Association for Information Systems
AIS Electronic Library (AISeL)

Wirtschaftsinformatik Proceedings 2009 | Wirtschaftsinformatik

2009

RFID IN REVERSE LOGISTICS RESEARCH FRAMEWORK AND ROADMAP

Lars Thoroe
Georg-August-Universität Göttingen, Institut für Wirtschaftsinformatik

Adam Melski
Georg-August-Universität Göttingen, Institut für Wirtschaftsinformatik

Matthias Schumann
Georg-August-Universität Göttingen, Institut für Wirtschaftsinformatik

Follow this and additional works at: http://aisel.aisnet.org/wi2009

RFID IN REVERSE LOGISTICS
RESEARCH FRAMEWORK AND ROADMAP

Lars Thoroe, Adam Melski, Matthias Schumann[1]

Abstract
Reverse logistics is constantly gaining in importance for both research and practice. Research on RFID has so far concentrated on the use of RFID in order to support forward logistics processes, but is beginning to realize the specific potentials and benefits of RFID systems in this evolving research area. IS research has so far addressed individual and rather isolated aspects of this topic. In order to promote this evolving field of RFID research, we present a structuring framework and propose a roadmap for future research.

1. Introduction

The integration of the real and the virtual world by the use of Ubiquitous Computing technologies promises new possibilities regarding the control of operational processes. In the context of logistics and supply chain management this integration corresponds to the linkage of flows of material and flows of information. The focus of both research and practice has so far been the use of RFID in order to support the classical logistics processes along the supply chain from suppliers to producers, retailers and customers. Flows of material which run in the opposite direction of the classical supply chain have in recent years increasingly been the subject of logistics research and practice. Collecting and processing goods and material outside of the classical processes of source, make, deliver are gaining importance due to changing socio-economic and legal conditions. These changes pose new challenges to logistics which are addressed by a relatively new area of logistics research denoted as reverse logistics. So far, IS research has only addressed isolated cases and aspects of the use of RFID in reverse logistics. In order to promote this emerging research area we provide a framework, which organizes the field in definable layers and interconnections. Based on this framework, we propose a roadmap for future research. The paper is organized as follows. In Section 2 we briefly present the concept of reverse logistics and review existing research on RFID in reverse logistics. In Section 3 we introduce our framework, based on which we propose a roadmap for future research in Section 4. The paper ends with the conclusion in Section 5.

---

[1] Georg-August-Universität Göttingen, Institut für Wirtschaftsinformatik, Professur für Anwendungssysteme und E-Business; Platz der Göttinger Sieben 5, D-37073 Göttingen

2. RFID in reverse logistics – state of the art

2.1. Concept of reverse logistics

A consensus regarding the definition of the relatively new concept of reverse logistics has not yet been reached in the scientific literature. The first proposals for a definition are from the early 90s and are limited to aspects like waste management and recycling [5; 8]. Nowadays, the term reverse logistics is mostly conceived in a more general sense, as is the case in the following definition, which was developed by the European Working Group on Reverse Logistics: "The process of planning, implementing and controlling flows of raw materials, in process inventory, and finished goods, from a manufacturing, distribution or use point, to a point of recovery or point of proper disposal" [5]. This definition encompasses flows of material originating from the end customer as well as those having its source further up the supply chain.

2.2. Literature review

One of the characteristic attributes, which distinguishes reverse logistics flows from those in forward logistics, is the increased uncertainty [4; 36]. This uncertainty pertains to time, amount and source of future flows, as well as identity and condition of the logistical objects which form the flow. The potential use of RFID in order to remedy the uncertainty in reverse logistics flows is mentioned by many authors [3; 11; 29; 38]. However, there is no profound analysis of potential applications of RFID in the reverse logistics literature. Previous research in the area of Ubiquitous Computing has addressed the use of RFID in some areas of reverse logistics:

