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Development of a Performance Measurement System for International Reverse Supply Chains

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Abstract

In times of globally connected production networks, supply chain management is a key discipline of modern living. Due to increasing commodity prizes and a greater awareness of resource efficiency, the relevance of international reverse supply chains is increasing. Unfortunately, there is a lack of knowledge when it comes to the assessment of international reverse supply chains. To close this lack, scientists from Bayreuth defined a performance measurement system to assess international reverse supply chains. The aim of this paper is to support the Circular Economy and the remanufacturing industry with an approach to optimize international reverse supply chains and thus to become more sustainable.

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Keywords: Reverse Supply Chain; Reverse Logistics; Supply Chain Management; Performance Measurement; Performance Measurement System

1. Introduction

The awareness of topics as *reverse logistics* and *reverse supply chain* are steadily increasing in the last years.

According to Asdecker, the retour rate of fashion products is up to 55.65 per cent [1]. According to the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, 127,577 tons of old products were reused or recycled within the electro and electronic sector in 2013 [2].

Both examples emphasize the necessity of efficient reverse logistics respectively reverse supply chains. Besides the above-mentioned sectors, reverse logistics is an important topic in other industry sectors as well, for example the automotive industry sector [3].

In 1989, Sink and Tuttle pointed out, that the management and thus the efficient operation is not possible without being able to measure the performance [4]. Therefore, also the efficient management of reverse supply chains is not possible without assessing its performance. Janse et al. [5] and Shaik [6] pointed out, that there is immatureness in science regarding performance measurement systems of reverse logistics.

2. State of the Scientific Knowledge and Need for Action

This section gives an overview about the state of the scientific knowledge regarding reverse supply chains, reverse logistics (RL), closed loop supply chains, international supply chains as well as barriers, drivers and success factors for reverse supply chains. Furthermore, the need for action is pointed out.

2.1. Reverse Supply Chains

According to Rogers and Tibben-Lemke, the term reverse supply chain is defined as following:

"The process of planning, implementing and controlling backward flows of raw materials, work-in-progress, finished goods and information, from the point of consumption to the point of recovery or proper disposal. " [7, p.2]

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Guimarães, Silveira and Salomon defined the term reverse logistics as following:

”The RL has the objective to facilitate the return of consumer goods or their constituent materials to production or business cycle, adding economic value, ecological, legal service and location. “ [8, p.140]

Guide and van Wassenhove defined the term reverse supply chain management more generically:

„It’s the series of activities required to retrieve a used product from a customer and either dispose of it or reuse it.” [9, p.2]

A scientific consideration of the differentiations between the two terms reverse logistics and reverse supply chains is done by Larson et al. [10]. For this paper, the terms are used as synonyms.

Another term that has to be defined is the closed loop supply chain. According to Guide et al., closed loop supply chains consist of forward and reverse supply chain activities. [11].

Further definitions regarding reverse supply chains can be found in the framework of Lambert et al. [12].

2.2. Drivers for Reverse Supply Chains

The main drivers for reverse supply chains were pointed out by Scott et al. [13]:

- Legislation
- Profit
- Corporate citizenship

These drivers were used as rudiments for this paper.

2.3. Reverse Supply Chains versus Forward Supply Chains

According to Gupta, reverse supply chains are facing a higher uncertainty as forward supply chains [14]. Furthermore, Tibben-Lembke et al. pointed out, that forecasting is easier in forward than in reverse supply chains [16a, 16b].

One reason for the uncertainty in reverse supply chains is the varying quality of products that enter the reverse supply chain [14, 16a].

One of the main differences between forward and reverse supply chains was described as the Many-To-One problematic by Fleischmann [17]. Within forward supply chains, the material flows from the lower number of supply chain participants, as for example factories, to the higher number of participants, as for example end customers [15].

Klaus and Krieger pointed out that the costs for stock must be lower in reverse supply chains as in forward supply chains, due to the lower value of the products [18].

Further, differences between forward supply chains and reverse supply chains, which were pointed out by Tibben-Lembke et al, are summarized in the following [15]:

- Undefined routes of products
- Aggravated price calculation
- No mature inventory management
- Low awareness of reverse supply chains at the management level
- Higher transportation costs
- Lower value of the products

2.4. International versus National Supply Chains

Zamjirani Farahani [19] and MacDonald [20] pointed out, that the management of international supply chains is a much bigger challenge as the management of national supply chains. Especially the variety of challenges is higher [19, 20].

