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The company perspective of product variety: a conceptual model

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Abstract

In economics research questions are often discussed in isolation, thereby forgetting the bigger picture, e.g. regarding product variety, and consumer needs and demands on a product. In this paper, we integrate miscellaneous aspects and establish a conceptual model of changing product variety from a company´s perspective using qualitative reasoning. We use a set of selected publications that gives a contemporary overview of this economic domain and how parts of the system are interconnected. The formalization and visualization of domain knowledge is expected to dissolve discrepancies and misinterpretations in meaning, since it empowers people involved in decision processes to enter in dialog and discussion more easily. The development of causal relationships turned out to be demanding, perhaps also because in the literature there is a lack of answers to some questions. However, that is also a benefit of our research: developing mechanisms that explain how these phenomena may work. The question of how the relevant parts of the system behave if a trigger from the outside comes (or the absence of a trigger) is helpful for thinking about business processes.

Keywords: product variety, customer needs, product range, increasing product variety, conceptual model, causality.

1 Introduction

Choice is good, more choice is better? The answer often depends on the stakeholder who is asking the question. Our conceptual model is about presenting the company's perspective. However, it will not give us an answer to this question either. That is not why we develop this model. The goal of the developed model is to show which causal connections exist, for example, between product variety and costs and sales; knowledge relevant to decision-making processes. Visualization of the causal relationships provides a new perspective and allows to tap into several things at once.

Imagine you are a manager in a company and you know that the market is struggling with changing consumer needs. Now that your competitors are offering a wider range of products to meet your needs, you want to do the same. Your conclusion is a greater choice of products will lead to more customer satisfaction and therefore more sales will be generated.

But would that not be too simplistic? As [Götzfried, 2013] argues, decisions for projects for new products and product variants are company-critical and decisions on product variety are closely tied to almost all other managerial decisions [Gao et al., 2004]. The connections seem to be more nested than assumed. Therefore, decisions on product variety should not be taken lightly and it is worthwhile to spend enough time on it. Decisions made with care consider affected parts as coherent.

Of course, it is also part of our job to think about what parts are outside and within our model. This is important to communicate, so that decision-makers do not get the idea that there are no other influences besides the presented connections in our model. So, the reasons why you as a manager are thinking of a wider range of products can be manifold. The argument that consumers are the ultimate source of demand for product variety [Kim, 2006] is from our point of view too one-sided. Competition among manufacturers [Lee and Schluter, 2002] is mentioned as a further reason for the expansion of the product range. By the way, here you can see that the knowledge is very scattered. Even if consumers are depicted as the only driving force for product diversity in our model, it is important to mention that there are more influences.

We model both the positive (e.g. increasing sales) and negative effects (e.g. increasing costs) of variety. We imagine mechanisms that can bring our model back into balance, and in which the negative sides of product variety outweigh the positive ones. By having a holistic view, we help people get involved in research without having to read all relevant literature.

The different simulation results help to get an idea of how the system could evolve. Our work with the model has shown that certain connections are only imaginable through visualization. In addition, we were occasionally also able to find areas that have not yet been sufficiently investigated. Here, we use assumptions on our part to complete the model. It helps to understand what happens when there are no certain regulatory management mechanisms (such as the technology mechanism).

This paper is structured as follows. Section 2 explains the basic concepts of the used Qualitative Reasoning (QR) software Garp3. Section 3 gives an insight into what is included in our model and in subsections the individual model fragments are presented. Section 4 shows the most important simulation results. Finally, Section 5 summarises the main objectives and reflects on results obtained.

2 Qualitative Modelling with Garp3

Garp3 [Bredeweg et al., 2009] uses entities, agents, assumptions as well as configurations to describe the physical system structure. Quantities, quantity spaces, magnitudes and derivatives, direct influences, proportionalities, correspondences and inequalities are used to describe the system behaviour.

Quantities are the relevant properties of entities that may change under the influence of processes. In contrast to entities, agents are used to model entities outside the modelled system. Configurations represent structural relationships between entities, and entities and agents.

Quantities consist of a quantity value which consists of a magnitude and derivative. The quantity space represents the range of possible values of a quantity. While the magnitude describes the current value of a quantity, the derivative is used to describe its direction of change.

