DEVELOPMENT AND USE OF SYSTEM DYNAMICS MODELS AS TOOLS FOR STRATEGIC PLANNING OF FLEXIBLE ASSEMBLY SYSTEMS

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1. INTRODUCTION

In recent years the way in which problems are approached in the assembly area within the manufacturing firm has gained increasing importance for economic planning. In connection with this, the demand for a long term economic flexibility of assembly systems comes to the forefront. A firm should not limit itself purely to investment decisions in the planning of assembly systems, if it is to successfully meet growing demand (on both the market and technology fronts). However, it has become essential even in this field that strategic thinking and planning are considered more important than they have been in the past.

There are considerable difficulties, however, associated with the strategic decision-making processes involved in the planning of flexible assembly systems. System dynamics assembly models are currently being developed at the Business Management Institute at Stuttgart University (within the framework of the "Sonderforschungsbereich 158" sponsored by the DFG). The aim of this is to understand and cope with these problems more easily, with specific reference to long-term decisions, the lacking objective assessment criteria and the high complexity of the problem.

2. CONCEPT FOR THE STRATEGIC PLANNING OF FLEXIBLE ASSEMBLY SYSTEMS

The starting point of the research outlines a concept, which firstly facilitates the systemisation of the flexibility analysis, and secondly, depicts the fundamental structures of a flexible assembly system (cf. fig. 1)(Bunz, Hopfmann 1987).

The given structures are based on the hypothesis that the firm's need for flexibility arises from the difference between its supply and the demand within the market. This in turn pressurizes the firm to invest. The measurement of the discrepancy between supply and demand is carried out based on the criteria of flexibility, namely quality, price and delivery time, by means of which both the supply and demand may be fully assessed.

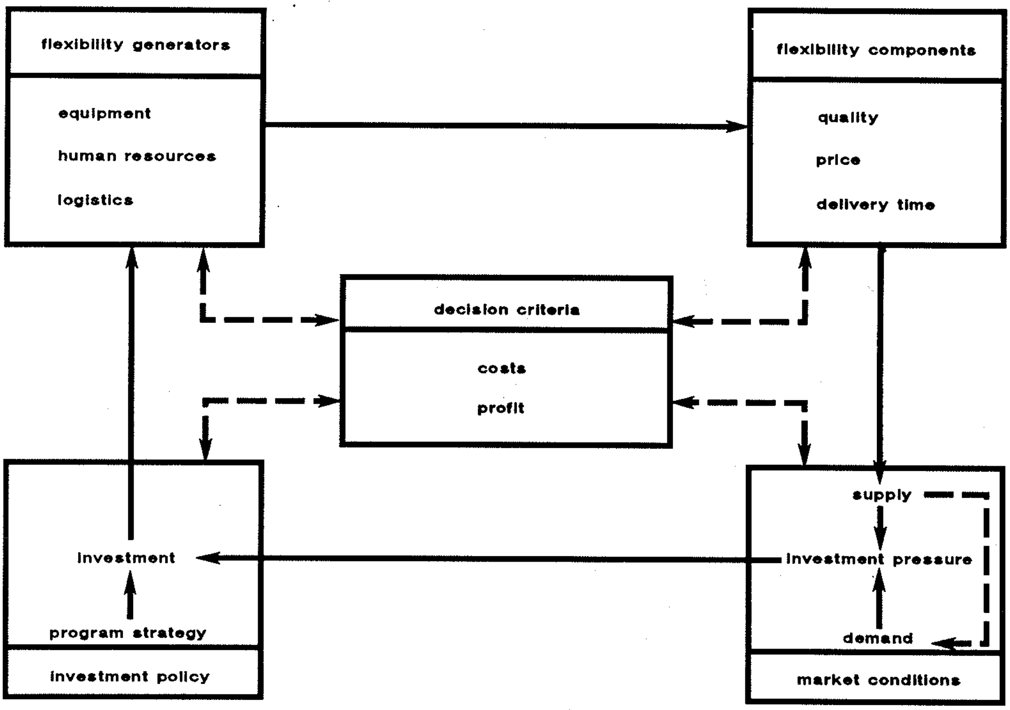


Fig. 1: Flexible assembly model concept

Within the framework of an investment policy, the pressure to invest and company strategies determine a particular level of investment, which in turn alters the parameters of flexibility, i.e. assembly equipment, human resources and logistics. Such changes subsequently lead to a modification of the firm's supply with regard to quality, price and delivery time. The central decision-making criteria involved in this concept are costs and profit, which ultimately form the basis of all decisions within the framework of the model and which facilitate all management assessment activities.

