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Development of Tracking Technologies and its Benefits for Purchasing

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Abstract
The global trends of increasing traffic, shorter delivery times, smaller shipments and lower stock levels within production networks lead to higher synchronization efforts between production and logistics processes. Nowadays it is often a raffle if purchased goods shall be delivered in time because delays mostly occur during transportation processes and the flow of information is operated semi-manually and therefore unreliable so that purchasing departments have to safeguard receipt of goods with lots of effort. By now, research activities in intelligent cargo, which means cargo that can identify, monitor or locate itself, gains in importance and the possibilities for usage expand fast. Using intelligent cargo or track and trace techniques within purchasing processes would be an improvement for the whole production chain. By purchasing intelligent cargo (RFID/GPS-equipped goods) an automated flow of information could be implemented so that process times for reacting after interruptions of the transport process extend, due to an immediate information of the scheduling department about an discrepancy at that moment when the delay or disruption occur. The paper at hand describes and compares different tracking technologies and discusses which consequences a continuous tracking of purchased goods have for sourcing strategies, lot sizes and order intervals. Based on this discussion a SWOT-Analysis is executed to identify development potential of procurement performance in case of running shipment tracking systems. The paper reveals that as with RFID technology in logistics for continuous tracking by GPS several benefits can be identified – but real improvements for business value can only be created in a comprehensive approach in line with changes in sourcing strategies and purchasing processes.

Keywords: Supply Chain Management Track & Trace, Sourcing Strategies, SWOT Analysis

1. Introduction

Purchasing, as a corporate key function, gains continuously in importance - supported by the fact that depth of added value decreases because of pursuing outsourcing strategies and the concentration on core competencies. Spend rates of more than 60 % are not a rarity anymore (Mohr 2009). This implies more players within a supply chain with a higher degree of specialisation, which is followed by a high coordination effort for purchasing departments. To organize and structure the purchasing process from order time till good receipts with the major goal of logistics *R's* (rights), it is important to realize a reliable and cost-efficient purchasing process. Therefore it is necessary to track goods for safeguarding delivery times of preferred suppliers (Fröhlich-Glantschnig 2005). This could be a person-based tracking by visiting supplier's production as well as a technology-based tracking with adequate information and communication technologies such as RFID or GPS. In times of lean production this is a challenge because short delays already follow in production down times which result in high troubleshooting efforts and emergency logistics processes to organize alternative goods or materials. In fact, studies show that only innovative suppliers which are involved in company's research and development projects can tackle future challenges of procurement and can secure their relationship position themselves (Batran et al. 2011, Schiele 2010). To improve their business relationship technical innovations have to find one's way into the delivery process of the supplier respectively the purchasing process of manufacturer in order to support companies for safeguarding their production processes.
Chapter two describes existing tracking concepts and technologies. The subsequent chapter three explores three different interaction areas with sourcing strategies and purchasing processes. Chapter four describes a SWOT analysis for the implementation of continuous

tracking in supply chains from the sourcing perspective. Chapter five provide a conclusion and outlook for further research topics.

2. Review of Track and Trace Technologies within Logistics Networks

Track and trace within supply chains is an important issue for supply chain planning and executing. Therefore not only transportation but also production processes should be able to be monitored according to actual progress. But especially potentials of tracking transport processes are immense because they are often bottlenecks within supply chains according to high traffic volumes and high uncertainty of planned execution because of possible disruptions. An early identification of disruptions is quite important to safeguard subsequent processes.

A common definition of track and trace does not exist in literature (Shamsuzzoha and Helo 2011). Although, several research papers use *tracking and tracing* or *track and trace* as generally accepted expression (e.g. Fritz and Schiefer 2009, Schiefer 2008, van Dorp 2002, Stefansson and Tilanus 2000). In fact, tracking is defined as the possibility of identifying actual status and/or position of shipments or goods during transportation, warehousing or production and tracing is the possibility to reproduce the transportation process with high resolution (Hausladen 2011). These definitions are also applied for this research paper. Figure 1 shows an overview of existing track and trace technologies.

