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ABSTRACT

Calculating the process driven value of RFID investments is very difficult. From a company's perspective it is important to understand the concrete contribution of an RFID system with regard to individual processes. The problem of profitability analyses in IS is that such technologies cannot be calculated as an economic standard investment. Hence, we propose a reference model as a generic knowledge base for referential RFID impacts. Our model supports the structuring and evaluation of RFID benefits along business processes. With this, we propose indicators for the derivation of an RFID cause-and-effect-chain. The allocation of RFID effects to processes within the reference framework helps in identifying the right logistic unit levels for RFID transponder investments.

Keywords (Required)

RFID investments, business value, process-driven analysis.

PROBLEMS OF ANALYSING THE BUSINESS VALUE OF RFID-INVESTMENTS: STATE OF THE ART

According to Thiesse, Floerkemeier and Fleischer (2007) companies from various branches are looking for RFID (Radio-Frequency Identification) based solutions for a wide range of management problems. RFID is a technology that is aimed at automatic identification of objects, by storing data on tags (located on i.e. products) and remotely retrieving this data via radiowaves using RFID transponders. The development of the global RFID market will be very strong especially in the area of supply chain management and logistics (Krasnova, Rothensee and Spiekermann, 2007). In particular, RFID based object identification offers a high dynamic in growth.

Nevertheless, research indicates that many RFID projects are economically not profitable despite of a positive forecast (Gaughan and D'Aquila, 2005; Wilson and Vesset, 2004). From a company's perspective it is important to understand the concrete contribution of an RFID system with regard to individual processes. The problem of profitability analyses in IS is that such technologies cannot be calculated as an economic standard investment. A well-defined scope and well-defined areas of influence are not possible. Furthermore, if the potential investment is strategic, the decision situation can be badly structured with many evaluation deficiencies in effectiveness, achievement of goals, goal definition and problem solving (Farbey, Land and Targett, 1999, p. 195). One cannot judge in advance what parts of the company or supply chain are affected or influenced. Furthermore, a lack of transparency with regard to alternatives increases the uncertainty. It is difficult to measure all effects of an RFID introduction in terms of quantity savings (labour hours, processing times etc.) and money.

Surveys by AMR Research and IDC especially highlight problems in evaluating the effects and effectiveness of RFID systems (cf Gaughan and D'Aquila, 2005; Wilson and Vesset, 2004). A systematic and transparent structuring of the investment decision is necessary to overcome these problems. The article contributes to overcoming these problems by introducing a reference framework approach for the measurement of ubiquitous technologies in supply chain logistics.

RELATED WORK AND RESEARCH METHODOLOGY

In contrary to various studies that focus on output ratios on a company level (e.g. increase in market share, increase in turnover, ROI) (Mooney, Gurbaxani and Kraemer, 1996), these ratios are estimated to be important but not sufficient for the derivation of a cause-and-effect-chain. In fact, a fine granular examination of individual business processes in their overall context seems reasonable. For example, Tellkamp (2006) conducted process based examinations of the RFID potential. Starting from their work, we have examined different logistics processes in accordance to the widely accepted SCOR model (Supply Chain Operation Reference-Model) regarding RFID impacts. The first version of the SCOR model has been developed by the Supply Chain Council in 1996, which currently includes over 1.000 members worldwide. Based on the SCOR model we have started to develop a reference model with a generic knowledge base for referential RFID impacts. Our model supports the structuring and evaluation of RFID benefits along business processes. Therefore, problems with calculating the effects and effectiveness of the process driven business value of RFID investments can be alleviated. Furthermore, benefits of the model include the identification of impact types and impact places within the value chain as well as the basis for a structured analysis combining logistics processes, RFID impacts and impact measurement ratios. Hence, our framework looks at important aspects for the measurement of ubiquitous technologies in supply chain logistics.

The development of the framework for the measurement of RFID technologies in supply chain logistics is based on a design science research approach by creating a new and innovative artefact (Hevner, March, Park and Ram, 2004). Fundamentally, it is a problem solving approach where the creation of new artifacts relies on existing findings that are applied, tested, modified, and extended through the capabilities of the researcher (Markus, Majchrzak and Gasser, 2002; Walls, Widmeyer and El Sawy, 2002).

