# Factors of Success of Technology-Oriented Competitive Strategies[1]

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## 1. Relevance of a technology strategy

The technological progress is an important determinant of industrial competition. Not only macroeconomic growth or the profitability of industries as a whole are influenced by the technological development. The competitiveness of the company is determined by the ability to handle the technological dimension of competition, too. This influence leads to the need of integrating a technological dimension in form of a technology strategy into the competitive strategy.

To cover the relevant dimensions of a technology strategy, decisions have to be made in the following fields:[2]

- the level of technological knowledge to be achieved;
- the timing of invention and innovation;
- the source of the technological knowledge;
- the usage to be made of the technological knowledge.

In each of these dimensions serveral options of action exist among which one has to choose when a technology strategy is to be defined. A technology strategy can only be successful if the relevant factors, which determine the success of the individual option, are known.

## 2. Building a System Dynamics Model to identify the relevant factors of success within the dimensions of a technology strategy

A system dynamics model was built to discuss the named dimensions of a technology strategy within a dynamic environment.

The model consists of 5 different sectors. Within the model, three different companies compete against each other; the companies are represented via Arrays.

Each company conducts R&D to develop new products. The size of the R&D-budget is variable, the implications will be assessed during the model analysis. The company's research leads to the development of new products which will be introduced into the market, once they have reached a sufficient degree of sophistication. The degree of sophistication requiered is defined by the company.

Other ways of getting the technological knowledge for introducing new products cooperative R&D as well as the buying of lincenses.

The market is represented by a diffusion model. The process of diffusion goes back to the Bass-Model[3], but is expanded for rebuying of products of newer generations. The demand is shared using the sophistication and the price of each product as an indicator.

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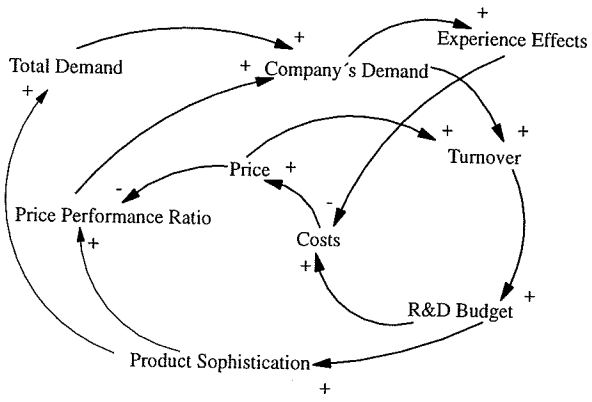
1 The research project was conducted as doctoral dissertation at the Industrieseminar der Universität Mannheim; Prof. Dr. Peter Milling, Schloss, D-68131 Mannheim.

2 See e.g. Ansoff / Stewart, 1967; Maidique / Patch, 1980; Porter, 1983; Clarke / Ford / Saren, 1989; Coombs / Richards, 1991; Dyer, 1994; Zahra / Sisodia / Das, 1994; Lee / Om, 1994; Gooodman / Lawless, 1994.

The pricing of the products is done by using a cost-plus approach. The cost are calculated by using standard costs, which can be lowered by experience-effects. A diffusion of experience takes place from the pioneer to the later entrants.[4]

The model is simulated over 150 time periods, each representing one month. Within this time, the companies introduce between three and five generations of products, depending on the amount of R&D investment.

An overview of the model is shown below.




## 3. Results

### 3.1. Research Intensity / Level of Technological Knowledge

The model demonstrates that the amount of R&D-investment is a critical decision. In case of high investments it must be certain that there is enough technological potential for exploitation. Otherwise there will be no return on the investment. Because R&D-investments have to be made in advance, while the return is achieved later with the marketing of the product, there is a conflict between short term financial goals and long term R&D goals. In addition, the model shows that this conflict increases in case of a turnover-proportional R&D-budgeting in combination with increasing turnover. In such situation the investment in R&D is always higher than the actual return from the sale of the product and this has implications for the cash management of the company.

The model shows two ways, which can lead to a return on the R&D-investment. One is the possibility of constructing a superior product, which will outpace the competition. The other is the possibility of an earlier market entry, so that early mover advantages can be used. The model shows, that both dimensions - amount of R&D-investment and timing of market entry - are not independent from each other. Especially the timing of market entry has major effects on the company´s market offer, due to the influence of early experience effects on the production costs.

A main result concerning R&D-policy is the conclusion, that a short term oriented policy is not successful at all. The most profitable companies in the model are those, which budget their R&D-investments with a long term perspective and which do not react to short term competitive forces.

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3 Bass, 1969.

