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# Addressing the performance of order acceptance

Johannes Cornelis de Man*, Bjørn Sørskot Andersen, Jan Ola Strandhagen

*Department of Production and Quality Engineering, Norwegian University of Science and Technology, S. P. Andersens veg 5, 7031 Trondheim*

* Corresponding author. Tel.: +4740141004. *E-mail address:* hans.deman@ntnu.no

**Abstract**

While there are many mathematical approaches to order acceptance (OA), the performance of OA in practice is overlooked. This paper assesses current OA methods and performance measures that could measure OA. The outcome is a conceptual performance measurement system for OA that measures performance through utilization of resources, output and flexibility in a diagnostic and predictive manner. This paper found a close relationship between OA and S&OP, as they both match supply and demand. The contribution of this paper is that it detaches OA from mathematical models and proposes a method to assess the value creation of OA in practice.

*Keywords:* Performance Measurement; Order Acceptance; S&OP, Supply Chain Management, Scheduling; Due dates; Pricing; Value Creation

## 1. Introduction

Orders acceptance (OA) is the function of either accepting or rejecting sales orders, often in combination with setting the correct price and due-date for the order [1]. For companies order acceptance is a vital decision in their production process, independent of whether it is an explicit decision, because order acceptance is "the joint decision which orders to accept for processing and how to schedule them" [2].

Mathematically there are many approaches to order acceptance, see for example Slotnick [2]. These methods are either to increase revenue, profit, decrease cost or improve due date reliability.[2] Literature discusses the implementation of these methods often from a mathematical and thus operations research perspective. Ebben, Hans [3] add to this that "it is hard to compare the tested OA methods with the OA performance of a planner in practice, since a planner probably makes his decisions based on experience"[3].

Performance measurement could evaluate order acceptance, because "performance measurement is the process of quantifying the efficiency and effectiveness of action"[4] or "the process of measuring actual outcomes or the end goal of performance, as well as the means of achieving that outcome as represented by in-process measures" [5].

Currently, the performance of order acceptance in practice is overlooked. The impact of order acceptance decisions on a supply chain, i.e. "an integrated process wherein raw materials are manufactured into final products, then delivered to customers" [6], is not reported in a structured way. Current literature on order acceptance now focuses on expected benefits or mathematical issues when constructing order acceptance methods; it does not address its performance in retrospect or relation to other company functions. Also, an approach in which a performance measurement system (PMS) includes order acceptance measures does not exist.

In this paper, we therefore address the following problem statement: The impact of order acceptance within companies is not measured and linked to company performance.

To tackle this problem statement, this paper addresses the following research questions:

- What are the goals of order acceptance methods?

The rationale for this question is to get an understanding of which goals OA has and how these are approached in both mathematical methods and industry practices.

- How can the performance of order acceptance be measured?

    In this question the relation between order acceptance and performance measurement is made. As it is a supply chain management process, it will be linked to both general and supply chain specific performance measurement literature.

- How can the performance of order acceptance be measured in a PMS?

    To answer this question, we design a conceptual model for measuring the performance of OA. This is based on the knowledge gained from answering the first two research questions in combination with a conceptual design approach.

    Section 2 discusses methodology to continue with a literature study in section 3. Section 4 discusses a conceptual performance measurement model before the paper is concluded in section 5.

## 2. Methodology

This paper explores the possibilities of performance measurement of OA, and by doing so builds a first concept to measure the performance of OA. Research question 1 and 2 are answered through a literature study, and a conceptual model of a PMS is designed to answer research question number 3.

Analytical concepts are based on logic, using introspection to derive concepts from the authors experience. A conceptual model, in this sense, is a "mental model of deduced relationships […], which may then be evaluated using a framework that captures the essence of the systems under investigation". [7]

This conceptual model is built on the found literature and the author's experience. To construct a conceptual model, we include a few criteria to construct our model:

- Thorough understanding of the background on which the model is built
- Clear description of the process for which the model is built.
- Construction of the PMS based on the process description, literature and the authors understanding of OA.

