The dynamics of innovation in networks: Analyzing product and technology process for market complexes

Uta Rudolph
PhD student
University of Muenster
Institute of Public Finance
Wilmergasse 6 – 8, 48143 Muenster
Phone: ++49(0)251 – 83 22873, Facsimile: ++49(0)251 – 83 22826
12utru@wiwi.uni-muenster.de

Dynamics of markets are even today not adequately represented in most market studies so that yet nowadays, wrong conclusions are quite common. A good tool for analyzing markets and its dynamic character is the coordination failure diagnostics concept (cfd-concept) which is based on the idea of control loops on the one hand and economic literature of competition on the other hand. Regarding innovations, it takes a closer look at product and technology progress which are core tasks to assure the survival of markets – or, to be exact, products. Nevertheless, even in this concept the direct influence of up- and downstream markets was ignored so far, although it seems to be obvious that innovations stimulate new innovations itself – they might occur on the same or on related markets. First thoughts of analyzing market complexes with the help of cfd and system dynamics are to be introduced in this article.

Key words: system dynamics, coordination failure diagnostics concept (cfd), interrelated markets, market analysis, simulation, product innovation, technology innovation

Part I: Market Analysis thus far

Strategic decisions in companies are mainly based on market analysis and market study. Thus, this should capture a broad field of research and should be carried out with great accuracy to get the most reliable results. Nevertheless, dynamics within markets and interactions between the investigated and other related markets are neglected in most times; wrong predictions and wrong decisions are the consequence. Depending on how long it takes to identify the mistake and to find a way out of what seems to be a deadlock, time is spent which really represents in this case money: market share might be lost, as a consequence profit decreases, money for further research and innovation might lack etc. However, there is a method to introduce dynamics to market analysis: the Coordination Failure Diagnostics Concept.

The introduction of this concept follows in part II; a critical statement about its quality is passed in part III when the CFD-Concept is upgraded by combining it with System Dynamics; first approaches for the illustration of innovation and their impact on markets are shown in part IV; the final chapter, part V, gives a summary of the article and

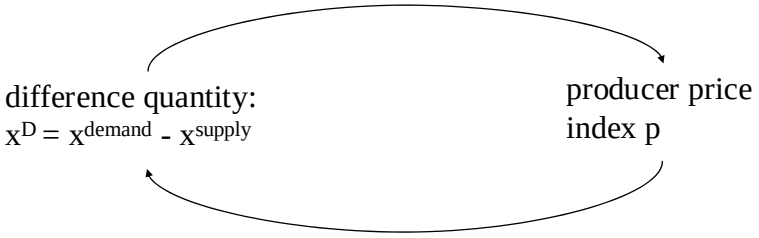
Part II: Market Analysis & Dynamics: The Coordination Failure Diagnostics (CFD-) Concept

Introduction of the concept

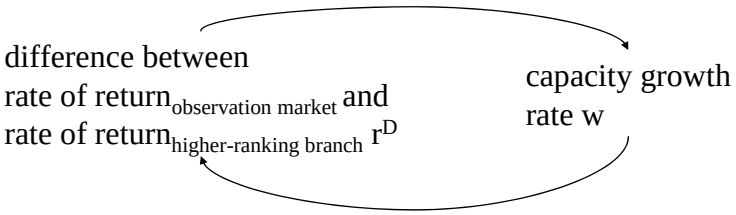
The CFD-Concept was established in the 1980s at the University of Muenster (Germany) and conducted by Professor Heinz Grossekettler. Aim of the concept was – and is until now – to

make market analysis and study comparable and operative, including dynamical basic approaches into the concept. For this, the concept neglected the claim that there should be an optimum; rather a feedback loop should help to decide whether a market works or not[1]. So, for basic tasks which are defined by economic literature[2] single processes are established. In detail, these processes are:

- Market Clearing Process (M-Process):
    - Compensation between demand and supply should assure that a profligacy of goods resulting from overproduction as well as consumers queuing due to inadequate consumer demand satiation is prevented. For further analysis, the difference quantity between supply and demand (x^D) is established and compared with the development of the producer price index (p)[3].



- Rate of Return Normalization Process (R-Process):
    - Economically speaking, the rate of return normalization process tries to ensure that companies acting at a market will survive. This survival ought to be ensured by high rate of returns enabling companies to re-invest and grow. With the CFD-Concept, one takes a closer look at the difference quantity of rate of return of the observation market and the higher ranking branch (r^D) and whether this corresponds to the capacity growth rate (w)[3].



