A MULTI-DIMENSION FRAMEWORK OF PRODUCTION PROCESS SERVICE LEVEL MEASUREMENT

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ABSTRACT

Traditional Type I and Type II service levels of production system only measure filling rate of demand. This does not capture the essence of the system service level. Inspired by the Gaps Model of service quality of service industry, we propose a multi-dimension service level measurement framework for the production process. In this framework, the service level will be measured from several perspectives; each corresponds to one phase of the manufacturing operation process. The measurements will reflect the characteristics we need to understand production process service level.

Keywords: Service Level, Production Process

INTRODUCTION

In past decades, most of the optimization works of operational management have been focused on cost reduction. Majority inventory and planning models are cost minimization models. However, with the development of the information technology, and as the competition become more and more intensive, the whole economic environment has changed in many aspects. Among the trends of today’s business, how to satisfy customer’s needs becomes one of the key issues of competition. Also, customer involvement in many manufacturing industries becomes more and more significant. It becomes clear that by only focusing on cutting cost you cannot always win the battle. As the products’ quality and price gaps between companies shrink, the whole operational strategy has to pay attention to the service level and tries to enhance the competition advantage by improving service.

Reflecting this phenomenon, optimization models start to turning from cost saving to revenue (profit) maximization. To make this change, one important thing is to include future revenue (profit) into the model (Nahmias, 2001). One way to consider potential revenue from a customer is to treat the revenue as a cost of loss sale if we cannot satisfy the customer’s demand. A loss of sale will not only loss one time revenue, but also may cause loss of sale in the future, which usually is multiple times of the onetime profit. The loss of sale is a key term in the revenue maximization models.

In traditional operation optimization models, the stock-out is treated as cannot meet a customer’s demand quantitatively (Schwartz, 1966, Oral, etc. 1972). The stock-out cost is based on this definition. In this article, we will argue that this stock-out percentage is not a proper
measurement of a company’s service level. Thus the stock-out cost based only on it will not be the right one.

**PRODUCTION SYSTEM ORDERING PROCESS**

A manufacturing firm is considered to have a good service if it can deliver a product to customer required place on time, at the right quantity and quality. Price is always considered in the sales process and is not included in the operation process. However, the popular service level measurement of manufacturing industry is over simplified and can not reflect the required criteria of a good service.

Traditional service level measurements of a manufacturing operation process are typically referred to either Type I service level, or Type II service level. The definitions of these two measurements are:

- **Type I**: the proportion of demands that are filled when they occur
- **Type II**: the proportion of demands that are filled from the inventory

To make it simple, Type I service level measures the percentage of orders that are fully filled, while Type II service level measure the filling rate of all orders at unit level. For example, assuming we receive following orders:

<table>
<thead>
<tr>
<th>Orders</th>
<th>Demand (Units)</th>
<th>Stock-Out (Units)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>150</td>
<td>50</td>
</tr>
<tr>
<td>3</td>
<td>150</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>100</td>
<td>0</td>
</tr>
</tbody>
</table>

We can see that order 2 is not fully filled, so we have three orders that have been successfully filled, and for the total 500 units demand, we’ve filled 450 units. By definition, the Type I service level is 3 divided by 4, which is 75%, while the Type II service level is 90% (450 / 500). For single-order system, these two service levels are equal. For mass-order system, Type II service level is always higher than Type I service level.

One major reason why these service levels are broadly adopted is that they are easy to calculate. Also, these service levels can be integrated into the inventory optimization and production planning models as a constraint. However, these simplified definitions do not reflect the reality, and this brings troubles when we want to integrate the service level term into the target function.

Figure 1 is the flow chart of a typical production operation process. When customers show up to place orders, we take a look at our capacity, on-going production plan, and our inventory to decide if we can take the orders under current constraints. If we cannot satisfy the order, we need to offer a feasible order quantity or delivery time to the customers, we may also give suggestions about the combinations of products in the order.
Customer Placing Orders

Can be met by current capacity and production plan?

Yes

Take the order

Order change happens?

