VALUE BASED ORDER PRIORITIZING IN PRODUCTION CONTROL – INTEGRATING CUSTOMER VALUE MANAGEMENT INTO THE LOGISTICS GOAL-SETTING

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INTRODUCTION

Customer orders in international supply networks can have different importance due to e.g. various order sizes or customer values (Pardoe, Stone 2005). Thus, customer orders should be assessed and treated individually in order to distinct between more or less profitable ones, as creating superior customer value is a key element for companies' success (Huber, Herrmann & Morgan 2001, Laitamäki, Kordupleski 1997, Milgrom, Roberts 1995). One approach to evaluate customer orders is the Customer Value Management (CVM) (Helm, Günter 2006). This concept explicitly focuses on the financial impact of a specific customer order and analyzes the corresponding customer value (Stirling 2000). It aims for a maximum lifetime profit from the entire customer base (Pease 2001).
However, by implementing the CVM, the logistics goals of a system might be affected (Lummus, Vokurka 1999, Woodruff 1997). For example, if more important orders are prioritized over less important ones, the overall due date reliability of the company is likely to decrease as the prioritized orders interfere with the planned production sequence (Nyhuis, Wiendahl 2008). In consequence, the CVM has to be integrated with the logistics goal-setting in order to ensure both: matching logistics goals as well as prioritizing orders due to their financial importance (Martin 2005).
Current approaches of order prioritization do not integrate logistics goals (e.g. high due date reliability or high machinery utilization (Nyhuis, Wiendahl 2008)) with financial goals obtained by the CVM (maximum lifetime profit from the entire customer base (Pease 2001)). Hence, a comparability and prioritization for balancing different customer orders with respect to logistics and financial requirements is not possible. Therefore, the paper aims to develop a solution, which incorporates the financial and the logistics perspective by combining CVM and production control methods.
One approach in production logistics to deal with this challenge is the so-called autonomous product construction cycle (APCC). It applies the idea of autonomously acting smart objects, which are able to route their way through a production process according to their goals (Windt, Jeken 2009). The smart objects decide at each step of production. The idea is to base the decision not only on logistics goals but also on the customer value obtained by applying the CVM. Thus, the logistics goal-setting of each object can be weighted according to the specific customer order's value (Mentzer et al. 2001).
The overarching idea of this paper is to develop a prioritizing model for balancing logistics and financial requirements of customer orders in production control in order to rank different orders based on their importance. Thus, the aims are threefold: Firstly, logistics goals, financial goals, and their interrelations in production control will be described; secondly, causal relations between the CVM and the APCC will be identified; thirdly, a tool for prioritizing customer orders for a practical application will be deduced.
In the second section the relevance of logistics goals in production control as well as financial goals will be discussed in order to clarify possible interrelations and requirements for developing a prioritizing model. In the third section, the concepts CVM and APCC will be introduced. Additionally, possible links between these concepts will be identified. Thus, the ideas of both concepts are attained and possibilities and limitations for their integration can be evaluated. Therewith, a basis for integration is established. Then, ex-

emplary characteristics of customer orders are weighted by applying a scoring model and a pair-wise comparison. Consequently, the characteristics can be ordered according to financial and logistics goals. Finally, a prioritization of customer orders is deduced from the scoring values and integrated with the APCC. The fourth section outlines contributions and limitations of the introduced concept. Finally, the fifth section subsumes central findings and provides an outlook for further research.