- Erosion of Market Power Process (E-Process):
    - With a working erosion of market power process, dominant positions on markets will not exist; a relapse in comparison to foreign competitors as the necessity for innovation is lacking will not happen. The market power is here measured with the common Hirschmann Herfindahl Index, represented by m^D.[3]

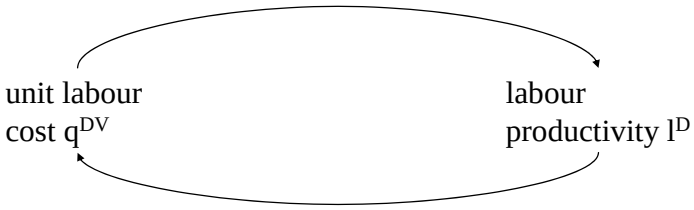
---

1 Cf. GROSSEKETTLER, H. (2001): Dynamik und Koordinationseffizienz von Marktprozessen im Verarbeitenden Gewerbe Deutschlands (*Dynamics and Efficiency of Coordination* of Market Processes *in the Manufacturing Industries*), in: Nordrhein-Westfälische Akademie der Wissenschaften (Hrsg.), Vorträge I 2, Wiesbaden, S. 7 – 47.

2 Cf. KERBER, W. (2003): Wettbewerbspolitik (*Competition Policy*), in: BENDER, D. ET. AL. (2003): Vahlens Kompendium der Wirtschaftstheorie und Wirtschaftspolitik, Band 2, 8., überarbeitete Auflage, Verlag Vahlen, München, S. 297 – 361.

3 For further information on collecting data please take a look at www.wiwi.uni-muenster.de/kmd.

- Product Innovation Process (P-Process):
    - Innovativeness in products is enunciated by quality leadership: the more innovative, the more high-class is a product. As finding a measure for this is quite complicated in reality, within the cfd-concept share of sales re-invested in research and development of different countries are compared. So, when this deviation is negative, then the observation market lags behind in comparison to a benchmark market; when there is a negative result, the observation market has the lead. This quantity is represented by q^{DP}. [3]
- Technology Innovation Process (T-Process):
    - Competitiveness for technology has a lot to do with cost, as other factors which used to determine quality are now comparable; in case of the CFD-Concept, technological competitiveness is enunciated by the variable unit labour cost (q^{DV}). This quantity should then correspond to labour productivity (v^{V})[3], so that – analogous to the M- & R-Process – this process can be illustrated as a basic causal loop.



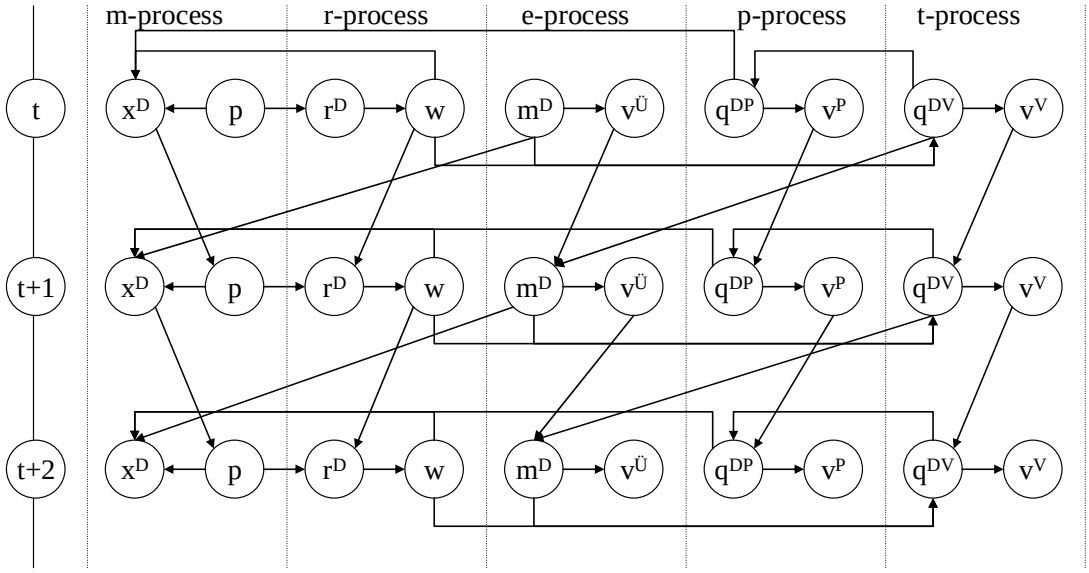
By now, typical indicators have been agreed on for every process and almost every market [4] to use the CFD-Concept for empirical studies: it has been used in the last years for approximately 100 market studies[5].