An extensive base model was developed founded on the given test model, which made it possible to subject the various aspects of flexibility of assembly systems to a detailed theoretical analysis (Hopfmann 1989). This theoretical model forms the basis for the application of system dynamics models as tools for decision making when planning flexible automated assembly systems in practice.

The modelling of assembly systems specific to a particular firm is supported by an expert system, whose potential is realised through the programming, structure identification and interpretation of the results produced by system dynamics assembly models (cf. fig. 2). The need for such an expert system is illustrated by the fact that in developing an assembly model both a sound understanding of the methods involved as well as an extensive comprehension of the problem are required. In both areas the developed system can give valuable support to, and thus facilitate the application of system dynamics models.

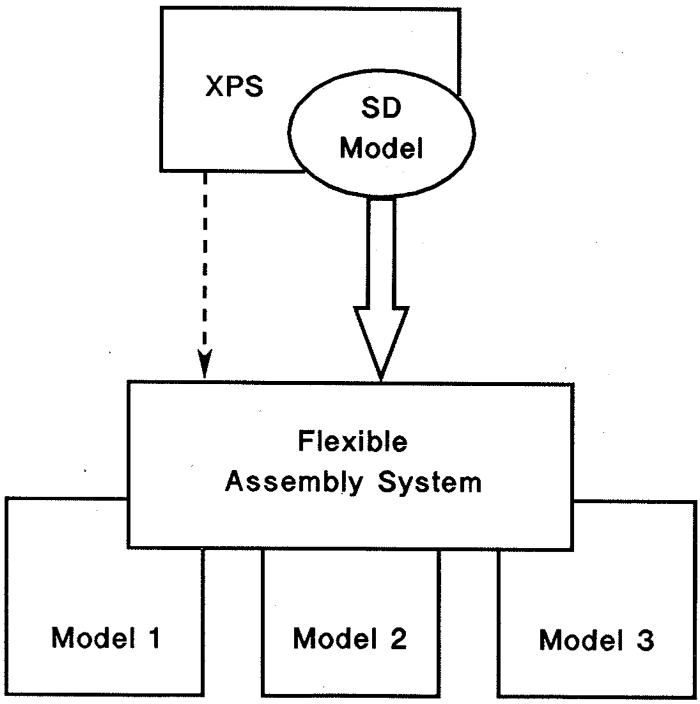
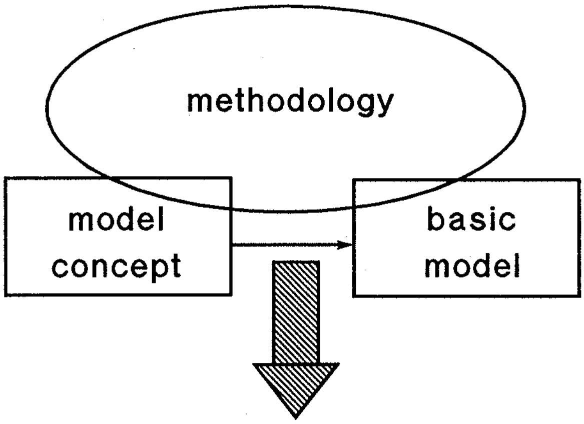


Fig.2: Expert system on flexible assembly models

3. PRACTICAL APPLICATIONS

Fig. 3 gives an overall view of the existing project in which system dynamics assembly models were used(Zahn, Bunz, Hopfmann 1987; Bunz 1988). One of these projects will be briefly examined, in order to illustrate definite examples of possible areas where the developed concept may be put into use.