The development of the reference framework is based on case study research (Eisenhardt, 1989). We follow Weick's (1995) sensemaking paradigm, in which the relevance of the research topic is derived from requirements the authors were faced with during RFID investment projects. The requirements gathered within these consulting projects were balanced with various RFID cases in the literature that have been contextually analyzed in order to build a business value model. Furthermore, knowledge gains from existing models such as SCOR, ARTS and the Retail-H have entered the model as well.

The question, how the human can achieve "true" cognition and therefore a qualitative causal model for RFID investments, aims at the question, whether "true" knowledge can be achieved (Haak, 1978). It is hardly possible to develop and evaluate qualitative research results such as modeling techniques and procedure models, as well as to verify information out of reference models in an objective manner. Hence, this paper is oriented to the consensus theory of truth (Apel, 1979) that implies the consensus among experts of a domain (Kamlah and Lorenzen, 1996). For the verification of the method description and the information contained in reference models and reorganisation recommendations methods like observation, interviews and interpretation of texts are used. The structuring of findings in our reference model especially depends on the subjective experience of the authors. Hence, we propose a reference framework approach that helps to ease the identification of impact types and impact places within the value chain. This is a first approach towards a causal model. It still needs continuative testing and evaluation in the scientific community and practice in order to further develop the approach.

IDENTIFYING THE MODEL ARTEFACTS

Identifying Relevant Reference Objects

Hierarchical processes provide the structure for the conceptual modelling of RFID effectiveness. A hierarchical process in our model refers to a process that belongs to a set of similar processes or as an activity is part of bigger process chain. For example a level 1 process in this sense is "delivery" which is a major logistical process with different process variants on a finer process level. On level 2 a sub-process for level 1 "delivery" process may be "one stage commissioning" as opposed to "two stage commissioning". In turn, on level 3 a more granular process within the process chain "one stage commissioning" is the process "collection of items" followed by the "compilation of logistical units". Hierarchical processes are the core basis of our reference model. The reference process hierarchy only observes processes that are relevant to an RFID investment; relevant processes in this sense may be positively or negatively influenced by RFID investments. The selective collection of processes narrows the decision problem down to relevant objects and therefore reduces the complexity.

The reference process hierarchy contains seven core processes. In figure 1 they are grouped by their relation to customers respectively suppliers. On the left side, processes have a relation to product suppliers or service suppliers, on the right side, processes have a relation to customers. Each core process can be broken down to a fine granular process level.

Next to the processes themselves the affected object and hence the process objects are also relevant. We understand process objects as business objects that are processed within the activity chain. For example, a pallet, a bill of delivery and an invoice that are compared to each other are all relevant process objects for the process of matching. Whether or not an object is a process object or not depends on the context of the process. A process object in the narrow sense of our reference framework is a physical object (e.g. pallet) that can be equipped with RFID transponders. From the supply chain's point of view, this object is a logistic entity or trading unit. The framework classifies these process objects according to ISO classification as product → packaging → transport unit → shipping unit → container → vehicle. Logistic unit level 5 (vehicle) is the highest logistical aggregation level. For example, identical products (level 0) can be combined on a pallet (level 3) and can be loaded on a truck (level 5).

