ABSTRACT number 015-0037

Call-Off Production, Triggered by the Traditional Kanban Card or by Electronic Kanban:

A Case Study at Ericsson

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POMS 21st Annual Conference

Vancouver, Canada

May 7 to May 10, 2010

Abstract

This study analyzes a concept for materials supply called *call-off production*, used by the telecom company Ericsson, where a case study was performed. Call-off orders are initiated from the production area and submitted through electronic data interchange (EDI) to an external supplier, a third-party logistics provider, skipping the traditional purchase ordering process. In call-off production Ericsson applies two forms of kanban for triggering the replenishment, namely the conventional kanban card and electronic kanban. For both variants, call-off production implies a short lead time, frequent deliveries, and the potential for controlling tied-up capital, using few resources, and providing a high level of delivery service. The study indicates that the conventional kanban card requires more handling than electronic kanban. On the other hand, electronic kanban could hide problems in the stock. To conduct the analysis, a theoretical framework and an analysis model were created as a foundation. Call-off production could be an uncomplicated and efficient method for manufacturing companies to manage some of the purchased products. This study's intended contribution is to increase the knowledge of a supply model in practice.

Keywords: materials supply, call-off production, kanban, electronic kanban

1 Introduction

In almost all supply chains, materials need to be stored or buffered. This means inventory management plays an essential role in a company's logistics success (Koster et al. 2007). Musalem and Dekker (2005) also focus on the importance of decisions made in inventory management, since they affect material flow and the availability of products. Inventory management is a challenge dealing with problems of balancing inventory costs and customer service in complex environments. So companies need inventory replenishment systems in order to improve customer service and at the same time reduce inventory costs (Myers et al. 2000).

To meet these challenges, companies have the opportunity to apply different methods for materials supply to different situations. However, it could be difficult for firms to choose, design, and apply a materials supply solution. In addition, according to Jonsson (2006) the best known and widely used materials planning methods can be applied in various ways. Several companies also have difficulty applying materials planning methods to their processes, and less effort has been spent on exploring how to apply these methods to achieve an efficient material flow (Jonsson and Mattsson, 2006). Therefore, Jonsson (2006) stresses that it is important to research different methods in order to increase knowledge and thereby achieve better performance and use of the methods in industry.

Ericsson has implemented and developed different methods for the replenishment process of materials. In one of these models, called by Ericsson *call-off production*, call-off orders are triggered by two different forms of kanban and submitted directly to a third-party logistics provider. The aim of this study is to analyze this model and show how it works in practice. The research questions are as follows:

- *What are the characteristics of the supply model?*
- *When is it appropriate to use this model?*
- *What are the effects on logistics goals of using this supply model?*

2 Methodology

The overall research is based on a systems approach (Arbnor and Bjerke 1994). A single case study was performed at Ericsson, focused on a specific plant in Gävle, Sweden. In the study, semi-structured interviews were used to collect empirical data. Most of the interviews were conducted at Ericsson's plant individually with respondents, but complementary data collection occurred by telephone and e-mail, as well as in informal discussions. Notes were taken and later rewritten and confirmed by the respondents, who included managers, purchasers, planners, material handling employees, operators in production, and process developers. To enhance the description of the supply model, additional observations of operators' daily work were conducted in the production area. During the observations, questions were asked of the production and material handling employees. In response to Ericsson's request, the content of the paper was also approved by the manager of information at Ericsson to prevent disclosing sensitive information. In order to understand important factors regarding materials supply and to conduct the analysis, a theoretical framework and a created analysis model were used as a foundation. This framework and model are modified and developed from a previous paper (Eriksson 2009) regarding another supply model at Ericsson. To collect and search material for the framework, various search terms were used when studying research articles from databases and other literature. The study does not include monetary aspects or quantitative measurements.

3 Theoretical framework and the analysis model

In this section important concepts and principles regarding materials supply are presented in the context of the developed analysis model (see Figure 1). The Call-Off Production supply model will later be analyzed with the help of this model in the Analysis section. The analysis model below is built upon five different areas.