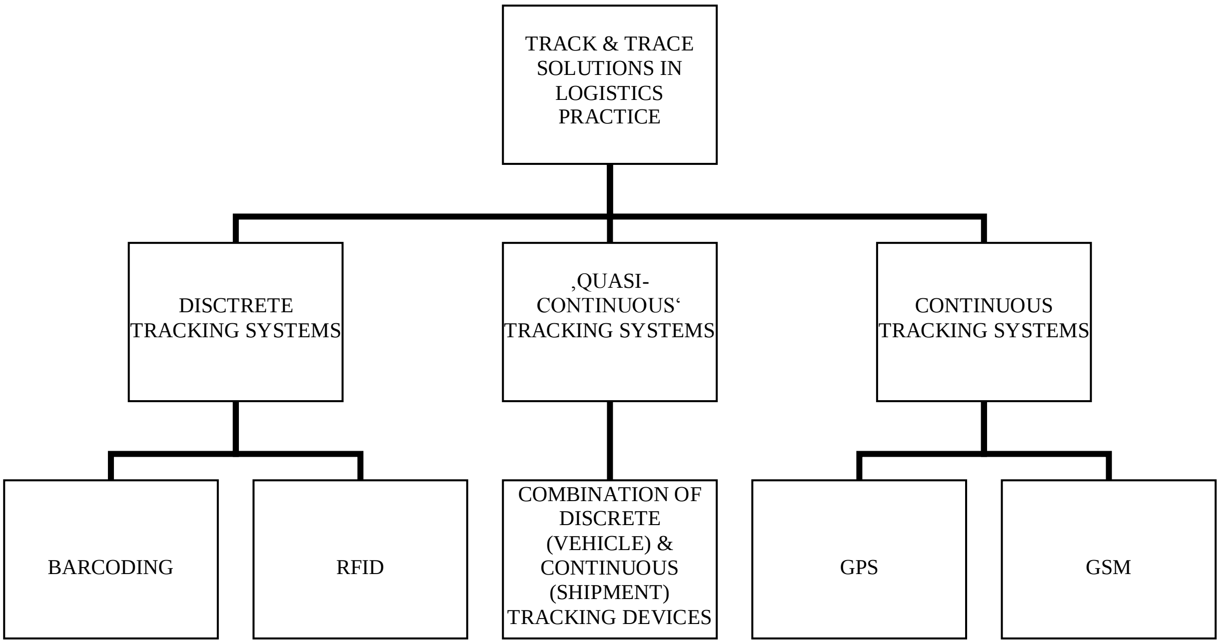


Figure 1. Categorization of tracking solutions in logistics practice.

Courier, express and parcel service providers offer web-based tracking solutions as a standard service to track parcels during the transport process. In this segment of standardized and restricted sizes and weights of shipments it is implemented with the help of *barcodes* and automatic scan devices (Vahrenkamp 2007). In groupage freight networks the implementation of track and trace solutions is more complicated because of the heterogeneity of shipped goods and often associated with more need of man power (Hillbrand and Schoech 2007).

Beside barcoding the *RFID* technology (Radio Frequency Identification) is also used in logistics practice. Therefore the shipment has to be tagged with a RFID transponder. The transponder can look like a label, a smart card or a plastic coin. They have to be read with RFID reader devices which can be installed at loading platforms, forklift trucks or warehouse gates. These readers can identify shipments with the help of information saved on the

transponders together with additional information like weight, temperature or construction date (Franke and Dangelmeier 2006). Disadvantages of the RFID technology are high investment costs and lacking data security (Wannenwetsch 2010). Despite this development of RFID for identifying shipments, practical importance of barcoding is still huge because of easy implementation and increasing activities in the field of e-commerce (Vahrenkamp 2007).
Barcoding as well as RFID can only be used when the logistics network is equipped with barcode scanning devices or RFID reader installations. This is even more complicated if several subcontractors are organized in a supply chain because the technical equipment has to be installed in the whole network. Due to several different standards continuous hardware integration and consistent data collection is nearly impossible. Furthermore both techniques only offer geographical positions when the tagged shipments are located near fixed reading installations. So the shipment is only tracked if it reaches pre-defined fixed positions. These track and trace solutions can only be described as *'event-monitoring'* because it is still unknown what is happening between two reading points, identified are only loading, handling or delivery points. That is why these tracking solutions are categorized as *discrete* tracking solutions.
On the other hand *continuous* tracking solutions make it possible to localize shipment positions at any time. A further possibility is a tracking by using the technology of mobile telephone transceiver stations (GSM), but this is not very common. GSM devices calculate the run-time to at least three radio signals to three GSM transceiver stations. Depending on the radio cell dimensions where the GSM device is located the accuracy of the position can vary from 100 m to 35 km (Hillbrand and Schoech 2007). This is obviously not feasible for logistics applications because of high variation in localization accuracy.
GPS tracking offers potential to close the described gap: The actual position is defined continuously by the use of GPS signals. GPS modules calculate the distances to a number of satellites - usually at least four satellites are necessary to determine the location accurately. For this reason the shipped goods can be localized anytime and with a satisfactory accuracy of a few meters (Daduna 2011, He et al. 2009). A GPS based track and trace solution can be categorized as continuous tracking (Hillbrand and Schoech 2007).
In combination with a discrete tracking technology, this *'quasi-continuous'* tracking solution can be realized: A shipment based discrete tracking solution combined with a vehicle based continuous tracking solution. Disadvantage is a high computation complexity because a 'virtual connection' between vehicle and shipment is necessary and this is not feasible for networks in which different logistics service providers execute the transport because it has to be guaranteed that all vehicles used in the transport chain are equipped with an on-board telematics system (Hillbrand and Schöch 2007; Meers et al. 2010; He at al. 2009; Brewer et al. 1999). Another possibility is an independent power supplied shipment based continuous solution. A power-supplied solution has the advantage that the integration of the tracking data is easier because it is supplier and forwarder independent and can be provided by the manufacturer and adjusted on its IT infrastructure (Kärkäinnen et al. 2004). It depends on size and weight of the cargo or on the lot size of one shipment.
Furthermore the integration of GPS track and trace is independent from the IT infrastructure of the carrier. If the tracking modules are battery-powered, the shipper can attach the GPS module to the shipment and can localize it independently. Often this is possible with the help of a web application without special software. Even in big and open logistic networks the implementation of a GPS-based tracking is feasible if the tracking modules are mobile (requiring their own electricity supply, e.g. via batteries) because no extra infrastructure is needed (Kärkkäinen et al. 2004).
There are lots of advantages of GPS tracking: For example a more transparent transport chain, an increasing delivery performance through faster problem identification, bottleneck identification in procurement logistics, more security for customers, more reliable data for