Parlikad et al. (2003) analysed requirements for object-related information in the context of reuse and recycling of end-of-life products [31]. Kulkarni et al. (2005) discuss the same topic in more detail. In their article, the authors present two case studies dealing with electronics product recovery and point out the benefits of object-related information provided by RFID-based information systems [25]. Dörsche et al. (2005) [7] and Khan et al. (2006) [20] propose a system for the support of product recovery decisions of vehicle components based on embedded sensor-equipped RFID tags. Kulkarni et al. (2007) [26] and Parlikad et al. (2007) [32] present quantitative models analyzing the value of RFID in remanufacturing. Another subject of research has been the use of RFID in managing the collection of product returns. Koh et al. (2003) have illustrated how RFID-enabled unique identification can support the collection of returns emanating from the customer (push-returns) [21]. These benefits have been corroborated in some practical applications, e.g. in speeding up return processes of printers at Hewlett-Packard Brazil [14]. The use of RFID systems in order to limit the negative impacts of product recalls (pull-returns) has been the subject of various publications dealing with models and methods for enhanced product tracing using RFID [e.g. 1; 6; 12; 19]. Karaer and Lee (2007) analyze benefits of RFID-based inventory information in handling returns at a distribution centre [18]. Benefits of RFID systems to support the management of returnable containers are relatively well documented in the relevant literature. The RFID-enabled increased visibility of containers such as bins, kegs and boxes has shown to decrease losses due to shrinkage and undocumented damages in sectors ranging from automotive to beverages industry and postal services [13; 30].

Potential negative impacts of Ubiquitous Computing in general and widespread use of RFID in particular have been the subject of research in recent years. In one of the earlier works, Hilty et al. (2003) address environmental risks connected with the vision of Ubiquitous Computing [17]. Koehler and Som (2005) analyze effects of this vision on sustainable development, pointing out – among other effects such as health-related aspects and social implications – the environmental impacts of integrating devices into everyday objects [22]. They identify increased resource consumption as well as the entry of electronics waste into other waste streams as the main threats.

Recently, the focus has shifted from Ubiquitous Computing in general towards RFID in particular. Kräuchi et al. (2005) assess the threats of widespread item-level tagging to waste management processes. For several scenarios concerning the diffusion of RFID, they analyze the quantities of different materials contained in transponders and try to identify potential consequences for waste management processes in Switzerland [23]. Based on this analysis, Wäger et al. (2005) call for a number of precautionary measures in order to reduce negative environmental impacts [37]. Gliesche and Helmigh (2007) conducted a more detailed analysis of the negative effects on processes in the recycling of plastic, paper, glass and aluminum [15].

Although all these works address some important aspects of RFID in reverse logistics, they are still piecemeal and do not cover the research area as a whole. We therefore present a structuring framework in order to promote this emerging field for research.

3. Framework

Our framework consists of five layers, which we have identified as important sub-areas when assessing the role of RFID in reverse logistics. An overview of the framework is given in Figure 1, followed by a more detailed description of its layers.
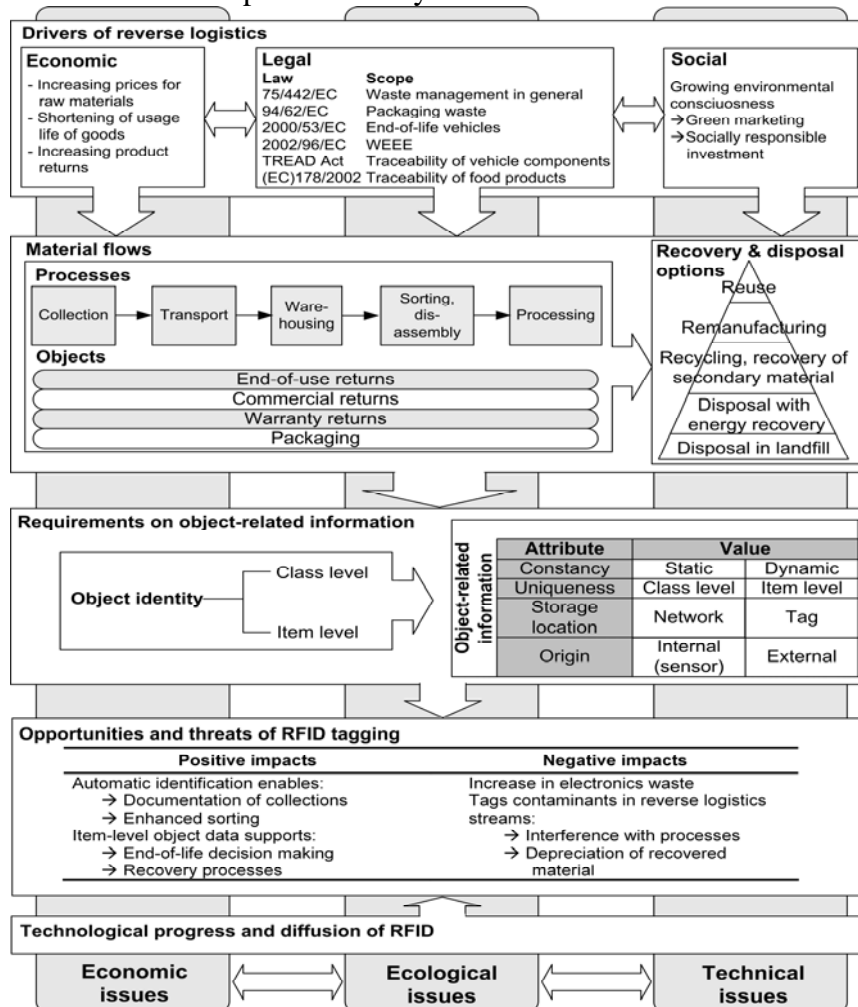

