

**Understanding the Dynamics Created by Management Decisions –
A Vensim-based Simulation Approach
for Management Education**

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Abstract

Industrial companies can be characterized as complex and dynamic systems that are only parts of more complex systems. Therefore the purpose of education of business administration students can not only be to teach the principles of different functional areas. Management education also has to enhance the understanding of how the different organizational parts of a company interact, how the dynamic consequences of decisions are and how decisions in one functional area of a company influence other parts. Here the traditional way of teaching in management education fails. Tools are needed that allow (1) to teach the structural fundamentals of companies and (2) to show dynamic behavior created by management decision making. Therefore System Dynamics is part of the education of students in business administration at the Industrieseminar of the Mannheim University.

The paper discusses a comprehensive model of a company and its interactions to the suppliers, the markets, the competitors and its use in management education. This management simulator is partly based on the model developed and published by Lyneis. Some of the sectors of the original Lyneis model were improved and completed by others that map market dynamics, research and development, and a more detailed representation of competitive structures. Opposed to the Lyneis model which was developed in DYNAMO the management simulator is implemented in VENSIM.

Students use this model in the advanced courses of System Dynamics. They analyze the structure of the model, the feedback relations and the management policies that are mapped. They are also forced to seek for better policies in the different functional areas and can test the dynamics created by their new policies. On that basis the understanding of the interactions of the functional parts of a company and the dynamic consequences of decision can be improved.

For the things, we have to learn
before we can do them,
we have to learn by doing them.

Aristotle

Management Education – Teaching Practices and Requirements

Managerial decision making is a highly dynamic and complex task. It requires knowledge about basic management principles and about the adequate management tools. But it is also necessary that managers have knowledge about their company, the markets, and the competition. In other words management needs an understanding of how different parts of the companies interact with each other and how the companies interact with their competitors. From a lecturer's point of view, the teaching of the basic management principles and the understanding of „how to use“ management tools is relatively easy. The lectures and case study based exercises at university and management seminars are sufficient to fulfill this task. For the clearly structured, understandable and interesting teaching of the complexity and dynamics of management decision making we need other tools (Graham et al. 1994). From the students point of view the learning and especially the understanding of the interrelations and the dynamic consequences of a decision is a very hard venture.

Teaching only the basic management principles is not sufficient for the efficient training of managers. Having good knowledge about basic management instruments is imperative for successful management but it is not sufficient. Management needs a mature knowledge and a plenty of experience about decision making. Managers must be aware of both, the short-term and the long-term dynamic consequences that are caused by their policies and their decisions. They need a detailed understanding of a system's dynamic behavior. Although these requirements seem to be obvious, management education usually does not consider these aspects in their curriculum. There is a conflict between the way management is currently taught and the requirements for the understanding of decision making. This will be clarified by some examples.

- In the lectures on financing and investment we teach the students how to judge the profitability of an investment by using the methods of present value or the capitalized value of the investment. But we do not explain where the incoming and outgoing payments come from, how they are influenced by the investment through e.g. an increase of manufacturing productivity and quality or a decrease in delivery delays. We assume a static scenario of payments and do not look at the dynamics that are caused by an investment decision.
- In marketing lectures e.g. we teach the students different strategies of pricing new products, like penetration pricing, skimming pricing or myopic pricing. We also explain the aims of the particular strategies. But we do not give the students the opportunity to learn something about the dynamics caused by a pricing decision. E.g., how do pricing strategies influence the required capacity? How is the impact of pricing on a company's liquidity? How are the consequences of pricing on the available cash for capacity investment, advertising, and R&D budgeting?
- In the courses on technology and innovation management or strategic management the students learn e.g., the product life cycle approach, the concepts of Foster's s-curve, sev-

eral portfolio concepts like the instruments of Boston Consulting Group, Mc Kinsey or Pfeiffer's technology portfolio. We also teach various instruments of competitive analysis, Porter's competitive strategies, or how to budget resources for research and development (R&D). We do that by describing the concepts, discussing pros and cons, and showing the students how possible strategies can be derived through the use of the approaches. But we can not show the students the use and practicability of these instruments in reality. We can talk about problems in an abstract manner and the students seem to understand it. But they never experience the dynamics created by the use of a particular instrument of strategic planning. They never reflect that the realization of a strategy requires financial and personnel resources and that the realization depends on the situation the company is confronted with.

The examples given above show that the traditional way of teaching only offers the chance to learn the concepts behind management instruments. It makes clear what information is required for management decisions. But it does not give the capability to learn something about dynamics created by the decisions. Beyond that, the instruments we teach are useful to analyze a problem situation from a static point of view. We are using static instruments for problem analysis and decision making in highly dynamic surroundings.