tour or production planners, an earlier start of logistics event management processes due to faster flow of information and a growing customer satisfaction (Carlino et al. 2009; Brewer et al. 1999). The criticism towards GPS tracking is the unreliability and the inaccuracy of position data because GPS signals are often not available inside of containers or vehicles, in valleys or between high-rise buildings in inner cities because the modules are not able to connect to the required minimum of four satellites.

Today GPS shipment tracking is used for example in container monitoring of overseas transports and for a tracking of railcars. The German logistics company DB Schenker Rail has installed GPS devices in about 15,000 railcars to generate data regarding travelled distance, service intervals or technical condition (Stopka 2009). GPS tracking is also used in context of telematics services, e.g. fleet management. This major practical application of GPS tracking includes vehicle tracking with driver and vehicle data, traffic information and on-board navigation. A GPS module is fixed inside the vehicle and connected with on-board power (Wang and Potter 2008).

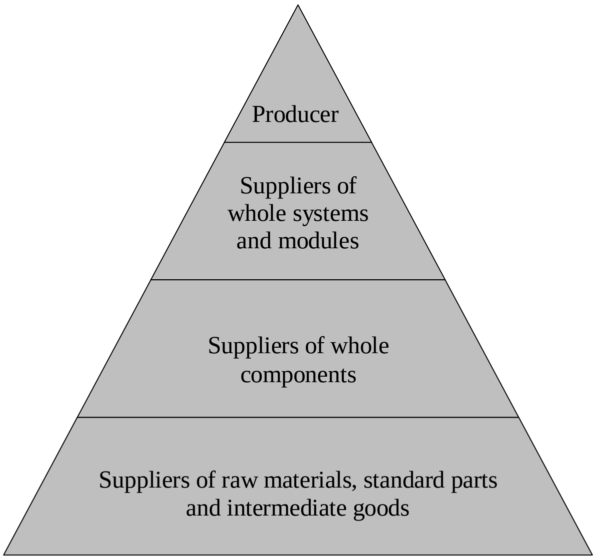
The major challenge is to combine real-time tracking information with production planning and control software to react to an identified delay of purchased goods with a re-scheduling in production or an alternative material input so that a delay in production or even a downtime can be avoided (Schenk and Richter 2007). Discrete solutions like barcode or RFID do not offer the needed information in a satisfied manner because they offer not the possibility to transmit information independently. A suggested solution could be an already described quasi-continuous tracking system with barcode labelled or RFID tagged shipments (intelligent cargo) which were virtually connected to a vehicle with a telematics device to transmit information of loaded items.

Telematics or cargo tracking in production alliances in general support the flow of information and improve the production system by reducing cycle-time, especially if tracking data is generated automatically and is transmitted in real-time to analyze data and to perform necessary actions in time (Brewer et al. 1999). Tracking data has to be continuously available at any time independent of transport mode and company boundaries, reliable and secure as well as easy to transmit and cost-efficient for the producer (Stopka 2009). The problem of using a tracking system within a supply chain is the holistic integration of one system, especially if actors within the supply chain vary from time to time. So for these short-term multi-company networks an independent forwarder tracking solution is needed. By this idea the main difficulties of software integration could possibly be solved (Kärkkäinen et al. 2004).

