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The models of system dynamics (SD) Interventions on Capacity Scalability Policies in RMS research (1990-2002) for 29 researchers: An academic literature review and classification

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Abstract:-System Dynamics (SD) is a widely used methodology to study complex feedback structures using computer simulation models. This paper discusses various SD interventions on capacity scalability polices in RMS. We will explain in detail some of the mostly related models to approach the subject, while other models will be summarized. The paper considers a general structure of the System Dynamics models. It starts by specifying the approach of interventions on capacity scalability polices in RMS.

Keywords:- RMS, Capacity scalability, System dynamics

I. INTRODUCTION

The concept of an RMS has been conceived to meet changes and uncertainties in a dynamic manufacturing environment. This paper summarizes our survey on the SD models for capacity scalability policies in RMS. Figure (2.1) shows the applicable SD models for capacity scalability policies. We will first start with the dynamic models for capacity scalability in RMS and then describe the capacity scalability problem using SD models and application of SD in manufacturing system that were results of related literature review as showed in Fig. 2.1 .

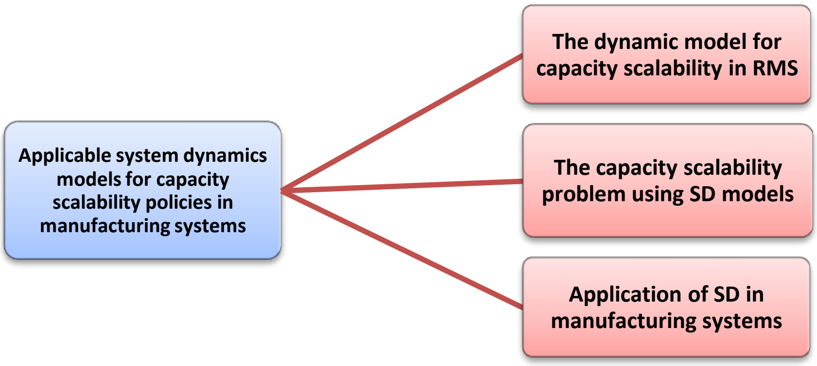

Figure (2.1): The applicable SD models for capacity scalability policies.

II. THE DYNAMIC MODEL FOR CAPACITY SCALABILITY IN RMS:

There are many Dynamic models for capacity scalability policies in RMS. Figure 2.2 shows some of these dynamic models for capacity scalability policies in RMS.

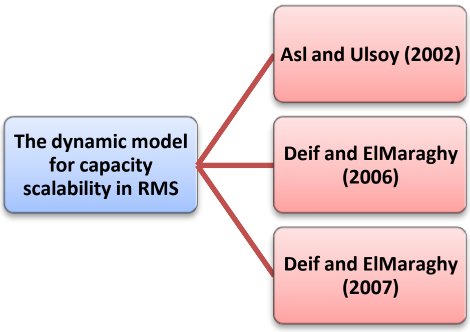

Figure 2.2: The dynamic model for capacity scalability policies in RMS.

2.1 Asl and Ulsoy (2002)

Presented a dynamic approach to capacity scalability modeling based on the use of feedback control. Suboptimal solutions that are robust against demand variations and partially minimize the cost of capacity scalability were presented [1]. The model is a new approach for the stability analysis, free solution and forced solution of the systems of linear delay differential equations. The solution obtained using Lambert functions is in a form analogous to the state transition matrix in the systems of linear ordinary differential equations. The main advantage of the presented analytical approach is its ability to provide a closed form solution to the systems of homogeneous linear delay differential equations in a compact form similar to systems of ordinary differential equations. The solution here is in the form of an infinite series of modes, which are expressed in terms of Lambert functions. It provides a tool to study the behavior of the individual modes of the equation. The solution, however, is presented by a linear combination of all the modes in the form of infinite series.

2.2 Deif and ElMaraghy (2006)

Developed a dynamic model for capacity scalability in RMS and analyzed the model based on control theoretic approaches to indicate the best design for the scalability controller. Results highlighted the importance of accounting for the different physical and logical delays together with the trade-off decisions between responsiveness and cost when designing the capacity scalability controllers [2]. The development of the model is based on set theory and the regeneration point theorem which is mapped to the reconfigurable manufacturing paradigm as the capacity scalability points of that system. The cost function of the model incorporates both the physical capacity cost based on capacity size and costs associated with the reconfiguration process which referred to as the scalability penalty cost and scalability effort cost. A dynamic programming (DP) approach is manipulated for the development of optimal capacity scalability plans. The effect of the reconfiguration costs on the capacity scalability planning horizon and overall cost is investigated. The results showed the relation between deciding on the optimal capacity scalability planning horizon and the different reconfiguration costs. Results also highlighted the fact that decreasing costs of reconfiguration will lead to cost effective implementation of reconfigurable manufacturing systems.