Figure 1: Research framework for RFID in reverse logistics

3.1. Influencing factors and drivers

The top layer of the framework describes the factors which cause the increase in importance of reverse logistics in recent years. These drivers pose new demands for reverse logistics processes, which in turn give rise to new requirements on additional object-related information. In the relevant literature, these driving forces are usually divided into legal, economic and social factors [5; 10; 29].

The first main area, in which legislation acts as a driving force on the importance of reverse logistics, is waste management and recycling. The growing social consciousness of ecological matters is, especially in Europe, reflected in recent legislation. Several laws have been passed promoting reuse and recycling of end-of-life products as well as intensified use of returnable packaging [27]. Table 1 shows an overview of the most important EU legislation on waste management:

Table 1: EU legislature on waste management

Directive	Scope	Contents
75/442/EC	Waste management in general	Umbrella Framework specifying general goals of waste management: avoidance of generation, promotion of recovery
94/62/EC	Packaging waste	Specific goals for reuse and recycling of packaging
2000/53/EC	End-of-life vehicles	Producer responsibility for recycling; quotas for recycling and reuse of vehicles and components
2002/96/EC	Waste electrical and electronic equipment	Producer responsibility for recycling; quotas for recycling and reuse of WEEE

The second area of legislation posing new challenges for reverse logistics is traceability and recall management. In recent years, several recalls due to safety concerns of food and other safety critical consumer goods have created numerous scandals and shattered consumer trust. Legislation responded with new laws on recall management tightening accountability and requirements on traceability for all supply chain partners. Two prominent examples are the TREAD (Transportation Recall Enhancement, Accountability and Documentation) Act which targets carmakers in the USA and the EU regulation 178/2002 which concerns the food industry [35]. Changing economic conditions also add to the continuous increase in importance of reverse logistics [5; 33]. Average usage periods of goods are decreasing. Therefore products which are disposed of by the end customer often still contain considerable value, which may be recovered profitably. An example is the remanufacturing of mobile phones which is done successfully since the mid-1990s [16]. Prices for almost all categories of raw material are constantly increasing since 2000 due mostly to increased demand induced by the economic growth of newly industrialised and emerging countries. For this reason, the use of secondary raw materials obtained from waste of industry and private households is increasingly economically advantageous [2]. Another economic driver is seen in booming e-commerce. With e-tailers traditionally suffering from a relatively high ratio of returned products, this results in increased effort in handling returns. The growing social environmental consciousness not only influences legal conditions of business, it is a driving factor of reverse logistics in its own right. As more and more consumers and investors include ecological considerations in their decisions, they are targeted by so-called green marketing, in which companies try to communicate ecological corporate and product images [9].

3.2. Material flows

Material flows as the central matter of reverse logistics practice and research is the second layer of our framework. Based on the definition in Section 2.1., the following categories of reverse logistics flows can be distinguished [5; 10]

- End-of-use returns: This category encompasses goods that are disposed of when their time of use has expired.
- Commercial returns: These flows are unused products returned in order to undo a preceding business transaction. The bulk of this category consists of returns from consumers to retailers, however these flows can occur between any two parties in a supply chain.
- Warranty returns: Defective or damaged products that are either returned by the recipient or recalled by the vendor fall into this category.
- Packaging: This category encompasses nonreturnable and returnable packaging, e.g. boxes, pallets, barrels, product packaging etc.
- Production scrap and by-products: We do not consider this fifth category in our framework as it is of relatively low relevance within our scope.