3. Impact of Track and Trace on Purchasing Process

3.1. Sourcing Strategies

Purchasing in a company is a key function for supporting the production process: Without a reliable purchasing department a successful production is impossible because of purchasing the production is supported with inputs, services and facilities which are needed (Thrulogachantar and Zailani 2010). Purchasing managers have to consider several supplier attitudes when deciding for a specific supplier depending on the sourcing strategy (Burke et al. 2009). Relationships between suppliers and producers experience often in bad atmospheres, win-win situations are rare: Short-term advantages like e.g. low price levels are preferred opposite to long-term fruitful relationships in context of research and development activities or winning of know-how (Wannenwetsch 2010). By contrast, single sourcing strategies, to supply one type of material exclusive from one supplier, gain in importance (Göpfert and Grünert 2009). But besides a single sourcing strategy many other strategies regarding the number and the localization of suppliers exist. The main difference by describing sourcing strategies is the degree of cooperation (González-Benito 2010). Table 1 shows an overview about existing strategies and their characteristics. The research question is what profits could be generate by using which sourcing strategy for the producer as well as for the supplier.



Sourcing Strategies	Characterizations	Degree of Cooperation
Single Sourcing Modular Sourcing Local Sourcing	High performance High dependency	++
Dual Sourcing Domestic Sourcing	Low risks High flexibility	o
Multiple Sourcing Global Sourcing	High flexibility High performance Low costs	--

Table 1. Classification and characterization of different sourcing strategies.

Especially by pursuing single or modular sourcing strategy for whole systems or modules (mostly also A-material) a high dependency between supplier and producer exists. This dependency can be used for common research and development projects or for transmitting knowhow to increase the supplier's performance. Modular sourcing suppliers are often located near the shop floor so that only short transport routes have to be travelled. By pursuing a local sourcing strategy the same characteristics occur (Werner 2010). Raw materials and standard parts were often purchased worldwide and in bigger lot sizes to realize economies of scale. Advantages are low costs according to a competition situation and a high flexibility. That is the reason why long travel times have to be accepted.

Independent of the sourcing strategy, delays or delivery failure of the suppliers were mostly detected not until the materials reach the shop floor in time. The consequence is a downtime in production and activities to organize a quick delivery, for example by plane or another material from an alternative supplier where it is on stock to go on with the production schedule. These are very expensive actions and because of the production downtime additional indirect costs have to be calculated.

Many sourcing risks are imaginable why to decide for a specific sourcing strategy. CANBOLAT ET AL. (2007) give a literature review of potential sourcing risks, which could occur during the whole purchasing process. Necessary when deciding for a specific sourcing strategy is the analysis and evaluation of risk. Important is the event risk, the probability that a failure or a delay of delivery occur and the rating of the risk for the production. A discrepancy on a long travel route is minor grave because reaction time is much longer to initiate counteractions. CANBOLAT ET AL. (2007) suggest a process failure mode and effects analysis to evaluate critical sourcing channels by evaluating severity, occurrence and detection of the different purchasing processes. The two columns of sourcing risks are displayed in figure 3.

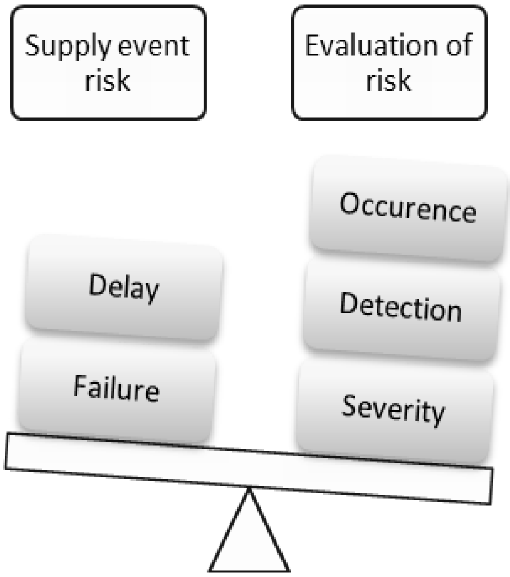


Figure 3. Sourcing risks and evaluation.

The detection of failures within the transportation rises enormously by using a continuous tracking and tracing system for supporting production scheduling department. A discrepancy is then detected at the moment it occurs and starting at this moment checking re-scheduling possibilities in shop floor. For example, the consequence could be a change in sequence of executing orders in production so that a downtime could be avoided.
For production execution, sourcing strategies with only one supplier are unfavourably because the dependency is high and local sourcing strategies are poor as well because alternative suppliers has to be found or an expensive extra transport has to be organized in case of failure. Short travel times in a local sourcing environment do not offer much time to identify alternatives, unless supplier is a retailer and could offer the same material from stock, longer travel times offer a longer reaction time. Apart from that a set of suppliers for each type of material offers more flexibility in a dynamic scheduling environment.