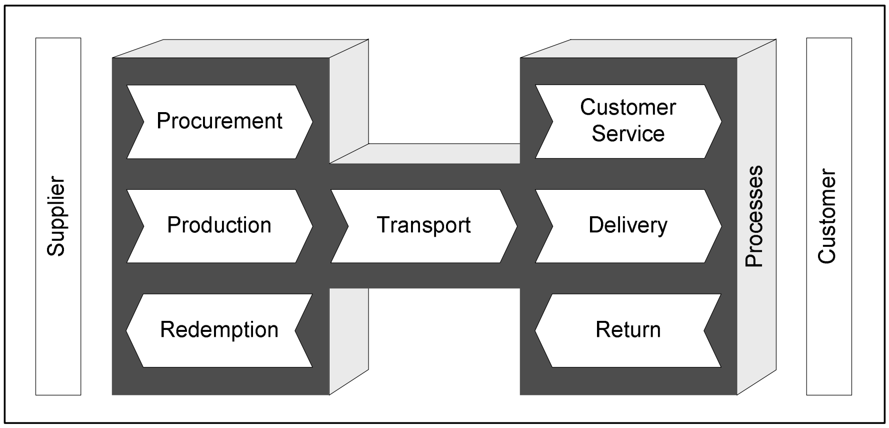


Figure 1. Core processes in supply chain management that are relevant in the RFID context

The process object hierarchy serves as a decision hierarchy for the conceptual evaluation of the technical realization of RFID value. The allocation of process objects to RFID values within the reference framework helps identifying the right logistic unit level for RFID transponder investments. Such a classification helps managers in defining the right RFID implementation scenarios. Furthermore, the allocation lightens the calculation of the process driven business value of RFID investments. From the organisational perspective different players within the supply chain (e.g. manufacturers, retailers, logistics service providers) can execute the processes.

Identifying Relevant RFID Effects

To identify effects of RFID investments on processes we take a top-down approach analyzing IT effects in general before deriving RFID effects in our given context. According to Mooney, Gurbaxani and Kraemer (1996) IT effects can be observed at the level of operational processes as well as on the level of management processes. In general they argue that there are three different types of IT effects:

- automation effects when information technology replaces human labor;
- information effects are caused by the ability of information systems to collect, store, process and distribute information;
- transformation effects are derived from the ability of information technology to permit or facilitate process innovations and changes.

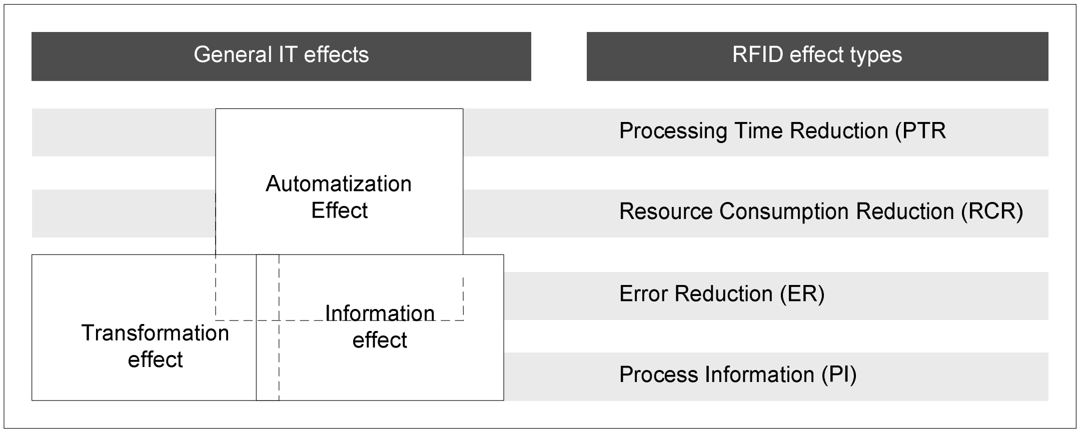


Figure 2. RFID effect types: Specialization of general IT effects

Thanks to the abstract nature of these IT effects, this classification of IT effects can also be used to structure RFID effects (Tellkamp, 2006). Nevertheless, for the development of a process-driven reference RFID effect model, this division is to generic, because no immediate conclusions regarding appropriate assessment methods can be drawn and since these IT effects have a lack of focus on business processes. In addition, a later ratio-based formalization of RFID effects, in the context of an economic analysis, also requires an adequate specialization of general IT effects. Therefore, our reference effect model will comprise four specific RFID effects that are closely related to a process view and comparatively easy to measure. Regarding the conceptual basis of the developed RFID effect types, figure 2[1] shows a mapping of the general IT effect types and how these correlate to the more specific RFID effect types, which we propose and are about to define.