The notion I+ is used to model positive influences [Forbus, 2008], which denote direct relations between two quantities. The notion I- is used for negative influences. Using proportionalities (P+ and P-), the derivative of the target quantities can be determined depending on the derivative of the source quantities. Correspondences (C) are used to model the relations between qualitative values of different quantities. Inequalities (≤, <, 0, >, ≥) are commonly used for indicating that one quantity value is different (or equal) to another quantity value (or dirivative).

Scenarios are applied to model the initial state of a system and serve as input for the qualitative simulator. Model fragments are required to describe the structure of a system and consist of conditions and consequences. Each model fragment represents part of knowledge of the domain that may apply to a certain scenario. The engine searches for model fragments that are applicable to the selected scenario and infers the system behaviour. With the mentioned inputs, different simulation outputs can be generated, including state-graph, value history, equation history and an integrated causal model for each state in the state-graph. States in the state-graph depict qualitatively unique behaviours of the modelled system.

3 Modelling of the problem domain

First of all we discuss the theoretical concepts that form the basis for the content of the presented model, then we move on to modeling and subsequent simulation.

3.1 Conceptual framework

Table 1 gives an overview of the relevant components of the system. It also highlights concepts that are interesting, but not part of our model because they represent a non-mandatory extension or even require a separate model.

According to Table 1, different drivers of product variety can be identified. For the work presented, we decided to focus on the consumer as the driving force. On the one hand, the majority of the articles we analyzed explore relationships between customer needs and product variety of a company and, on the other hand, we agree with Peter Drucker's argument [Webster, 2009] that the customer needs should come first in all situations.

As Table 1 shows, our focus is on the company perspective [Gao et al., 2004] and [Webb, 2011] although the consumer view [Riemenschneider, 2006] and [Kahn, 1998] is to some extent included in the decisions of the company (e.g. company responds to customer needs by adapting its product variety) and therefore in our conceptual model. We understand the company as a closed system and we focus on this system. An extension of the model to the customer perspective would not be expedient. From our point of view, the customer perspective is a separate conceptual model with its own quantities and causal relationships.

3.2 Initial situation

At this point, we model the initial situation of a company facing changing customer needs that are triggered by an external drive. The initial scenario (Figure 1) created in the Garp3 Build environment defines three entities (named Customer, Industry and Management) and one agent (named Society). As explained in Section 2, the agent enables us to model exogenous influences on the system. The entity name was chosen industry (and not just company), because we want to speak to a broad readership of decision makers (for example, individual companies or even participants in a supply chain).

There are three configurations in the scenario (named Member, Engages, and Manages). Configurations are used to define the structural relationships between the entities, and with the agent. Configurations are particularly relevant when searching for model fragments that are applicable to the scenario.

Society has a quantity Drive with magnitude zero. The blue arrows in the quantity spaces show the starting values of their associated quantities. As Figure 1 shows, each qualitative value is either a point (quantity: Drive), or an interval (qantities: Needs, Variety, Costs, Sales, Technology and Production) or not specified in the scenario (quantities: Ratio fit, Ratio profit and Ratio innovation).

Drive is represented as an exogenous quantity (denoted by the exclamation mark in Figure 1). The derivative of drive is influenced by "parabolic positive" (bell-shaped development). Drive may transfer its behavior to other quantities of the system. Customer has been assigned the quantity Needs, with the quantity space Interval, which has only a single value, namely Interval. The accompanying quantities of Industry are: Variety, Costs, Sales, Technology, Production, Ratio innovation, Ratio fit and Ratio profit, whereby the last three have the quantity space {Min, Zero, Plus}.

The derivative quantity spaces (δ) of all quantities in the scenario are unspecified, that is, they are intially unknown.

The scenario starts with needs being equal to variety (shown by the equal sign = between needs and variety).

Costs and sales, technology and production as well as ratio fit and ratio profit have the same value in the initial state. Hence, we start with a balance in the initial scenario (the agent also starts at stable) and therefore there is inititially no reason for a regulatory management actions.