3.2. Material Classification

Purchased goods or materials can differ according to its specificity, availability, quantity, quality, value, demand, etc. (Melzer-Ridinger 2004). The purchasing process for each good is not handled with an equal effort. Goods and materials are classified and are purchased with different sourcing strategies. When realizing an automatic dynamic production scheduling, it has to be defined which materials or which group of materials should be tracked. So it has to be defined which objectives are important for deciding whether the purchasing transports of a material should be tracked or not.
Different classification possibilities are widespread; very common is the ABC analysis. A materials of high value and low demand are often important for the production because they mostly represent core technology of the produced goods and because of that are important for the functionality of the product (a). So a high effort is invested to supply A material of high quality with high savings. Because of the high value of these goods, stock levels are often minimized or totally cut; Just-in-Time is widespread for A materials. So a delivery directly to the shop floor is not a rarity. B or C materials are of (very) low value and often not important for the key functions of the products. Especially C materials which in production environments can be classified as additives are mostly on stock at production, for example by using kanban systems (Melzer-Ridinger 2004). So the inventory strategy (b) for the different

materials is an important objective, which can be identified for example by using ABC analysis.
Besides the ABC analysis, other classification possibilities are common. To evaluate the importance of material for production four main objectives to classify material has been established: quality (c), costs (d), dependability and flexibility (González-Benito 2010). Quality is a main objective to assure high levels of functionality, reliability or durability whereas costs are of interest, e.g. for reaching customer's price range. These two objectives are often conflicting in procurement. Dependability and flexibility mainly describe the relationship between supplier and manufacturer which were discussed in the previous paragraph satisfactory.
Therefore it has to be identified what objectives influence procurement and production. Besides a classification on a value basis, it is important how many of the products required a material, which can be expressed as scope of good within production range (e). The greater the share at product level the more important is the material, independent of value or quality. Another classification would be the importance of the material for the functionality of the product. If the functionality mainly depends on a single material, the importance for purchasing as well as production rises.

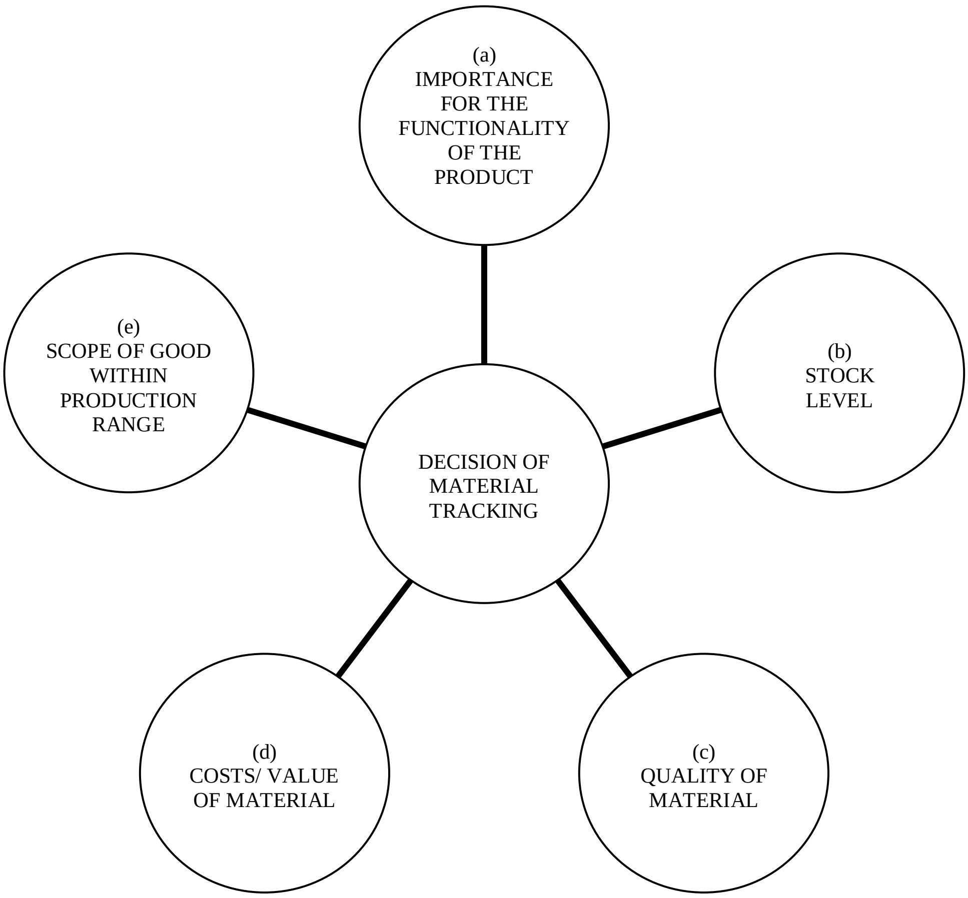


Figure 2. Objectives of tracking decision of materials.

Figure 2 shows an overview of the above mentioned and explained objectives to evaluate material according its importance for production to support the decision whether a type of material should be tracked to generate detailed transport information. To sum up this short discussion following correlations between decision of track and trace of supplied goods and their classification can be drawn:

(a) The higher the importance the more important is supply tracking.
(b) The less the stock level the more important is supply tracking.
(c) The higher the quality the more important is supply tracking.
(d) The higher the value the more important is supply tracking.
(e) The smaller the scope of the good the more important is supply tracking.