MOTIVATION OF INTEGRATING LOGISTICAL AND FINANCIAL GOALS IN PRODUCTION CONTROL

The overarching goal setting of a company comprises strategic goals, which are according to Müller-Stewens and Lechner (2005) ensuring the survival of a company and creating and maintaining competitive advantages. Other goals like logistics as well as financial goals can be subsumed under this strategic goal setting (Lechner, Müller-Stewens 2005).
In logistics research, scientists attempted to identify Key Performance Indicators (KPIs) for measuring logistics goals (Shepherd, Günter 2006, Gunasekaran, Kobu 2007). While these surveys offer a comprehensive understanding of different logistics KPIs in general, Nyhuis and Wiendahl (2008) offer a condensed approach for production logistics KPIs by defining and integrating two logistics performance (due date reliability and throughput time) and two logistics cost targets (inventory level and machine utilization):
High *due date reliability* represents a company's ability to deliver according to the confirmed delivery date and therefore contributes to the customer satisfaction. Short *throughput times* allow for quick responses to changes in demand as they represent the time span from order release till end of production. Low *inventory levels* are important to keep the capital tied up in stock as low as possible and contribute therefore to a company's liquidity. High *machine utilization* contributes to a decrease of the fixed cost portion per unit. From a logistics point of view, these objectives can lead to reasonable prices and high customer service levels (Nyhuis, Wiendahl 2008).
Following Nyhuis and Wiendahl (2008), improving these KPIs with regard to their objectives, a logistics system's target achievement can be enhanced. However, beside these KPIs, there are also other objectives like financial goals logistics systems strive for.
In finance research, Smart, Megginson and Gitman (2004) introduced five functions of corporate governance financial managers have to take into account. Two of them directly follow the mentioned strategic goals ensuring survival (financial management function) and creating and maintaining competitive advantages (capital budgeting function) and are therewith the goals this paper focuses on.
The *liquidity* is a business ratio telling to what extend companies can use available liquidity potential for covering their existing liabilities. Therewith, a high liquidity indicates a high reliability according to serve liabilities (Wöhe 2008). Consequently, companies with a high liquidity can improve satisfaction of their stakeholders leading to a positive perception of a company among their stakeholders. This is important, since stakeholders form the relevant environment of a company (Lechner, Müller-Stewens 2005) and decide about its existence and success (e.g. a company obtains better ratios leading to cheaper credits from banks) (Hicks et al. 1975).
The *profitability* business ratio calculates the return of total capital employed for a specific investment (Wöhe 2008). This is important because the more profitable the more attractive a company is to investors, since they prefer investing into a more profitable company in order to obtain higher return (Wöhe 2008, Hilpisch 2005). Thus, acquiring new credits or getting other investment assets is facilitated and cheaper. Accordingly, investing into new strategies becomes possible for companies due to this enhanced financial flexibility. Moreover, profitability focuses on an optimal utilization of resources for obtaining competitive advantages (Lechner, Müller-Stewens 2005).
In conclusion, these goals cannot be considered separately, since they focus on two essential objectives of strategic management: potential to survive (liquidity) and ability to create competitive advantages (profitability) (Lechner, Müller-Stewens 2005). If a company fails only one objective, it is either unable to serve liabilities and becomes insolvent or it cannot create competitive advantages and will also become insolvent in the long run due to missing revenues.

In addition, the logistics and financial goals also cannot be regarded separately, since they affect each other. For example, one logistics goal is to minimize inventory in order to reduce tied capital (Nyhuis, Wiendahl 2008). This can cause a higher profitability, since lower inventory implicates fewer expenses (through less production or supplies), more earnings (through e.g. more sales decreasing inventory of finished products) or both. Accordingly, if the logistics goal to minimize inventory is fulfilled in a better manner, the financial goal profitability is also affected positively. Another example is the relation between liquidity and due date reliability. If the liquidity is negative, companies will receive a worse rating towards investors (e.g. banks) than with a higher liquidity (Hilpisch 2005). Thus, obtaining credits is hardened and consequently, required cash for investments into e.g. machinery cannot be paid. Hence, due date reliability might be decreased, since a new machine is required due to new requirements in production but it cannot be paid. Like these exemplary interrelations, there are also additional effects between logistics and financial goals. Hence, logistics goals and financial goals have to be considered integrated in order to achieve the best system performance.

According to e.g. Gunasekaran and Kobu (Gunasekaran, Kobu 2007), Shepherd and Günter (Shepherd, Günter 2006) or Neely et al. (Neely, Gregory & Platts 1995), there are actually different performance measurement approaches available for evaluating logistics systems and supply chain performance. However, criticisms of these existing approaches have been widely addressed in the performance management literature (e.g. Neely, Gregory & Platts 1995). The main criticisms are e.g.

- Lack of connection with strategy (Beamon 1999)
- Focus on cost to the detriment of non-cost indicators (Beamon 1999, De Toni, Tonchia 2001)
- Insufficient focus on customers and competitors (Beamon 1999) and
- Loss of supply chain context leading to local optimization (Beamon 1999).

Since this paper focuses on an integration of logistics and financial goals, existing approaches are inappropriate for an application, as they omit this integration of both perspectives in production logistics. Therefore, the paper strives for a new approach, which explicitly considers both a logistics and a financial perspective in production control.

A CUSTOMER-VALUE BASED CONCEPT FOR PRODUCTION CONTROL

The new approach of this paper comprises two concepts: one concept of production logistics (Autonomous Product Construction Cycle (APCC)) for covering logistics goals and one concept of marketing (Customer Value Management (CVM)) for covering financial goals.