Further differences of international supply chains compared to national supply chains, according to Zamjirani Farahani, are named in the following [20]:

- Differences in language and culture
- Differences in law and currencies
- Longer distances and thus longer delivery times
- Higher costs for transportation and storage
- Higher uncertainty
- Security and technology problems

2.5. Barriers for Reverse Supply Chains

The barriers for efficient reverse supply chains, described in scientific literature, were condensed by Agrawal et al. in their study in 2015 [21]. The 59 barriers identified by Agrawal et al. were structured into eight categories. Following are the eight barrier categories:

- Resource scarcity
- Awareness of the top management
- Legislation
- Customer preference
- Poor knowledge regarding reverse logistics
- Poor IT infrastructure, forecasting methods
- Undefined recycling technologies
- Poor knowledge regarding taxes

2.6. Success Factors for Reverse Supply Chains

Verweiji et al. described the success factors for reverse supply chains in a study in 2015. Table 1 illustrates an overview of the ranked success factors for reverse supply chains, according to Verweij et al. [22].

Table 1. Success Factors for Reverse Supply Chains, according to [22].

Success factor	**No.**
Strategy focus on avoiding returns	1
Detailed insight in cost and performance	2
Strategic partnerships with chain partners	3
Top management awareness	4
Reclaiming value from returns	5
Capability to put returned products rapidly in the market	6
Visibility of quality and value in product life cycle	7
Automating returns process	8
Efficient gatekeeping	9
Track and trace capabilities	10
Strategic partnership with other producers	11

2.7. Need for Action

Unfortunately, there is a lack of knowledge when it comes to the assessment of international reverse supply chains. Without a holistic assessment of international reverse supply chains, it would not be possible to manage them efficiently. To close this lack of knowledge, both in industry and science, scientists from Bayreuth developed a holistic approach to assess international reverse supply chains. The focus of this paper is the development of a performance measurement system for international reverse supply chains. The performance measurement system is the first of two steps of the holistic approach to assess international reverse supply chains.

3. Research Approach

The aim of this paper is the development of a performance measurement system to assess international reverse supply chains. As base for the development, the state of the scientific knowledge and the need for action are described in section two. In section four, approaches to assess reverse supply chains and performance measurement approaches are identified and analyzed by doing a literature review. In section 5, the performance measurement system to assess international reverse supply chains are defined.

The development of the performance measurement system to assess international reverse supply chains is the first step of the development of a holistic approach to assess international reverse supply chains.

The holistic approach to assess international reverse supply chains is based on the Balanced Scorecard (BSC) approach and the Analytic Hierarchy Process (AHP). The BSC approach is used to develop the performance measurement system, whereas the AHP is used to define and calculate the performance index.

4. Assessment Approaches for Reverse Supply Chains

4.1. Performance Measurement and Performance Measurement Approaches

Neely at al. defined the performance measurement as following [23]: „Performance measurement can be defined as the process of quantifying the efficiency and effectiveness of action.” Typical performance measurement approaches are the BSC, the Skandia Navigator, the Performance Pyramid and the Quantum Performance Measurement [24]. In the context of supply chain performance measurement, the Supply Chain Operations Reference (SCOR) model is probably the most common approach [25].

4.2. Performance Measurement Approaches for Reverse Supply Chains

In this section, the results of a literature study about performance measurement respectively performance measurement systems for reverse supply chains are described. Approaches and methods, which are important for this paper, as the Framework, BSC and the AHP are described in more detail.

In the following, the catchwords used for the literature study are shown:

- Performance measurement reverse logistics
- Performance measurement reverse supply chain
- Performance evaluation reverse logistics
- Performance evaluation reverse supply chain

The literature study was done with the following online literature databases:

- Science Direct
- Emerald Insight
- SpringerLink
- IEEE Xplore

Within the literature review, 14 scientific sources were identified, which were written between 2009 and 2015. Table 2 illustrates the scientific sources identified.

Table 2. Identified scientific sources regarding performance measurement respectively performance measurement approaches.

No.	Autors	Titel	Source	Year
1	Milind Bansia, Jayson K. Varkey, Saurabh Agrawal	Development of a Reverse Logistics Performance Measurement System for a Battery Manufacturer	Science Direct	2014
2	Mohammed Shaik, Walid Abdul-Kader	Performance measurement of reverse logistics enterprise: a comprehensive and integrated approach	Emerald Insight	2012
3	M.B. Butar Butar, D. Sanders, G. Tewkes-bury	Measuring performance of reverse supply chains in a computer hardware company	IEEE Xplore	2014
4	Radoslav Škapa, Alena Klapalová	Reverse logistics in Czech companies: increasing interest in performance measurement	Emerald Insight	2012
5	Dianne J. Hall, Joseph R. Huscroft, Benjamin T. Hazen, Joe B. Hanna	Reverse logistics goals, metrics, and challenges: perspectives from industry	Emerald Insight	2013
6	Stefan E. Genchev, R. Glenn Richey, Colin B. Gabler	Evaluating reverse logistics programs: a suggested process formalization	Emerald Insight	2011