The reason for this approach is to explore the possibilities of performance measurement in relation to OA. We argue that continuing to expand mathematical OA models leads to a further disconnect between practice and theory building. This approach deviates from the mathematical approach, which in turn could lead to cases and action research that reviews actual OA performance in practice.

## 3. Literature study

### 3.1. Goals of order acceptance methods

The first and foremost goal of order acceptance is maximizing monetary value generated, either through maximizing net present value (NPV), revenue, profit or minimizing cost by accepting the optimal orders from an order set. Secondary objectives are to maximize service levels and utilization, minimize tardiness and lateness. [2] For example, [8] accepts orders based on order priority, while [1] looks at pricing and the delivery date after the order has been accepted. These goals are similar to other mathematically defined scheduling problems, incorporating the possibility to reject an order. Most mathematical OA methods, only address one optimization criteria. [2] Ebben, Hans [3] describe that sales departments often try to maximize turnover by accepting all orders, while production departments try to maximize utilization and minimize tardiness [3].

OA can be seen as a hierarchical process step, or as process that is integrated both with scheduling and sales. The main difference is that as a hierarchical process step, OA accepts or rejects orders based on static information, while as an integrated process OA is part of production planning and scheduling. [9]. With a strong relation to scheduling, OA accepts the orders that hold the maximum value. Therefore, we address the goal of OA in this paper as follows:

- Accepting orders from a sales order set that hold the maximum potential value.

In the operations research domain the further relation to day-to-day business is not described, while there are several relations to the day-to-day operations of a manufacturing operation. First, for more complex manufacturing environments order acceptance is often not a routine operation, involving product design and specification [10]. Second, companies do not consider advanced order acceptance methods [3]. Also, it can be argued that sales orders are often preceded by information requests, requests for quotations or requests for proposals from the vendor. Once vendors send out a quotation or proposal, they often commit to accept the following sales orders. Lastly, OA is often not only a mathematical decision, but also involves stakeholders needs and interests, is influenced by a sales representative intuition, and is a manual process.

Therefore, while the goal of order acceptance is clear, the solution from a mathematical perspective is limited, making only an acceptance and scheduling decision for an arriving order. If we reflect on this, OA should not only look at order intake itself, but has to look at the causes of order generation as well. In some cases, orders are one-offs that do not have a preceding action, but often at least a quotation process has taken place. The quotation process sets a price and often a delivery date for the goods requested.

Therefore, it is questionable that order acceptance methods are only valid for order intake; they should be used during quotation and contracting phases as well. Otherwise, the rejection function of order acceptance methods has limited value. Rejecting orders, however, does not only turn away one order, but also potential future orders from the same customer.

Current order acceptance methods relate to scheduling problems. Orders are accepted if it fits the schedule or minimum lateness for the existing order set is incurred. In this context, the relation between sales and operations is addressed [9]. Also in sales and operations planning (S&OP), the main goals are to align demand and supply, and to improve operations. [11] In S&OP literature, however, there is no relation to order acceptance. The outcome of S&OP is an alignment of plans by marketing, sales, production, logistics, sourcing, and finance. It is a cross-functional and integrated

tactical planning process within a firm. Thomé, Scavarda [12] discuss the effect of S&OP on firm performance. They found a positive relation to performance, but state that most S&OP papers are descriptive and prescriptive with limited data to back this up. [12]

While both OA literature and S&OP literature both match demand and supply, they do not refer to each other. If OA both is the acceptance of orders and scheduling them concurrently, OA could be considered an operationalization of sales and operational forecasts or even S&OP.

### 3.2. Performance measurement of order acceptance methods

Neely, Gregory [4] discuss performance measures in a framework with three levels; individual measures, the relation between measures and the relation to the environment in which it operates. This paper addresses the system of measures, i.e. relation between measures, so the working of individual measures or the relation to the external environment is not extensively covered. In this paper, a PMS is therefore seen as a system that:

- Quantifies the effectiveness and efficiency of action [4] and supports stakeholder action to improve the object that is measured.