Apart from basic logistics processes as transport, storage and cross-loading, reverse flows consist of the following specific processes: The collection of logistical objects constitutes the start of reverse material logistics flows. Two kinds of collection processes need to be distinguished. Pull collections, which are triggered by the receiving party (e.g. producer recalling defective products) and push collections, which are prompted by the source of the flow (e.g. customer after concluding usage of a product). As reverse flows are – in comparison to forward flows – relatively heterogeneous [35], some kind of sorting is often required. Sorting splits heterogeneous material flows in separate fractions for further processing. Similarly, disassembly processes may be needed in order to separate components for separate processing. At the end of the reverse logistics process chain, objects are processed and subjected to a variety of recovery and disposal alternatives. According to the relevant EU legislature, these alternatives form a hierarchy with priority given to reuse, and disposal in landfill as the least desirable option.

The role of RFID in these processes is twofold: Firstly, RFID tags as part of these material flows are themselves objects, which pass through the reverse logistics process chain towards recovery or disposal. Secondly, the tags may provide object-related information and thus act as instruments for these processes.

3.3. Requirements on information flows

The influencing factors depicted in the top layer pose challenges for reverse logistics processes, some of which entail new requirements for object-related information. Reverse logistics processes have – in comparison to forward logistics – specific requirements for object identification and information, because these processes are relatively poorly controlled and monitored [35]: In forward logistics, object identities are seldom completely unknown at process transitions, as they are often announced by preceding information flows. As forward logistics systems are usually well monitored, the object state is relatively stable. By contrast, reverse logistics processes are far less planned and so far hardly controlled by information systems. Furthermore, reverse logistics objects are far more heterogeneous. Formerly homogenous objects are subject to generation of variants once they leave the controlled systems of forward logistics, which calls for a finer granularity of object-related information. These characteristic requirements on object identification and information are summarized in Table 2.

Table 2: Identification and information requirements in forward and reverse logistics

Characteristic	Forward logistics	Reverse logistics
Identification purpose	Confirm relatively certain identity	Establish completely unknown identity
Object configuration	Static bill of materials, documented at class-level	Dynamic bill of materials, to be documented at item-level
Object state	Rather known and static due to	Rather unknown, sensor-equipped RFID tags document

	controlled processes, sensor-equipped RFID tags serve quality checks	unknown effects in usage life
Sufficient tagging level for product identification	Product packaging	Packaging, product (and components)
Prevalence of barcode	Very high	Rather low, as barcodes labels are often no longer usable (end-of-life products)

The general requirements described above have to be refined when considering specific reverse flows: Object identification as the basis of linking flows of material and information can be done either at class-level or on item-level. In some cases, reverse logistics processes do not require item-level identification. For the sorting of end-of-life products or packaging, which are recovered as secondary material or disposed of, class-level information is usually sufficient. So far, these sorting processes are not based on identification, as barcode labels are no longer usable. In the absence of readable data carriers, sorting processes either rely on manual inspection or on technologies which automatically detect relatively broad physical characteristics such as size, weight and magnetism of objects.

Other reverse logistics processes can however benefit from item-level data: In addition to specific collection processes (e.g. targeted recalls), sorting and recovery of high-value objects may benefit from item-level information regarding the state of the object. These processes rely on object-related data like bill of materials. However, the usefulness of object-related data based on the state of the object at the time of its assembly can be quite limited at the time of its recovery. Meaningful and reliable data regarding the current state of the object has to be gathered dynamically during its lifecycle and needs to be documented and accessed at item-level [25, 31].

3.4. Opportunities and threats of RFID tagging

Both potential positive and negative impacts on reverse logistics processes can be expected from item-level RFID tagging.

In order to meet the demands on object-related information discussed on Section 3.3, RFID systems have been proposed for various scenarios: Collection processes may benefit from automatic identification, from collections of commercial returns and recalls [21], to enabling deposit systems [35] and enhanced compliance with laws regarding extended producer responsibility [24]. Sorting processes are among the most costly processes in reverse logistics (e.g. sorting of packaging waste in Germany accounts for approx. 40% of the total disposal cost [34]) and may be considerably enhanced, if they are based on object identity instead of broad detectable characteristics [35]. Finally, RFID-enabled documentation of an objects' individual history may provide valuable information during end-of-life decision making and recovery processes [26; 31; 32].