However, to use the CFD-Concept for analysis without looking at the interrelations between the processes makes the concept somewhat senseless. Because of this, in 1991, a first simulation approach was started to only take a look at these interrelations. Perhaps the most important result of this work can be seen in the next illustration: the links between the different processes. Influences which seem to be quite obvious – the impact of price on rate of return – are validated; some others which are not so evident – changes in product innovation affects the difference quantity of demand and supply – could be proven. Another important fact with this illustration is that the different existing time lags can be shown: differences of market power and its change have impact on x^{D}, which also influences the price index. Last but not least, some primary process-spanning feedback loops can be identified: price index affects rate of return which affects capacity growth rate which affects demand and supply difference which affects price index.

---

[4] For a broader discussion of indicators and data for their use, please take a look at www.wiwi.uni-muenster.de/kmd.

[5] Q. v. www.wiwi.uni-muenster.de/kmd.



Legend:
x^D: difference quantity of demand and supply
r^D: difference rate of return investigated market - branch
m^D: measurement of market power (Herfindahl-Index)
p^{DP}: measurement of quality leadership
q^{DV}: measurement of cost leadership (unit labor cost)
p: price index
w: capacity growth rate
$v^Ü$: auxiliary term
v^P: auxiliary term
v^V: labor productivity

Picture 1: Interrelations between the processes[6]

Innovation and its measurement

As mentioned before, two processes aim at representing innovation on markets: product and technology innovation process. Thereby, the first mentioned is targeted on quality leadership, the second on cost leadership; both are necessary to support the companies at the market. Data for the indicators of these processes can be collected here – as long as one analyses a market which is part of the manufacturing industry:

- For product innovation the share of sales re-invested in research and development was introduced. The data for this measure can be collected for the US from the National Science foundation; for Japan from the Statistics Bureau of Japan; for Germany from the so-called "Stifterverband für die deutsche Wissenschaft".
- Concerning technology innovation, relevant data is shown in the OECD STAN database for Industrial Analysis. Here, one can find data for markets which are classified according to the "International Standard Industrial Classification of all Economic Activities, Revision 3" (ISIC Rev. 3)

Some note has to be given: with these data only highly aggregated markets, rather branches, can be analyzed. So, the more one wants to get into detail with describing a market the less information will be available – more or less – for free and without collecting data on your own; For four- or more digit markets one has to decide on his own whether to work with the more aggregated two-digit branch, which seems to be quite legitimate as long as the market makes up more than 50 per cent of the branch, or not.

How this concept with its difficulties can be combined with System Dynamics, is to be shown now.

---

6 Q. v. KRÄMER, T. (1991): Simulation und Funktionsfähigkeitsprüfung verbundener Marktprozesse *(in English: Simulation and functional analysis of connected market processes)*, Verlag Peter Lang, Frankfurt am Main, Berlin, Bern, New York, Paris, Wien.

Part III: Market Analysis & System Dynamics

Quite palpably, there exist some parallels between the Coordination Failure Diagnostics Concept and System Dynamics (SD): both are more or less based on the thought of feedback loops, both methodologies are used for socio-economic topics etc. According to Peter Milling and his speech at the Conference "System Dynamics in the Financial Industry", the problems where both methodologies are used overlap:

- today's world is full of complexities: one can know all sources of impact neither on a market (CFD) nor any other socio-economic structure (SD)
- both agree on non-existence of equilibrium as single elements relate to each other via causal loops etc
- there's no perfect information
- rationality in behaviour is absent[7]

Again, both methodologies aim at the same:

- both want to explain existing causalities and want people to know about the interconnectedness
- with sharing of assumptions, final models and results can be accepted by a majority of people
- reliable scenarios can be deduced
- consequences for acting are the result[7]

With classical approaches, such as operations research, econometrics, or agent-based modeling the problems depicted before cannot be solved. Yet, a combination of System Dynamics and the CFD-Concept might help when analyzing different markets as complexity which is the most evident problem should be got under control. In a first approach, indicators and their elements are used as variables to build the causal loop diagram as well as – later on – the stock and flow diagram.

With trying to make up an analysis of a market complex which is a network of markets directly influencing each other such as *beer* on which *malt* and *hop* as pre-products and components have impact the combination of CFD and SD is even more important. For first insight, the multiplication of complexity is shown by taking a closer look on innovation processes.