In this way, the function of order acceptance gets measured on its effectiveness and efficiency, but also implies actions to improve its function by addressing the correct stakeholder to do so. Stakeholders in this sense are employees working with order acceptance, involved managers and supporting staff that maintains necessary infrastructure to perform OA. This is to avoid that stakeholders are general and not practically defined as is often the case [13].

By measuring OA performance, a decision process within a supply chain is measured. The acceptance of orders depends on the responsiveness of the supply chain such that different kinds of orders in different kind of volumes can be delivered on-time. This means that there is a need for measures that cover resources, output and flexibility [6].

An example to measure resources is manufacturing cost, i.e. the total costs to manufacture as specific order. Another example would be inventory cost of work-in progress. [6] An example for output would be order fulfillment cycle time, i.e. "the (average) actual cycle time consistently achieved to fulfill customer orders" [14].

Flexibility can also be captured in OA performance measurement. A forecast is only one expected outcome of the future. Similar performance under higher sales volumes or different product-mixes can be attributed to the flexibility of the supply chain. The bandwidth in which sales volume is expected to be also anticipates needed resources for the agreed upon S&OP plan, while by measuring the performance of OA, the lack or abundance of resources becomes clear. Also, flexibility can be very well described with mix flexibility, i.e. the differences in product mix that can be incurred without "high-costs or large changes in performance" [15].

OA is one part of supply chain management for which, like any other process, probably no unique measures exist. For example, the Supply Chain Operations Model (SCOR) shows that most metrics can be used in multiple processes. [14]

Beamon [6] discusses that for a supply chain PMS at least one measure for resources, as well as output and flexibility is needed. The relation between these three types are apparent, e.g., a company can only produce if enough resources are available, but needs enough output to pay for these resources and needs to cope with volatile demand patterns through flexibility [6]. These measures have been extended to resource utilization, costs, quality, flexibility, visibility, trust and innovativeness, moving towards much more qualitative PMSs. The use of different types of performance measures, however, highly depend on how the supply chain functions optimally. [15] Furthermore, measures either measure a strategic, tactical or operational aspect [16]. Clear examples of metrics can be taken from the SCOR model which refers to reliability, responsiveness, agility, cost and asset management efficiency for which metrics are developed. [14] In current research, the majority of measures still determine cost levels and are quantitative [17]. There is, however, not a universal approach to generate a specific supply chain PMS. [6]

Harbour [5] describes that a performance measure system needs to be descriptive, diagnostic, and predictive, i.e. what is happening, why is it happening and what will happen in the future. This proposes both the need for leading and lagging indicators when proposing a PMS [5]. And also supply chain management sees the merit of predictive measures, going from feedback to "feed-forward" [18]. Predictive measures are forecasts. The more detailed a forecast becomes, the more unreliable it is. Predictive measures therefore not only need to be predicting a value, but also need to state their reliability. [5]

As discussed in the last section, there is a strong connection between S&OP and OA. The performance of OA therefore can indicate the performance of the S&OP workings. Likewise, the prospects of S&OP, such as sales forecasts are a predictor of the functioning of OA. This both tackles the need for leading and lagging indicators.

While there are many bodies of research looking at supply chain performance as a whole, they do not relate to improving the object that is measured. And it is a challenge to do so: Overall performance measurement is a result of different processes, decisions, actions and external factors that influence different measures. In the SCOR model, for each measure it is clearly indicated in which process they can be used. How individual decisions within these processes affect measures is not indicated [14].

## 4. Conceptual model

This paper addressed the performance measurement of OA. It was argued that OA could be considered the operationalization of S&OP. Furthermore, we showed that OA accepts orders if it is expected that the supply chain can fulfill the requested demand at the right time profitably. Based on these findings, this section represents a conceptual PMS for OA based on a OA flow. This flow is extended from existing flows [1, 8]. We incorporate that orders could come forward from a quotation phase. We also integrate the delivery performance of the order and the possibility to renegotiate the price and delivery date, recognizing that orders can be accepted under other conditions than originally proposed.