Table 1. Model-relevant research concepts

		References	Central argument	Implementation in the model
Drivers of product variety	Consumers	[Kim, 2006]	Consumers are the ultimate source of demand for product variety.	Consumers are modelled as an entity with the quantity needs that has a positive influence on the product variety.
	Competition	[Lee and Schluter, 2002]	Separation from competitors through product the number of product variants.	*Not part of the model*
	Information technology	[Brynjolfsson et al., 2010]	There are demand-side technological drivers (e.g. Search and Database Technologies) of changes in product variety.	
Effects of changes in product variety (consumer perspective)	On costs (e.g. more time for decision-making due to high product variety)	[Riemenschneider, 2006]; [Kahn, 1998]	More product variants may entail more time for decision-making in the purchasing proces.	
	On utility	[Riemenschneider, 2006]	More product variants may lead to increased value for the customer.	
Effects of changes in product variety (company perspective)	On information technology	[Gao and Hitt, 2004] Firms seeking to offer greater variety can facilitate this strategy through IT investment.		The quantities product variety, technology and costs are seen in a triangular relationship. A cost-effective situation occurs if technology and product variety are balanced.
	On costs			
	On sales	[Randall and Ulrich, 2001]; [Kim, 2006]	Offering products, which ideally satisfy customer needs, may increase a company's sales.	Sales decrease if customer needs are bigger than product variety.
	On profit	[Webb, 2011]	Product variety creates both problems and opportunities for firms and this affects firm profitability.	There is a mechanism that expresses costs as well as benefits of product variety in the form of the quantity profit.

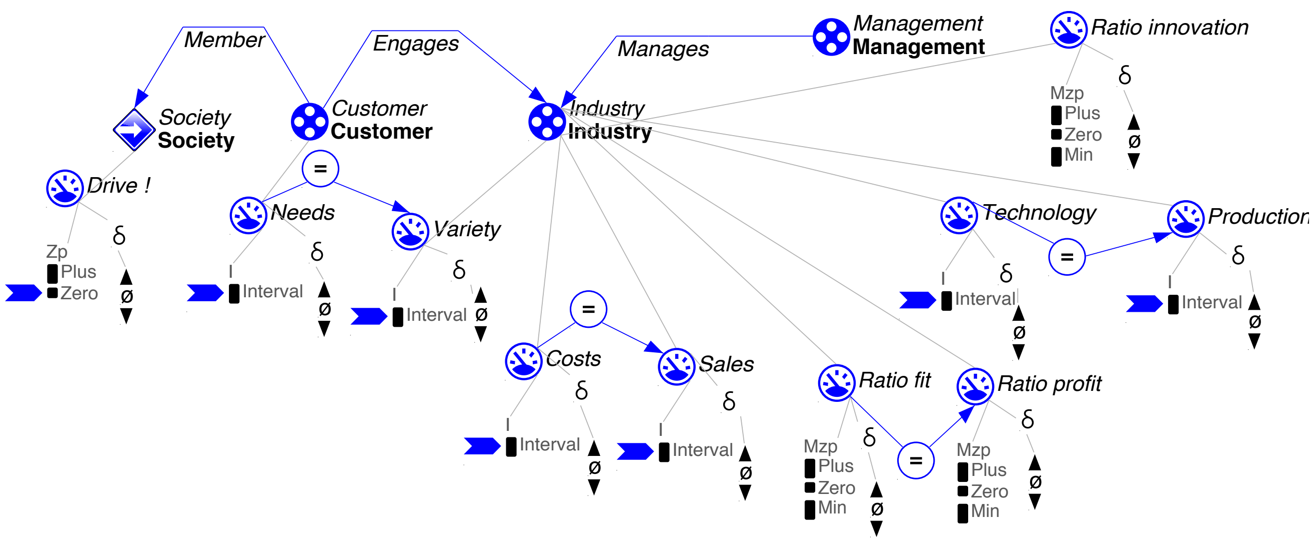

Figure 1. Initial scenario for a company facing changing customer needs.

3.3 Society drive and the effects on critical product variety decisions

We use the exogenous quantity drive which is associated to the agent society (Figure 2). The configuration member from customer to society shows the structural relationship between these two entities. The positive direct influence (I+) between drive and needs is used to express information regarding causality and shows that drive has a positive effect on needs. The I+ causes the quantity needs to increase if the magnitude of drive is positive, decrease if it is negative, and remain steady when it is zero. The derivative quantity spaces (δ) of both the quantities drive and needs are unspecified in the model fragment and change during simulation.