PRACTICAL APPLICATIONS			
branch	furniture industry	electronics industry	electronics industry
concrete problem	* decision: investment in alternative assembly installations * aim: reduction in delivery time	* decision: - investment in installations - keeping of stocks * aim: reduction in delivery time	* decision: alternative logistic concepts * aim: minimisation of stocks
suggested solution	investment in a partly automated circular system	investment in installations	investment in a high-shelved warehouse
suggested strategy	limitation of variants	limited growth	

Fig. 3: Practical applications

The subject of the investigation was the assembly area of a firm in the electronics industry, which ranks amongst the leading suppliers within its market segment. An analysis of the problem, representing the starting point for the construction of a model, leads to the conclusion that the critical factor determining success or failure within that market is the delivery time; both the price and the quality of the product are to be seen as already determined (this is limited with regard to the quality of the production programme). Since the products as a rule had a very long assembly period (up to 9 months), and bearing in mind that incoming orders cannot be predicted with any great precision, up until now the firm had not been able to adequately meet the delivery times accepted within the market (up to 1 month). In order for the firm to achieve the desired growth in market share, it was imperative to reduce delivery times. With this in mind, the following alternatives were taken into consideration :

* an increase in stocks (buffer stocks)
* a reduction in the length of assembly time by means of investment in the assembly system.

With the aid of an assembly simulation model both the effects of an increase in stocks and investment in the assembly system were investigated. In addition to this, it was necessary to relate the various measures to the costs which arise each time.

The results of the simulation are illustrated in fig.4. It was established that a reduction in delivery time through investment, which, in turn, gives rise to a decrease in assembly time, can be achieved more cost-effectively than through keeping buffer stocks. Hence, in accordance with the results of the model, investment in assembly technology is to be recommended, thereby offering competitive terms of delivery.

buffer stocks	costs	delivery time	costs	assembly period
0	0	1,4	0	9
10	14 000.-	1,2	10 000.-	8
20	29 000.-	1,0	25 000.-	7
30	51 000.-	0,7	40 000.-	6
40	89 000.-	0,3	60 000.-	4

Fig. 4: Alternatives to reduce delivery time

As previously mentioned, since a firm must not limit its assembly plan purely to investment or investment decisions, the firm, following the decision to reduce delivery time by means of investment, is then confronted with a question of strategic dimensions : which competitive strategy, and resulting from this, which investment strategy for the assembly system, should be adopted, firstly to justify the aim of increasing market share, and secondly to generate a satisfactory return on investment? In particular, the firm found itself faced with the problem of how far the assembly system must be placed in a position to cover peaks in demand (of both a quantitative and programme qualitative nature).

A strategy which aims to permanently cope with demand, i.e. also to meet peaks in demand (strategy 1), results in a great decrease in assembly profitability (cf. fig. 5). This is mainly due to the fact that the assembly system is not utilized to its full capacity. On the other hand, the profitability development is completely different under a strategy, which, due to "cautious" investment, acknowledges that it will not be able to meet peak demands (strategy 2). In this case, despite the whole simulation process the profitability can be maintained at a distinctly higher level.