The use of RFID systems in order to fulfil the specific information requirements is advantageous because of two characteristics of the technology: Firstly, RFID-enabled unique identification is especially beneficial in reverse logistics processes, due to the increased heterogeneity of pertaining objects. Secondly, it is the persistency of RFID tags compared to barcode labels which may enable – and not just, as is the case in forward logistics, enhance – widespread automatic identification in reverse logistics systems.

Threats on reverse logistics processes may arise from tags as electronic components entering waste streams. Assuming that all units of packaging waste in Germany were tagged with light smart labels weighing only 0.1 g, this would lead to 20000 t of electronics waste annually entering the processes of packaging waste management [35]. End-of-life electronics equipment is usually processed separately, as it contains hazardous and valuable materials which have to be treated separately [37]. With the spread of item-level RFID a separate collection of transponder and object

will in most cases no longer be feasible, which on the one hand hinders a proper disposal of the tags as electronics equipment and on the other hand makes recovery of the objects they are attached to difficult. Tags in specific sorting and recovery processes may interfere with existing technologies (e.g. smelting processes in glass recovery) and secondly contaminate (and thus depreciate) recovered secondary material [15; 23].

The potential opportunities and threats for reverse logistics which may arise from RFID tagging are summarized in Table 3:

Table 3: Potential impacts of RFID tagging on reverse logistics processes

Process	Opportunities	Threats
Collection	- Enabling registration and documentation of collections e.g. for - Extended producer responsibility - Deposit systems - Tracing data enables targeted recalls, verification of warranty claims	No separate collection of tags as electronics components
Sorting	- Reverse flows heterogeneous → increased need for sorting - Waste flows: Sorting based on identity instead of broad physical characteristics → potential for better separation of waste fractions - Increased value of recovered material - Efficient sorting out of hazardous materials	Tags as contaminants of material fractions difficult to separate
Recovery	Item-level product history can improve recovery decisions and processes	Tags as contaminants may reduce value of recovered material

3.5. Technological progress and diffusion of RFID

Only in few cases, RFID systems will be implemented solely for the purpose of supporting reverse logistics processes. In most cases, RFID will first and foremost be implemented for the support of forward logistics processes – with possible secondary benefits and challenges in reverse logistics. Therefore the role of RFID in reverse logistics will considerably depend on the diffusion of RFID in forward logistics. Thus the barriers of item-level RFID in forward logistics processes are of importance when analyzing its role in reverse logistics. This diffusion depends in large parts on technological progress which may help overcome existing technical barriers. Tag prices are usually seen as an important challenge for widespread item-level RFID, with progress in the area of polymer electronics as a possible long-term solution. Substituting several (semi-)metals in transponders with polymer semiconductors may (by enabling low-cost printing production) dramatically lower the costs for simple, short-range transponders and therefore increase diffusion of RFID at item-level. Apart from its impact on diffusion, technological progress is an important aspect of research on reverse logistics in its own right, as the use of different materials may pose different challenges on recovery processes and the value of recovered materials.

4. Roadmap: Issues for future research

The five layers presented in the framework are delineable sub-areas of research on the role of RFID in reverse logistics which are useful for structuring the field. However, in order to comprehensively explore the area, research questions spanning these layers are necessary. We categorize these issues according to scope into economic, ecological and technical issues.

4.1 Economic issues

The use of RFID promises significant potential to close the gap between forward and reverse logistics information flows. However, except for successful applications in closed loop logistics of returnable containers, there is hardly practical evidence for these potential benefits. Future research should provide methods and models in order to quantify benefits enabled by RFID systems spanning forward and reverse logistics. This should also include aspects of the distribution of costs and benefits of RFID systems in logistics. In the context of consumer goods it is often assumed that large retailers are using their market power to force the introduction of RFID at the expense of manufacturers who have to bear the costs of tagging although it is the retailers who benefit most from it. Incorporating potentials regarding the support of extended producer responsibility may give new impetus to this debate. Additional problems arise from aspects concerning the diffusion of RFID technology in reverse logistics application scenarios. On the one hand, RFID systems can in most cases not be implemented at once, as untagged products will remain in use for years. Reverse logistics processes therefore cannot be changed to operate on tagged objects exclusively, as untagged objects will have to be handled for years to come. On the other hand, unlocking benefits of item-level RFID adds further complexity as more parties (e.g. maintenance, repair and disposal companies), become actively involved in the use of the system and may need to be offered incentives, in order to, for example, participate in documenting object history.