Teaching Dynamics of Management Decisions using Management Simulations

Concepts for Teaching Management Decision Making

Although the process of decision making and the decisions themselves are influenced by the specific structures within a company, their individual problems, and their particular situation we have to train decision making to get -- from a systems thinking point of view -- well educated and competent managers. Managers must have the chance to learn what decision making in a dynamic world means. They must be aware of the fact that each decision influences the behavior of the system, that decisions have a certain feedback on future decisions, and that in most cases there is a difference between the short-term and the long-term consequences caused by the managerial decisions. In accordance with these claims we need a comprehensive approach to management education.

Integrating system dynamics based simulation into the curriculum of management education was a prerequisite and powerful step into the right direction. The emergence of user friendly and powerful personal computer hard and software has been very helpful to intensify system dynamics and systems thinking in teaching and training of students and managers. But in the beginning the aim of the system dynamics courses was the teaching of how to build models, using different simulation software and to understand the interactions and the behavior of the elements of the systems under consideration. Building system dynamics expertise was the main aim of these courses. There is no doubt that this led to a better understanding of management as acting in complex systems. But models that have been developed in these courses mostly were kept small and easy in order to teach system dynamics modeling and to educate sophisticated model builders. Although this opens the field of systems simulation to management, it is not sufficient. For the teaching and training of decision making this would mean that managers must have model-building capabilities and simulation experiences to test decisions and policies.

On the other hand it is obvious that the training of students and managers could not take place in the real world. Instead of the real world we need virtual realities that (1) allow decision making without risk and cost, (2) immediately show the consequences of the actions taken, and (3) allow the analysis of a system's behavior. Without detailed knowledge about simulation and simulation software the training of management decision making requires instruments like management games or management flight simulators. Just like a flight simulator for the training of a pilot, these approaches are suitable instruments for management education (Senge 1990).

*Management Games and Management Flight Simulators for the Training
of Decision Making and Policy Design*

Management games and management flight simulators are different concepts for the teaching and training of decision making. The use of management games allows at a general level, to teach:

- how to make decisions, especially how to decide in groups,
- which information is necessary,
- which instruments are useful,
- how to use different kinds of management tools,
- how the own decisions influence the behavior of the own company and the competitor's,
- and, last but not least, the players learn what feedback in complex systems means.

A management game that considers these aspects is used at the Industrieseminar of Mannheim University in management education to train decision making (Milling 1991, Milling and Lehmann 1994). The game considers the problems of budgeting for research and development, advertising or pricing as well as financial or investment problems. The structure of the underlying model is complex. It consists of different sectors of competing companies, like a sector of capacity planning and investment, a sector of financing, production, marketing, the annual financial statements, and a sector of research and development. Additionally, a market sector maps the structural fundamentals of an oligopolistic diffusion model to generate the demand for each company's products. The companies compete with their products, which have to be developed and introduced.

The students of a course are separated into different groups; each group is acting as the board of directors of a company. The students have to decide on a plenty of variables, like pricing strategies, R&D budgets, investment, or market entry time. In each decision period the players get a report that contains information about the actual state of different variables of their company and their markets. A distinguishing characteristic of this type of management flight simulator is that the students do not play against an imaginary competitor „inside the computer“. The groups play against each other. The computer model only serves as a clearing facility to generate the companies demand and to calculate the results.

The complexity of the model structure, the necessary decision processes, the group dynamics, and time pressure gives the students a good impression of the complexity and the dynamics of management reality.

However, due to the complexity of the underlying corporate and market model it is difficult to teach systematically the problems of the dynamics caused by management decision making. Furthermore, the way in which the game is organized and played does not allow that a single group

tests its decision, analyzes the consequences, then move back one time period and test another decision. The outcome of any particular decision of a group in the game depends on the decisions of all competing groups. This complicates the analysis of the decision consequences and makes it more difficult to draw conclusions about the underlying feedback structure (Goodman 1994).

Therefore, to teach the dynamics caused by management decisions in addition to the described competitive management game the use of management flight simulators -- such as the People Express Management Flight Simulator (Sterman 1988) or the Hanover Insurance Claims Game (Diehl 1992) -- is very helpful. The benefits of a simulation based approach and the advantages of management flight simulators in education are broadly recognized (Meadows 1989). These approaches allow:

- interactive gaming with a computer model,
- to simulate various decisions,
- to compare the results of the different simulations, analyze the results,
- to draw conclusions on feedback relations between model variables,
- and eventually to rethink the users mental model.