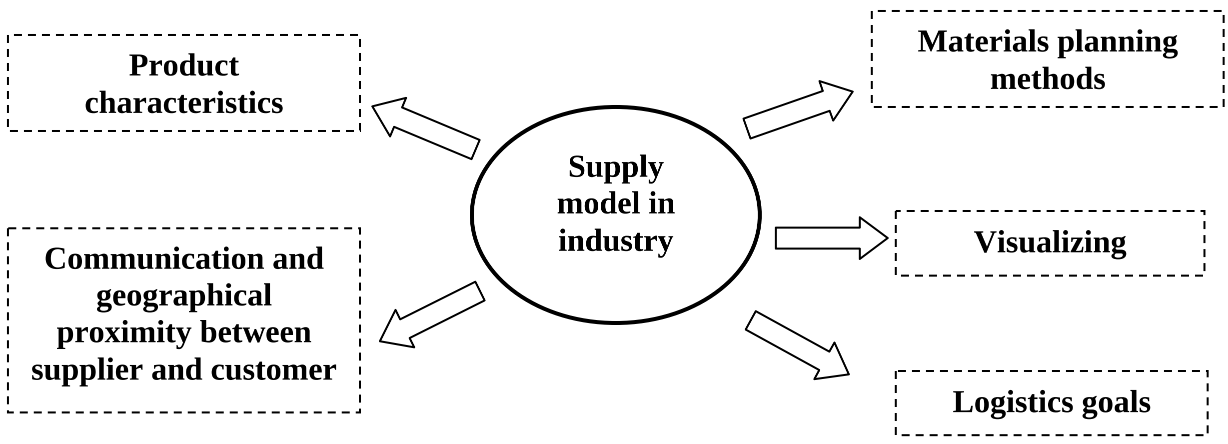

Figure 1. The analysis model.

3.1 Product characteristics

When deciding how to design or choose a solution for materials supply, different aspects of purchased products should be taken into account. Examples of important issues could concern product complexity, availability on the supplier market, cost, volume, the need for quality control and the product’s size/shape. The size/shape of the product could perhaps necessitate different solutions for storing and handling (Institute for Transport Research 2002), and thereby influence the design. Whether there should be quality control of purchased products is also an essential parameter, because quality control takes time and demands resources, and could influence decisions. According to Oskarsson et al. (2003), a company often exercises control over a product’s quality/functioning, but quality control can also include control over the quantity delivered, to ensure that sufficient inventory is on hand. For example, registering a product in the Enterprise Resource Planning (ERP) system erroneously could result in the wrong data for the ordering process, possibly leading to material shortages or other problems. The extent of the quality control depends on the product’s price, its complexity, and the supplier’s ability to deliver high quality goods.

In order to segment suppliers and select supply solutions, the so-called Kraljic's matrix (Figure 2) could be used. In the matrix presented by Bjornland et al. (2003), the x-axis indicates the complexity of the supplier market, which includes aspects concerning the number of suppliers, availability on the market, and the speed of technology development. The y-axis symbolizes the product’s economic importance (Bjornland et al. 2003).

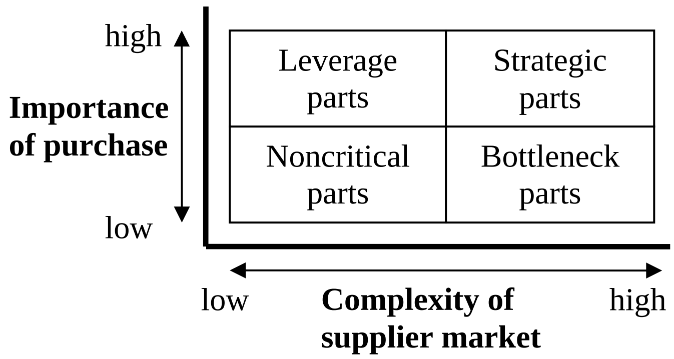

Figure 2. Kraljic's matrix, from Bjornland et al. (2003).

The matrix is divided into four squares. *Noncritical parts* mean most standard parts with little economic importance and of least importance for the company. Here simple forms of collaboration and routines could be appropriate (Mattsson 2002). *Leverage parts* are characterized by many suppliers and plentiful materials on the market. These items make up a large part of the total procurement costs. The *bottleneck parts* have a small impact on the company’s budget (low price per part) but high complexity, low availability on the market, and a small number of suppliers. The last square contains the *strategic parts* that are most important for the company and characterized by high complexity, a small number of suppliers, and a great economic impact (Bjornland et al. 2003).

3.2 Materials planning methods

The most known and used materials planning methods are material requirements planning (MRP), re-order point systems, run-out time planning, order-based planning, and kanban (Jonsson and Mattsson, 2002). This section describes these methods (with the exception of the conventional order-based planning) and briefly describes other aspects of materials planning, such as the importance of inventory accuracy and deliveries directly to production from a supplier.

Material Requirements Planning

MRP is regarded as one of the most widely used principles in industry. MRP relies on data such as bills of materials, inventory on hand, already planned orders, lot-sizing principles, and lead times to calculate purchase and manufacturing orders (Mattsson and Jonsson 2002). But different kinds of uncertainties exist with this principle of planning, such as meeting changes in volume and the demand for immediate deliveries (Kumar and Meade 2002). The company's ERP system usually includes MRP modules that take care of the data and calculations mentioned above. These data are very important in MRP and must be current and accurate for correct calculations (Kumar and Meade 2002, Jonsson 2008).