Figure 1 displays a possible flow of order acceptance. The figure makes a link with the generation of orders, either a quotation or direct sales order, compares the order to sales forecasts, and then determines the delivery date and price of the order, integrated into the scheduling process of a firm. The quotation is either send back to the customer or the sales order is finalized and put into the system. A sent out quotation can be rejected or renegotiated.

From the first moment the quotation starts, there are possible metrics to apply. The first phase is regarding requests for quotations. Then the second phase is about acceptance, i.e. metrics on order acceptance and rejection based on S&OP or scheduling problems. The third part discusses pricing and due date setting decisions, which are based on scheduling problems and sales requirements. Finally, order delivery is measured, i.e. whether orders are delivered on time.

Furthermore, the performance measurement of order acceptance can both be single order based, or based on the functioning of an order acceptance method as a whole, such that single order decisions and all order decisions can be evaluated. Table 1 describes possible measures and metrics for the several phases, both for single and multiple orders.

Table 1 contains reflective metrics that tell something about one order or a set of orders. Through this metrics we reflect on the OA flow as depicted in Figure 1. We do not state that OA is singly responsible for all these metrics, e.g. scheduling, production and the delivery process could influence many of these metrics. When measuring the performance of an order once it is delivered, it is however in the best interest of planner or sales executive whether he should have accepted that order for that price on that delivery date. For example, if in retrospect the profit margin is negative, the acceptance and pricing decision for that order needs to be reviewed.

The same holds for sets of orders: Revising acceptance policy through either product groups, (seasonal) time periods or different sales persons could reveal the impact of order acceptance policy by different aspects that change the dynamics of OA. Through this design of being able to select groups of orders, comparisons can be made and correct actions can be invoked to the correct stakeholder.

To invoke stakeholder action in this case means to change either behavior or a process from a supply chain manager, sales person or planner such that OA starts to function better. While the metrics presented are absolute, the reasons for them vary across OA decisions. The numbers that a PMS represent are supportive to invoke actions. These actions can of course
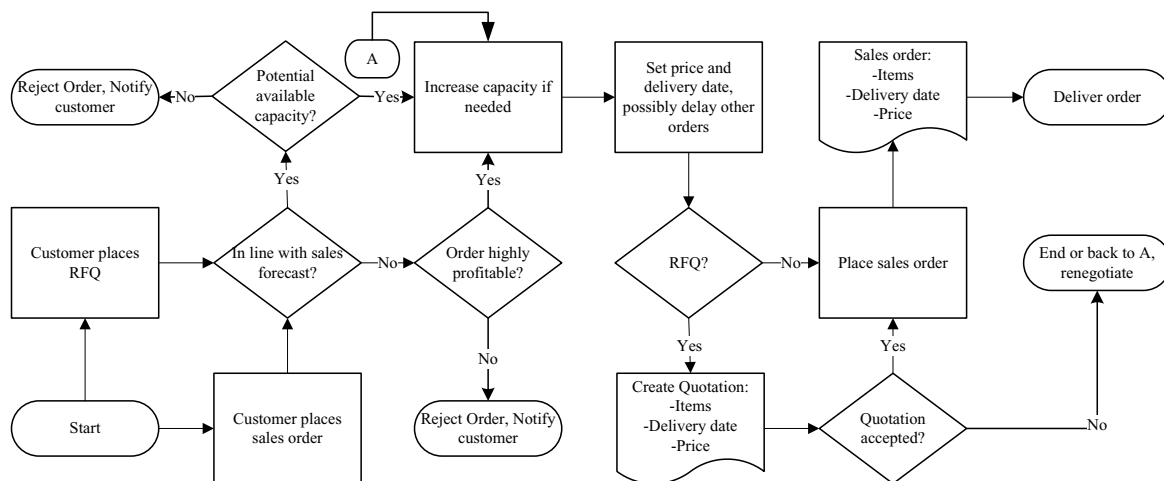


Fig. 1 Conceptual order acceptance flow as an operational activity, based on literature study and [1,8]

be necessary short-term decisions, but also need to lead to long-term improvements and the correct targets that can be related to a company's strategy. Short-termism and myopic decision making must be avoided. Questioning the why and causal relation to financial performance is therefore very relevant. [19]