III. THE CAPACITY SCALABILITY PROBLEM USING SD MODELS

There are many capacity scalability problem using SD models. Figure 2.3 shows the researchers on the subject of the capacity scalability problem using SD models.

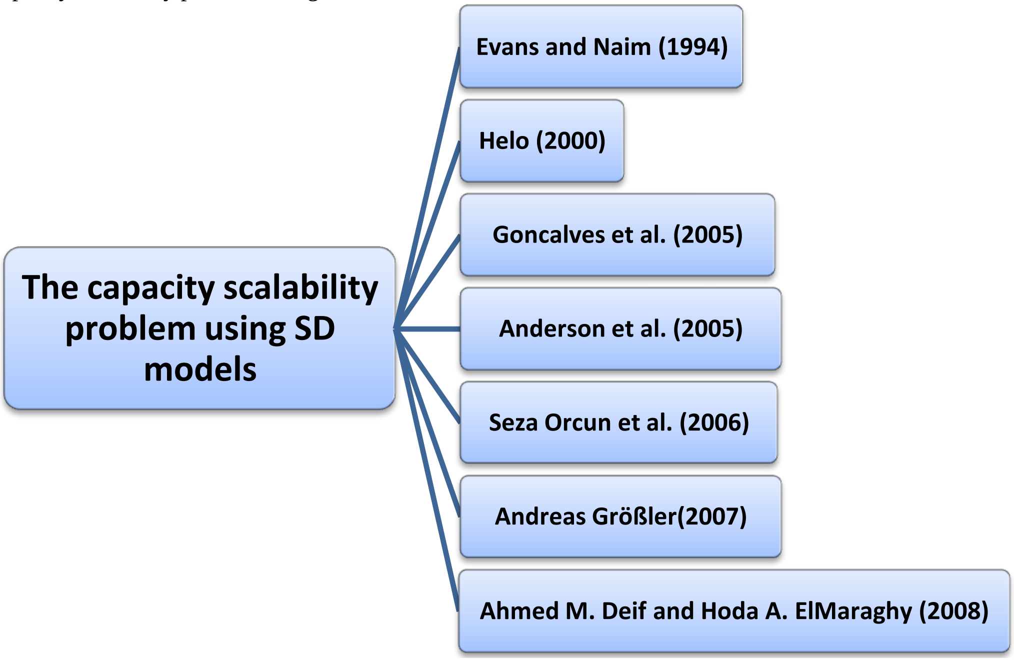

Figure 2.3: The capacity scalability problem using SD models.

3.1 Evans and Naim (1994)

Aimed to develop a SD model for supply chains with capacity constraints and, studying the effect of capacity constraints on a system's performance [3]. **Helo (2000)** suggested a capacity-based supply chain model that includes a mechanism for handling the trade-off between lead time and capacity utilization. It was shown that this capacity analysis, including the surge effect, in supply chains would improve their responsiveness [4]. He applied the SD models to analyzing strategic as well as simulation of policies and operation in manufacturing systems. **Goncalves et al. (2005)** highlighted the issue of capacity variation in their push–pull manufacturing SD model through the effect of capacity utilization on the production start rate [5].

3.2 Anderson et al. (2005)

Considered logical capacity scalability in supply chains for service and custom manufacturing. They showed the effect of reducing lead-time and sharing the demand information on improving system performance [6].

3.3 Seza Orcun et al. (2006)

Use system dynamics simulations of a simple capacitated production system to examine the performance of several different capacity models that yield load-dependent lead times, and relate these models to those used in system dynamics models of production systems [7].

3.4 Ahmed M. Deif and Hoda A. ElMaraghy (2008)

Present a model for assessing different capacity scalability policies in RMS for different changing demand scenarios. The novelty of the approach was two fold: a) It is the first attempt to explore different capacity scalability policies in RMS based on multiple performance measures, mainly scaling rate, Work In Process, inventory level and backlog level, and b) the dynamic scalability process in RMS is modeled for the first time using SD [8].