A distinguishing aspect to competitive management games is that the behavior of the model depends on the users' decisions only. The behavior is not influenced by „real“ competitors' decisions like in the competitive management game. Management flight simulators make the understanding of feedback structures much easier, is less time consuming, and therefore enhances learning and understanding in management education (Sterman 1994). However, using management flight simulators has the disadvantage that the group discussions are less intensive and that decision making often has the character of gaming. Beyond that management flight simulators as well as management games can be used for policy design but they are not suitable for policy implementation to a model. In the following an approach will be shown that supports all the above mentioned aspects of education in the field of decision making.

A Vensim based approach to Management Education

Basics of the Advanced Tutorial Classes on Management Decision Making

The lectures and exercises on management decision making are open for advanced students that already have passed their examinations of the basic management studies. They have also joined a basic lecture on system dynamics, where they were taught the principles of systems thinking and modeling using Vensim as simulation software. Although the students learn during the course on management decision making advanced modeling techniques, the main objective is decision making and policy design in a complex and dynamic virtual reality.

The exercises are based upon a model developed and described by Lyneis in his book „Corporate Planning and Policy Design: A System Dynamics Approach“ (Lyneis (1980)). This model shows in a very systematic way the dynamics created by decisions and policies of different management areas as well as the dynamics created by interactions with company suppliers, markets and competitors. This model, that originally was implemented in DYNAMO, was converted to Vensim and completed through a sector that maps the process of research and development for

new products as well as a detailed diffusion model to generate the product life cycles of successive product generations. Additionally, the corporate structure of the competitor is modeled more in detail (König 1995). The coarse model structure is shown in Figure 1.