Re-order point

Different types and performances of re-order point systems exist. In each variant of the re-order point system, consumption initiates the replenishment. One variant continuously compares inventory on hand with a defined re-order point (a reference quantity). Another one is the periodic review system, which makes comparisons with stock inspections at predetermined constant intervals. If the quantity on hand is lower than the reference quantity, a replenishment process or order/refill process is initiated. With the periodic review system, administration can be more efficient and ordering and transportation can cost less, due to the opportunities for consolidating orders and deliveries (Jonsson 2008).

Run-out time planning

Run-out time planning uses a time expression instead of quantity. This could lead to a better understanding of how long a stock quantity will last and an improved ability to decide when ordering is necessary. Time period coverage is the term that describes the time that the available quantity on hand is expected to cover; it is calculated by dividing the available quantity on hand by expected demand per some time unit (Mattsson and Jonsson 2003).

Kanban

Kanban, related to the re-order point system, is a well known and uncomplicated method that implements the pull method. Often this means that materials are pulled through a visible card to the production areas only when materials are required. This is closely related to just in time (JIT) (Sykes 1994, Kouri et al. 2008). Besides low levels of tied-up capital, additional advantages with the kanban pull system could be shorter lead times, increased efficiency over the push system, ease of control, lower costs, and higher customer satisfaction (Wan and Chen 2008).

Besides the traditional kanban that is based on some form of physical and visual initiation of new orders, there are also electronic kanban systems where initiation is carried out through a computerized planning system (kanban could e.g. be a printout, a piece of paper) (Jonsson 2008, Jonsson and Mattsson 2002). Wan and Chen (2008) also describes forms of electronic kanban that have been developed based on existing ERP systems, electronic data interchange (EDI), or Web-based technology.

According to Wan and Chen (2008) the weaknesses with a conventional kanban system are: lost kanbans, incorrect kanban deliveries, delivering kanbans with inaccurate information, less efficiency in distant delivery, no visibility in distance delivery, limiting tracking and monitoring capability, limited support for performance measurements, consuming work time in managing the cards. They state that an automated process with electronic kanbans can solve or reduce these weaknesses. Other studies also point out weaknesses with the purely traditional kanban system, such as problems with lost cards and dealing with the cards (see Drickhamer 2005 and Jarupathirun et al. 2009). Jarupathirun et al. (2009) also describe a variant of electronic kanban where an EDI system (using scanned bar codes from the card) transferring information to the supplier reduces steps in the work process of kanban, lead times, amount of materials, inventory costs, waste, and storage area. In addition, electronic kanbans create better and more immediate results when data is bar-coded directly into the system, which also enables real-time supplier performance measurements (Moody 2006). It is essential to be aware that many versions of kanban solutions exist and they vary from company to company (Kouri et al. 2008).

Inventory accuracy

Inventory inaccuracy is a well-known phenomenon. It is generally difficult to maintain a good inventory balance (Wild 2004). This problem could affect the whole company, from stockroom operations to sales, reducing profits (Fleisch and Tellkamp 2005, Wild 2004). Different reasons/sources for inaccuracy are administrative errors, in and out registrations, misplaced items, theft, or items that are out of date (Axsäter 1995, Fleisch and Tellkamp 2005). However, implementing simple processes to operate inventories could increase inventory accuracy. Factors could include ease of use, bar coding, avoiding movements, using kanban methods, and maintaining low stock levels (Wild 2004).

Deliveries directly to production from a third-party logistics (3PL) supplier

It is possible for manufacturing companies to let the supplier provide materials directly to the production line. Due to the demands on lead time, this could be difficult to achieve. However, a 3PL provider could gather the material flow from different suppliers and store them, delivering materials when the need arises. This allows opportunities for small and frequent deliveries from suppliers at long distances, which would otherwise have been difficult economically (Oskarsson et al. 2003).

3.3 Visualizing

Different aspects of visualizing are discussed in the literature, from visibility through the whole supply chain down to a detailed, effective visual control system in a production environment (see Petersson et al. 2008, Liker 2004, Greif 1992, Emiliani and Stec 2005). The literature has emphasized that visual systems could contribute to increased productivity, better information and control, lower costs, and reduced defects and mistakes. According to Dreyer and Romsdal (2009) visualizing involves representing information in order to clarify and easily abstract, transfer, and exchange knowledge. They also state that efforts should be applied to what and how to visualize. Furthermore, according to Bellgran and Säfsten (2005) visual solutions could contribute to a good production system, where the visibility helps avoid problems and could mean satisfaction for employees. Liker (2004) states that the company should use simple and visual solutions to support the flow and the pull system. Moreover, he says that visual control could be used to uncover problems and help employees to determine whether their work meets standards or not. The computer screen should be avoided if it distracts the operator and reduces the number of reports to one single paper. According to Greif (1992), the term visual control does not rule out using a computer-controlled warehouse or other storage. Visual control is not just about techniques, but also concerns communication between people and logistics systems.

