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ORIGINAL PAPER

Incentive alignment at the manufacturing–marketing interface: Design and validation of a management game

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Abstract Supply chain coordination problems are frequently found at the manufacturing–marketing interface. Inspired by a case study from the food industry, we designed and validated a management game that focuses on potential conflicts between sales order acceptance and manufacturing utilization. We discuss how individual behavior under distributed decision making can be improved to comply with overall company objectives if system awareness is increased, incentive systems are carefully aligned, and cross-functional communication protocols are improved. An empirical investigation in a controlled laboratory experiment with university students shows the game's effectiveness to achieve the key learning objectives. The results show that both an aligned bonus scheme and information and communication increase overall performance and decrease frictions between the two functional areas. As a further result from the experiment, we find that an improved bonus scheme has a larger impact than improved communication and information.

Keywords Marketing–operations interface · Incentives · Management game · Laboratory study

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1 Introduction

"Can marketing and manufacturing coexist?" This question which Shapiro posed in 1977 has frequently been quoted. "Can marketing and manufacturing afford to not coexist?" was one answer [14]. Aligning the two functional areas has a significant impact on company performance, but looking at manufacturing and marketing from a resource-based and a market-based point of view visualizes that these two essential functional areas are often clear opponents [8]. In many companies, interaction at the interface of sales and manufacturing is coined by fundamental conflicts, lack of mutual understanding and communication, perturbing company efficiency [3, 18]. While sales is typically rewarded based on revenues, manufacturing is rewarded for achieving high operational efficiency and low production cost. With significant changeover times and a variety of customer-specific orders, this is a challenging task. These diverging interests of sales and manufacturing naturally lead to conflicts [6]. The different tasks and objectives of both areas are often reflected in the compensation and mindset of the people involved, often resulting in suboptimal system performance [7]. Recent literature has proposed mechanisms to mitigate the adverse effect of local incentives and private information, mostly through various contractual arrangements providing incentives for all players involved to make decisions that serve the entire system best [2]. However, the complexity of business reality does not allow perfect guidance of decisions by incentives.

By integrating *compensation*, *transparency*, and *attitude* into a single framework, we adopt a broad view on aligning individual behavior with total system's objectives. Based on this unified perspective, we develop a business game focusing on coordination problems at the manufacturing–marketing interface. A case study of a real company served as a starting point for our investigation and provided the basis for developing the game. Information was gathered by expert interviews and assessment of company data. The case company belongs to the food industry and offers a wide and increasing variety of product specifications. About 50% of the products are made to order (MTO) being the focus of this study. Demand is sensitive to the length and reliability of quoted lead times. Standard order lead times are on the order of 5 days. However, the company receives a considerable amount of rush orders which, upon order acceptance, have to be produced within 1–2 days. The manufacturing process is characterized by substantial changeover times, mainly due to cleaning processes. Therefore, producing rushed customer orders requires a careful trade-off between manufacturing and revenue concerns. Despite a potentially negative impact, management has observed the acceptance of an increasing number of rush orders.

Figure 1 shows a simplification of the as-is processes. A lack of coordination between decisions, as well as a lack of transparency and missing system awareness, leads to inefficiencies. Specifically, sales accept a variety of orders, which often include specific features and are on short notice, without considering their negative effects on supply chain costs. A reward system providing sales with incentives for achieving high sales volumes and manufacturing for achieving high operational efficiency, i.e., misaligned incentives, is a major cause for conflicts and inefficiencies as local incentives reinforce local optimization. Compensation based on revenue naturally provides sales with incentives to accept as many orders as possible, irrespective of their cost implications. Compensation based on individual revenues fosters competition between sales people for scarce capacities and amplifies the problem, especially in the presence of many customer enquiries for rush orders. Lastly, non-monetary rewards such as nominating the "employee of the month" based on sales volumes reinforces the problem.

At the case company, sales and manufacturing are coordinated by an order management function. Ideally, all incoming orders are processed centrally. However, desired communication structures are often not adhered to, e.g., order placement and due date negotiations often take place between a customer and the responsible sales person. Order acceptance and scheduling decisions can lead to waiting times including planned waiting times (e.g., the customer is quoted a later due date than desired, a sales decision) and unplanned waiting times (e.g., due to frictions in scheduling, on first sight a manufacturing problem). In the management game, these waiting times are combined into a single queue.

Optimizing a complex MTO production system with considerable changeover times and limited capacities facing time-sensitive demand is a challenge on its own. Due date management investigates how to optimize such a system, but most of the existing literature ignores both pricing decisions and the impact of prices and lead times on demand [11]. Scheduling research (e.g., [16]) and revenue management [19] contribute solution approaches to MTO systems, but changeover times are scarcely included. Joint consideration of order acceptance, due date determination, and scheduling is rare [10].

To achieve a coordinated pursuit of company objectives, the behavior of decentralized decision makers has to be aligned. Monetary incentives constitute a central pillar. Implemented by means of compensation such as bonus payments, they provide the core element of influencing and aligning behavior. This is the essence of agency theory as the theoretical basis to monetary incentive provision in distributed decision making systems. Porteus and Whang [17] use a principal-agent framework to investigate the coordination of the manufacturing–marketing interface. The company owner as the principal creates an internal market in which manufacturing and marketing managers as agents operate in. Kouvelis and Lariviere [13] present a generalization of the internal market mechanism. They show that a system can be decentralized efficiently by distributing