3.5 Andreas Größler(2007)

The purpose of his study is to demonstrate that price decreases or performance enhancements within a subset of a company's products can have counter-intuitive effects on the global performance of the company. Using naïve reasoning, price reductions and performance enhancements imply a bigger market share. Under the assumption that volume increases outweigh price reductions and costs for enhancements, a bigger market share leads to more sales revenue and thus higher profits. Although marketing theory acknowledges that this thinking is too simplistic by recurring to the concept of price elasticity, prices are still cut under the general assumption that price reductions would be beneficial for the competitive position of a company. The study argues that such behavior might result in a loss of sale and profit, even when a company is in a market leader position with a proven reputation for quality and service. Often, the potentially positive effects of price reductions and performance enhancements in one product line are not considered in combination with the impact of these measures on other product lines of the company. The structure of the study is as follows: In the introductory section, the problem setting is briefly reframed by reviewing the core literature and the case study is presented: "*The company, the market and the competitive situation*". Within this project, a formal model has been developed to support strategic decision-making in the case company. Besides, some general remarks on measuring the impact of price changes are given. In the third section, the results gained with the help of the SD model are presented. Using the simulation experiments, the impact of price or product strategy changes on the competitive situation of the firm is examined. The discussion is concluded in the fourth section, where issues are presented for further marketing research too [9].

IV. APPLICATION OF SD IN MANUFACTURING SYSTEMS:

There are many Application of SD in manufacturing systems. Figure 2.4 illustrate the most important researchers in the subject.

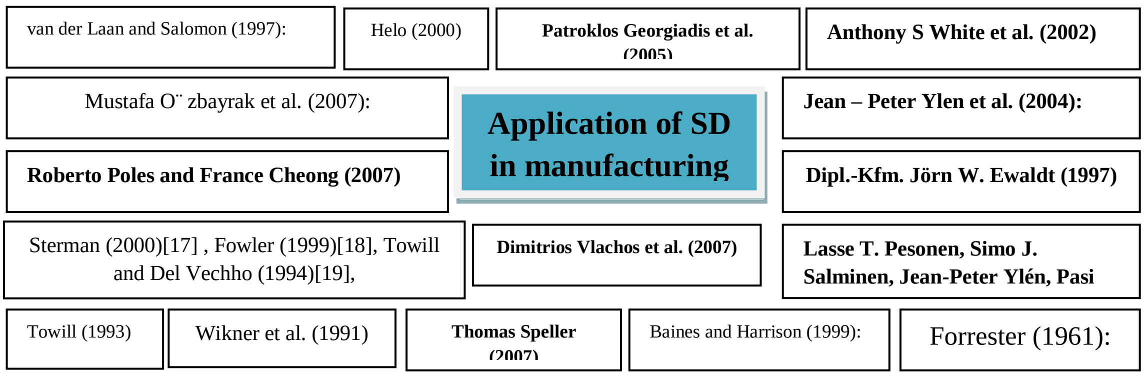

Figure 2.4: Application of SD in manufacturing system.

4.1 Sterman (2000)[10] , Fowler (1999)[11], Towill and Del Vechho (1994)[12], Towill (1993)[13], and Wikner et al. (1991)[14]

Applied the SD in manufacturing systems focused mainly on pure inventory supply chain where the objective was to study how the system can be designed and analyzed to respond to unanticipated demand with maximum stability and minimum cost.

4.2 Forrester (1961)

Introduced the System Dynamics (SD) in candidate approach to dynamically model and analyze manufacturing systems, and especially their different planning and control policies [15].

4.3 Baines and Harrison (1999)

Argue that SD has distinctive performance when considering strategic issues in manufacturing companies [16].

4.3 Helo (2000)

Applied the SD models to analyzing strategic scenarios as well as simulation of policies and operations in manufacturing systems [17].

4.4 van der Laan and Salomon (1997)

Analyzed a comparison between the push and pull inventory strategy based on the optimal total system costs in their model. A production planning and inventory control system was developed tackling more explicitly the push and pull inventory strategy on remanufacturing and disposal activities The result shows that pull is preferred to push strategy if recoverable inventory is lower than serviceable inventory [18].

4.5 Mustafa O¨ zbayrak et al. (2007)

The model was propose comprises four echelons and was build around a central medium-sized manufacturing company operating as a typical Make-to-Order (MTO) system. The developed model was built using a systems dynamics (SD) approach. The operations performed within a supply chain were a function of a great number of key variables which often seem to have strong interrelationships [19].

4.6 Roberto Poles and France Cheong (2007)

Explore a SD approach in order to model an inventory control system for a remanufacturing process in the context of a Closed Loop Supply Chain (CLSC). Specifically, the return process is modeled using several factors which influence relationships within the process. The factors considered are residence time of the product with customer, service agreement with customer and customer behavior in returning used products. The findings suggest that a reduction of residence time and an increase in the level of service agreement with customers, which in turn increases customer behavior in returning used product, can lead to efficiency in inventory management for companies involved in the remanufacturing process. In addition, we provide two simple case studies to support these findings [20].