3.4 Communication and geographical proximity between supplier and customer

As a result of technological advances, supply chain partners can now work in tight coordination, where information sharing is an essential prerequisite (Lee and Whang 2000). Mattsson (2002) and Christopher and Lee (2004) also draw attention to the great importance of sharing information of good quality between supplier and customer. For an effective supply chain there is a need for access to information about orders, delivery, inventory status, plans/forecasts and history of consumption. The information should be highly accurate and timely so that it can be used to take control of supply chain operations, thereby reducing uncertainties and providing prerequisites for a demand-driven chain. In this context, Pohlen and Goldsby (2003) point out that trust is necessary between the parties to make the relationship work. According to the literature, geographical proximity between supplier and customer is also important. Among others, Mattsson (2002) stresses the need for short distances for effectiveness in the supply chain. The benefits could be lower transportation costs, higher frequency and flexibility of deliveries, and better prerequisites for effective communication and development work. Additionally, Karlsson and Norr (1994) point out that suppliers in a just-in-time system have an advantage if they are located close to the buyer’s plant.

3.5 Logistics goals

The connection between the goals of logistics or supply chain management and profitability is clarified by Persson (1997). She stresses that increased profitability is achieved by reducing costs and improving revenue, which is achieved by efficient use of resources, reduced inventory, reduced lead time and increased customer service. According to Jonsson (2008), the service related to carrying out the order-to-delivery process is usually called delivery service and included in customer service. Christopher and Lee (2004) stress that one must focus on different delivery service elements. In this section different elements regarding logistics goals will be described, starting with different delivery service elements.

Delivery service elements

Jonsson (2008) mentions five common delivery service elements. The first element is *Inventory service level* (or *fill rate*), which describes to what extent stock items are actually available in stock when they are demanded. The next one is *Delivery time* (often called *lead time*) which expresses the time from receipt of customer order to completed delivery. The lead time could include the administration of orders, dispatch, transportation, and receiving activities. Another element is *Delivery precision* (or *on-time delivery*), which describes to what extent the delivery takes place at the agreed-upon delivery time. *Delivery reliability* is used to measure the quality of delivery in terms of the right product being delivered in the right quantity. The fifth common element is *Delivery flexibility*, which refers to the supplier's ability to adapt and comply with changes in customer requirements (e.g., changes in delivery times, order quantities or contents, and the performance of the product delivered). It is essential to be aware that delivery service is not just important for deliveries externally between supplier and customer, but also for the internal flow (deliveries between different departments) (Oskarsson et al. 2003).

Capital tied up

Many authors/researchers stress that reducing inventory is important, since inventory ties up money and has an impact on the profitability. Although the predominant cost for tied-up capital is the capital cost itself (the cost for the purchase of raw material), there are also costs for material handling, facilities and equipment, insurance and the warehouse employees (Olhager 2000).

Use of resources

Use of resources could include a lot of aspects, but here the focus is on resources associated with purchasing and administration. According to Gadde and Håkansson (1998), a company's ability to earn revenue depends on how its purchase activities are handled, since the purchase costs are a large part of the total costs in a company. Besides the cost of the product itself there are also indirect costs, such as tied-up capital, administration, claims, and material handling, which could affect how purchase activities are carried out. Examples of potentially high indirect costs are those related to planning and administering orders and activities regarding invoicing. These costs may be relatively considerable, especially for products of low economic value. But if supplier and customer together develop an effective system for these activities and cooperate more thoroughly and with a long-term perspective, savings is possible. This could also lead to better coordination and commitment.

4 Call-Off Production at Ericsson

In call-off production (see Figure 3), replenishment takes place through call-off orders initiated from the production area. The products are in the production stores organized in a two-bin system; when one bin is consumed, a call-off order is triggered by a kanban principle. Bins are dimensioned to cover a number of days' consumption (including a safety time). Each bin is of the same size. The call-offs are submitted directly through EDI to a third-party logistics provider (3PLP), without any traditional purchase ordering process. The call-off order will be delivered within 24 to 48 hours, depending on what point within a twenty-four-hour period the call-off is made. The supplier needs forecasts for internal and long-term planning. The bins must also be updated when plans are changed. Ericsson uses this concept for electronic components such as resistors, capacitors, and integrated circuits. In call-off production no quality control takes place, nor are products stored in a main warehouse, so from the receiving area products flow directly (after registration) to the production store.