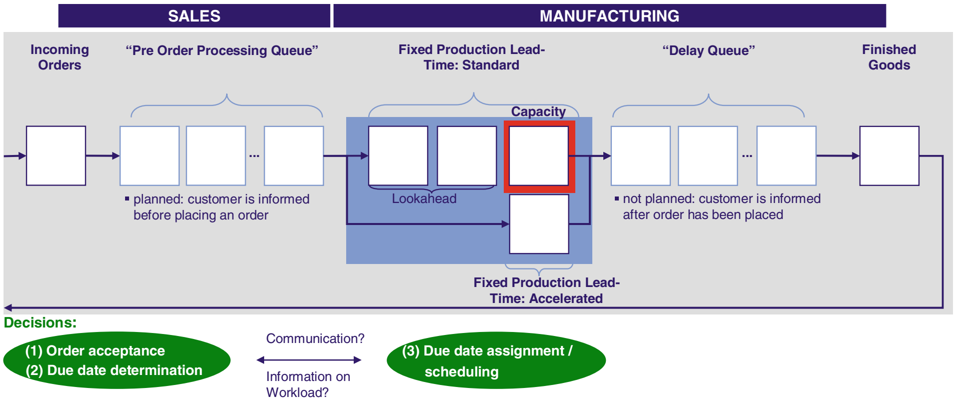


Fig. 1 System processes, characteristics, and key decisions

decision control to a number of agents, while implementing suitable incentive mechanisms that align each agent's individual goals with overall company objectives. Quantitative performance measures can be complemented by qualitative measures. However, the effectiveness of system coordination solely by means of monetary incentives is challenged by several factors. The complexity of reality causes contracts to be nearly unavoidably incomplete. Additionally, motivation theories suggest that decision makers are not solely pursuing monetary objectives; the decision maker's attitude, e.g., entrepreneurial thinking, can influence his actions. Lastly, the transparency of the system, including communication and information, can have an impact on decisions.

The manuscript is organized as follows. In Sect. 2, we discuss the development of the management game with its learning objectives. Section 3 reports on the design and results of a game validation and further includes a centralized stochastic dynamic optimization model to benchmark the game performance. Conclusions and discussion are given in Sect. 4.

2 Management game development

We developed a management game for guiding behavior in decentralized systems, specifically addressing the coordination issues at the manufacturing–marketing interface.

2.1 Management games as interactive learning tools

Management games are an increasingly popular method of active learning. The term "Management Game" involves the interaction between some models of a company, which determines the impact of decision making and human behavioral elements [5] and the participants. Although less information is conveyed, active learning methods excel by the depth of learning which is increased by personal involvement [5]. One key benefit of management games that are widely used as risk-free learning environments is to understand the interaction between different functional areas. Knolmayer et al. [12] provide an overview on freely accessible, interactive learning objects in the area of logistics.

We developed a partial model board game as an interactive learning tool to be employed during company trainings following the idea of the "Beer Distribution Game" as a role model, customized for tackling the case company's problems of suboptimal system performance—misaligned incentives, lack of transparency, and lack of system awareness. A board-based game was chosen to allow for the possibility of including lively discussions between sales and manufacturing; participants should experience conflicts and their causes. The intended key learning objectives are (A) the effect of aligned incentives, communication and information at the interface of sales, and manufacturing on company performance and (B) the potentially negative impact of rush orders.

The game aims at *improving system awareness* in general. Taking a process-oriented bird's eye view on the company, it allows recognizing the interdependencies between time-sensitive demand, order acceptance, and due date determination under capacity constraints and considerable changeover times. Due to the simplifications, cause-and-effect relationships can be seen, and participants can experience how their local actions affect the system as a whole. Not only awareness for the processes is ameliorated, but also comprehension of the behavior of all game participants is enhanced [4, 15].

The key learning is conveyed by contrasting a situation with misaligned *incentives* to one with aligned incentives in two separate game rounds. With misaligned incentives, the participants should have the feeling that it is best for them if they decide independently. This, however, leads to lower the company performance. In the second round, they should feel that it is best to cooperate. This leads to improved company performance and to a higher bonus of the participants, who thus learn that misaligned incentives can be a major cause for inefficiencies. Also, participants see the impact of inappropriate performance measures when, e.g., not utilization per se, but the number of orders delivered in time is the decisive criterion instead. Lastly, they experience that an effective bonus design can not only make the company better-off but also can increase the reward of each employee.

Rush orders often have a negative impact on supply chain costs and operating efficiency. However, this impact of an incoming order can often not be easily assessed but depends on the complex interplay between order characteristics and the production system's state. Regarding the case study, one core problem is that sales people are not aware of the negative impact that accepting rush orders might have. In a production setting with restricted capacities and considerable changeover times, understanding opportunity cost of changeovers is a vital component: not the changeover induces cost, but the products that could have been produced and sold had the changeover not been carried out. Furthermore, the production of a rush order can cause a delay of standard orders. The associated delay cost can outweigh the margin the rush order would contribute to company profits. In the game, optimizing system performance involves the rejection of some, yet not all, rush orders. The core learning is that a rush order can naturally still be accepted even if causing frictions, but it is important to carefully judge its impact on system cost. The game increases the awareness for this trade-off by providing information transparency.

2.2 Design

For the game design, a relatively low level of complexity was chosen to allow for robust conveyance of the key learning. This included sacrificing some levels of realism, for example, by keeping demand exogenous. Yet, the core elements of the company situation including the roles of sales and manufacturing were mapped.

The game board is depicted in Fig. 2: Part 1 shows the places of the two sales people, working individually as "Sales A" and "Sales B"; Part 2 includes the places of two manufacturing employees working jointly together. Sales and manufacturing can be separated by a screen. The top corners of each part include a key and a short instruction per player (for a larger scale, see Fig. 3). LEGO® tokens are used to represent order cards and game tokens.

Demand is differentiated by product type (red or white), order type (standard [gray] or rush order [yellow]), and order size (small (one unit) or large (two units)). A standard order has a desired lead time of 3 periods, a rush order of 1 period. A specific demand sequence was constructed to meet the objectives of (1) fair treatment of sales people who are individually compensated and (2) conveyance of the key learning that acceptance of rush orders can cause substantial delays. The latter was done by building large lots and adding a rush order of the other color to the demand sequence, which would cause changeovers and thus delays to orders already accepted. This demand sequence was tested and validated in the experiment (see Sect. 3.1).

Before the start of the game, participants are instructed on game sequence and rules (as explained in the following) as well as the framework: the game is played in periods, measurement of monetary components is in Thaler. Demand consists of 2–3 orders (4–6 units) per period, capacity per period is 5. The game starts in period 1. The initial state of the game includes open orders of previous periods. Each period is announced by the instructor and includes four key steps:

Incoming customer demand, order acceptance check, and decision Both sales persons receive order cards (see S1 in Fig. 2), including information on product type, size, order type (including requested lead times), and order size. The players build the corresponding LEGO®-order cards (S2) and forward the incoming orders to manufacturing (S4), if applicable by traversing the screen (S3). Manufacturing tries to integrate orders into their planned schedule taking into account promised due dates if an order is accepted. For a standard order, the planned lead time is 3 periods, i.e., the due date is set equal to the index of the current period plus 2. For a rush order, the planned lead time is a single period, i.e., the due date is set to the end of the current period. Manufacturing decides which orders they would prefer to accept, these orders are kept (S5). Orders that manufacturing prefers to reject are passed back to the respective sales person (S6). Each sales person makes the final decision on these orders (S7): they can overrule manufacturing by adding a wildcard (one per unit of demand) to the respective order, forcing production (S5); or else may agree with manufacturing's preference and reject the order (S8).