4 Lieberman, 1987.

Looking at empirical research concerning the topic of successful R&D-investment leads to the conclusion, that too little as well as too high R&D-investments lead to unsatisfactory results.[5]

### 3.2. Technological Timing

A lot of research has been conducted regarding the timing of innovations.[6] The results of different studies lead to different recommendations. Serveral arguments exist in favor of both possibilities, an early or a late innovation.[7] Concentrating on empirical research, the majority of studies show advantages for the pioneer.[8]

A lot of theoretical work focusses on the experience effects and the potential diffusion of them as the major first-mover advantages. The model shows, that the first-mover has advantages, even when there are no experience effect or a high diffusion of the effects to later entrants. Even in the situation, in which a slow diffusion of the products among the customers takes place, the early mover has major advantages. Therefore it can be said, that a general superiority of an early timing of market entry, which is supported by most of the empirical findings, is supportet by the model, too.

The model shows that the duration of a monopolistic market situation is a major factor for the advantage of an early mover. In this context the model identifies the speed of the technological progress as a major factor, which influences the success of an early market entry. In case of a high rate of technological progress, the first-mover has a shorter period in which he can make use of a monopolistic situation. This situation is also influenced by the speed of the diffusion of the product. If the speed of the diffusion is high, then the number of products, which are sold per time period, is higher than in a situation of slow diffusion. A higher number of products per period during a shorter monopolistic situation can lead to the same total number of sold products.

Given these major advantages of first movers, it can be seen with the model that a follower makes the right decision, if he tries to introduce his product as soon as possible after the market has been opened by an innovator. Even in case of an inferior product the final result of the follower is better in a situaiton, in which he introduces his product immediately after the leader than in a situation, in which he completes the research until the final phase of development has been reached, as long as the follower´s product fulfills the basic requirements of the customers.

It has to be said that there is a certain risk connected to the attempt of becoming a technological leader. The model shows that in cases, in which all competitors try to reach an early market entry, the lifetime of the products is reduced. This leads to a situation, in which all competitors spend more on R&D but do not gain any advantage out of it. In total, the profitability of all companies is lowered. To prevent a situation like this, a market signaling between the competitors is necessary.[9]

The literature shows, that at least some of the results of R&D diffuse to other companies.[10] The model is able to show, that the amount of this diffusion has a major impact on the success of a technological pioneer. In that way, the diffusion of knowledge about a product is much more critical to the success of a pioneer than the diffusion of experience.

The most important result of the model is the insight, that an early build-up of knowledge is essentially important for the success of a company. In all simulations of the model there was no situation, in which an early advantage in the amount of technological knowledge of the leading

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5 Gierl / Kotzbauer, 1992.

6 E.g. Vinton, 1992; Vesey, 1991; Backhaus, 1991; Milling, 1990.

7 E.g. Zahra / Nash / Bickford, 1995; Vidal, 1995; Schewe, 1994, Perillieux, 1991; Stalk / Hout, 1990.

8 Gemünden, 1993; Perilleux, 1995.

9 Heil / Robertson, 1991.

10 Mansfield, 1985.

company and the rsulting profits, could be outpaced by other companies within the duration of the simulation of 150 periods.

### 3.3. Cooperation

A R&D-cooperation is a major tool for reaching state-of-the-art knowledge without having to make the investments all alone. The model shows that a cooperation is in the majority of cases superior over non-cooperative research. In the oligopolistic situation of the model, non-cooperative research is only then superior, if the potential partner does substantialy less research than oneself. In all other cases the disadvantages, which result from the shared knowledge as an outcome of the cooperation, are succeeded by the lower cost of research. In that way the model shows, that doing research just by oneself is only better than joint efforts, if quite restrictive assumptions are made.

### 3.4. Licensing

Since research is a very expensive thing to do, a lot of companies are successfully practicing alternative ways to get the necessary amount of know-how. Additionaly, there are famous examples that show the benefits of a good licensing policy.[11]

In the same way that cooperation is a major tool for gaining advantages within the technological competition, licensing can be, too. The model shows that the two most important factors of a successful licensing agreement are the timing and the licensing fees. If these are chosen right, a win-win-situation between the two partners is given. It has to be said, that a strategic threat goes along with the buying of licenses. In a situation, in which the buying of licenses is no longer possible for future product generations, the licensee is not able to build up own R&D-facilities, which enable participation in the competition. Even in case of very high R&D-investments the company was not able to become profitable again during the time of the simulation.

## 4. Conclusion

The model identifies serveral determinats of competition and the influencing factors of success, which haven't been adressed in the literature so far. It has to be seen that some of the effects are driven by the underlying assumptions of the model. Especially the missing marketing-component in the sales efforts of the companies might lead to other results than given in reality. Despite these limitations, the model results show directions for further - model-based and empirical - research.

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[11] See the example of the VHS video system by Ohmae, 1980.

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