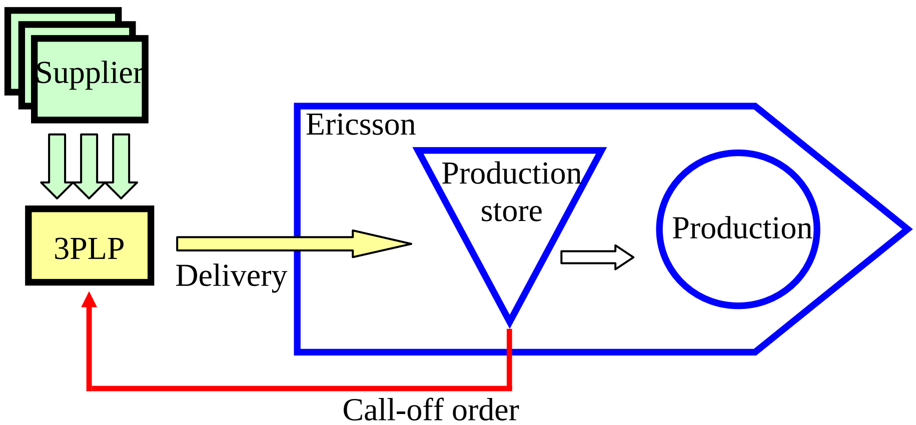

Figure 3. Ericsson's Call-Off Production model.

The production stores are located near the production line and are known as paternoster storage (see Figure 4), controlled by a separate computer system integrated in the storage (for registrations, inventory on hand, etc.) in combination with the kanban principle. The products/bins are located on different shelves, which can rotate. The computer system communicates with the ERP system and provides it with stock information. Furthermore, the specific plant in the case study has several production stores, some using traditional kanban and others electronic kanban. The study includes both variants.

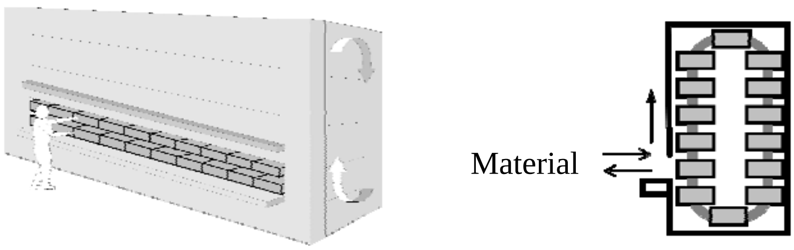

Figure 4. Paternoster storage.

Triggering replenishment with traditional kanban

Figure 5 shows the principle with the two-bin system and traditional kanban. When the last package has been picked in the bin, the need for replenishment is made visual through this physical card attached to the last package in the bin. Material handling employees remove the kanban from the package, scan the bar code on the card, and submit a call-off electronically to the supplier.

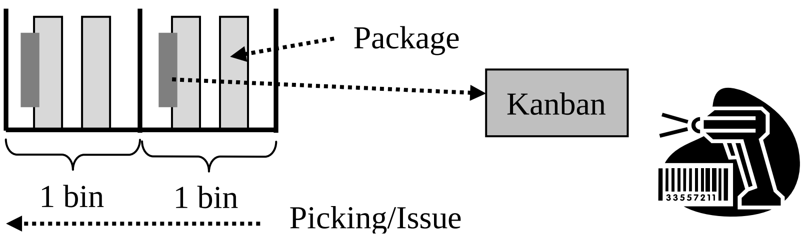

Figure 5. The principle shown with traditional kanban in a two-bin system.

Figure 6 below shows the flow of kanban and materials. X and Y are in the figure symbols used to describe stock location in system. At the receiving area (1) the materials (delivered by the call-off) are registered in the ERP system (whereupon the delivered quantity has stock location X in the production area). A forklift then transports the delivery to a special square in the production area (2). A material handling employee picks the corresponding kanban from a certain box (7) and tapes the kanban to the package. Then the packages are moved to the production store (3). Before the material goes into storage, the computer system is updated with stock information (part number and quantity) through bar coding at the storage terminal. Then the stock location of the product is also changed to Y. On the terminal a display shows the location/position (what shelf and where on the shelf) the material will be stored in; the corresponding shelf is moved so the material can be placed there. In the storage it is not necessary that the bins are physically located close to each other, since the system controls the positions. It is important that the package with the kanban is placed as the last package in the bin. Material handling personnel are responsible for all of the activities mentioned.