Scheduling The scheduling and production part is divided into 6 horizontal rows, representing 6 periods. These are used to keep track of time. Rows 1 (S9) to 3 (S15) represent the order pool without a delay, whereas rows 4 (S18) to 6 (S19) collect orders beyond the due date, which are subject to waiting costs. Production planning fields (S12–S14) show the period capacity of 5 units and represent the plan to be executed in the current period (Production) and a look-ahead planning with a horizon of two periods (Planning). The latter, however, can still be modified when new information about accepted orders becomes available in the next period. Manufacturing forwards the order cards according to type: standard orders to the first row (S9), accelerated orders (following the yellow arrow) to the third row in the yellow field (S10), and issues the corresponding raw material (from S11) to the planning field(s) (S12–S14). Production rules are as follows: between different colors, a changeover (black token) is necessary; after a changeover any color can be produced ("clean machine"). Each changeover reduces the available capacity by one unit. The current setup can be seen on the board (S13). Any order in the order pool (rows 1-6) can be produced; however, orders have to be produced without interruption. In the planning fields, manufacturing plans the production schedule for 3 periods using the game tokens and decides on a production sequence for the current period in the production field in the third row (S13). The entire production plan can be revised until the production decision has been made. While sales decides on order acceptance including the implicitly determined due date according to order type, manufacturing decides on the schedule, thus determining the realized lead time and delivery date. At the end of step 2, manufacturing fixes the production schedule.

Production and packaging Orders are (instantaneously) produced, the setup marker (S13) is changed to the last color produced, and the finished products are attached to the order cards (in rows 1–6), which had triggered production; this movement is indicated by the black arrow between production and order cards. Changeover tokens are collected in a bin (S16).

Shipment Completely fulfilled orders in rows 3, as well as in rows 4–6, are delivered to the customer (S17). All other order cards are forwarded one step as a means to keep track