Autonomous Product Construction Cycle

The complexity of nowadays logistics processes has significant impact on the performance of logistics processes in terms of delivery time and delivery reliability (Bozarth et al. 2009). In order to deal with these challenges one possibility could be to increase the level of autonomous control of logistics processes (Scholz-Reiter, Windt & Freitag 2004). Autonomous logistics processes enable logistics objects (i.e. parts, containers) "*to process information, to render and to execute decisions on their own*" (Windt, Böse & Philipp 2008). For a typical job-shop manufacturing scenario, the idea of autonomous processes means that a part is capable to route itself through the production process.

The central idea of the APCC is that a part not only decides autonomously about the next production step, but takes also into consideration the available product variants and the placed customer orders. The decision method has to consider both, logistics criteria like throughput time as well as technological criteria like tools machine combination.

A product construction cycle spans from order release till product completion and refers to an incremental and variant oriented construction of the product; the adjective autonomous stands for a flexible and self-determined development of a product during its production cycle. For that purpose, a method was developed to provide each single item at any time with the situational product variant-customer order combination based on the current customer order pool. This loose allocation of manufactured products and confirmed customer orders represents an additional logistic flexibility potential and contributes to target achievement of the introduced logistics goals (Windt, Jeken 2009).

Various autonomous control methods have been proposed (Armbruster et al. 2006, Cicirello, Smith 2001, Scholz-Reiter et al. 2006), but none of them considers to evaluate different decision alternatives offered by the herewith proposed approach. A situational allocation of product variants and customer orders calls for an integrated evaluation of logistics and financial criteria related to different customer values. The APCC approach can integrate these different criteria, as it allows reallocating production orders due to their importance during the manufacturing cycle autonomously. To obtain the importance of a specific order, it has to be calculated based on financial ratios. Therefore, the CVM is applied, as it links single customer orders to the mentioned financial goals ensuring liquidity and maximizing profitability by increasing customer benefits or decreasing customer costs related to a single order, directly contributing to these financial goals.

Customer Value Management

The central idea of the CVM is that it treats each customer relationship with the goal of achieving maximum lifetime profit from the entire customer base. Therefore, revenues coming from customers should be increased and more frequent, whereas costs should be reduced and less frequent (Pease 2001). Thus and by focusing on single customers, the main goals of the CVM can be achieved, since (1.) the right customers can be identified (acquiring the customers who will be most valuable to the business), (2.) the right relationship can be established (customers who do don't receive the right touch or get too many conflicting offers lose rather than gain value), and (3.) the right retention towards customers can be kept (retaining the right customers, not every customer) (Pease 2001). By achieving the goals of the CVM it can also contribute to the mentioned financial goals, since e.g. (1.) contributes to the profitability (most valuable customer creates the highest profit) and (3.) is conducive to the liquidity (only profitable customers will be served leading to increased liquidity). Consequently, managers should increase customer value in order to improve the target achievement of the financial goals.

For increasing customer value, managers have two possibilities: increasing customer benefit or decreasing customer costs (Lechner, Müller-Stewens 2005). The customer benefit contains benefits a customer expects from a service or product. Customer costs comprise all costs related to a specific customer order based on activities between a customer and a company (Lechner, Müller-Stewens 2005). Thus, the customer value can be enhanced by adding e.g. new services (increase of customer benefits) or reduced by e.g. economies of scale (decrease of customer costs). In order to be able to rank specific customer orders, the underlying customer value has to be calculated based on specific parameters of customer benefits (e.g. frequency of order or revenue of orders) and customer costs (e.g. negotiation and production costs).

Integration of the Autonomous Product Construction Cycle and the Customer Value Management

There are two required steps for integrating the CVM and the APCC: first, the creation of a ranking according to the customer orders; second, release the order into the APCC.

In a first step, a ranking of orders based on the customer's value can be obtained by applying e.g. a scoring model (Geml 2008). The scores are obtained through different subsequent steps as shown in Figure 1:

I. Constitutive characteristics of customer benefits (e.g. frequency or revenue of orders) and customer costs (e.g. negotiation costs) are identified by e.g. analyzing orders or applying questionnaires. As one pre-condition, the concept demands for independent characteristics, since interdependencies between characteristics would make an appropriate weighting impossible (Geml 2008).