Table 1: Conceptual lagging measures and metrics for OA, based on [6, 14, 17]

| # of orders | RFQ/RFP | Acceptance | Scheduling/ pricing decisions | Order delivery |
|---|---|---|---|---|
| 1 | | Acceptance (yes/no) | Price vs. list price | On time (yes/no) |
| | | Order profit margin (%) | Expected lead time vs. standard lead time (days) | Days late/early |
| Period/ Season/ Set/ All | (order winning %) | Acceptance/ rejection ratio | Price vs. list price (difference %) | On time (%) |
| | | Average profit margin (%) | Expected lead time vs. standard lead time (avg. days) | Average days late/early |
| | | | Realization exp. Sales vs. Forecasted sales | |

The functioning of OA relies on agreed upon demand and supply forecasts. Predictive measures can be directly taken from forecasts of expected demand and available supply, i.e. production resources. This supports OA by matching incoming orders to expected demand from the demand forecast. To serve this need, the conceptual PMS also needs to consider forecasts as leading indicators. The measures taken from forecasts in relation to OA are shown in Table 2, which is further explained in the next paragraphs.

Expected sales can be forecasted and forecasting in combination with current manufacturing utilization leads to a known available production capacity. Flexibility then shows under which production volumes the company can run profitably, whether standard due dates can be moved forward in favor of customers and how flexible production facilities can setup for another type of product [6].

Through reliability analysis of the expected demand and supply, the bandwidth in which the expected demand and available production capacity will be can be forecasted. The combination of expected sales and production with flexibility and bandwidth then predicts whether the company will run profitably.

Lastly, diagnostic measures on expected versus actual demand can be taken. This is to verify the validity of the forecasts and relate the forecasts to OA. Earlier, OA was defined as accepting the orders that hold the potential maximum value. The maximum value of potential orders, however, might not be forecasted, or extra capacity is needed to produce them, which can be verified by comparing forecasts to the outcome of the accepted order set.

Table 2: Conceptual leading measures to support OA

| | Demand | Supply |
|---|---|---|
| Expected | Sales | Available production capacity |
| Flexibility | Demand range (lower and upper limit) under which the company functions profitably. | |
| Bandwidth/Reliability of forecast | Possible variation in sales volume and product mix | Possible variation in production capacity availability |
| Expected vs. actual | Diagnostic measure | Diagnostic measure |

A good source for these forecasts would be S&OP forecasts, but similar values or more detailed values can be found in stand-alone forecasts if those are not available.

The relation from leading to diagnostic measures can be made, e.g. managers that expect lower sales can expect a lower profit margin but a better delivery performance and shorter lead time.

This conceptual model has shown potential measures and metrics to assess the performance of OA. This has showed the integration with planning and scheduling processes. Furthermore, we demonstrated the needs of predictive measures coming forth from forecasts.

If we reflect back on the conceptual process of OA, we can relate the found performance measures of OA to the process, describing which parts of the process are measured by which type of performance measures. We can look back at figure 1 to understand the performance measures, e.g. for a set of orders the "on time" and "days late/early" can be measured by comparing the sales order delivery date with the actual delivery date. Another example is the "acceptance" ratio, comparing the amount of orders with the total number of orders.

## 5. Conclusion

In this paper, we addressed the impact of OA on company performance. Through a literature study on both OA and performance measurement, we derived a conceptual PMS that serves as a basis to assess the performance of OA.

It is found that mathematical models for OA often address one optimization criteria by accepting and rejecting orders and using scheduling techniques. OA in practice, however, is often an experienced based procedure that is grounded between sales and operations for which the performance is unknown.

The performance of OA can be measured by using predictive and lagging measures from the supply chain performance measurement domain. This resulted in a conceptual PMS. It focuses on all decisions that are taken during order acceptance. Through the depiction of the OA process, we derived performance measures that form the conceptual PMS.

This research has developed a conceptual PMS for OA, such that the impact of OA on company performance can be addressed. Both OA and S&OP try to match demand and supply in their own capacity, and measuring the performance of OA through forecasts might improve S&OP or forecasting

methods. This relationship needs to be further assessed in future research.