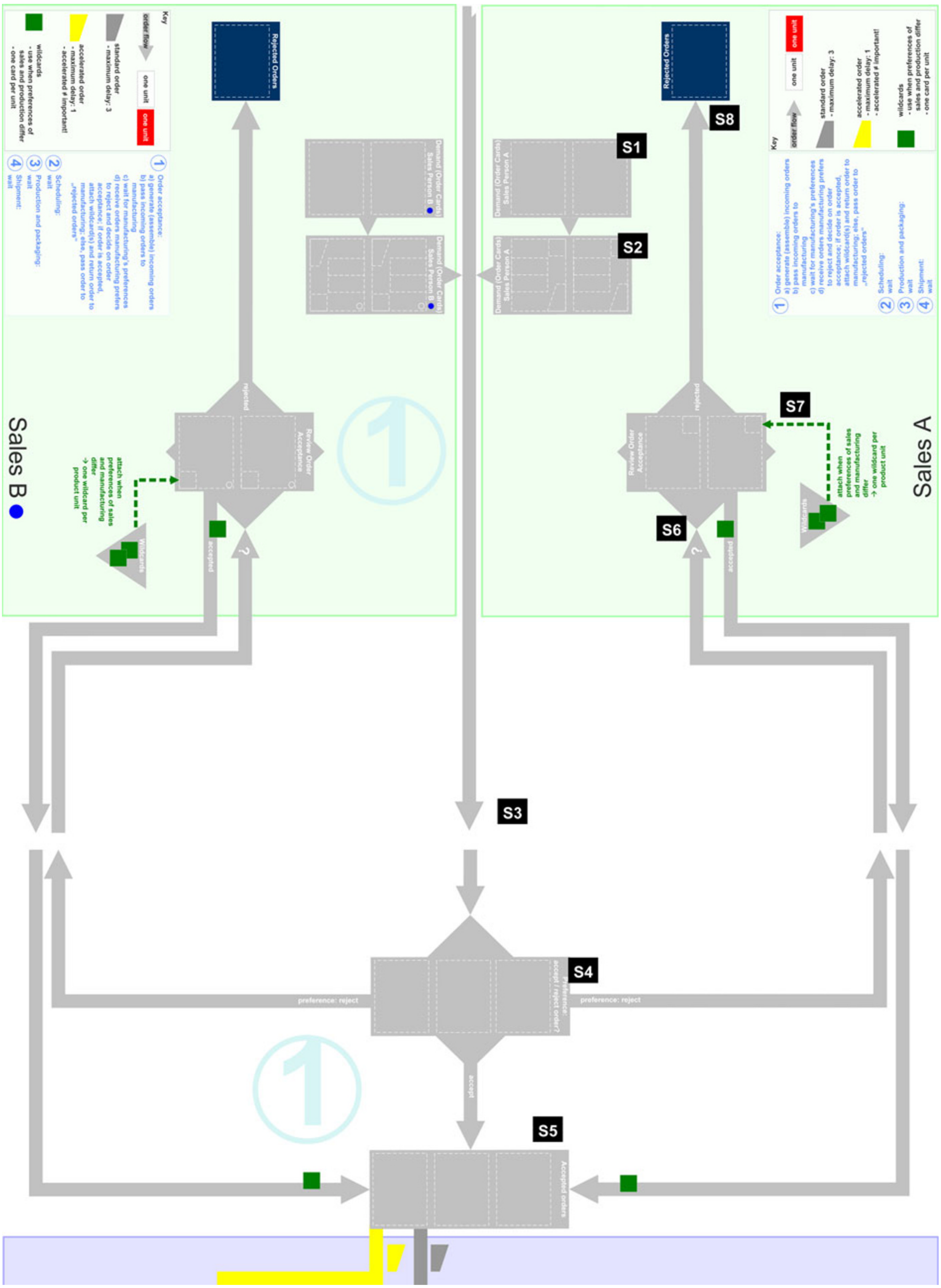


Fig. 2 Game board: parts 1 and 2

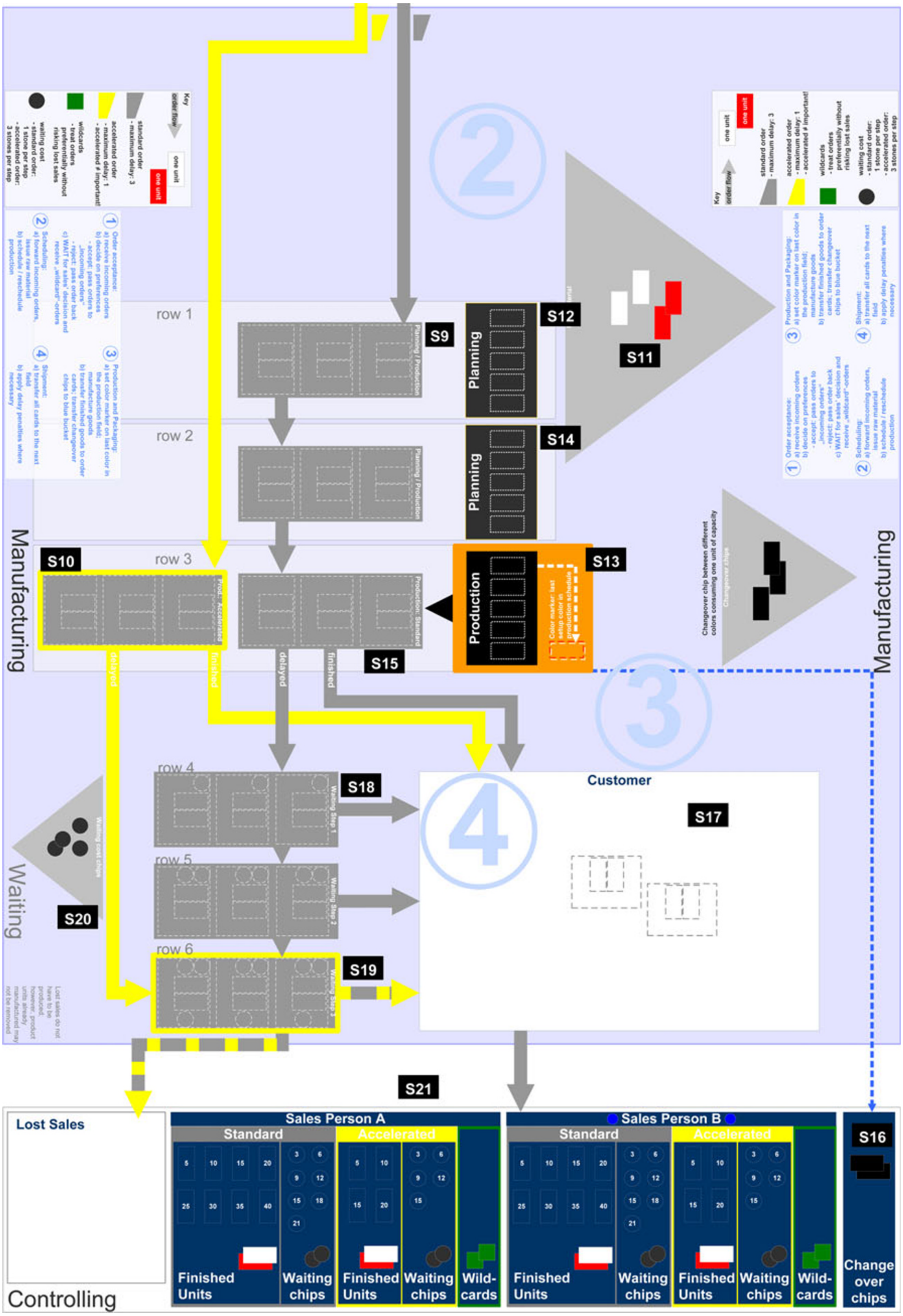


Fig. 2 continued

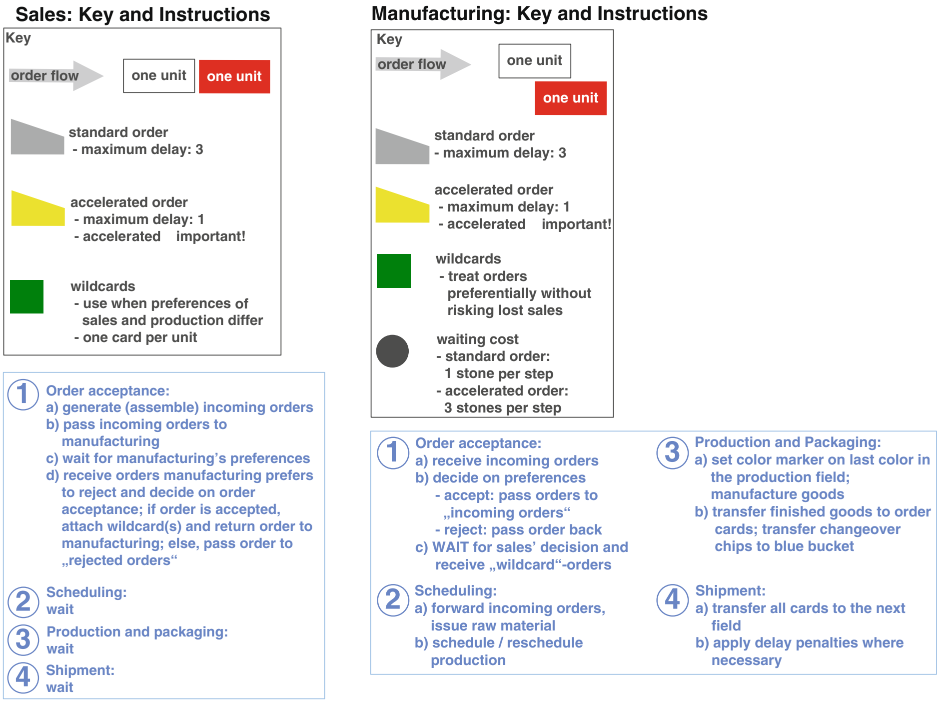


Fig. 3 Details of game board: key and instructions

of time, e.g., from row 1 (S9) to row 2, from row 2 to row 3. Orders in row 3, which could not be produced in time, are transferred to the waiting rows (e.g., from row 3 (S15) to row 4 (S18) for a standard order, from row 3 (S10) to row 6 (S19) for an accelerated order) and tagged with penalty tokens (S20). After the maximum waiting time (standard order: 3 periods, rush order: one period), orders are lost at a penalty cost (field "lost sales"). After forwarding the order cards, the game period is finished.