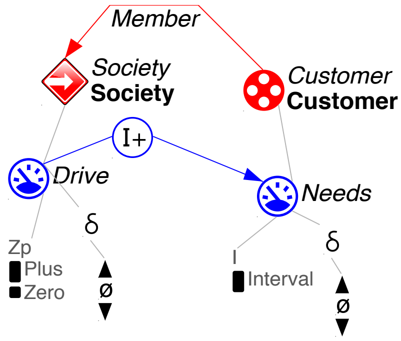

Figure 2. Drive on Needs.

Figure 3 shows a mechanism that tries to balance variety and needs via a management action. The configuration Manages connects the entities Management and Industry. The black part of the model (with the entities industry and customer and the quantities variety, needs and ratio fit) is a static model fragment that has been modeled as such and therefore defines the structure of the system. As we reuse this model fragment within the process model shown in Figure 3 as a condition, we refer to it as an imported model fragment. The imported model fragment is named Variety and needs (coloured red in Figure 3).

There is a calculus specifying: Needs – Variety = Ratio fit. Moreover, Needs has a positive proportionality (P+) with Ratio fit. Therefore changes in needs propagate to changes in ratio fit in the same direction. The negative proportionality (P-) between variety and ratio fit cause ratio fit to decrease if variety increases, ratio fit to remain steady if variety remains steady, and ratio fit to increase if variety decreases.

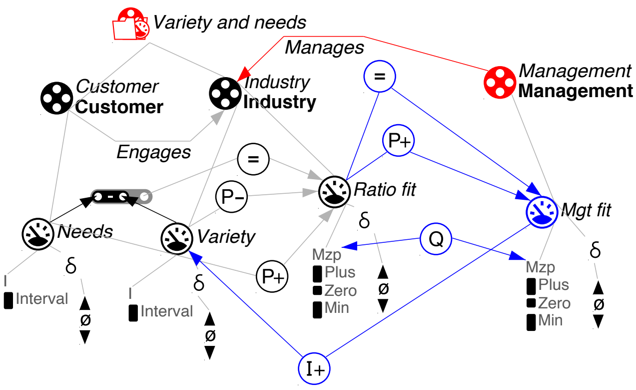

Figure 3. Mechanism management fit.

The entity management with its accompanying quantity Mgt fit has a quantity space {minus, zero, plus} and shows how well the industry meets the needs of its customers with the product range. If needs is bigger than variety, variety has to be increased (denoted by the I+ from Mgt fit to Variety). The fragment specifies a positive proportionality (P+) between Ratio fit and Mgt fit (the latter following changes happening to the former). There is a correspondence (Q) between the quantity spaces of Ratio fit and Mgt fit; specifying that these two quantities have co-occurring magnitudes. The two quantities also have an equality (Ratio fit=Mgt fit).

Figure 4 shows the relationship between Ratio fit and Sales (I- from Ratio fit to Sales). This mechanism triggers sales to fall if customer needs and product variety are not in balance. Therefore, when Ratio fit has value Plus, it makes the Sales decrease, and when Ratio fit has value Zero, it does not change the Sales, and when Ratio fit has value Minus, it makes the Sales increase.

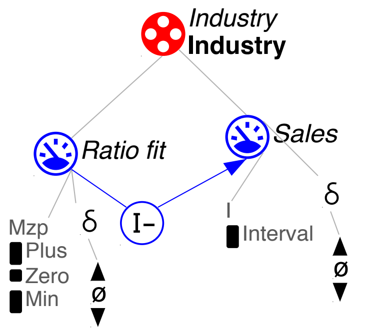

Figure 4. Ratio fit on Sale.

3.4 Product variety and IT as complementaries

Figure 5 shows a mechanism that tries to balance technology and production via a management action. There is a cause-effect dependency (P+) from Production to Ratio innovation, therefore ratio innovation follows changes happening to production. Technology has an indirect negative influence (P-) on Ratio innovation. The negative proportionality will decrease Ratio fit if Technology is increasing, has no effect on Ratio fit if it is stable, and will increase Ratio fit if it is decreasing. The calculus relation (Technology – Production = Ratio innovation) shows the change for Ratio innovation when Technology and Production are out of balance.

If production is bigger than technology, technology has to be increased by management (denoted by the I+ from Mgt innovation to technology). Mgt innovation has quantity space {minus, zero, plus}. Ratio innovation has a positive proportionality (P+) with Mgt innovation. Therefore changes in Ratio innovation propagate to changes in Mgt innovation in the same direction.

