Abstract
The aim of the article is to open a discussion about information systems that support reverse logistics processes. The outcome of the article is a concept of reverse logistics information system and will serve as a bottom line for further research in this area.

Reverse logistics has been occurring in academia discourses since 1974 and a positive trend of more frequent presence in logistics literature can be spotted. This article follows such a trend and tries to summarize and broaden the information technology topic in the reverse logistics field, as there are only a few works on the topic. This situation is in direct contradiction with the significance of information technology and information systems in the current economy.

The aim of the article is to open a discussion about information systems that support reverse logistics processes. The outcome of the article is the concept of a reverse logistics information system and will serve as a bottom line for further research in this area.

In order to gather knowledge about the current state of the art the, a literature review on the following topics was made: reverse logistics processes, information system support of reverse logistics processes, models of corporate information systems. The design is also a result of findings from the literature review and from research that was aimed at value creation in reverse logistics.

Keywords: Reverse logistics, information system support, business processes, information systems model

1. INTRODUCTION

The term “reverse logistics” appeared for the first time in the article: “Reverse channels for recycling: an analysis for alternatives and public policy implications” in 1974 [1]. This doesn't mean that reverse logistics hadn't existed before. It has only begun to be explicit since then. The formal definition of the term was published in 1992 by Council of Supply Chain Management [1]. At that time, the research on reverse logistics began [2]. Since then, the interest in reverse logistics has been showing a positive trend continuously [2], [3], [4].

The importance of reverse logistics in the current economy was proved by several studies. Some industries have to deal with returns as high as 50% [5], the value of goods returned annually in the USA exceeded $100 billion [6], proper reverse logistics management can lower total logistics costs by 10% [7], the return costs in the US market reached 4.5% of total logistics costs [8]. Therefore, the proper management of reverse logistics provides an opportunity for lowering total logistics costs and by reselling returned products to increase company's returns. One possibility of how to improve reverse logistics performance is by information technology. The positive impact of information technology on the supply chain is documented [9], [10], [11], [12]. Thus, we can assume that information system support could have potential towards performance of reverse logistics.

Despite the potential and increasing trend of interest in reverse logistics, there is less rather than more known about it. Interest in reverse logistics is not by far comparable with the interest in Supply Chain Management [13]. Moreover, the information system support of reverse logistics is one of the least explored areas of reverse logistics [14]. Therefore, it was necessary to start the research with an overview of current state of the art, which was published in [14]. The outcomes are that the knowledge about the information
support of reverse logistics is not very wide and is scattered throughout various sources and most of them aim primarily at other topics than information system support [14].

As there is little known about the information system support of reverse logistics, the aim of the article is to identify the processes of reverse logistics and suitable types of information systems and synthetize this into a concept of a reverse logistics information system. This should serve as a bottom line for further research on that topic.

The rest of the paper is organized as follows. A brief literature review is presented in the next chapter. It covers the following topics: reverse logistics, processes of reverse logistics, existing information systems supporting reverse logistics, information system support of reverse logistics, and models of information systems. Next, a concept of an information system that supports reverse logistics is introduced. Outcomes and future research will be discussed in the last section.

2. LITERATURE REVIEW

2.1 Reverse logistics and its processes

For the purpose of this article reverse logistics is defined as: The process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal [5].

Although reverse logistics is technically part of the Supply Chain Management, it is better to distinguish between forward flows (supply chain) and reverse flows. Therefore, the term closed-loop supply chain is used for the combination of both forward and reverse flows [5].

No proper business process analysis of reverse logistics was found in the literature. For the purpose of this article the modified model of Pokharel and Mutha [3] was used. The authors developed the model only on high level abstraction, so the description (content of the terms) of the processes had to be gathered from other articles (see Tab. 1). Unfortunately, for some processes, there are no proper standardized definitions. Therefore, only possible activities were gathered from [3], [15].

As some processes may seem almost identical by definition to forward flows in supply-chain, the reality is different. For example the transportation has very different characterization. The transportation pattern typical for forward flows is one to many, although the pattern many to one is typical for reverse logistics [16]. Another differences concerning varying quality and packaging of a product, bigger difficulties to forecast, more exception, non-consistent inventory management, less transparent process visibility [16]. Therefore, it is not possible to use information systems available for forward supply chains.
### Tab. 1: Processes and activities of reverse logistics