After each period, the instructor collects the finished orders (S17) and sorts the tokens for evaluation in the accounting section (S21). These tokens are the basis for bonus calculation and game evaluation. After all periods have been played, the tokens are counted, the performance measures computed and the bonus payments calculated. Finally, the results are communicated to the participants. Game parameters used are detailed in the benchmark model, see Sect. 2.3.

For performance measurement, *EBIT,* defined as revenue minus cost, was chosen as the objective. The measure profit (EBIT minus bonus payments) was additionally computed for the purpose of evaluating game results. *Revenue* is the standard measure from which variable costs are deducted to compute the gross margin of sales. *Wildcards* have to be used by a sales person who wants to have an order produced, which manufacturing preferred to reject. The rationale behind the cost is additional handling cost as well as frictions in scheduling. *Utilization* (produced units/available capacity) is a measure of throughput. *Waiting costs* include rebates granted to the customer for a due date later than their desired due date (costs accrue at the sales department) and costs due to overtime or expediting shipments to compensate for delayed production. *Lost sales* are orders that were accepted yet could not be produced within a certain time limit of 6 weeks for standard orders and 2 weeks for rush orders. *Rejected orders* are orders which, due to scarce capacities, could not be accepted, they do not have a negative impact in this short-term game setup.

2.3 Benchmark model

For comparison purposes, the problem for known demand can be modeled as discrete time lot-sizing and scheduling problem with setups (see e.g., [9]. The deterministic problem with all demands being known represents the best solution only the instructor is able to obtain. The game participants only have incomplete information, i.e., 2–3 orders but do not know the distribution between the two products and the extent of rush orders. To determine the centrally optimal solution for both, a demand sequence under certainty and uncertainty, we developed a (stochastic) dynamic program. In the following, we only show the deterministic version and briefly sketch the required extensions for the stochastic version.

The planning horizon is $T = 17$ where orders only arrive in the first 15 periods, and the two remaining periods are used to manufacture waiting orders. In every period, there is a limited manufacturing capacity of $C_t = 5$. Two products $i = 1, 2$ are considered and for each product, there exist two types of orders: rush (r) and standard (s) orders. Rush orders have a unit margin of $p_i^r = 50$ and a due date of 1 week. They can be either small with a capacity requirement of one unit or large with a capacity requirement of two units. The respective demands are denoted by d_{it}^{r1} and d_{it}^{r2}. Standard orders with demand size d_{it}^{s} have an unit margin $p_i^s = 50$, the due date is 3 weeks, and they require 2 units of capacity. Orders that were accepted but cannot be finished on time (within 1 week for rush orders and 3 weeks for standard orders after the due date) are lost at a penalty cost $v = 600$. Delayed orders are subject to waiting cost $w_i^s = 100$ and $w_i^r = 300$ per unit and unit of time after the due date has passed for standard and rush orders, respectively.

The optimization problem formulation exploits the following properties of an optimal solution to reduce complexity: (i) there is at most a single setup operation for each product in a period, (ii) (accepted) rush orders are satisfied with priority before any standard order is satisfied, and (iii) orders of any type are satisfied first-in-first-out. Furthermore, we assume a pure make to order, zero inventory regime, i.e., no products that have not been ordered are manufactured. In dynamic programming, a simultaneous optimization problem is decoupled into a sequential problem by introducing stages (here periods). At the beginning of every period, previous decisions have resulted in an initial state (here orders of a certain age and the setup status of the machine). Given this state, the optimal decision for the period (consisting of order acceptance and a production schedule) is determined such that the sum of direct rewards (from accepting orders) minus costs (for manufacturing, waiting, and lost orders) plus all the costs that result from taking optimal decisions in all future periods (given the current periods decision). Next, we describe the dynamic program by stating the state of the system at the beginning of every period, the decisions to be taken, the state transition, and the functional equations.

2.3.1 State

A state at the beginning of period t is represented by the number of waiting rush orders of size one (r1) or two (r2) units (y_i^{r1}, y_i^{r2}), standard orders of age j, y_{ij}^s, ($j = 1,\ldots,5$), and the initial setup state of the machine $z_t \in \{1,2\}$. Each individual order pool state variable can take values between 0 and 3. Let y_t denote the vector of all order state variables.

2.3.2 Decision

Decisions to be taken are which of the incoming orders to accept, how many units of each product to produce, and setup changeovers between products. Let $r_{it}^1 \le d_{it}^{r1}$ ($r_{it}^2 \le d_{it}^{r2}$) denote the number of accepted rush orders of size 1(2) and $s_{it} \le d_{it}^s$ the respective accepted standard orders. Further, we need to determine production quantities x_{it}, number of setups u_{it}, and the new setup state z_{t+1}. The logic for the setup decision variable is

$$u_{it} = \begin{cases} 1 & z_t = j \wedge x_{it} > 0, z_t = j \wedge x_{it} = 0 \wedge z_{t+1} = i, z_t = i \wedge x_{jt} > 0 \wedge z_{t+1} = i \\ 0 & \text{otherwise} \end{cases}$$

A setup for product i is required in the following cases: (i) the machine is initially setup for the other product j and the production quantity for i is positive, (ii) the initial setup is for the other product j, i is not produced but the initial setup state in the following period is for i, and (iii) the initial and final setup status are for product i but the other product j is produced in between. Production quantities and setups are limited by the available capacity of 5 units.

2.3.3 State transition

The new state of the following period y_{t+1} is a function of the current state y_t and the decisions about order acceptance and production quantities. We do not show the system of equations but rather sketch the logic behind the state transition. For both products $i = 1, 2$, manufacturing quantities x_{it} are used to satisfy waiting and accepted orders in the sequence rush orders first, then oldest to newest standard orders. In case, only a single capacity unit remains, i.e., an order with a capacity requirement cannot be satisfied in full, manufacturing will be started and completed in the following period (therefore reducing the capacity by one unit).