RFID Effect Type „Processing Time Reduction"

Results from numerous case studies such as Tellkamp (2006) and Fleisch, Ringbeck, Stroh, Plenge, Dittmann and Strassner (2004) have shown that process automation of formerly manually performed activities is the most common benefit of RFID systems. Process automation in this sense refers to the partial and complete transformation of manual tasks performed by people towards automatically performed activities operated by RFID systems. Primarily these tasks include data entry and data processing. Both of these tasks are important to automatize, since they have several disadvantages if they are done manually: time consuming, error prone, consumption of auxiliary materials may be necessary.

The RFID effect type "processing time reduction" therefore refers to the savings achieved solely by avoiding human resources for data entry and data processing. A high potential can be seen especially in the automation of routine activities, especially when these are done quite often and are intensive regarding human resources. However, since many processes in warehouse for example already use barcode technology, etc. only looking at this RFID effect type alone seems to be inappropriate for an extensive evaluation of RFID systems (Beckenbauer, Fleisch and Strassner, 2004).

RFID Effect Type „Error Reduction"

A high proportion of manual process execution not only binds human resources, but is also error-prone. An error (especially incorrect data collection or processing) here refers to a deviation from a standardized process execution. The focus lies on the reduction or even avoidance of even multiplying consequences that data and processing errors can have throughout the value and supply chain. Not all errors in a supply chain must have multiplying consequences due to a certain fault tolerance in processes and process networks. This is the case for example if a supplier delivers the wrong articles to a retailer, but the retailer can compensate this wrong delivery by using his safety stock to deliver the articles to a customer on time. Bronner (1992) argues that an increase in the complexity of supply chain networks, resulting from the number of relations between processes rather than the number of processes themselves, leads to a decrease in the fault tolerance of processes.

[1] The mapping of RFID effect types to general IT effects considers typical business contexts and neglects potential exceptions. The graphical overlap of IT effects is only for mapping purposes regarding RFID effect types and does not imply any substantive overlap regarding IT effects themselves.

The RFID effect type "error reduction" only refers to those errors that can be avoided or reduced through the use of RFID technology; errors that cannot be reduced by the use of RFID technology are not relevant for the added value of the RFID system.

RFID Effect Type „Resource Consumption Reduction“

Material assets of a company (in opposition to human resources, which are expressly excluded since these are already subject of the RFID effect "processing time reduction") in the context of RFID effects are referred to as resources. Resource consumption therefore means that money and material resources are consumed in a company. If, however, a RFID effect type "resource consumption reduction" takes place, we conclude that consumption of resources in relevant processes (process costs) is minimized:

- material: material costs, especially operating materials and consumption tools;
- funds: costs for external services and imputed costs, especially capital commitment (e.g. the need for security stocks), warehousing and depreciation (e.g. for the use of a vehicle fleet).

The following example shall clarify the "resource consumption reduction" effect. If we take a look at the commissioning process of a warehouse, which is supported by RFID technology, some possible resource consumption reduction effects can occur in the following areas:

- elimination of consumables for the printing of commissioning lists (material)
- reduction of depreciations for a commissioning PC and printers (funds)
- reduction of the number of conveyance vehicles (funds)
- reduction of the fuel consumption for conveyance vehicles (material).

RFID Effect Type „Process Information“

Enhanced „process information“, as an effect of RFID investments, can occur when electronic data is captured, processed and disseminated by RFID systems. Enhanced "process information" in our understanding depends on the nature of the process information, which is obtained through the RFID system. Here, only process information that results in more effective and or efficient processes is considered to be a relevant RFID effect. Therefore, new process information needs to be available upfront. Furthermore, information granularity and or timeliness of process information can be an indicator for enhanced process information. Error reduction due to better process information, however, is not considered to part of this effect type since the other RFID effect types "error reduction" and "customer satisfaction" already relate to this effect.

Figure 3 presents a summary of the characteristics of our identified RFID effect types, which are part of the reference effect model.