The quantity space correspondence (Q) between the quantity spaces of Ratio innovation and Mgt innovation indicates that these two quantities have co-ocurring magnitudes. The two quantities Ratio innovation and Mgt innovation have an equality (Ratio innovation=Mgt innovation).

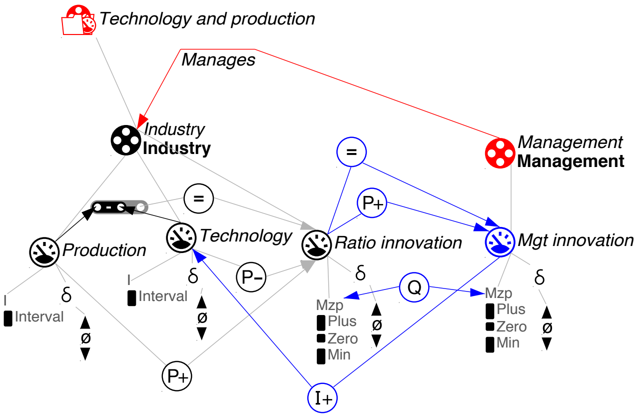

Figure 5. Mechanism innovation management.

Figure 6 shows the causal relationship between Ratio innovation and Costs. Therefore, when Ratio innovation has value Plus, it makes the Costs increase, and when Ratio innovation has value Zero, it does not change the Costs. When Ratio innovation has value Minus, it makes the Costs decrease.

The negative influence (I-) from Ratio fit to Sales will decrease Sales if Ratio fit is Plus, will increase Sales if Ratio fit is Min, and remain stable if Ratio fit is Zero.

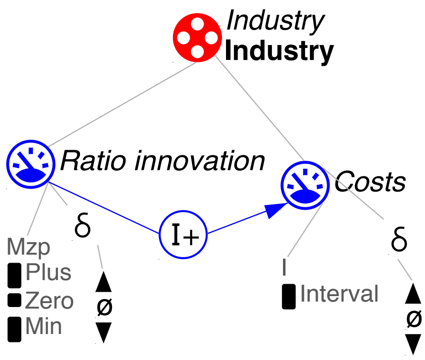

Figure 6. Ratio innovation on Costs

Recall that Figures 3 and 5 show our two management mechanisms. On the one hand Management and the accompanying quantity Mgt fit tries to achieve a balance between Variety and Needs (see Figure 3) and on the other hand Management and the accompanying quantity Mgt innovation tries to balance Technology and Production (as shown in Figure 5).

Variety and needs (use in the model fragment shown in Figure 3) as well as Technology and production (used in the model fragments shown in Figure 5) are imported model fragments that are reused for these mechanisms.

Figures 4 and 6 show the consequence on Sales and Costs, following the balance between Variety and Needs, and Technology and Production. Respectively. Only in the case that the ratios (Ratio fit and Ratio Innovation are zero, there is no change for Sales or Costs.

3.5 Sales and costs balance

Figure 7 depicts the possible effects of Sales and Costs on Ratio Profit. The mathematical calculus (Minus) is used to calculate the difference between Sales and Costs. We define a positive proportionality (P+) from Sales to Ratio profit and a negative one (P-) from Sales to Ratio profit, indicating that a potential increase in Sales would result in an increase in Ratio profit, and an increase in Costs would set the Ratio profit to decrease.

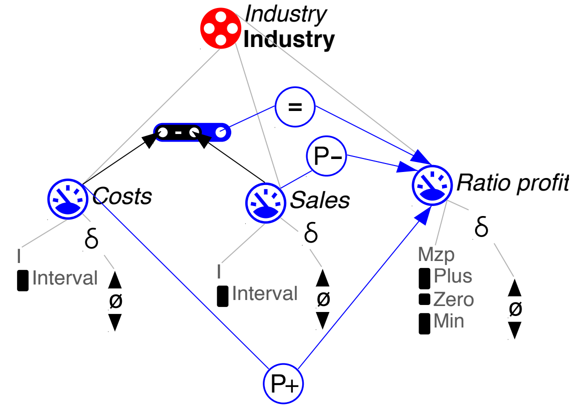

Figure 7. Costs and Sales.