II. Weightings according to their importance are created by applying a pair-wise comparison (Geml 2008) of every characteristic with each other; the better a characteristic regarding target achievement (e.g. higher revenue and therewith higher liquidity) the higher its value. At first, the characteristics are entered into the upper right part of the matrix and then, they are compared to each other. If a characteristic in the top row contributes more to the financial goals than another in the second row, it obtains a 2, if both are equally important a 1, otherwise a 0. At last, the counter value is entered in the corresponding field in the lower left part (0 instead of 2 and 2 instead of 0, 1 remains the same).

III. Underlying customer orders are prioritized with regard to the obtained scores. All available orders will be compared to each characteristic. Thereby, a ranking will be built according to how a specific order matches these characteristics. The subsequent value in each cell is calculated as

$$\text{Cell Value} = \sum \text{Orders} - \text{Rank Order}_i \text{ with } 0 \leq i < \sum \text{Orders}$$

Finally, each Cell Value is multiplied with the SUM in Figure 1 of each characteristic in II. Thereby, the overall scoring of each customer order can be generated.

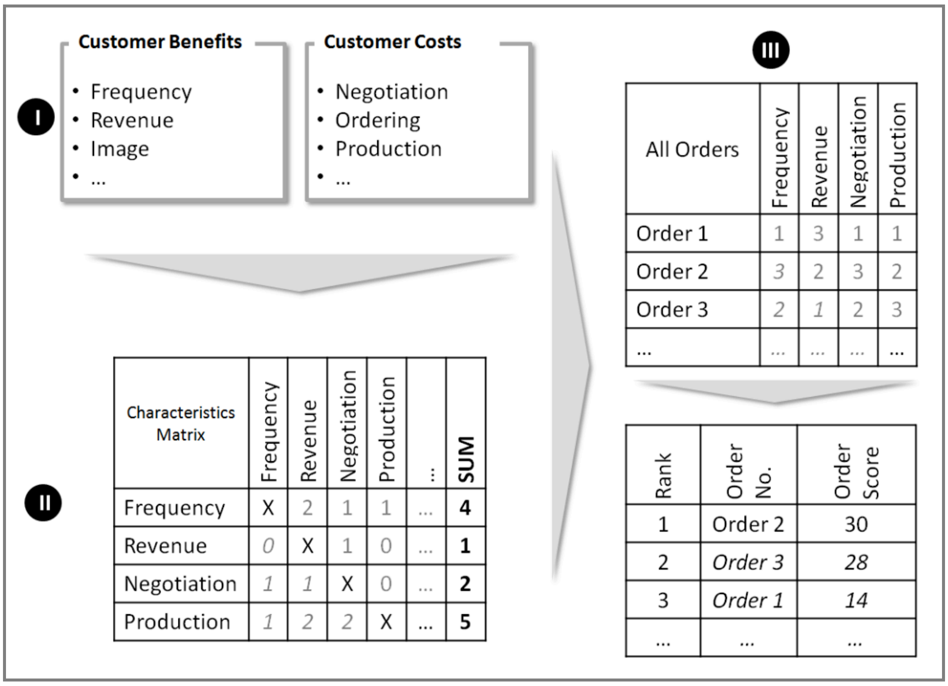

Figure 1: Pair-wise Comparison for building an Order Prioritization

In a second step, the obtained ranking shall then be released for production planning and control into the APCC. Taking the confirmed due date for the customer order and the derived rank of the customer order into account, a backward scheduling is conducted to determine the release date for the customer order. As the actual process plan of the part is not predetermined, a default process plan is composed based on the derived customer order ranks, in order to carry out the backward scheduling. The default process plan determines the sequence of operations and the selected work systems with their individual throughput time to perform the operations for the respective product, but becomes obsolete once the production has started.

In order to determine the individual throughput time of a specific work system, flow rate oriented scheduling can be applied (Nyhuis 2007). Flow rate oriented scheduling is based on the theory of logistics operating curves (Nyhuis, Wiendahl 2006), and allows to determine individual throughput times for specific work systems taking into consideration the work content of the operation, the capacities and the planned work in process level of the work system leading to a higher planning accuracy (Nyhuis 2007).

The resulting order release date allows starting production of the demanded product at the respective date and thereby initializing the autonomously controlled process. Once an order is released and production has started, the APCC logic takes control of the part. In order to route through the manufacturing cycle, the part, as an intelligent object, decides not only about the actual sequence of processing steps and the work systems to perform the steps, but it is also able to react to changes of customer orders. In case of quantity changes, parts reallocate themselves to serve the order with the highest rank. In case of due date changes requested by customers, the part also considers the rank of the order before reallocation. However, for all changes in product order allocation the trade-off between a higher prioritized order versus a lower prioritized order has to be positive in the sense of the CVM meaning that the re-adjusted ranking of the higher prioritized order is higher than the ranking of the lower prioritized order.