Yes

Adjust the order

No

Negotiate the order

Final order

Production

Delivery

Figure 1: A Typical Production System Ordering Process

This may go back and forth several times before we reach an agreement with the customers. Then we will start the planning process.

However, customers may change their orders after the initial placement. If this happens, we need to renegotiate orders with customers, and redo the production plan. There is a certain time point after which all the production plans can not be changed any more, i.e. the manufacturing process start. After the goods are produced, they will be delivered to customers’ dock.

Even for this simple operation process, we can see neither Type I nor Type II service levels can describe the service level of the process properly. If we use these service levels to measure the difference between initial customer orders and goods customers receive, it ignores too much detail. Even if we have only one product, we still can use price stimulation or coordinate with customers to make them happy without fully filling their initial orders. If we have more than one product, and they are in some degree substitutable, we will have more choice to satisfy customers. Not to mention there are other important service criteria to customers, like the order adjustment window, etc. All these issues are not reflected by current service level measurements. If we use current service level measurements, they may be able to measure one or several steps of the whole operation process, but they will never able to measure the service level of the whole process, no matte how accurate it captures the property of the step.

THE MULTI-DIMENSION SERVICE LEVEL FRAMEWORK

Gaps model of service quality was first proposed by Parasuraman, Zeithaml, and Berry in 1985 (Parasuraman, Zeithaml, and Berry 1985). The model uses five gaps to describe potential quality problems in the service industry, as shown in figure 2.
A company’s performance in filling these gaps can be used as a measurement of the company’s service quality. The same authors published following articles about how to measure the service quality (Parasuraman, Zeithaml, and Berry 1988, Parasuraman, Berry, and Zeithaml 1991), and developed ServQual Scale. Generally speaking, we can use the difference between expectation and perception as the measurement of a gap.

Though there are arguments about the ServQual Scale assessment (Cronin and Tylor, 1992, Parasuraman, Zeithaml, and Berry 1994, and Teas, 1993, 1994), the gaps model is widely adopted as service quality measurement model. The key contribution of the gaps model is that it breaks down the general, hard to define service quality concept to several small, tangible, measurable terms, which makes the measurement of service quality become meaningful. Inspired by the Gaps Model, we propose a multi-dimension framework of service quality for the manufacturing operations process, as shown in figure 3.
If we compare the service operation process with manufacturing process, there are several differences. One major difference is that in service operations, the service (or output) usually is consumed when it is generated. For a manufacturing operations process, there always exists a lead time. Different operations steps happen along the time axis, between the time that the customer enters the door and the time that the customer gets the goods he/she orders, as demonstrated in figure 4. This characteristic introduces an extra dimension, the time, to the service level measurement. Based on the characteristics of the operation process, we can divide the whole timeline into four phases. The service measurement for these four phases are different to customers.

**Phase 1**: the phase between the initial customer order arrival and the initial order taken by the manufacturing system.

Phase 1 reflects the system’s general capability. When we measure this phase, we should not simply reflect the difference between the system’s capacity and customers’ mean demand. Notice that there exists a negotiation process if we can not meet the initial order. The purpose, or the measurement of a good service, is to satisfy customers, not just to meet customers’ demand without questions. If we can not meet customers’ initial order, but we can offer a good substitution, either with different delivery time and product price, or offer substitute products, or other methods, as long as customers are happy with the negotiation result, it is still considered that we are providing a good service.

The reason why we emphasis the negotiation is that, to optimize the whole system, we need to think about the whole system’s production planning from the beginning of the operations process, which is the time we take orders. Taking order should not be considered as job only for
marketing/sale department. If we just let the sale take whatever order placed by customers, we may face troubles in future. It may turn out that the order will not generate profit for the firm, or we can not satisfy the order and irritate customers. Also, we hope the combination of orders we take can make the manufacturing system runs at optimal level. Here the optimal level means that we can get maximum revenue (profit) from the system output. With this target in mind, we hope to guide the customers’ order while make them satisfied at the same time. This needs us to break down the wall between marketing/sales and operations.