3.6 Simulation results

We use the simulation preference *fastest path* heuristic to avoid overwhelming results. Simulating the initial scenario (Figure 1) produces a state graph with 14 states (see Figure 8) as an end result, whereby state 12 is the only stable end state. Each state reflects a qualitatively distinct behavior of the system. The arrows between two states (e.g. between state 1 and 2) are the state transitions. We select the behaviour path [1 ➝2 ➝ 3 ➝ 4 ➝ 5 ➝ 6 ➝ 12] for further analysis.

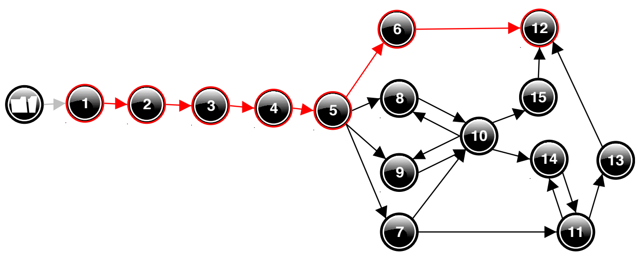

Figure 8. State graph with selected path.

As well as the state graph, the value history provides a particualar view on the simulation results. The value history diagram (Figure 9) enables us to follow the changes each quantity undergoes during the simulation. The selected path as well as all the other paths show the same basic behavior:

Needs increase and Variety tries to follow Needs. As shown in Figure 9, Needs increases from state 2 onwards . Variety follows this rising trend from state 3 on. The diagram presents an increase in Costs (states 4, 5 and 6) as well as a decrease in Sales (states 3, 4, 5 and 6).

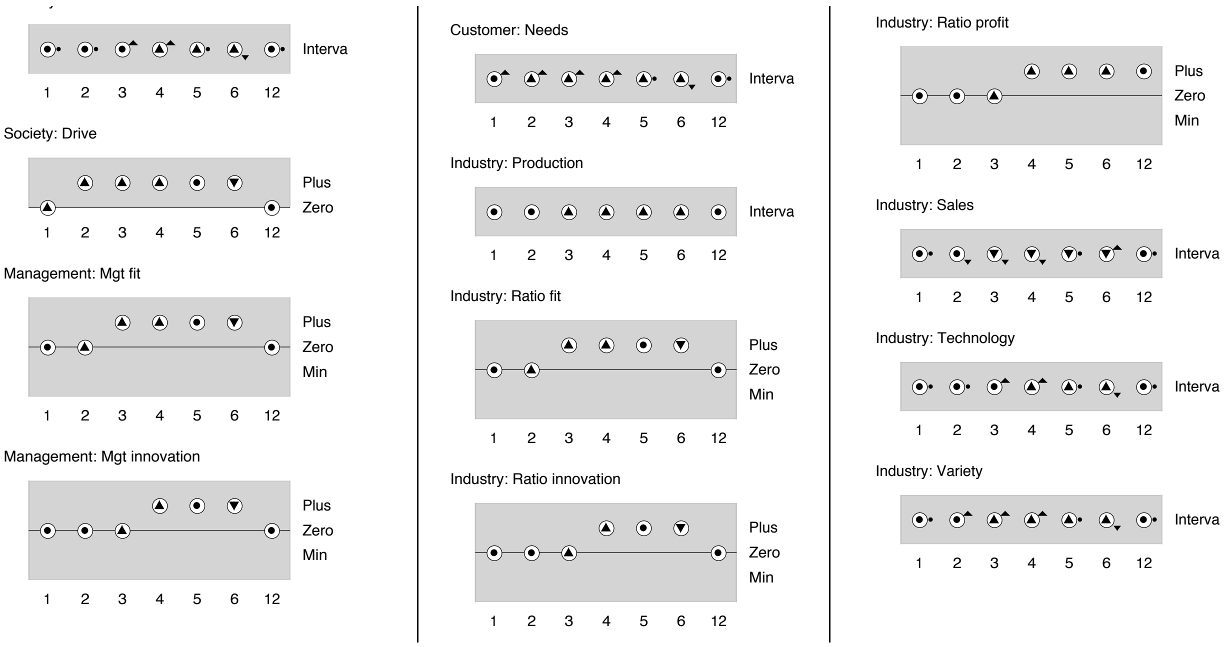

Figure 9. Value history for path [1 ➛2 ➛ 3 ➛ 4 ➛ 5 ➛ 6 ➛ 12]