2.3.4 Functional equations $t = 1, 2,\ldots,T$

For each given initial state, the objective is to maximize the expected profit for accepted orders minus costs for waiting and lost orders. The constraints ensure the bounds for accepting orders and the manufacturing capacity constraint.

$$\begin{aligned} \max \ V_t(y_t, z_t) = \sum_{i=1}^{2} \Big(& p_i^r (r_{it}^1 + 2 r_{it}^2) + 2 p_i^s s_{it} \\ & - w_i^s (y_{i3}^s + y_{i4}^s + y_{i5}^s) - w_i^r (y_i^{r1} + y_i^{r2}) \\ & - v (y_i^{r1} + y_i^{r2} + y_{i5} - x_{it})^+ \Big) \\ & + V_{t+1}(y_{t+1}, z_{t+1}) \end{aligned}$$

$$\begin{aligned} \text{s.t.} \quad & r_{it}^1 \le d_{it}^1, \quad r_{it}^2 \le d_{it}^2, \quad s_{it} \le d_{it}^s, \quad i = 1,2 \\ & \sum_{i=1}^{2} (x_{it} + u_{it}) \le C_t \\ & u_{it} \in \{0,1\}, \ x_{it}, \ r_{it}^1, \\ & \quad r_{it}^2, s_{it} \ge 0 \text{ and integer}, \ i = 1,2 \end{aligned}$$

$$V_{T+1}(y_{T+1}, z_{T+1}) = 0, \quad (x)^+ = \max\{0, x\}$$

The demand data and the optimal decisions are shown in Table 1. At the beginning of the game, there exist already 4 accepted orders for product 1 that were accepted in periods -1 and 0, respectively. Given this initial order pool and that the machine is initially setup for product 1, the optimal decisions for each period are determined by forward evaluation of the eventual plans obtained from the functional equations.

The columns in Table 1 show the respective demands. In the optimal solution, all standard orders are accepted. For rush orders, the numbers in brackets show the number of accepted orders. The optimal solution under full information yields $V_0 = 4{,}000$. For the decision problem under uncertainty, every period has several scenarios with respective probability and demands. Decisions in every period have to be detailed by scenario. We assume that there will be exactly three orders in every period. The split between the two products is uniformly distributed. Furthermore, with probability 2/3, one of the three orders is a rush order. In case there is a rush order, the sizes of one or two units are equally likely. This in total results in 16 demand scenarios for each future period. After the realization of demand in every period, the optimal decision is implemented for the realized demand. The expected value using the above assumptions is 3862.57. However, given the realized demand sequence, this results in the same optimal decisions.

Table 1 Customer orders, acceptance decisions, and manufacturing quantities

t	d^s_{1t}	d^s_{2t}	d^{r1}_{1t}	d^{r2}_{1t}	d^{r1}_{2t}	d^{r2}_{2t}	x_{1t}	x_{2t}
−1	2							
0	2							
1	3						5	
2	2				1(0)		5	
3	2					1(0)	5	
4		3					5	
5		2	1(1)				3	1
6		2				1(0)		5
7		2	1(0)					5
8		1		1(0)				5
9	2	1						5
10	2				1(1)		2	2
11	3						5	
12	2					1(0)	5	
13		2	1(1)				5	
14		2	1(1)				3	1
15		3						5
16								5
17								3

3 Game validation

3.1 Experimental design and implementation

We designed a controlled experiment tested with university students in order to validate the game's effectiveness in meeting its key learning objectives. Figure 4 shows the four treatments, each representing a combination of a bonus payment and the availability of information/communication. Treatment 1 [T1] is assumed to be the worst case and treatment 4 [T4] the desired solution.

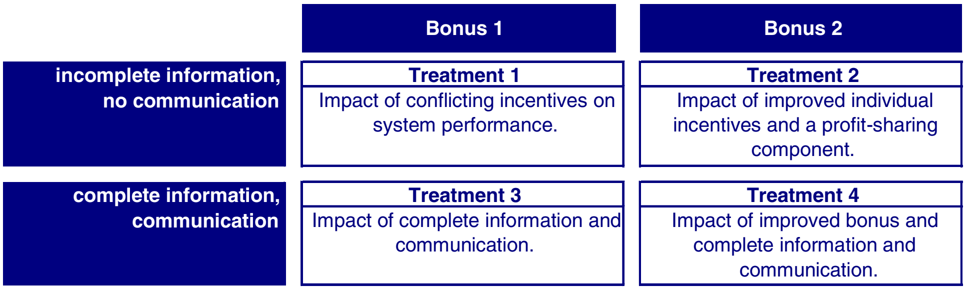
In treatments 1 and 2 without information/communication, manufacturing utilization was not visible to sales and only limited information on game parameters was available. After each period, sales were informed about the number of delayed orders. With the availability of information and communication (treatments 3 and 4), visibility of the whole game board was enabled, and full information on the game parameters was given to the participants.

Secondly, we manipulated the players' performance measurement systems by means of incentive alignment. Bonus 1 (shown in Table 2) represents the initial situation of misaligned incentives to visualize its resulting problems (treatments 1 and 3).

Manufacturing is primarily evaluated based on utilization. Waiting costs as the influential factor on company performance are only included with a small weight. Sales are compensated based on individual revenues and competes for scarce capacities. As the demand sequence includes rush orders causing changeovers, incentive conflicts arise. Each sales person is interested in having each incoming order produced, whereas manufacturing aims at minimizing the number of changeovers even if this causes delays. Additionally, not the gross margin, but only revenues are included in the bonus of sales. This conceals the fact that one waiting step reduces the margin to zero. Also, compensating sales primarily on the basis of revenue weighs customer service as a sales' objective (measured by waiting costs) only insufficiently within the bonus. As an additional bonus component, each sales person is penalized for using a wildcard as a measure of conflict. Bonuses of both sales and manufacturing include a penalty on waiting cost. Lastly, lost sales are penalized.

Bonus 2 implements aligned incentives as the core pillar of the solution approach to improve coordination (treatments 2 and 4). Bonus payments were constructed, considering both the realities of the case study and the implementation within the game. The bonus for both sales and manufacturing comprises an individual component (as for Bonus 1) with a weight of 80% and an overall profit sharing component with a weight of 20%. As profit depends on final bonus payments, EBIT was used as a measure for the bonus calculations. For the determination

Fig. 4 Overview of treatments



	Bonus 1	**Bonus 2**
incomplete information, no communication	**Treatment 1** Impact of conflicting incentives on system performance.	**Treatment 2** Impact of improved individual incentives and a profit-sharing component.
complete information, communication	**Treatment 3** Impact of complete information and communication.	**Treatment 4** Impact of improved bonus and complete information and communication.