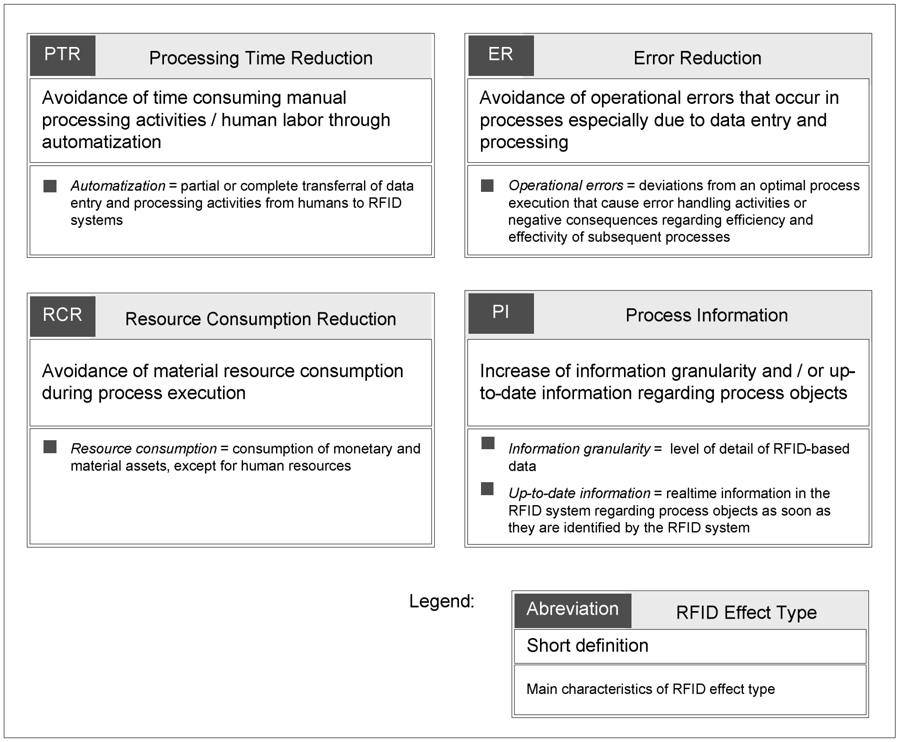
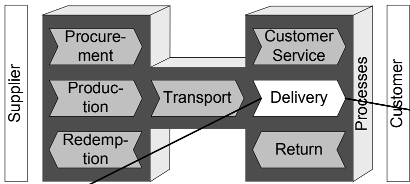


Figure 3. Characteristics of the selected RFID effects classification

DERIVING THE RFID BUSINESS VALUE MODEL

The core of our model is built upon the four component types: processes within a process hierarchy, process objects, supply chain roles and the four already discussed RFID effect types.

The seven RFID relevant core processes of a company (procurement, production, redemption transport, customer service, delivery and return) are first organized in an H-form depending on their proximity to the supplier side or customer side. In addition, each core process is broken down by two levels for a deeper process insight. On the lowest-level processes are mapped to supply chain roles. This mapping allows a quick documentation of the typical processes that are relevant for companies for a RFID cost-benefit analysis, depending upon the company's individual supply chain role. On the process level we also recorded which of the six RFID relevant process objects (product, product packaging, transport unit, reusable transport unit, cargo container, vehicle) typically must be considered for process analysis. The RFID effect types are also mapped on the lowest level processes and thus illustrate the extensive impact that RFID solutions can have on enterprises (fig. 4). For example, the collection of articles (D1a.1) in a one-stage commission (D1a) can be done by manufacturers, suppliers, retailers or logistic service providers. RFID objects can be used on product level, product packaging level or transport level. The usage of RFID can lead to processing time reduction, error reduction and resource consumption reduction.