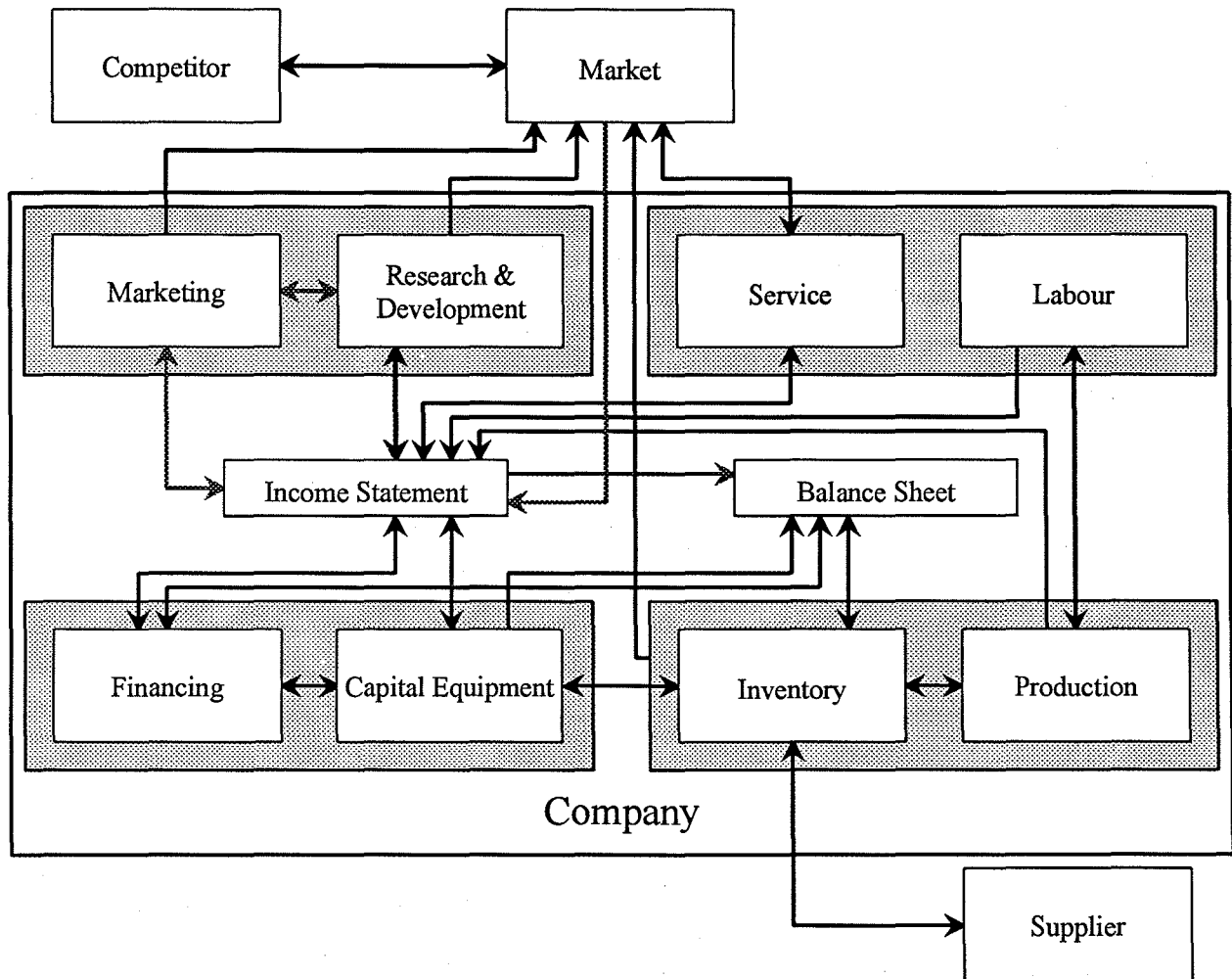


Fig. 1: Coarse structure of the model

The model comprises the structures of a competitor, a sector to map the oligopolistic markets, the manufacturing process of the company's suppliers, and the structure of the company itself. The company that has to be managed is separated into four functional areas:

- The area of production and inventory.
- The area of marketing and research and development.
- The area of human resources.
- The area of financing and capital investment.

Additionally a balance sheet and the income statements of the company are modeled to summarize the company's actual situation in terms of financial variables.

Parallel Program

This model serves as the virtual company the participants of the classes have to manage. It is the learning laboratory for the training of decision making. How the model is used to teach the different aspects of management decision making will be shown in the following.

Course of an Advanced Tutorial Class

Four weeks in advance to the tutorial classes the model, a detailed case description, including a discussion of the model equations and the underlying book of Lyneis is handed over to the participants. The students are separated into groups of 3 to 4 and have to take over the responsibility for one management area. During the 4 weeks before the classes start the students have the task to read the description, simulate different strategies and policies and analyze the model in order to better understand the feedback relations and the dynamic behavior. The students also have the duty to seek for strategies within their management area. Therefore they are allowed to modify the structure of the model. However, the modifications of policies or model structure they suggest and test are restricted to the management area they are responsible for.