4.7 Jean – Peter Ylen et al. (2004)

Give a short introduction to the field of system dynamics and it serves as a compendium to the other survey paper by the same authors. The basic structures and capabilities of system dynamics are shortly discussed and the major commercial products on field are introduced. There is active research going on and the number of industrial applications is increasing rapidly. The commercial tools are improving and different analysis and design tools within these commercial products are developing significantly. As a result the amount of tedious hand work needed for system dynamics modeling is reducing rapidly and the modeling process is becoming faster and faster. In the coming paragraphs, the model will be described in details **[21].**

4.8 Dimitrios Vlachos et al. (2007)

Tackle the development of efficient capacity planning policies for remanufacturing facilities in reverse supply chains, taking into account not only economic but also environmental issues, such as the take-back obligation imposed by legislation and the "green image" effect on customer demand. The behavior of the generic system under study is analyzed through a simulation model based on the principles of the system dynamics methodology. The simulation model provides an experimental tool, which can be used to evaluate alternative long-term capacity planning policies ("what-if" analysis) using total supply chain profit as measure of policy effectiveness. Validation and numerical experimentation further illustrate the applicability of the developed methodology, while providing additional intuitively sound insights[22].

4.9 Patroklos Georgiadis et al. (2005)

Adopt the system dynamics methodology as a modeling and analyze tool to tackle strategic issues for food supply chains. They present guidelines for the methodology and present its development for the strategic modeling of single and multi-echelon supply chains. They analyze in depth a key issue of strategic supply chain management, that of long-term capacity planning. They examine capacity planning policies for a food supply chain with transient flows due to market parameters/constraints. They demonstrate the applicability of the developed methodology on a multi-echelon network of a major Greek fast food chain[23].

4.10 Anthony S White et al. (2002)

Describe a control systems approach to the management of inventory. Normal inventory operation is an example of proportional control. Several control algorithms including Pseudo-Derivative Feedback (PDF), Proportional, Integral and Derivative (PID) and Feed forward control are used in their paper to produce a more sophisticated form of inventory operation that can easily reduce stock levels by up to 80% compared to 20-30% with MRP and hence reduce cost. Settling times are reduced by a factor of 50%. Modeling was achieved using the Simulink simulation package using equations developed by Ferris and Towill [24] for a single level industrial system model rather than a conventional System Dynamics computer package. The best controller is shown to be a PID controller with Feed forward. This controller did not cause any significant oscillatory inventory level changes. These techniques compare well with other investigators using control strategies. This has special significance for JIT and MRP methods[25].

4.11 Lasse T. Pesonen, Simo J. Salminen, Jean-Peter Ylén, Pasi Riihimäki (2008)

Lasse et al created a dynamic model of product development and applied to manage Product Process complex dynamic behavior on system level in order to reduce product development cycle times, slippages and costs as well as improve perceived product quality [26]. In their simulation case, which was conduct the search in Nokia mobile phone business, the product structure has been divided into four parts: engine part, electro mechanic part, software part, and product specific increment part. The first three parts are independent sub models that develop and maintain building block releases for the final product. Each of these classes can be divided into several subcategories. The product level exploits these sub-models by integrating them together and developing some extra to meet the given specifications [27].

4.12 Dipl.-Kfm. Jörn W. Ewaldt (1997)

The structure of such a multi-level production chain can be described as a row of level variables connected with each other by some rates. The stocks represent the production stations in which the arriving products are transformed into a new semifinal product. The flows stand for the transport of the products from one station to the next. The system's boundaries are defined by the inflow of basic products to the first production level and the outflow of final products from the last production level. With the exception of integrated, the model networks basic products can be seen as goods already produced and available on an external of internal market at a certain price. The final product typically flows into a sales storage ready to be sold to a customer. Any quality check and rework is not part of the production chain anymore. The average duration time is the same at all stations. Different duration phases would change the quantitative results, but not the qualitative statement. The storage and transportation capacities are unlimited. A combination of limitations causes multiple disturbances in the material flow [28].

4.13 Thomas Speller (2007)

The first loop starts with an order receipt, which requires an order fulfillment, which leads to an increased level of customer satisfaction. With higher customer satisfaction, more requests for proposals (RFPs) will be received and, therefore, more orders will be processed. If, for some reasons, the order is not processed, then customer satisfaction will decrease, which leads to fewer orders received and processed. As long as orders are being processed, this positive feedback loop means that the connected variables spiral upward forever. Once an order is not processed, the opposite will happen and the linked variables may eventually fall to zero [29].

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