As it can be seen many dependency between the different classification characteristics exist, so a decision whether a tracking of supplied goods is beneficial is not trivial by far. But especially for Just-in-Time production strategies it is important to make sure that the material reaches the shop floor in time to avoid downtime. So this challenge of deciding tracking strategy according to specific material should be executed professionally.

3.3. Lot Sizing and Order Intervals

The question of sizing lots in production and the order quantity is important for feeding production. The lot size thereby depends on the production strategy as well as on costs. Smaller lots leads to higher purchasing costs but offer a high flexibility for the production scheduling because order and also delivery intervals by the suppliers are short as well as the inventory level is small. With bigger lots cost savings in purchasing could be generated but this result in a loss in flexibility because of longer order intervals (Gudehus and Kotzab 2009). This dilemma is illustrated in figure 4.

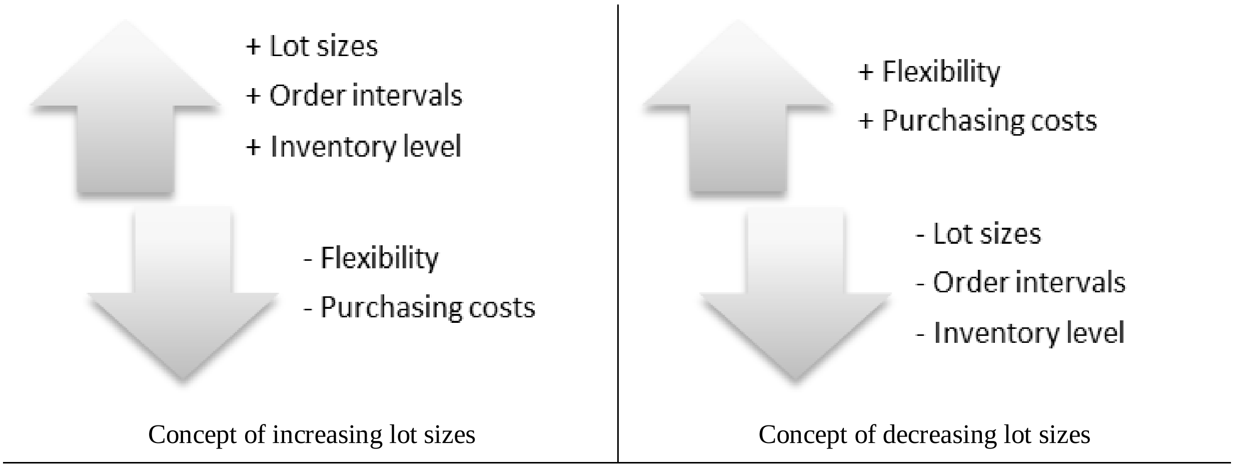


Figure 4. Dilemma of lot sizes and production flexibility.

In a conventional static scheduled production with constant demand the classification of material and the overall costs are the main objectives for estimating optimal lot sizes and order intervals as well as the production strategy, e. g. Just-in-Time. Therefore the following cost rates have to be considered:

- Costs per order,
- Purchasing costs per unit i and
- Stock-keeping costs per unit i.

The optimum of these costs rates results in the economic order quantity model by Andler and Harris (e. g. Wannenwetsch 2010). Further research activities deal with dynamic lot sizing according variable demand (Tempelmeier 2006).

In a dynamic production environment, flexibility is very important for the success of this dynamic environment. A tracking of supplied goods supports this flexibility because based on the tracking data it is impossible to adjust production schedule after unforeseen events.

Empirical study also shows that a concentration on flexibility instead of costs often results in a more successful commercial and financial performance (Gonzàles-Benito 2010). Smaller order quantities result in a higher flexibility for the production scheduling but more supplies increases the event risk in transportation by reducing the importance of an event and vice versa.

4. SWOT Analysis of continuous Track and Trace for Purchasing

4.1. Methodology

The objective of a SWOT analysis is to give an overview of internal strengths and weaknesses of companies, departments or products and external related opportunities and threats. It is often executed as a basis for strategic development discussions and further analysing methods. The results are displayed in a clearly arranged matrix as it can be seen in table 2 (Schawel and Billing 2011).

	Positive	Negative
Internal	Strengths	Weaknesses
External	Opportunities	Threats

Table 2. Presentation of SWOT analysis results.

Summing up, SWOT analysis is a quite easy and integrative methodology, which is the major advantage of this method. It can be discussed if SWOT analysis is goal-oriented for defining strategic policy of purchasing departments, but FRÖHLICH-GLANTSCHNIG (2005) described a systematic approach for analysing strength, weaknesses, opportunities and threats for purchasing departments based on empirical results of a trend researches. Geared at this approach the SWOT analysis is executed in the following chapter to identify operational benefits of track and trace systems for purchasing departments based on the discussion in paragraph 3 and the results of the trend researches by SCHIELE (2010) and BATRAN ET AL. (2011).