Table 2 Details of bonus calculation

Bonus 1	Bonus 2 Profit sharing component: weight 20% 5% of EBIT
Sales	
Individual component: 100%	*Individual component: weight 80%*
+5 per sold unit of product	+5 per unit
−1 per waiting period standard order	−1 per waiting period standard order
−3 per waiting period rush order	−3 per waiting period rush order
−1 per used wildcard	−3 per used wildcard
−100 per lost order	−100 per lost order
Manufacturing	
Individual component: 100%	*Individual component: weight 80%*
Initial bonus payment: 180	Initial bonus payment: 180
Target: 96%; ±10 per% utilization more/less	
−1 per waiting period standard order	−10 per waiting period standard order
−3 per waiting period rush order	−30 per waiting period rush order
−100 per lost order	−100 per lost order

of the individual part, utilization is excluded from manufacturing's bonus and substituted by a 10 times higher penalty on waiting costs. This aligns manufacturing's objectives with company objectives. Sales' incentives are aligned through a penalty on wildcards 3 times higher, which gives them an incentive to adhere to manufacturing's decisions.

The standard methodology of experimental economics was used (e.g., [4]. Eighty students were recruited as participants at the University of Mannheim, mostly graduate business students specializing in logistics. For each treatment, five individual sessions were conducted, and a between-subject design with different participants was chosen. The students were assigned roles as sales (2 per session) and manufacturing (2 per session). Participants were provided with instructions, both written and oral. Instructions contained information on the bonus payment including how their performance in the game (measured in Thaler) translated into real monetary payments (in Euros) after the game. Compensation of the students consisted of a fixed show up fee of €7.50 and a performance-related bonus with an expected value of €3.

3.2 Results

Table 3 gives an overview of average key performance measures and bonus payments for all four treatments for the first 15 periods of the game. The gross margin is relatively stable. Note that the corresponding value of gross margin in the optimal solution is 3,600 (4,000 minus the revenue of 8 units produced after the horizon of 15 periods). *Waiting costs* show substantial differences, whereas *wildcard costs* are mostly negligible. *EBIT* differs between the treatments, so does *utilization*, but to a smaller extent.

Result I System performance is improved by incentive alignment as well as by information and communication. The impact of aligned incentives on system performance is larger than the impact of information and communication. Better company performance is reflected in higher bonus payments.

First, the influence of bonus design is analyzed. Comparing T1 and T2 yields significant differences ($p = 0.008$) for all values but gross margin; T3 and T4 are significantly different concerning all values except wildcard cost. With

Table 3 Overview of key performance measures and bonus payments

	Bonus 1		Bonus 2	
	T1	T3	T2	T4
Gross margin	3,380	3,460	3,450	3,560
Total cost	−2,008	−1,693	−252	−23
Thereof waiting cost	−1,920	−1,660	−240	−20
Thereof wildcard cost	−88	−33	−12	−3
EBIT	1,372	1,767	3,198	3,537
Utilization (%)	90	93	93	95
Bonus sales (total)	301	323	332	354
Bonus manufacturing (total)	206	267	314	356
Profit	865	1,177	2,552	2,828

EBIT, being the key measure, Bonus 2 leads to better results than Bonus 1 for both treatments with and without communication. This result confirms the choice of monetary incentives as the central pillar to guide behavior. The students were influenced in their behavior both by the fictional game setting and the intention to "win" and by the real monetary pay.

Secondly, the influence of information and communication is reviewed: T2 and T4 are different with regard to EBIT ($p = 0.016$) and gross margin ($p = 0.056$), however both with a small difference of absolute values. T1 and T3 are not significantly different. The result thus mainly holds with regard to T2 and T4, implying that information and communication improve system performance with Bonus 2. An explanation for T1 and T3 not being significantly different is the observation of different risk attitudes: in T1 (without visibility of capacities), sales was often afraid of lost sales and hence did reject more orders as compared to T3, where capacities as well as waiting queues were visible. Bringing improved information and a better aligned incentive system together, T4 yields significantly better results compared to T1 in all performance values ($p = 0.032$ for gross margin, $p = 0.008$ for EBIT, waiting costs and wildcard cost). Bonus payments and information transparency lead to improved coordination of sales and manufacturing.

When comparing the impact of bonus (T2) with the impact of information (T3), we get the following results: Looking at EBIT and waiting cost, there is a significant difference between T2 and T3 ($p = 0.095$ and $p = 0.032$). This indicates that an improved bonus (T2 to T1) has a higher positive impact on total system performance (measured by EBIT) as a change in information availability (T3 to T1). This result shows a successful implementation of a parameterization that allows to conveying the key learning of the impact of incentive alignment. In a real world setting, this result may differ depending e.g., on the total amount of the bonus compared to fixed compensation.

In order to sustainably implement an aligned incentive scheme, the results need to be Pareto-improving, i.e., not only the company but also the employees have to be better-off. An acceptance of a new policy by employees implies that higher bonus payments for all players should follow better company performance, which is confirmed by the results: EBIT (i.e., the total of profit and bonus payments) and manufacturing bonus are positively correlated (Spearman's ρ value of 0.931), EBIT and bonuses of the two sales persons are correlated with values of 0.849 and 0.724, respectively (all significant at the 0.01 level, 1-tailed). Additionally, the absolute bonus values of T2 and T4 (Bonus 2) were significantly higher than the values in T1.

The second result focuses on the analysis of order acceptance/rejection decisions of sales and manufacturing (see Table 4). In the optimal solution, 34 standard orders and 4 rush orders are accepted, whereas 6 rush orders are rejected.

Result II Conflict between sales and manufacturing causes inefficiencies through waiting costs. Acceptance of rush orders is a main cause for these inefficiencies. Rejection of the "right" orders improves company performance.

In T4, the highest number of orders is accepted in the first step, indicating the lowest necessity of direct interaction at the interface and therefore little frictions. In T1, manufacturing rejected the largest amount of orders (rejected orders and orders with wildcards). Comparing T1 and T4, the number of rejected standard orders is significantly different ($p = 0.008$), as well as the number of rejected rush orders ($p = 0.032$). In T4, no standard orders were rejected.