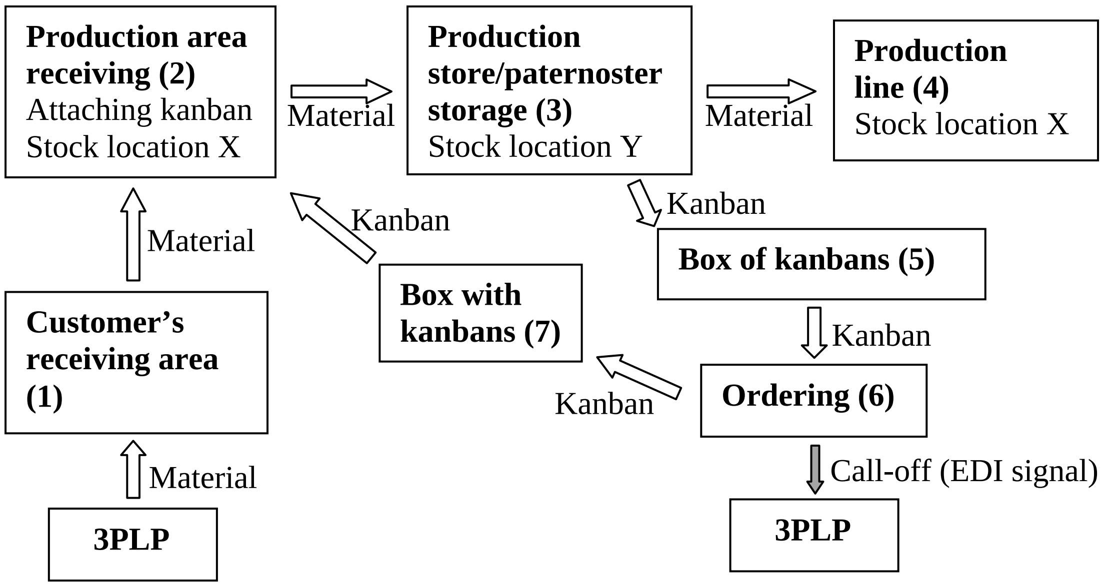

Figure 6. The flow of kanban and materials.

Issuing of material is mostly done by operators from the production line (4). When they need replenishment they take the empty package at the line to the paternoster storage terminal (3). The bar code on the package is then scanned and the shelf is rotated to allow picking the right product. Stock picking must be from the right to the left in the bin. During scanning (of the new package), the quantity is also moved to stock location X. The operator then brings the material to the production line (4).

When the last package in the bin is picked, the kanban is removed from the package and placed in the box of kanbans (5). The other bin then covers the material needed until refill. Kanbans in the box indicate needs for replenishment. At regular intervals materials handling employees check the box and take the kanbans to another nearby area for ordering (6). Here the bar code of the kanban is scanned and then the order, the call-off, is submitted automatically as an EDI signal to the supplier. The ERP system contains the order quantity (bin quantity) related to the part number, supplier information, etc. The kanban is then moved to a certain box (7) where the kanban "awaits" the delivery. When the corresponding quantity then is delivered to the production area (2), a materials handling employee fetches the kanban from the box (7), attaches the kanban, and stores the materials (3) (as described earlier).

Triggering replenishment with electronic kanban

Since many of the activities are the same as with the traditional kanban, only the differences from traditional kanban will be described here. See also Figure 6. With electronic kanban the paternoster storage computer program checks the inventory on hand, and if replenishment is needed (a bin is empty) an electronic kanban is printed on a piece of paper. The replenishment process relies on correct in and out registrations and stock data. The triggering can be illustrated as in Figure 7. From the start the two bins are full, with the quantity of Q each. When the stock level reaches

A, an electronic kanban is generated. Until replenishment, bin 2 covers the need. The computer system controls the bins to uphold the FIFO principle. The display on the terminal will show the right position for picking, and the right shelf will be moved so picking is possible.

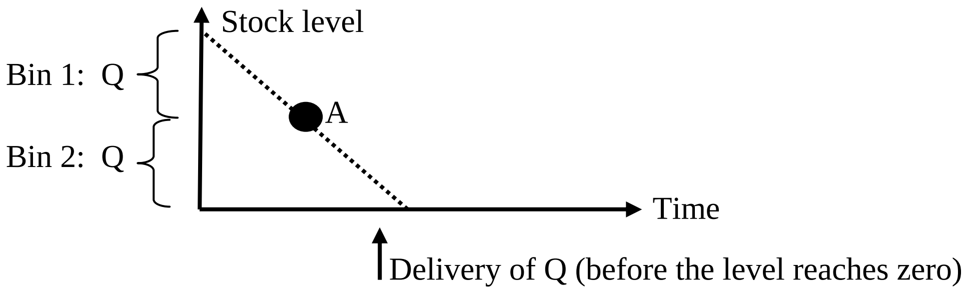

Figure 7. Triggering replenishment with electronic kanbans.