4.2 Results

The major goal of tracking supplied goods is to avoid an expensive production downtime. But because of manifold correlations which were described above it is not a general advantage and connected to additional effort to implement a continuous tracking solution within the purchasing process from order till goods receipt. By analysing results of the purchasing trend studies it can be noticed that especially innovative suppliers can benefit based on future developments. Many trends which were mentioned in both surveys depend on the integration of technologies to improve product design as well as process design. SCHIELE as well as BATRAN ET AL. expect that better and more sustainable savings could be reached by establish long-term innovation relationships instead of reducing costs by global sourcing. Based on this the integration of a continuous tracking solution in the purchasing process could support further developments in the future (e.g. some social media or web applications), offers some risks (e.g. higher costs or integration effort), but provides the purchasing department by several additional advantages (mainly the higher security of incoming goods in transit). Table 3 shows the results which were generate by analysing the trend studies in connection with the discussion in paragraph 3.

	Positive	Negative
Internal	<u>Strengths</u> • Higher security for goods in transit (especially for high value/ long transit times) • Better detection problem during supply process • Improvement of automated workflows and event management • Increase of purchasing importance as interface of supplier and shop floor/ construction within the company	<u>Weaknesses</u> • Costs of implementation and operation of a system • Much know-how for the tracking decision necessary
External	<u>Opportunities</u> • Driver for further innovations based on tracking data/information • Win/win-situation in long-term supplier relationships through technological integration • Shorter time-to-customer based on more flexibility in production because actual	<u>Threats</u> • Complicated integration and qualification of new suppliers because they have to support material tracking • Negligence of personal contact with supplier because of technological support

Table 3. Possible impact of supply process tracking for purchasing and supplier relationship.

5. Conclusion and Outlook

The presented research results showed first of all the state-of-the-art in tracking technologies and their increasing implementation in logistics and supply chain applications. Futhermore tracking systems were attached to existing purchasing management fields such as sourcing strategies, material classification systems and lot order sizing concepts. There already it got obvious that the coming improvement and implementation of tracking technologies in logistics will have huge impacts and interactions with purchasing policies in companies and supply chains. Furthermore the subsequent SWOT analysis showed that in a general management view the strengths and opportunities for the use of tracking technologies in purchasing are larger and more prominent than the possible weaknesses and threats attached to them.

Therefore further research and pilot implementations in business practice is necessary and important to gain further experience and results regarding the benefits of tracking technologies within the field of purchasing management.

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6. References

Batran, A., Brumer, I., Schulz, R., 2011. *Challenges in Procurement 2011*. Whitepaper. München, Düsseldorf, Paris, Wien, Zürich: h & z.

Brewer, A., Sloan, N., Landers, T. L., 1999. Intelligent tracking in manufacturing. In: *Journal of Intelligent Manufacturing*, 10 (3-4), 245-250.

Burke, G. J., Carrillo, J. E., Vakharia, A. J., 2009. Sourcing decisions with stochastic supplier reliability and stochastic demand. In: *Productions and Operations Management*, 18 (4), 475-484.

Canbolat, Y. B., Gupta, G., Matera, S., Chelst, K., 2008. Analysing risk in sourcing design and manufacture of components and sub-systems to emerging markets. In: *International Journal of Production Research*, 46 (18), 5145-5164.

Carlino, M., Confessore, G., Liotta, G., 2009. Potentials of satellite-based traceability services in logistics. In: *Proceedings of the European Navigation Conference – Global Navigation Satellite Systems 2009*, Naples, Italy, May 3-6, 2009, 1-6.

Daduna, J. R., 2011. Aspects of Information Management in Road Freight Transport. In: Böse, J. W., Hao, H., Jahn, C., Shi, X., Stahlbock, R., Voß, S., (eds.): *Computational Logistics*. Lecture Notes in Computer Science 6971. Berlin, Heidelberg: Springer, 29-43.

Fritz, M., Schiefer, G., 2009. Tracking, tracing, and business process interests in food commodities: A multi-level decision complexity. In: *International Journal of Production Economics*, 117 (2), 317-329.

Fröhlich-Glantschnig, E. 2005. SWOT-Analyse – Möglichkeiten einer strategischen Beschaffungsanalyse. In: Fröhlich-Glantschnig, E. (ed.): *Marketing im Perspektivwechsel*. Berlin, Heidelberg: Springer, 1-16.

González-Benito, J., 2010. Supply strategy and business performance, An analysis based on the relative importance assigned to generic competitive objectives. In: *International Journal of Operations & Production Management*, 30 (8), 774-797.