4.2 Ecological issues

Research on the overall ecological impacts of item-level RFID is still in its infancy. The articles mentioned in Section 2.2 either focus on negative (usually in worst case scenarios) or positive impacts of RFID (in isolated application scenarios); profound research assessing the ecobalance of item-level RFID is lacking. Research should provide life cycle analysis of different tagging scenarios, incorporating potential ecological opportunities and threats. This may help policy-makers to assess its impact before the reality of item-level RFID catches up with the relevant legislation (see Section 3.1.). New legislation may for instance be needed in order to prevent negative impacts of widespread item-level tagging or in order to make use of the possibilities of RFID which could make legal instruments such as obligatory deposit systems or extended producer responsibility feasible.

4.3 Technical issues

Integrating the different technical requirements on RFID systems in forward and reverse logistics is a critical issue. Privacy concerns and customer acceptance are in both forward and reverse logistics a major challenge for item-level tagging of consumer products [28]. In forward logistics these concerns can be met with deactivating tags after purchase by default, e.g. by using the kill-command which is implemented in the most important tag standard EPC class 1 Gen 2. This measure is both effective and feasible; however deactivating tags permanently prevents all uses in reverse logistics beyond the point of sale. The development of effective low-cost security measures which increase customer acceptance and allow for the use of RFID throughout the supply loop remains an important subject for future research. This is just one example where technical requirements on RFID differ significantly for forward and reverse logistics. Analysing and reconciling these different requirements regarding tag and reader architecture as well as data management aspects needs to be the subject of future research.

In an integrated view on positive and negative impacts of RFID in reverse logistics, the separation of tag and object is an important aspect, which should be considered in the development of methods of binding tag and object. In order to maximize potential benefits (both economic and ecological)

and minimize negative impacts, we deduce the question of the optimum decoupling point of tag and object as an essential issue. An exemplary decision problem is shown in Figure 2:
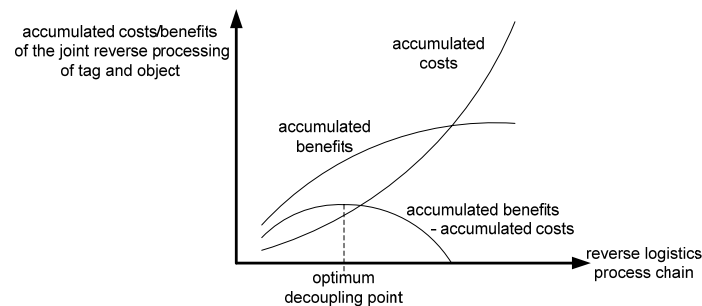

Figure 2: Exemplary decision problem of optimum decoupling point

5. Conclusion

Reverse logistics is constantly gaining in importance due to changing legal and socio-economic conditions. The expected diffusion of RFID towards the item-level entails both opportunities and challenges for reverse logistics processes, which constitute an important field for future research. Only isolated aspects of this complex research area have so far been addressed, focusing either on negative impacts of item-level tagging or on potential RFID applications in specific areas of reverse logistics. In order to promote a comprehensive approach, which covers the wide area of RFID in reverse logistics and incorporates both positive and negative impacts, we developed a framework structuring the field. We then deduced issues, which future research should address. If the specific challenges can be overcome and positive practical experiences of the use of RFID in the management of closed loop container systems can be transferred to other areas of reverse logistics, RFID systems promise to reduce the inherent object-related uncertainties and thus contribute significantly to the closing of the supply loop.