CONTRIBUTIONS AND LIMITATIONS OF THE INTRODUCED APPROACH

The following table gives a briefly overview about some selected contributions and deficits of the APCC, the CVM and the integrated approach of in this work:

Selected Contributions	Selected Limitations
- Individual treatment of single orders - Focus on important KPIs - Integrated view of financial and logistical targets for production scheduling and control - Connectivity to strategic management - Consideration of cost-factors and non-cost factors	- Simulation for proof of concept is missing - Threat of local optima - Cost-factors used in customer costs may change during production - Non-cost factors hardly measurable - Weightings of characteristics among single orders difficult

Table 1: Contributions and limitations regarding the introduced approach

The introduced concept treats each order individually enabling it to offer a high flexibility and customization. Therewith, matching new requirements for logistics like customization (Klaus, Kille 2008), can be improved. In addition, by focusing on important logistics KPIs (e.g. due date reliability), the design of an underlying system can be oriented on relevant target achievements. Consequently, the impact of short-term logistics KPIs can be linked to financial KPIs relevant for managing a company. Therewith, effects on the operational level of logistics can be estimated in the long run facilitating managers' decision rendering according to which customer order to serve. The reason is that their decisions' consequences can be estimated in a better manner through applying business ratios like the Cash-Flow or the Return on Investment. This concept also allows for a connection of operational logistics to the strategic management of a company by integrating logistics and financial goals, which helps closing the gap between the strategy of a company and its operations as addressed in section 2. Last, the concept of customer value management considers both cost-factors and non-cost factors, since it integrates e.g. image effects or negotiation costs via the customer benefits and customer costs respectively.

Beside the mentioned potential contributions of the introduced concept, there are some remaining deficits. First of all, a suitable simulation for a proof of concept is missing. Additionally, an empirical validation of the concept lacks as well. In conclusion, an application in practice may cause risks, since verification and validation are missing and stability of the concept has not been proofed. Resulting risks might be e.g. the threat of local optima, as the idea of the APCC implements the concept of autonomous control. Since parts in the APCC are autonomous, they follow their own goals. Hence, they might get stuck in local optima, as they do not know the global optima and once they achieved their goal they do not go for a further optimization. Beside the threat of local optima, another problem is that cost factors used in customer costs may change during production of a single order. Accordingly, the ranking obtained through the pair-wise comparison before and therewith the optimal production cycle may change. This is not considered in this concept so far. Furthermore, the customer benefits as well as customer costs may contain non-cost factors, which are difficult to measure. Consequently, a ranking can be built but estimating financial KPIs may be hardened, since these factors are difficult to determine exactly. Finally, obtaining suitable weightings of characteristics among single orders is complicated, since they may vary from company to company and depend on a company's strategy as well as on individual preferences of decision makers.

CONCLUSIONS

This paper intended to develop a prioritizing model for balancing logistics and financial requirements of customer orders in production control in order to rank different orders based on their importance.

The main contributions towards the described concept is the integration of an operational logistics perspective with its goals (high due date reliability, short throughput times, low inventory levels , high machine utilization) and a strategic financial perspective with its goals (ensuring liquidity and maximizing profitability) for production logistics. Furthermore, the application of the concept of autonomous control by utilizing the APCC enables the concept to cope with new requirements logistics systems are confronted with.

However, the concept has remaining limitations. At first, identifying relevant characteristics of customer orders is difficult and depends on various factors, which might differ from company to company. Furthermore, obtained characteristics have to be independent from each other (Geml 2008), what cannot always be guaranteed, since interrelations between specific characteristics might be unrevealed during identification. Moreover, the feasibility of the APCC logic for different manufacturing scenarios has to be studied in more detail, as different industries apply different manufacturing principles (e.g. flow production, job-shop production). Finally, the described threat of local optima has to be avoided by carefully designing and testing decision criteria in simulation studies.

Further research should focus on the remaining limitations. The next step could be the development and computation of a simulation model. Therefore, on the one hand software technologies have to be identified and perhaps advanced in order to implement, integrate and simulate the introduced concepts (APCC and CVM). On the other hand, due to the complexity and dynamics, essential problems like vulnerability against changes and non-predictability of the system behaviour persist and have to be investigated.

In conclusion, there are possible contributions of the introduced approach but they have to be out weighted carefully with the risks.

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