Göpfert, I., Grünert, M., 2009. Logistiknetze der Zukunft – Das neue Hersteller-Zulieferer-Verhältnis in der Automobilindustrie. In: Göpfert, I. (Eds.): *Logistik der Zukunft – Logistics for the Future*, 5th edition. Wiesbaden: Gabler, 127-166.

Gudehus, T., Kotzab, H., 2009. *Comprehensive Logistics*. Berlin, Heidelberg: Springer.

Hausladen, I., 2011. *IT-gestützte Logistik. Systeme – Prozesse – Anwendungen*. Wiesbaden: Gabler.

He, W., Tan, E. L., Lee, E. W., Li, T. Y., 2009. A Solution for Integrated Track and Trace in Supply Chains based on RFID & GPS. In: *Proceedings of the 14th IEEE International Conference on Emerging Technologies and Factory Automation*, Palma de Mallorca, Spain, September 22-26, 2009, w.p.

Hillbrand, C., Schoech, R., 2007. Shipment Localization Kit: An Automated Approach for Tracking and Tracing in General Cargo. In: *Proceedings of the 6th International Conference on Management of Mobile Business*, Toronto, Ontario, Canada, July 9-11, 2007, 46-52.

Kärkkäinen, M., Ala-Risku, T., Främling, K., 2004. Efficient Tracking for short-term multi-company networks. In: *International Journal of Physical Distribution & Logistics Management*, 35 (1), 281-309.

Meers, S., Gärtner, H., Nyhuis, P., 2010. Logistische Herausforderungen in Produktionsnetzwerken. In: *ZWF Zeitschrift für wirtschaftlichen Fabrikbetrieb*, 105 (11), 949-952.

Melzer-Ridinger, R., 2004. *Materialwirtschaft und Einkauf, Band 1: Beschaffung und Supply Chain Management*. München: Oldenbourg.

Mohr, G., 2010. *Supply Chain Sourcing. Konzeption und Gestaltung von Synergien durch mehrstufiges Beschaffungsmanagement*. Wiesbaden: Gabler.

Schenk, M., Richter, K., 2007. Telematik und RFID – Elektronische Beobachter gestalten die sichere Warenkette. In: Bullinger, H.-J., ten Hompel, M., (eds.): *Internet der Dinge*. Berlin, Heidelberg: Springer, 77-90.

Schiefer, G. 2008. Tracking and Tracing – A Challenge for System Organization and IT. *Journal of Information Technology in Agriculture*, 3 (1), 19-25.

Schiele, H., 2010. *Innovation von und mit Lieferanten – Ergebnisse einer quantitativen Studie.* Enschede: BME-Report.

Shamsuzzoha, A. H. M., Helo, P. T., 2011. Real-time Tracking and Tracing Systems: Potentials for the Logistics Network. In: *Proceedings of the 2011 International Conference on Industrial Engineering and Operations Management*, Kuala Lumpur, Malaysia, January 22-24, 2011, 242-250.

Schawel, C., Billing, F., 2011. *Top 100 Management Tools*. Wiesbaden: Gabler.

Stefansson, G., Tilanus, B., 2001. Tracking and tracing: Principles and practice. *International Journal of Service Technology and Management*, 2 (3/4), 187-206.

Stopka, U., 2009. Herausforderungen und Potenziale von Mobilfunk-, Ortungs- und Navigationsdiensten in Güterverkehr und Logistik. In: *Wissenschaftliche Zeitschrift der Technischen Universität Dresden*, 58 (1-2), 81-89.

Tempelmeier, H., 2006. *Material-Logistik, Modelle und Algorithmen für die Produktionsplanung und -steuerung in Advanced Planning Systemen*, 6th edition. Berlin, Heidelberg: Springer.

Thrulogachantar, P., Zailani, S., 2011. The influence of purchasing strategies on manufacturing performance, An empirical study in Malaysia. In: *Journal of Manufacturing Technology Management*, 22 (5), 641-663.

Vahrenkamp, R., 2007. *Logistik, Management und Strategien*, 6th edition. München: Oldenbourg.

Van Dorp, K.-J., 2002. Tracking and Tracing: A Structure for Development and Contemporary Practices. *Logistics Information Management*, 15 (1), 24-33.

Wang, Y., Potter, A., 2008. The application of real-time tracking technologies in freight transport. In: *Proceedings of the 3rd International IEEE Conference on Signal-Image Technologies and Internet-Based Systems 2007*, Shanghai, China, December 16-19, 2007, 298-305.

Wannenwetsch, H., 2010. *Integrierte Materialwirtschaft und Logistik. Beschaffung, Logistik, Materialwirtschaft und Produktion*. 4th edition. Berlin, Heidelberg: Springer.

Werner, H., 2010. *Supply Chain Management, Grundlagen, Strategien, Instrumente und Controlling*, 4th edition. Wiesbaden: Gabler.