6. References

[1] AGRAWAL, R., CHEUNG, A., KAILING, K. AND SCHONAUER, S. Towards Traceability across Sovereign, Distributed RFID Databases, Proceedings of the 10th International Database Engineering and Applications Symposium, Deli 2006, pp. 174-184.
[2] BARDT, H. Die gesamtwirtschaftliche Bedeutung von Sekundärrohstoffen, IW-Trends, Vol. 33 (2006), No. 3.
[3] BREEN, L. Give me back my empties, or else! A preliminary analysis of customer compliance in reverse logistics practices (UK), Management Research News, Vol. 29 (2006), No. 9, pp. 532-551
[4] CHOINARD, M., D'AMOURS, S. AND AIT-KADI, D. Integration of reverse logistics activities within a supply chain information system, Computers in Industry, Vol. 56 (2005), No. 1, pp. 105-124.
[5] DE BRITO, M. AND DEKKER, R., A Framework for Reverse Logistics, in Dekker, R., Fleischmann, M., Inderfurth, K., Van Wassenhove, L. N. (Eds.): Reverse Logistics, Springer, Berlin Heidelberg 2004, pp. 3-27.
[6] DE, P., BASU, K. AND DAS, S. K., An RFID based technique for handling object distribution and recalls in pervasive transaction environments, Proceedings of the 2004 IEEE Conference on Mobile Ad-hoc and Sensor Systems, Fort Lauderdale 2004, pp. 349-358.
[7] DÖRSCH, C., FIKOURAS, I., BURKERT, R. AND MÜLLER, D. H., Eco-conscious Design Based on Single Component Polymers for Sustainable Supply Management in Automotive Production, Proceedings of the International Conference on Engineering Design, ICED 2005, Melbourne.
[8] DOWLATSHAHI, S., Developing a Theory of Reverse Logistics, Interfaces, Vol. 30 (2000), No. 3, pp. 143-155.
[9] D'SOUZA, C., TAGHIAN, M. AND KHOSLA, R., Examination of environmental beliefs and its impact on the influence of price, quality and demographic characteristics with respect to green purchase intention, Journal of targeting measurement and analysis for marketing, Vol. 15 (2007), No. 2, pp. 69-78.
[10] FLEISCHMANN, M., Quantitative models for reverse logistics, Springer, Berlin Heidelberg 2001.
[11] FLEISCHMANN, M., VAN NUNEN, J., GRÄVE, B. AND GAPP, R., Reverse Logistics – Capturing Value in the Extended Supply Chain, in An, C. and Fromm, H. (Eds): Supply Chain Management on Demand. Springer, Berlin Heidelberg New York 2005, pp. 167-186.

[12] FOLINAS, D., MANIKAS, I. AND MANOS, B., Traceability data management for food chains, British Food Journal, Vol. 108 (2006), No. 8, pp. 622-633.

[13] FOSTER, P., SINDHU, A. AND BLUNDELL, D., A Case Study to Track High Value Stillages using RFID for an Automobile OEM and its Supply Chain in the Manufacturing Industry, Proceedings of the 2006 IEEE Conference on Industrial Informatics, Singapore 2006, pp. 56-60.

[14] GAMBON, J., Best RFID Implementation: Keeping Tabs on Printers, http://www.oatsystems.com/media/Best_RFID_Implem_article2.pdf, retrieved 2008-07-14.

[15] GLIESCHE, M., AND HELMIGH, M., Auswirkung eines RFID-Masseneinsatzes auf Entsorgungs- und Logistiksysteme, Dortmund 2007.

[16] GUIDE, V. D. R., NEERAJ, K., NEWMAN, C. AND VAN WASSENHOVE, L. N., Cellular telephone reuse: the ReCellular Inc. case, in: Flapper, S. D. P., Van Nunen, J. and Van Wassenhove, L. (eds.): Managing closed-loop supply chains, Springer, Berlin Heidelberg New York 2005, pp. 151-156.

[17] HILTY, L., BEHRENDT, S., BINSWANGER, M., BRUININK, A., ERDMANN, L., FRÖHLICH, J., KÖHLER, A., KUSTER, N., SOM, C., AND WÜRTENBERGER, F., Das Vorsorgeprinzip in der Informationsgesellschaft: Auswirkungen des Pervasive Computing auf Gesundheit und Umwelt, Bern 2003.

[18] KARAER, Ö. AND LEE, H. L., Managing the Reverse Channel with RFID-Enabled Negative Demand Information, Production and Operations Management, Vol. 16 (2007), No. 5, pp. 625-645.

[19] KELEPOURIS, T., PRAMATARI, K. AND DOUKIDIS, G., RFID-enabled traceability in the food supply chain, Industrial Management & Data Systems, Vol. 107 (2007), No. 2, pp. 183-200.

[20] KHAN, O., SCOTTI, A., LEVERANO, A., BONINO, F., RUGGIERO, G. AND DÖRSCH, C., RFID in Automotive: a Closed-Loop Approach, 12th International Conference on Concurrent Enterprising, Milano, 2006.