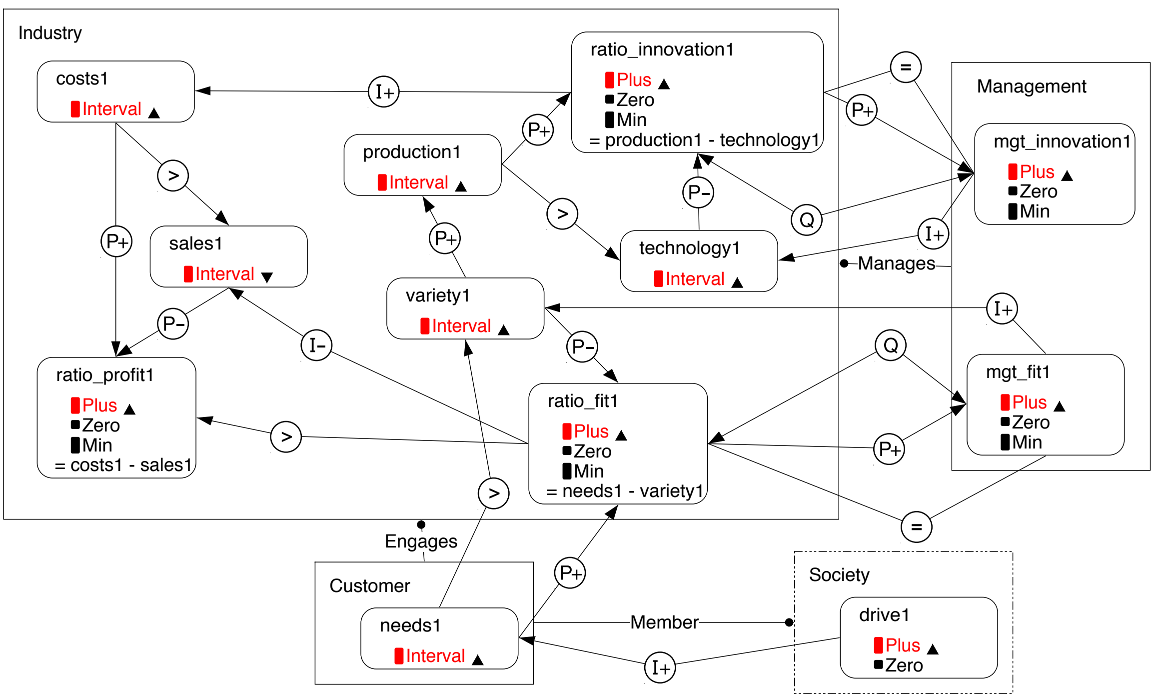

Figure 10. Dependency view for state 4.

The dependency view (also referred to as the causal model) provides an overview of the causal relationships between the quantities in a particlar state (see Figure 10). Once again, it becomes clear at a glance which entities play a role in our conceptual model, namely society, customer, industry and management. The red marking in the individual quantity spaces shows the current value of the quantities in state 4. The black arrows in the quantity spaces show the derivatives. Except for sales, a rising trend is expected for all quantities.

4 Concluding remarks

The main question that initiated this research was how to formalize knowledge about a company's product variety – that is all the products and variants it offers – jand its causal relationships. We started with a literature research to identify key drivers of product variety as well as the interdependencies between product variations and other business sectors. The accurate demarcation of parts inside and outside the system sharpened our common understanding of the domain to be modelled.

The following insights have emerged from the presented work.

- Language is sometimes difficult to understand and leaves room for interpretation. Common concepts are often named differently. Therefore visualization is a good means to overcome this, since it helps to recognize potential errors.
- It was hard to find the right abstraction level, which provides a value added for the user. Distinguishing relevant from irrelevant content turned out to be difficult. For this, one must already have a good overview of causal relationships in order to accomplish this step.

The paper reveals that it is possible to use conceptual modelling for developing ansswers to ecnomical questions. The visualization capabilities of the Qualitative Reasoning (QR) software (Garp3) help to make complex phenomena insightfull and understand them.

For future research, we are working on further management mechanisms. In concrete terms the planned management mechanisms are:

- Marketing management as an awareness creator and therefore the driver of sales.
- Cannibalization management to defend turnover and sales.
- Product bundling management as an effective means to boost profit.

We plan to introduce further quantities in the model, including complexity. In addition, there will be a max value in the quantity space of variety, that should not be exceeded (otherwise sales will be lost).

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