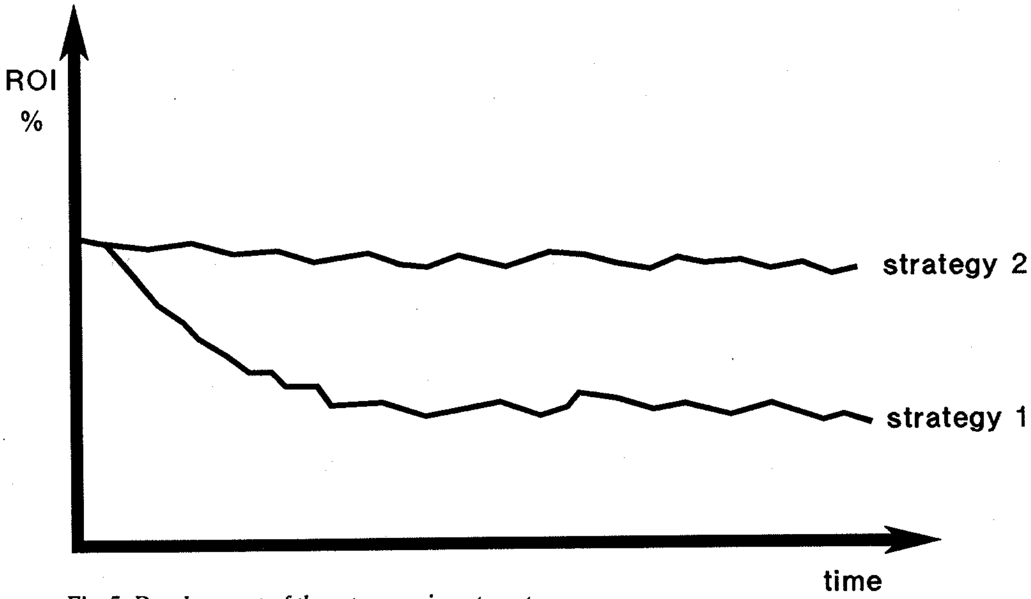


Fig. 5: Development of the return on investment

It is possible under strategy 1 to determine a clear increase in market share, but the development of market share ensured by strategy 2 is only marginally less favourable (cf. fig 6). The minimal market share advantages offered by strategy 1 are in this case based mainly on an overproportional increase in the efforts required to further expand an already very high share of the market. In the light of the simulation, a cautious investment strategy is to be recommended in order to achieve the desired increase in market share and a satisfactory profitability.

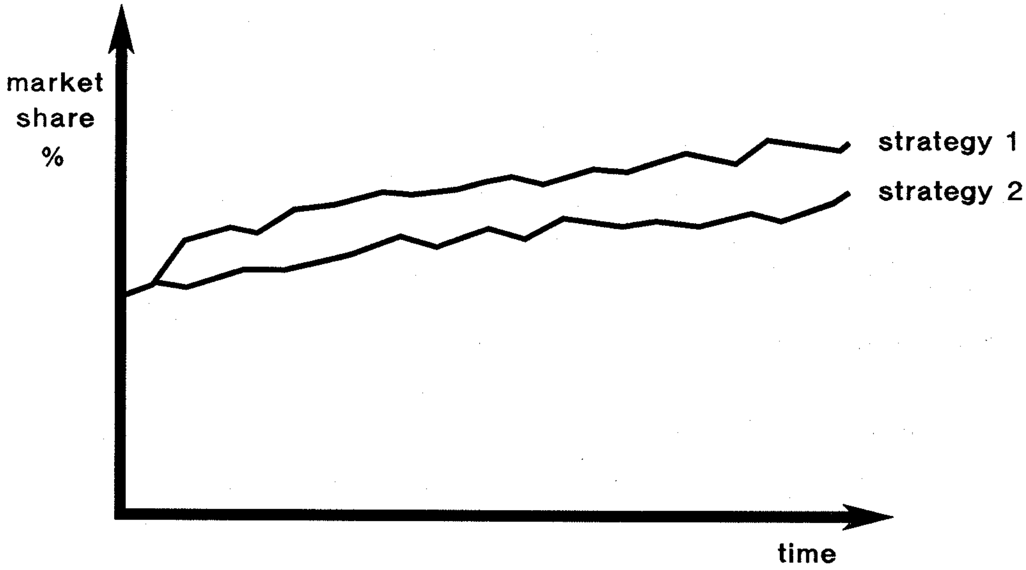


Fig. 6: Development of the market share

As a result of this application, it is to be emphasized that a firm's competitive strategy must not be orientated solely towards the requirements of the market. It is absolutely essential to make allowances for the technical and managerial restrictions on the part of production or assembly systems(Zahn 1988; Zahn 1986). "Excessive demands" on production or assembly inevitably lead to negative effects as far as profitability is concerned. This in turn endangers the fulfillment of an aim important for a firm's survival, this being the realisation of a sufficient return on investment. It is important to strive for a closely-linked coordination between the company's competitive strategy and its production or assembly strategy thereby smoothing the path for the successful development of the firm by achieving an "optimum" flexibility.

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