The contribution of this paper is that it detaches OA from mathematical models and proposes a method to assess the functioning of OA in practice. This is a starting point to assess how OA can influence value creation within supply chains.

The limitation of this paper is that it has not been tested or compared to other methods in practice. To extend this work further, extensive case and action research is needed to test and improve this conceptual model. This has to be done in two directions. The first direction is research that statistically tests the relation between performance measures and OA. The second is the facilitation and implementation of performance measurement for OA in companies.

Apart from testing and refining this model, the next step in research is to define what kind of actions and decisions are needed based on outcomes of the OA performance measurement. Also, the integration into existing supply chain management PMS need to be researched.

Furthermore, the research conducted looked from a general company perspective, but the effect of production strategy on OA performance must be researched, e.g. the difference between produce to order versus produce to stock companies.

Lastly, the implementation process of an OA PMS must be designed and researched.

This leads to the following implications for managers: In existing PMS, managers could consider the impact of OA on existing measures. This might lead to a review of decision-making policies by connecting incoming orders to operational efficiencies and effectiveness. It might also lead to an understanding of performance variability on different measures that could not be explained before and thus to a greater understanding of the supply chains they manage.

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## References

[1] Kalantari M, Rabbani M, Ebadian M. A decision support system for order acceptance/rejection in hybrid MTS/MTO production systems. Applied Mathematical Modelling. 2011;35:1363-77.
[2] Slotnick SA. Order acceptance and scheduling: A taxonomy and review. European Journal of Operational Research. 2011;212:1-11.
[3] Ebben MJR, Hans EW, Olde Weghuis FM. Workload based order acceptance in job shop environments. OR Spectrum. 2005;27:107-22.
[4] Neely A, Gregory M, Platts K. Performance measurement system design: A literature review and research agenda. International Journal of Operations and Production Management. 1995;15:80-116.
[5] Harbour JL. The basics of performance measurement: CRC Press; 2009.
[6] Beamon BM. Measuring supply chain performance. International Journal of Operations and Production Management. 1999;19:275-92.
[7] Wacker JG. A definition of theory: research guidelines for different theory-building research methods in operations management. Journal of operations management. 1998;16:361-85.
[8] Hemmati S, Ebadian M, Nahvi A. A new decision making structure for managing arriving orders in MTO environments. Expert Systems with Applications. 2012;39:2669-76.
[9] ten Kate HA. Towards a better understanding of order acceptance. International Journal of Production Economics. 1994;37:139-52.
[10] Zijm W. Towards intelligent manufacturing planning and control systems. OR-Spektrum. 2000;22:313-45.
[11] Thomé AMT, Scavarda LF, Fernandez NS, Scavarda AJ. Sales and operations planning: A research synthesis. International Journal of Production Economics. 2012;138:1-13.
[12] Thomé AMT, Scavarda LF, Fernandez NS, Scavarda AJ. Sales and operations planning and the firm performance. International Journal of Productivity and Performance Management. 2012;61:359-81.
[13] Choong KK. Understanding the features of performance measurement system: A literature review. Measuring Business Excellence. 2013;17:102-21.
[14] Supply Chain Council. Supply Chain Operations Reference Model. Revision 11.0 ed2012.
[15] Chan FTS. Performance measurement in a supply chain. International Journal of Advanced Manufacturing Technology. 2003;21:534-48.
[16] Gunasekaran A, Patel C, Tirtiroglu E. Performance measures and metrics in a supply chain environment. International Journal of Operations and Production Management. 2001;21:71-87.
[17] Shepherd C, Günter H. Measuring supply chain performance: Current research and future directions. International Journal of Productivity and Performance Management. 2006;55:242-58.
[18] Van Hoek RI. "Measuring the immeasurable" - Measuring and improving performance in the supply chain. Supply Chain Management. 1998;3:187-92.
[19] Ittner CD, Larcker DF. Coming up Short on Nonfinancial Performance Measurement. Harvard Business Review. 2003;81:88-95+139.