Delivery

Supply chain role						Process			Process object						RFID effect			
Manufacturer	Supplier	Retailer	Logistic service provider	Other Service Provider	Consumer	Level 1	Level 2	Level 3	Product	Product packaging	Transport unit	Reusable transport unit	Freight container	Vehicle	Processing time reduction	Error reduction	Resource consumption reduction	Process information
							D1a One-stage commissioning											
x	x	x	x					D1a.1 Collection	x	x	x				x	x	x	
x	x	x	x	x				D1a.2 Compilation of logistical units	x	x	x	x			x	x	x	x
							D1b Two-stage commissioning											
x	x	x	x					D1b.1a Collection	x	x	x				x	x	x	
		x						D1b.1b Placing of articles into sales area	x	x	x				x		x	x
x	x		x	x				D1b.2a Resorting	x	x	x				x	x		x
		x						D1b.2b Shelf replenishment	x	x	x				x		x	x
x	x		x	x				D1b.3a Compilation of logistical units	x	x	x	x			x	x	x	x
		x						D1b.3b Removal of articles from shelves	x	x								x
							D2 Goods issuing											
x	x		x	x				D2.1a Creation of accompanying documents	x	x	x	x	x		x	x		x
		x						D2.1b Generation of sales slip	x	x					x			x
x	x		x	x				D2.2a Book out	x	x	x	x	x		x	x	x	x
		x						D2.2b Check-out	x	x	x				x			x
							DS Delivery support											
x	x	x	x	x				DS.1 Delivery evaluation										x
x	x	x	x					DS.2 Customs	x	x	x	x	x	x	x			x
x	x	x	x		x			DS.3 Status tracking										x

Figure 4. Extract from the RFID framework for delivery processes

For the use of the RFID reference effect model in the context of company-specific RFID cost-/benefit analyses, we recommend to adjust the underlying reference processes according to the individual business processes. The transformation of the general reference effect model towards a company specific RFID effect model for processes can be done by two different routines: attribute-based or generic. Attribute-based transformation refers to the selection of processes of the reference effect model based on a company's supply chain role. Generic transformation refers to the modification of processes in the reference model, as well as insertion of new processes, which may be company specific and not already documented in the reference process model. Both of these adjustment mechanisms can be used individually as well as in combination. In the ideal case an attribute-based selection is first executed to filter relevant processes for a company. Then – if necessary – a more time- and cost-intensive generic adaptation of the reference effect model is done.