The usage of wildcards, which was subject to a cost of 5 Thaler per unit, is interpreted as follows: orders rejected by manufacturing could be accepted by sales using a wildcard, thus overruling the recommendation of manufacturing. In T1, significantly, more wildcards are used than in T4, as well as in T2 ($p = 0.008$ for standard orders, $p = 0.056$ for rush orders). With wildcards as a measure of conflict, T2 and T4 (Bonus 2) are thus better than the original setting (T1) in this respect. Communication, which was observed during the experiment, made wildcard usage unnecessary.

Lastly, the correlation between order acceptance/rejection decisions and waiting costs as a measure for production delays, and thus low customer service is analyzed. The number of accepted orders with wildcard as a measure of cross-functional conflict are positively correlated with waiting costs ($\rho = 0.748$, significant at the 0.01 level (1-tailed)). The ρ value of rush orders with wildcards was 0.528 and standard orders with wildcards 0.678, both significant at the same level. This indicates that wildcard

Table 4 Order acceptance decisions

	Bonus 1		Bonus 2	
	T1	T3	T2	T4
# of accepted orders without wildcard: standard	22.4	29.4	31.0	34.0
# of accepted orders without wildcard: rush	3.6	5.8	4.8	3.4
# of accepted orders with wildcard: standard	8.8	2.6	0.8	0.0
# of accepted orders with wildcard: rush	2.4	1.4	0.4	0.4
# of rejected orders: standard	2.8	2.0	2.2	0.0
# of rejected orders: rush	4.0	2.8	4.8	6.2
Subtotal: # of accepted orders: rush	6.0	7.2	5.2	3.8
Subtotal: # of accepted orders: standard	31.2	32.0	31.8	34.0
Subtotal: # of accepted orders without wildcard	26.0	35.2	35.8	37.4
Subtotal: # of accepted orders with wildcard	11.2	4.0	1.2	0.4
Total: # of accepted orders	37.2	39.2	37.0	37.8
Total: # of rejected orders	6.8	4.8	7.0	6.2

All values: average values per treatment

usage leads to production delays. The number of accepted rush orders with wildcard and waiting costs are correlated ($\rho = 0.528$, $p = 0.01$). However, rush orders without wildcard and waiting costs show no significant correlation. Yet, the subtotal of rush orders and waiting costs are correlated with $\rho = 0.547$ ($p = 0.01$). Again, the parameterization allowed for a conveyance of the intended key learning of the negative impact of most rush orders in this specific setting. Lastly, total order rejection and waiting costs are not significantly correlated, yet rejected standard orders and waiting costs show a correlation ($\rho = 0.507$). Rejected rush orders are correlated with waiting costs ($\rho = 0.547$); this shows that not the total number of rejected orders is decisive but rejection of the “right” orders.

4 Conclusion and managerial implications

Based on an industrial case from the food industry, we developed a management game to involve decision makers in the core conflicts at the manufacturing–marketing interface, revenue versus utilization maximization. Thought as a training tool to support change management and provide mutual understanding of different functional areas, we conducted a laboratory experiment with student subjects to stress the importance of empirical game validation as real behavior might deviate from standard theoretical predictions [1]. We found that the developed game served the purpose of highlighting the importance of incentive alignment by the design of bonus schemes and the role of information and communication.

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References

1. Bendoly E, Donohue K, Schultz K (2006) Behavior in operations management: assessing recent findings and revisiting old assumptions. J Oper Manag 24(6):747–752
2. Cachon GP (2003) Supply chain coordination with contracts. In: de Kok AG, Graves SC (eds) Supply chain management: design, coordination and operations, handbooks in OR & MS, vol 11. Elsevier, Amsterdam, pp 229–339
3. Chayet S, Hopp WJ, Xu X (2004) The marketing-operations interface. In: Simchi-Levi D, Wu SD, Shen Z-J (eds) Handbook of quantitative supply chain analysis: modeling in the e-business era. Kluwer, Norwell, Massachusetts, pp 485–554
4. Croson R (2002) Why and how to experiment: methodologies from experimental economics. Univ Illinois Law Rev 2002(4): 921–945
5. Elgood C (1990) Using management games. Gower, Aldershot
6. Eliashberg J, Steinberg R (1993) Marketing-production joint decision making. In: Eliashberg J, Lilien G (eds) Handbooks in operations research and management science. Elsevier, Amsterdam, pp 625–880
7. Ellinger AE, Daugherty P, Keller SB (2000) The relationship between marketing/logistics interdepartmental integration and performance in US. Manufacturing firms: an empirical study. J Bus Logist 21(1):1–22
8. Ellinger AE, Keller SB, Hansen JD (2006) Bridging the divide between logistics and marketing: facilitating collaborative behavior. J Bus Logist 27(2):1–27
9. Fleischmann B (1990) The discrete lotsizing and scheduling problem (DLSP). Eur J Oper Res 44(3):337–348
10. Gunasekaran A, Ngai EWT (2009) Modelling and analysis of built-to-order supply chains. Eur J Oper Res 195(2):319–334
11. Keskinocak P, Tayur S (2004) Due date management policies. In: Simchi-Levi D, Wu SD, Shen Z-J (eds) Handbook of quantitative supply chain analysis: modeling in the E-business era. Kluwer, Norwell, Massachusetts, pp 295–334
12. Knolmayer G, Montandon C, Schmidt R (2004) Interaktive Lernobjekte zur Logistik. Wirtschaftsinformatik 46(2):139–151
13. Kouvelis P, Lariviere MA (2000) Decentralizing cross-functional decisions: coordination through internal markets. Manage Sci 46(8):1049–1058
14. Malhotra MK, Sharma S (2002) Spanning the continuum between marketing and operations. J Operat Manag 20(3):209–219
15. Mentzer J, Stank T, Esper T (2008) Supply chain management and its relationship to logistics, marketing, production, and operations management. J Bus Logist 29(1):31–46
16. Pinedo M (2002) Scheduling. Theory, algorithms, and systems, 2nd edn. Prentice Hall, Upper Saddle River
17. Porteus EL, Whang S (1991) On manufacturing/marketing incentives. Manage Sci 37(9):1166–1181
18. Shapiro BP (1977) Can marketing and manufacturing coexist? Harvard Bus Rev 55(5):104–114
19. Talluri KT, van Ryzin GJ (2005) The theory and practice of revenue management. Springer, Berlin