The following indications of benefits and deficiencies with call-off production emerged from the study:

Benefits for call-off production *(with both kanban methods):*

- Short internal/external lead times
- Orders initiated directly from production (where the consumption is)
- High availability of materials, frequent deliveries and volume flexibility
- Low level of stock and control of tied-up capital
- Low level of administration
- Not complicated to understand and operate
- No time-consuming quality control
- No main storage
- Particular solutions, including indications of the inventory status, visible cards/paper, separate squares/boxes, empty packages for issuing, bar coding

Benefits of traditional kanban:

- Visibility indicates needs clearly
- Positive influence on inventory accuracy
- Reduces the possibilities of material shortages. Figures in an IT system do not provide data for replenishment.

Benefits of electronic kanban:

- Requires less manual handling
- Picking from right to left in the bin is not necessary

Deficiencies of traditional kanban:

- Requires more handling than electronic kanban
- Lost kanban. Forgetting to attach kanban
- The one who picks the last package with the kanban must release it and put the kanban in the box
- Picking from right to left must be upheld

Deficiencies of electronic kanban:

- Basic data for replenishment are figures in an IT system. This could lead to material shortages or inaccurate orders, and consequently to inventory inaccuracy. It relies on correct in and out registrations and stock data in the paternoster storage; electronic kanban could hide problems in the stock
- Not the same visibility as conventional kanban

5 Analysis

This section discusses and analyzes call-off production using the analysis model from section 3.

5.1 Product characteristics

Referring to Kraljic's matrix, products appropriate for call-off production fit into the segments called noncritical and leverage parts. One reason is that the concept works well together with a 3PLP. According to Oscarsson et al. (2003), the idea with a 3PLP is to gather the flow from several suppliers and store items, allowing for small, quick, and frequent deliveries. Strategic and bottleneck parts are not appropriate for call-off production because of their complex and sensitive nature. Additionally, working with call-off production assumes that the yearly requirement should be high and that there should not be any quality control, which delays the deliveries. Moreover, in this concept the item’s size/shape is not of importance since electronic components by nature are small. Because of this the stores are also adapted to that, but in principle call-off production could use other types of storage for larger products.

5.2 Materials planning methods

Call-off production is an uncomplicated pull method, closely related to JIT, where kanbans are used to trigger replenishment directly from a supplier, with short lead times. The flow is also quick and direct from the receiving area to production. The system also uses bar coding (avoiding erroneous registrations) and is easy to operate and understand, which Wild (2004) and Fleisch and Tellkamp (2005) assert is beneficial for inventory accuracy. Moreover, the supply models utilize EDI for the call-off to the supplier, which is also efficient (Jarupathirun et al. 2009). Items in the production store are organized in a two-bin system where the bin sizes represent coverage for a particular time period, i.e., dimensioning in call-off production follows the principle of run-out time planning.

Two different variants of the kanban system are in use (at different production stores) in call-off production. Traditional kanban in call-off production, with the visible card being a clear indication of need for replenishment, could also reduce risks for material shortages and inventory inaccuracy, since the basic data for replenishment are not figures in an IT system. Some deficiencies with the conventional kanban are the need to pick the package with the attached kanban as the last one, the potential for lost kanbans, and time-consuming handling activities. Other studies have brought attention to other problems with conventional kanban, e.g., distance to supplier, limitations in tracking/monitoring, and inaccurate measurements (see Wan and Chen 2008, Jarupathirun et al. 2009). However, since call-off production with conventional kanban is combined with an automated process with bar coding and an EDI/ERP system, these problems are reduced.

Turning to the electronic kanban used in call-off production, the benefits include the lack of a requirement to pick parts in a special order and the lack of any attaching and releasing activities. Electronic kanbans also signal clearly the need for replenishment (but only when they are printed out). This variant also reduces the risk of lost cards (even if there is a possibility of losing the kanban printout). However, incorrect figures in the IT system could lead to material shortages or inaccurate orders, and consequently to inventory inaccuracy. This is similar to the problems that can appear in MRP, where data must be current and accurate for correct calculations (Kumar and Meade 2002, Jonsson 2008).

5.3 Visualizing

In call-off production different visual solutions could be identified to support the flow and replenishment processes, in line with Liker (2004). Systems for visualizing information could, according to the literature, contribute to increased productivity, better information and control, lower costs, and reduced mistakes. In the supply model different visual solutions support the processes. For instance, the two-bin system itself indicates inventory status, the kanbans showing need for replenishment, separate squares and boxes for kanbans and materials, and the bar coding of empty packages for issuing new materials. Even if visual solutions are generally beneficial, mistakes do happen, such as lost kanban cards and errors in the handling of cards and materials.