So the phase 1 measurement is not what percentage of customers’ initial orders we can fill, it should be how satisfied the customers are when they show up and accept what we can provide.

Phase 2: the phase between the initial order taken and the order ready to produce

As we mentioned early, manufacturing systems usually have lead time for all orders. At a certain point of time, the production plan will be frozen and no further change will be accepted. Ideally, this frozen period should be just equal to the manufacturing lead time, but from time to time it will be longer than the manufacturing time because of raw material procurement, labor force arrangement, production planning and scheduling, batch size constraints, etc. Once an order enters the frozen period, we can no longer change the production plan by customers’ requests.

For the measurements of phase 2, we need to consider two issues. The first one is after the initial order placement, how much time we give customers to adjust their orders before the order is frozen. We call this the order adjustable time. Notice that we should not extend the overall lead time for the exchange of longer order adjustable time. Given that the overall lead times are the same, the system that has longer adjustable time period usually is more flexible, or they have a better planning or operations strategy that gives them shorter internal lead time. Longer adjustable time means that customers have longer time to adjust their orders, from quantity to variety. For goods that have volatile demand, the longer the adjustable time is, the more accurate the final demand forecast will be, and the more satisfied the customers will be.

We still need to think about the problem that a customer wants to change his/her order after the order is frozen. Usually this will be considered from the beginning of contract design. Several choices exist for this case, the worst case is that we don’t provide any flexibility and customers have to take what they order before. Or, they can pay some penalties and change their order, thus avoid larger loss. The best case is that we can use the total order information, which include all our customers’ (or potential customers’) demand information and try to absorb the demand change for this single (or even some) customer(s).

The purpose of the phase 2 measurement is to provide what degree of flexibility we provide to our customers.

Phase 3: the phase between the start of frozen time to the time we get output from the production line

The measurement of this phase is the criteria of our manufacturing process, and it is what traditional manufacturing performance and quality are about. At this level, there will not be any
change on production plan, and we just expect the production process can manufacture goods at expected amount, quality and finish on time.

The service level of phase 3 is an internal service level. It measures the company’s ability to keep the manufacturing process as designed and expected. A simple measurement is the production line yield. However, we can always add other criteria, such as lead time, to make the measurement more complete.

Phase 4: the phase between the time that goods are produced and the time they arrive customers’ dock.

This phase captures all other issues that have not been included in previous three gaps. The customer’s order here is not the initial order placed by customer. It is the order comes from the last time when the customer reaches an agreement with us.

One major factor that is included in this phase is the transportation. For most of the production systems, customers’ orders should be delivered to required places. Any bad thing happens during the delivery will affect the service level we provide. Other accidents that could happen include mis-package, wrong billing, etc. We will not consider after sale service and warranty in our model.

**FUTURE STUDY DESIGN**

The purpose of the study is to provide the right way to measure the service level of production operations process. In this paper, we propose the multi-dimension framework to measure the whole operation process by several small but measurable criteria. We hope we can reach two targets eventually. The first one is that the new metric can be recognized by the management teams, and can provide managerial insight for the operation process. The second one is that we hope we can find a proper set of assessment of the measurement, and eventually we can integrate these new criteria into the optimization models. So the validity of the model needs to be confirmed first, which will be the focus of our next step research.

In next step, we plan to work on a case study, i.e. try to introduce the model to the people of one major manufacturing company and get feedbacks. By this study, we expect to thoroughly understand the model and the possibility of applying it in reality. Before doing the case study, we need to propose our assessments of each of the measurement. We want to know which criteria can reflect the essence of each phase. For example, in phase 1, will a single satisfaction measurement enough? If not, how many criteria are enough? How to measure the service improvement by providing alternative choice for customers? How much behavior factor, like the difference between expectation and perception, should be included? These are questions we need to answer before we can give an assessment of the measurement.

The case study will provide us an opportunity to evaluate our assessments. After the validity of the model is verified in the case study, we need to confirm it in a larger scale. This will be done through a survey. Weather it will focus on a single industry, or cross multiple industries in the survey is still to be decided.
REFERENCES