[21] KOH, R., SCHUSTER, E. W. AND LAM, N., Prediction, Detection, and Proof: An Integrated Auto-ID Solution to Retail Theft, Cambridge 2003.

[22] KOEHLER, A., AND SOM, C., Effects of Pervasive Computing on Sustainable Development, IEEE Technology and Society Magazine, Vol. 24 (2005), No. 1, pp. 15-23.

[23] KRÄUCHI, P., WÄGER, P. A., EUGSTER, M., GROSSMANN, G., AND HILTY, L., End-of-Life Impacts of Pervasive Computing – Are RFID tags a threat to waste management processes?, IEEE Technology and Society Magazine, Vol. 24 (2005), No. 1, pp. 45-53.

[24] KUHNHENN, K. AND URBAN, A. I., ELEKTROG-Produktverantwortung - Individuelle Produktverantwortung für Elektroaltgeräte – Durch RFID zum Ziel?, Müll und Abfall, Vol. 38 (2006), No. 12, pp. 638-644.

[25] KULKARNI, A. G., PARLIKAD, A. K., MCFARLANE, D. AND HARRISON, M., Networked RFID Systems in Product Recovery Management, Proceedings of the 2005 IEEE International Symposium on Electronics and the Environment, New Orleans 2005, pp. 66-71.

[26] KULKARNI, A. G., RALPH, D., AND MCFARLANE, D., Value of RFID in remanufacturing, International Journal of Services Operations and Informatics, Vol. 22 (2007), No. 3, pp. 225-252.

[27] KUMAR, F. AND FULLENKAMP, J., Analysis of European Union environmental directives and producer responsibility requirements, International Journal of Services and Standards, Vol. 1 (2005), No. 3, pp. 379-398.

[28] LANGHEINRICH, M.: RFID and Privacy, in: Petkovic, M., Jonker, W. (eds.): Security, Privacy, and Trust in Modern Data Management, Berlin Heidelberg New York 2007, pp. 433-450.

[29] MEADE, L., SARKIS, J. AND PRESLEY, A., The theory and practice of Reverse Logistics, J. Logistics Systems and Management, Vol. 3 (2007), No. 1, pp. 56-84.

[30] PARK, J. AND LEE, B., RFID Application Model and Performance for Postal Logistics, Lecture notes in computer science, Vol. 4537, (2007), pp. 479-484.

[31] PARLIKAD, A. K., MCFARLANE, D., FLEISCH, E. AND GROSS, S., The Role of Product Identity in End-of-Life Decision Making, Auto-ID Centre White Paper, Cambridge 2003.

[32] PARLIKAD, A. K., MCFARLANE, D., RFID-based product information in end-of-life decision making, Control Engineering Practice Vol. 15 (2007), pp. 1348-1363.

[33] STEVEN, M., Networks in Reverse Logistics, in Dyckhoff, H., Lackes, R. and Reese, J. (eds.): Supply Chain Management and Reverse Logistics, Springer, Berlin Heidelberg 2004, pp. 163-180.

[34] STEVEN, M. AND LAARMANN, A., Lerneffekte in der Entsorgungslogistik, ZfB Zeitschrift für Betriebswirtschaft, Special Issue: Reverse Logistics 1, 2005, pp. 95-114.

[35] THOROE, L. AND SCHUMANN, M., Objektinformationsbedarfe und RFID-Nutzenpotenziale in Reverse Logistics, in: Breitner, M.; Breunig, M.; Fleisch, E.; Pousttchi, K.; Turowski, K. (eds.): Proceedings zur 3. Konferenz Mobile und Ubiquitäre Informationssysteme, Bonn 2008.

[36] TIBBEN-LEMBKE, R. S. AND ROGERS, D. S., Differences between forward and reverse logistics in a retail environment, Supply Chain Management: An International Journal, Vol. 7 (2002), No 5, pp. 271-282.

[37] WÄGER, P. A., EUGSTER, M., AND HILTY, L., Smart labels in municipal waste – a case fort he Precautionary Principle, Environmental Impact Assessment Review, Vol. 25 (2005), No. 5, pp. 567-586.

[38] ZHENG, J., ZHENG, W. AND LIU, P., Research on information integration management of reverse logistics, Proceedings of the 7th international conference on Electronic commerce, ACM Press, New York 2005, pp. 851-855.