MAXIMIZING SERVICE OR VOLUME ?

A System Dynamics Approach

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ABSTRACT

A System Dynamics model has been developed and used to help compare advantages and disadvantages of **Volume vs Service** maximization. The results show that scheduling at less than 100% of capacity does smooth out the orders that can be accepted, and permits maintenance of high and consistent service, with the result that over an extended time horizon, total orders and therefore market share are higher.

I - **INTRODUCTION**

This paper describes the result of a joint effort between a Decision Making Manager of a large IC manufacturing Company and a professional System Dynamics modeller.

This paper will show briefly :

The initial question was voiced as follows : what are the respective advantages and disadvantages of striving for **volume maximization** versus **service maximization** ?

More precisely, should one schedule orders to 100% of capacity, leaving no flexibility to compensate for production shortfalls, or schedule to less than 100% capacity, with the risk of underutilizing capacity and of foregoing potential gain in market share, but maintaining flexibility and service ? The question is critical when demand exceeds supply for some extended period. Other questions were asked concerning the need and the effect over time of improving the Company's "**Responsiveness**" and **Service**.

The model which resulted from these questions grew from a simplified but everlasting analysis which old-timers know as the "Precision Case, an early version of what has now developed into the concept of Balanced Scorecard.

1 - the main concepts, both qualitative and quantitative, introduced to represent the company's business process.

2 - some results to the questions initially asked.

II - **SHORT-TERM VERSUS LONG-TERM**

Initially, the question of volume vs service maximization appeared to be a rather short term one, requiring suggestions applicable and results obtainable within a few months. Very soon, however, a rational analysis of "what causes what" led us to introduce and take into account long term variables, with the obvious consequence of long term simulations and analyses.

Short-term variables

In the present supply chain process, short-term will mean anything between a few weeks and a few months. Backlog, Production, Accepted Orders are usual quantifiable variables of this type.

Less quantifiable are variables much used and quoted these days, in particular in the "Balanced Scorecard" concept, such as Lead Time, Just in Time, Early Warning, which strongly influence the notions of Service and Client Satisfaction, and which can vary drastically within short notice.

Long-term Variables

At the other extreme of the time scale, Investments, Production Capacity, Planned Capacity, Demand Trend and Research constitute long-term variables whose evolutions are slow (years) but may result in unavoidable and sometimes drastic effects. A System Dynamics analysis which is meant to be used by decision makers whose responsibility is to "look ahead" and analyze all possible consequences of any decision, cannot and must not avoid taking such long-term variables into consideration, along with short-term constraints, changes and results.

Intermediate-term variables

Numerous variables which concern the operation of a company, show behaviors with time-constant of months rather than weeks or years. For example : Responsiveness, Service, Marketing Efforts, which can vary appreciably within months, as a result of changes in Lead Time, Just in Time, Orders, etc..., also have an effect on long term variables such as, among others, Demand Trend.

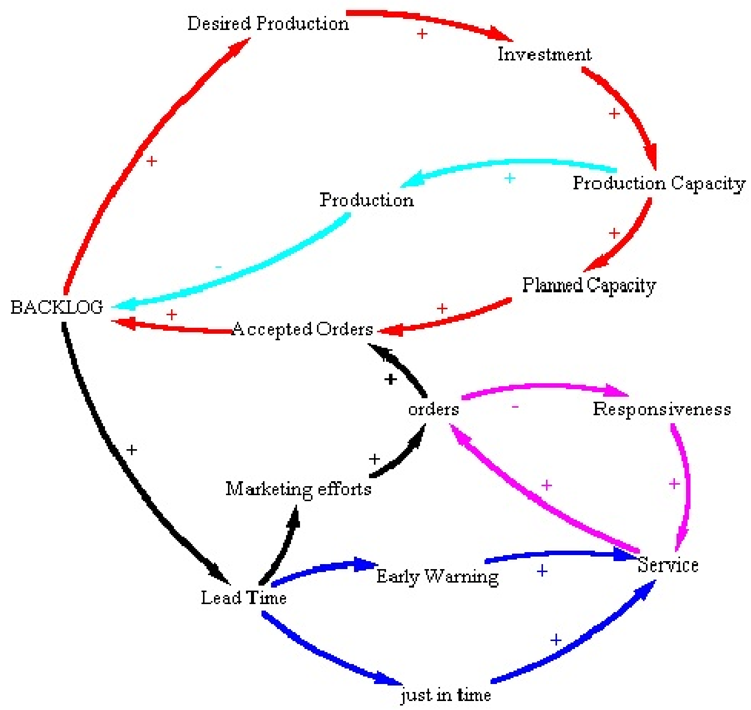
III - **CAUSAL DIAGRAM** (Fig 1)