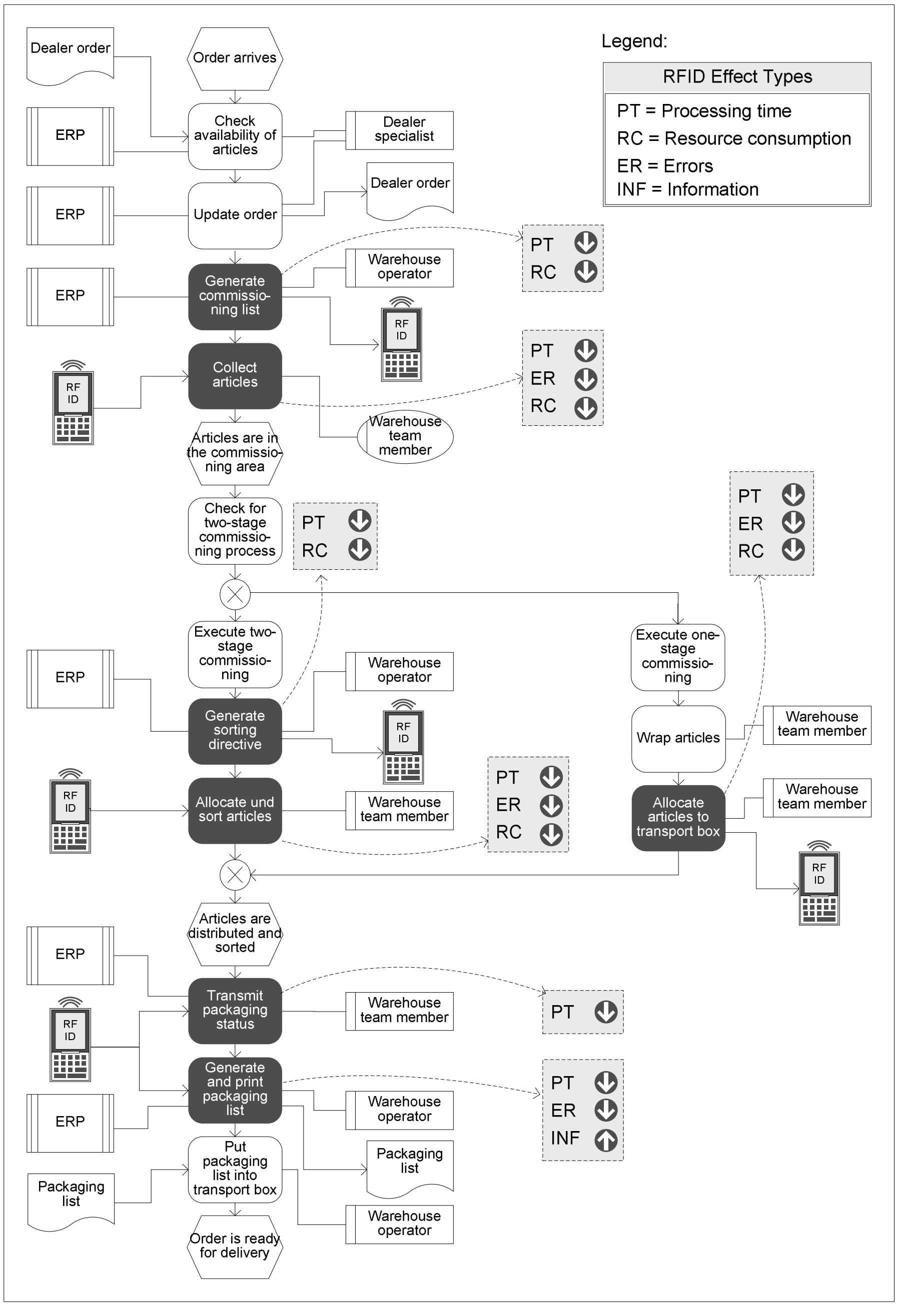


Figure 5. Example of an underlying business process

In figure 5 we show an example of an underlying process in the EPC-notation that locates RFID relevant process parts. The EPC represents a (shortened) example of a process with RFID usage. Within the delivery process the articles have to be collected in the warehouse. For that, the warehouse operator has to generate a commissioning list. In some warehouses, where the list is compiled manually, many companies already use modern technologies such as pick-by-voice or pick-bylight in combination with automatic generation through the ERP system. An electronic generation that will be sent to RFID handheld readers helps to reduce processing time and resource consumption. Even though picking technologies help reducing the processing time already, they are not able to identify articles with serial numbers that are stored on the same storage cell. Hence, RFID helps reducing picking errors and also helps reducing picking times as employees do not have to confirm each pick and are faster with the picking of goods. In addition, the electronic preparation of sorting directives for RFID readers can improve processing times and resource consumption as well because warehouse employees are able to allocate and sort articles faster and less erroneous. Furthermore, the allocation of articles to transport boxes is less error-prone because the article combination can be checked during any time of the process.

The process changes here predominantly refer to the above discussed automation effects. In addition to the development of formal process descriptions, the main task for the modelling of to-be processes can be seen in the systematic discovery, localization and documentation of RFID effects within the specified processes.

CONCLUSION AND FUTURE RESEARCH

Calculating the process driven value of RFID investments is very difficult. With the help of our proposed reference framework approach it becomes easier to identify the impact types and impact places within the value chain. Building a reference model for the evaluation of RFID investments is a first step for company specific assessments. With the adaptation of the reference effect model to a company's specific situation, a basis for a process-driven economic analysis of RFID investments is given. Such a customized model then requires the further development of ratio categories and specific assessment ratios related to the identified RFID effect types.

So far, the reference model is work in progress. By creating a comprehensive ratio framework for the processes and RFID effects in each process, we expect to be able to define ratio hierarchies and aggregate ratios to calculate key ratios giving an overall estimation of the value of an RFID investment based on underlying empirical data from various branches and projects.

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