<table>
<thead>
<tr>
<th>Process</th>
<th>Description</th>
<th>Activities</th>
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<tbody>
<tr>
<td>P1. Inputs (Collection)</td>
<td>Collection refers to all activities rendering used products available and physically moving them to some point where further treatment is taken care of [15].</td>
<td>Pricing, Categorization of returns, Purchasing, Transportation, Storage activities</td>
</tr>
<tr>
<td>P2. Coordination</td>
<td>only activities</td>
<td>Coordination, Communication</td>
</tr>
<tr>
<td>P3. Remanufacturing (Re-processing)</td>
<td>Re-processing means the actual transformation of a used product into a usable product again. This transformation may take different forms including recycling, repair, and remanufacturing. In addition, activities such as cleaning, replacement, and re-assembly may be involved [15].</td>
<td>Managing remanufacturing (MRP), Disassembly</td>
</tr>
<tr>
<td>P4. Supply chain planning</td>
<td>only activities</td>
<td>Strategic planning, Decisions, Location and allocations problems, Forecasting</td>
</tr>
<tr>
<td>P5. Inventory control</td>
<td>only activities</td>
<td>Inventory control</td>
</tr>
<tr>
<td>P6. Outputs (Disposal or resale)</td>
<td>Re-distribution refers to directing re-usable products to a potential market and to physically moving them to future users [15].</td>
<td>Transportation, Sales, Storage activities, Pricing</td>
</tr>
</tbody>
</table>

#### 2.3 Information systems supporting reverse logistics

In reverse logistics, the support from powerful management information system is scarce [17]. Although the availability of commercial systems is rising, they still require a fair deal of customization [18]. The available literature does not contain any comprehensive requirements for reverse logistics information systems. Klapalová et al. [14] gathered known requirements for information systems that support reverse logistics:

- R1. enabling external communication and coordination with involved parties,
- R2. managing returns and remanufacturing routing,
- R3. integrating return information into database,
- R4. providing advance notification that returns will be received,
- R5. supporting decision making,
- R6. supporting life-cycle management,
- R7. supporting external and internal coordination and automatizing of activities.

#### 2.3 Information system models

Any (conceptual) model of information system can't be designed without a taxonomy that would theoretically support it. In previous sections reverse logistics processes were described and suggestions about some
information system support of reverse logistics stated. The former will be used together with findings from this section to design the concept model.

The IS taxonomies and models began to appear soon after the start of the commercial using of IS/ICT. Probably the first taxonomy was introduced in 1958 and it inspired most other taxonomies [19]. The typical taxonomy including transaction processing systems (TPS), management information systems (MIS) and decision support systems (DSS) can be compared to a pyramid with TPS being the foundations and DSS being the top. But these traditional categories are inadequate for many information systems being developed today [19]. Nevertheless, the influence of the pyramid model is strong even now and is used mostly for educative purposes as simplification.

But the pyramid model doesn't reflect the current state of the art in IS/ICT field [19]. Therefore, there was a need to create a new taxonomy that would explain the new reality [19], [20]. Choosing taxonomy depends on the purpose why it needs to be chosen. The taxonomy (see Tab. 2) that is used in this article is based on the type of support the systems provide [19].

**Tab. 2:** Doke's and Berrier's [19] information systems taxonomy

<table>
<thead>
<tr>
<th>System</th>
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<tbody>
<tr>
<td>DCS</td>
<td>Data Communication System: used to share and transfer information.</td>
<td>GIS</td>
<td>Geographical Information Systems: manipulates and analyses information based upon its spatial location.</td>
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<tr>
<td>DSS</td>
<td>Decision Support Systems: class of systems that support decision making.</td>
<td>IRM</td>
<td>Information Resources Management Systems: involves the integration of diverse disciplines, technology, database and other information handling resources.</td>
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<tr>
<td>EDI</td>
<td>Electronic Data Interchange: transfer of data for businesses with customers and vendors.</td>
<td>MIS</td>
<td>Management Information Systems: provides past, present and future information that support decision making.</td>
</tr>
<tr>
<td>EIS</td>
<td>Executive Information Systems: designed specifically to provide information for one or more executives, typically in preformatted displays.</td>
<td>SDSS</td>
<td>Spatial Decision Support Systems: offers specific solutions that can be derived from spatially referenced data.</td>
</tr>
<tr>
<td>ESS</td>
<td>Executive Support Systems: supports needs of executive through mathematical modeling.</td>
<td>SIS</td>
<td>Strategic Information Systems: use of information technology intended to support or shapes the competitive strategy of the enterprise.</td>
</tr>
</tbody>
</table>

3. CONCLUSION

We have used a literature review to design a concept of an information system supporting reverse logistics (see Fig. 1). The model tries to connect existing types of information systems with requirements. The requirements are tried to connect with processes according to definitions and activities. Not all connections are indirect (i.e. information system – requirement – process). Some information systems were not used and some were used more than once.

The concept has some limitations mainly because of incomplete list of requirements and activities with process definitions. Therefore, the main use of this concept is to formulate further research. First, the missing knowledge needed to construct better and more complete model are required. Because as there is not any proper business process analysis of the reverse logistics and no available list of requirements is comprehensive, future research should focus on that topic. Without suitable process analysis, all conceptual information system models will be lacking important point of view.
Second, there is little known about types of information systems that are really used in practice. Therefore, some study focused on types of information systems among companies are dealing with reverse logistics should be made.

We hope that this article will contribute to the knowledge in the field of information system support of reverse logistics and it will open discussion about this topic. Hopefully, future research will broaden this narrow topic further.

Fig. 1. Concept of an information system supporting reverse logistics

LITERATURE