5.4 Communication and geographical proximity between supplier and customer

The 3PLP in call-off production must be provided with accurate and regularly updated forecast plans and bin levels, so the 3PLP can dimension its own process and communicate with its own suppliers. Trust between supplier and customer is important when using call-off production, because the supplier relies on the 3PLP keeping a well-dimensioned store and sending accurate deliveries in response to the call-off. In a just-in-time system this is very important, since the customer’s production stores are strongly limited and depend on small and frequent deliveries. Trust is also important because the 3PLP stores material for other companies, so there must be no interference between dedicated items. Furthermore, in the supply model geographical proximity between customer and supplier is a good way to ensure the high frequency of deliveries with short lead times, reducing disturbances such as late deliveries and keeping the inventory levels low.

5.5 Logistics goals

Delivery service elements

Fill rate and delivery reliability: The call-off production principle allows for high fill rate and delivery reliability, offering capability of picking the right product in the right quantity when needed, within the bin levels. The inventory levels in the bins are expected to cover the requirement until the next refill, due to the principle of run-out time planning. However, the fill rate is dependent on a regularly updated process.

Delivery time: There is not the lead time that is the case with the traditional ordering process; the kanban/pull system leads to short lead times. The call-off order will be delivered with a short lead time, in accordance with a just-in-time system. The time from call-off to delivery is 24 to 48 hours, depending on what time the call-off is made.

Delivery precision: In this model delivery precision concerns deliveries within 24 to 48 hours. Late deliveries become obvious in call-off production, because of the visible kanbans that accumulate.

Flexibility: The two-bin system allows for the possibility of varying or increasing the amount of material issued from the production store, yet within the limits given by the maximum levels. With frequent information exchange about forecast plans and bin levels, it is easy to update the volumes quickly. Since the concept is used for products with high availability on the supplier market, updating bins and responding to call-offs should not become a problem. Furthermore, the parts could be used for several end products, implying high flexibility in the product mix.

For this concept to function with high-quality delivery service, all of the following conditions must be met:

- The 3PLP must follow the agreement about the call-off orders.
- There can be no disturbances in transportation.
- The 3PLP must always have a well-dimensioned stock and never run out of material.
- The 3PLP must maintain good communication with its own suppliers.
- The bin levels must continually be updated and the 3PLP provided with accurate information.

Capital tied up

In call-off production no main store is used, implying low stock levels. There is just a production store dimensioned for a certain maximum level controlled by the kanban principle, implying control of and low levels of tied-up capital.

Use of resources

According to Wan and Chen (2008), kanban solutions lead to efficiency, lower costs, and ease of control. In call-off production a 3PLP provides materials frequently and with short lead times from suppliers at a distance. A 3PLP can in many cases perform this at a lower cost than the company itself could (Oskarsson et al. 2003). In the supply model there is no need to create traditional purchase orders, control the delivery schedule or administer orders, perform quality control, nor use a main warehouse and with its related activities, enabling savings in these aspects. Call-off production runs by itself to a large extent, although some activities concerning handling kanbans are necessary. The conventional kanban requires more handling activities than the electronic kanban. On the other hand the electronic kanban could hide problems in the stock. In both variants registrations are necessary, but these occur through bar-coding which also eliminates errors. Additionally the visual parts of the supply model reduce errors and contribute to uncomplicated processes. The resource aspects of EDI were beyond the scope of this study.

6 Conclusions

The Call-Off Production method could be described as a just-in-time or pull system. In the model replenishment is triggered by kanban and the products are organized in the production store in a two-bin system, where bins are dimensioned according to the principle of run-out time planning. When one bin is consumed, a call-off order is submitted by the kanban principle to the 3PLP, through bar coding and EDI. The other bin then covers the material needed until replenishment. In the concept no quality control takes place, nor are products stored in a main warehouse. Products appropriate for call-off production are high-use products, noncritical, and leverage parts, according to Kraljic's matrix. Regarding the relationship between supplier and customer, it should be characterized by good communication, good information exchange, and trust, all of which are important prerequisites for successful deliveries.

For both kanban variants, call-off production implies frequent deliveries with a short lead time, the potential for low tied-up capital, few resources, visibility/simplicity and a high level of delivery service. The study also shows that the conventional kanban card requires more handling activities than the electronic kanban, but implies a higher degree of visibility. Kanban cards could also be lost. On the other hand the electronic kanban could hide problems in the stock if figures are incorrect in the IT system. This could lead to material shortages or inaccurate orders, and consequently to inventory inaccuracy.

The intended contribution of this study to academia and industry is to increase the knowledge of a supply model in practice. Call-off production is not dependent on any specific type of industry, since the concept relies on well-known and general logistics principles. Call-off production could be an uncomplicated method for manufacturing companies to manage some of the purchased products in their supply chain with low resources, yet with a high level of customer service.

Further research should include measurements comparing errors and handling activities between conventional kanban and electronic kanban. Additionally, comparison with similar principles and other kanban solutions at other companies could be of interest.

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