The following simplified causal diagram shows the mutual influences between some of the variables mentioned previously. We have shown the Backlog of Orders as a central variable, since it is the variable most monitored on a short-term basis, and also because - as can be seen on the diagram - it is a variable which has both short-term (on lead-time) and long-term (on investment) influences.

There is another reason which led us to accentuate the position of Backlog in the diagram. Contrary to frequent models of Production, rather than representingn Backlog as a single stock, we had to model it as a series of stocks by future time frames (up to eight periods). There is a backlog of orders being processed during the current month (month 0), a backlog of orders whose production has been delayed - voluntarily or not - to the following month (month 1), a backlog of orders whose production is planned in month 2, etc....

Hence the diagram of Fig 1 must be considered, as far as some variables are concerned, such as Backlog, Planned Capacity, Orders, Just in Time, as made of several layers of similar diagrams operating simultaneously but in separate time slots, from the present (t0) to month +7 (t_7). Transfer from backlog i to backlog i+1 or vice-versa, will depend on many factors such as Production Capacity Availability, Urgency of Orders, the amount of Backlog itself, etc....

Fig 1



When several such successive backlogs are interconnected, one can expect any perturbation on any of the backlogs to have an effect similar to the movement of wagons in a train when the locomotive starts pulling : a progressive transmission of the forward movement, with accompanying oscillations. In fact this is what simulations showed : although orders were scheduled only to X% (<100) of capacity, production - which takes place during time slot T_0 - was planned to 100%. To realize 100% loading requires shifting backlog forward from T_1 to T_0, T_2 to T_1, etc., thus depleting future buckets and allowing scheduling of additional short term orders. Investment decisions were not driven by total backlog, but by how many periods in the future that capacity was scheduled - i.e **lead time**.

IV - **VOLUME versus SERVICE MAXIMIZATION**

Among numerous possible uses, the model was applied to help analyze the question initially asked concerning maximization of volume (all orders accepted, with a probable deterioration of service) or service (only some fraction of orders accepted, with the risk of losing clients). Wisely, it was soon felt that the problem should be analyzed from both short term and long term view points, and that one should profit from the availability of a System Dynamics model to combine both such visions.

Fig 3 shows comparative results of three policies :

Policy 1 represents maximization of volume (customer orders scheduled to 100% of planned capacity)

in Policy 2, only 90% of capacity scheduled, whereas in Policy 3, 85% of capacity is scheduled.

Fig 3

The results show that scheduling at less than 100% of capacity does smooth out the orders that can be accepted, and permits maintenance of high and consistent service, with the result that over an extended time horizon, total orders and therefore market share are higher. Improvement relative to the maximum volume (100% scheduling) case, grows down to 85% and then does not improve further. Below 80%, « pull-in » becomes difficult and there is a risk of underutilization of capacity. There seems to be an optimum window in the range of about 81-86%.

V - **CONCLUDING REMARKS**

I - It is rather counterintuitive that scheduling to less than 100% of capacity will result in higher long term sales and market share.

1. It appears that rather small changes in decisions can generate very large changes in long term results, implying that we are operating in « far from equilibrium » conditions, which is where simulation probably delivers its greatest value.