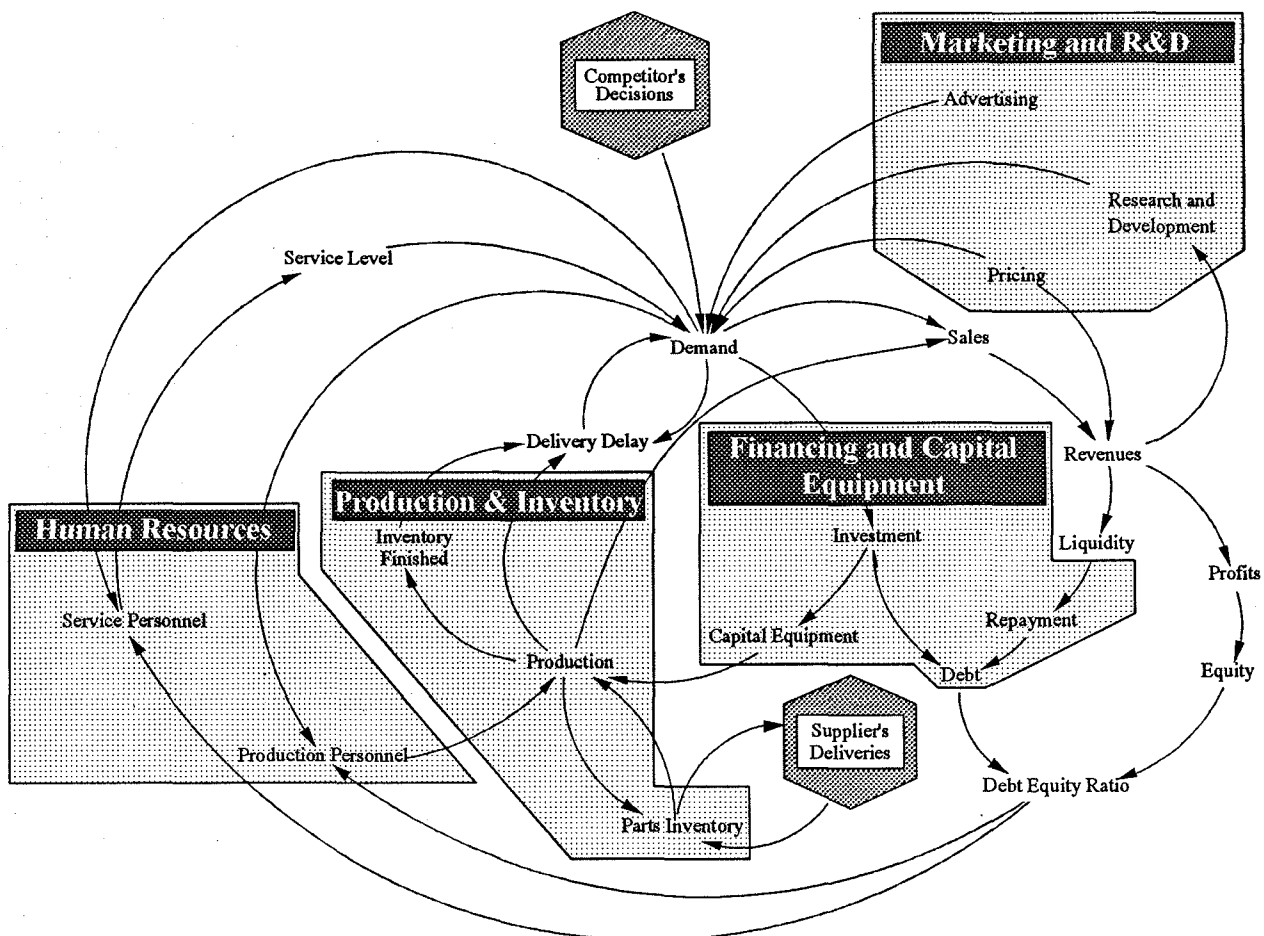


Fig. 2: Elementary feedback relations and management areas

The discounted cumulative profits and market share serve as performance measure of the suggested strategies. When the students are seeking for better strategies they are forced again and

again to analyze the feedback relations and limits of their own policies that may result from feedback from other sectors. E.g., the „managers“ of production and inventory suggest higher production output in order to reduce delivery delays and gain market share. But this strategy may be limited by the actual hiring policy the „human resource managers“ use. Or it is restricted by slow capacity expansion that again results from the „financial manager’s“ conservative financing strategy, or insufficient liquidity caused by the „marketing manager’s“ penetration prices. Figure 2 shows some of these essential feedback relations the students are confronted with and the decision areas they are responsible for.

After the exhaustive analysis of the model and the development of improved strategies the students have to summarize the findings about their management area in a paper that must not exceed 12 pages and has to be delivered to the lecturer before the semester starts. In the classes then each group -- the managers of an area -- has two sessions to present the structure of their management area, to show the original and their improved policies, and to discuss limitations eventually caused by other parts of the company. After each group has presented their strategy recommendations in two to three sessions, the improved policies of the single functional areas are brought together and were implemented into the model. At this point in most cases the students experience that optimal strategies of the different parts must not mean an overall optimum for the company. The classes are finished by a session where they seek for commonly shared strategies to improve the overall behavior of the company.

Experiences and Conclusions

The experiences we have made using this way of teaching management decision making, policy design, and corporate planning are very encouraging for several reasons. Although the students „only“ learn decision making in a particular microworld that must not be an adequate image of the company the students will work for after passing their examinations, they really understand the importance of a systems thinking approach to management. Without exception the students told us that they got clear insight in the interrelations of a company’s functional areas, and -- more important -- that thinking in their own area and acting only to reach their own objectives is less optimal for the company. Beyond that it is important to mention that the students do not only suggest -- at a low level of strategy development -- changes in parameters or table functions that map some of the policies that are implemented in the original model. They also propose useful strategies of how to restructure feedback relations within the company and to the suppliers and therefore how to restructure the fundamentals of their business.

Other experiences we have made and reasons that clearly recommend the use of this approach in future are as follows.

- The students learn the importance of clearly formulated objectives.
- They experience what conflicting goals are, what these goal conflicts may mean for the company, and they learn how to solve conflicts in a group of decision makers.
- The students learn that arguing on the basis of formal models is much more powerful than discussing different people’s mental models of a problem, that are never the same (Forrester 1975).

- They experience the convincing power of argument and debate in the presence of a commonly shared model.
- The students get experiences in group decision making, they learn, how to solve problems within a group through convincing argumentation.
- And last but not least the students experience the importance of a shared vision in the company.

For the teaching and training of the interrelations within an enterprise the management game approach we also use may be sufficient. For the teaching of feedback structures and the dynamics created by management decisions the above described simulation based approach is more adequate. However, the management game approach has the advantage that there is competition among the different companies and the students experience the pressure and consequences of competition. Therefore, we recommend using both approaches in management education.

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