment with a low trend of changes, the difference between the fast and slow reviser is diminished. Thus, in a turbulent

business environment, the significance of a manager's ability to revise the network picture fast is decreased.

Limitations and future directions

The numerical comparisons between managers with fast and slow network picture revision abilities show that the differences between these two scenarios are small. It's not possible to state with full certainty whether this is correct or not, but in analyzing the model some potential reasons can be found. First, decision quality was executed in a linear fashion. Quality could also be argued to be curvilinear, which depending on the type of curvilinearity would affect the difference between the two scenarios. The second problematic area in the model is the implementation of network picture revision. No clear way could be found as to how this revision should be modeled. Changing the implementation method, and especially how the difference between managers with a fast or slow ability to revise the network picture is realized, would affect also the actual difference between the scenarios.

Modeling has not previously been used in network picture research. As such, this opens a new research stream on the topic, and also explains the problematic areas in the model, as there are no current models against which to benchmark. In future research, the model should be verified empirically to improve the validity of our results. In addition, the current state of the model should be developed further to increase its accuracy. Questions considering the implementation of difficult issues, such as revision speed and decision quality, can be improved. In the current model, these issues have been resolved correctly from a relational perspective, where a fast reviser is faster than a slow reviser. The most problematic issues are related to whether this difference should be linear or non-linear. Also, the number of external parameters is currently limited. Additional parameters could be included and tested in the model, if relevant parameters and their implications could be defined. The problem in defining new parameters for the model is that each additional parameter complicates it, and making the model harder to understand decreases its value.

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