Part IV: Market Analysis & Innovation

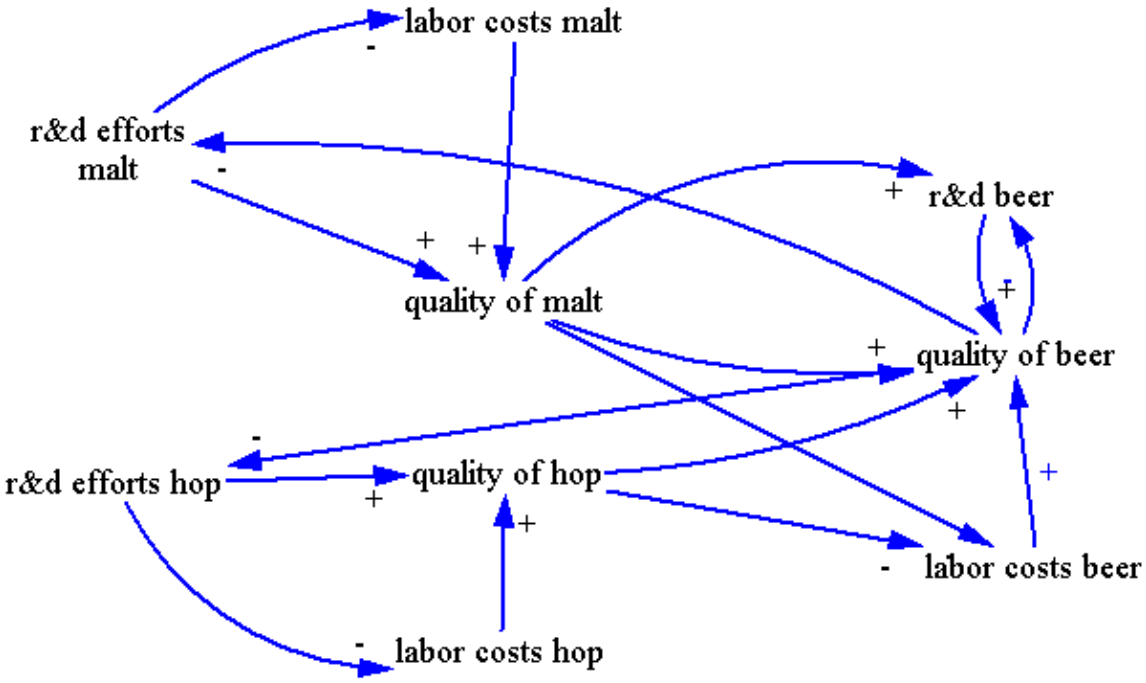
The innovation processes of the CFD-Concept, product and technology innovation, are represented by three indicators:

- share of sales re-invested in research and development (r&d efforts), expressing the quality of the product;
- unit labour cost and
- labour productivity, which both should measure the cost leadership.

To get a first impression, how these three factors might influence each other, a causal loop diagram is illustrated.

---

[7] Q. v. MILLING, P. (2006): Strategische Modellierung und Simulation (*in English: Strategic Modelling and Simulation*), Vortrag, Handout und Mitschrieb am 24. Mai 2006 an der HfB – Business School of Finance and Management im Rahmen der Tagung „System Dynamics in der Finanzindustrie"



Picture 2: Causal loop diagram for the innovation network of beer, hop and malt

In this simple illustration, first interrelations between the observation markets can be shown, e. g. r&d efforts on the malt market improve the quality of malt, which subsequently upgrades the quality of beer as a whole where the idea of improving the quality of the product arises and is passed on due to the power mismatch between those two markets.

Next studies have to be done to further improve the causal loop diagram and finally get a stock and flow diagram to analyze impact of observation markets on other related markets in detail.

Part V: Conclusion & Future Prospects

Aim of this article was to give a first insight into studies of innovation and its impact not only on one single market, but on a market complex. Within this study, the CFD-Concept is used as a basis for having a first insight on every single market of the complex. Due to the indicators used in the CFD-Concept and with strong roots in economic literature, there is a lead of which factors are important for simulation and further analysis. On basis of the Systems Thinking and System Dynamics, causal loop diagrams can be drawn and interpreted.

For future work, after the stock and flow diagram exists for the innovation processes, the innovation network examination has to be enlarged to an analysis of the markets as a whole. As processes influence each other and themselves, it will be new approach to see how much and to what extent markets affect each other.