7	José Leonardo da Silveira Guimarães	ANP Applied to the Evaluation of Performance Indicators of Reverse Logistics in Footwear Industry	Science Direct	2015
8	Bastiaan Janse, Peter Schuur, Marisa P. de Brito	A reverse logistics diagnostic tool: the case of the consumer electronics industry	Springer Link	2009
9	Jianhua Yang	On the construction and implementation methods for performance measurement of reverse supply chain	IEEE Xplore	2010
10	Huang R.H.	Constructing a performance evaluation model for reverse logistics - Cases of recycled tire traders	IEEE Xplore	2010
11	Mimouni Faycal	Evaluation of performance on reverse logistics of a production line of a direct logistics	IEEE Xplore	2014
12	Bai Chunguang, Sarkis Joseph	Flexibility in reverse logistics: a framework and evaluation approach	Science Direct	2013
13	Luger Tobias, Herrmann Christoph	Referenzprozessbasierte Gestaltung und Bewertung von Reverse Supply Chains	Springer Link	2010
14	Serge Lambert, Diane Riopel, Walid Abdul-Kader	A reverse logistics decisions conceptual framework	Science Direct	2011

The evaluation of the literature showed, that three approaches to develop a reverse logistics performance measurement system were used by several authors. Seven authors used a framework as a base, five authors used an AHP as a base, and three authors used a BSC as a base. Furthermore, three authors used a combination of a BSC and an AHP as a base.

A framework is defined as a consistent construct, which is used to identify and describe the components of reverse supply chains [26]. These components are used to derive the performance measurements [27].

The BSC approach was developed by Kaplan and Norton in the 1990s. Nowadays, it is one of the most common approaches of the performance measurement [24]. The BSC approach is structured into four perspectives [28]:

- Financial perspective
- Customer perspective
- Internal business process perspective
- Organizational capacity perspective

The consideration of the four perspectives allows the balanced definition of performance measures. The BSC approach enables the deduction of performance measures based on the companies' strategy and vision. According to Kaplan and Norton, only the balanced assessment of performance increases the competitiveness. [28]

The AHP is a multi-criteria decision analysis, which was developed by Saaty in the 1970s. The aim of the AHP is to find solutions for complex problems by comparing pairs [29]. For the performance measurement system, the AHP is used to calculate the performance index, which represents the performance of a reverse supply chain as an indicator.

The results of the literature evaluation are illustrated in Table 3.

Table 3. Categorized scientific sources.

No.	Autor	Frame-work	BSC	AHP
1	Milind Bansia , Jayson K. Varkey, Saurabh Agrawal		√	√
2	Mohammed Shaik, Walid Abdul-Kader		√	√
3	M.B. Butar Butar, D. Sanders, G. Tewkesbury	√		
4	Radoslav Škapa, Alena Klapalová			
5	Dianne J. Hall, Joseph R. Huscroft, Benjamin T. Hazen, Joe B. Hanna			
6	Stefan E. Genchev, R. Glenn Richey, Colin B. Gabler	√		
7	José Leonardo da Silveira Guimarães	√		√
8	Bastiaan Janse, Peter Schuur, Marisa P. de Brito	√		
9	Jianhua Yang		√	√
10	Huang R.H.			√
11	Mimouni Faycal			
12	Bai, Chunguang; Sarkis, Joseph	√		
13	Luger Tobias, Herrmann Christoph	√		
14	Serge Lambert, Diane Riopel, Walid Abdul-Kader	√		

5. Definition of Performance Measures to Assess International Reverse Supply Chains

Based on the identified barriers, drivers and success factors as well as the assessment approaches described, the performance measurement system was developed based on the BSC approach. The defined perspectives and their details are illustrated in Table 5.

According to Shaik and Abdul-Kader [6], the primary BSC approach is not holistic enough for reverse logistics. In addition, Yang [30] as well as Huang and Wang [31] did not stick to the primary perspectives. Due to the specific restrictions of international reverse supply chains, the perspectives of the primary BSC approach were also adapted and extended in this paper. As illustrated in Table 4, the perspective citizenship and legislation as well as the perspective flexibility were added. Furthermore, the customer perspective was adapted into a stakeholder perspective.

Table 4. Perspective of the performance measurement system to assess international reverse supply chains.

Citizenship and Legislation Perspective	
Aim	**Performance Measurement**
Protection of the environment and observance of public restriction	Number of offenses of public restrictions in the field of logistics
	Carbon footprint of the transports
	Reuse rate
	Disposal rate
Financial Perspective	
Aim	**Performance Measurement**
Maximization of the profit and reduction of the costs	Cost for the reverse supply chain
	Tax for the reverse supply chain
	Disposal value of the regenerated products / disposal value of new products
Stakeholder Perspective	
Aim	**Performance Measurement**
Maximization of the stakeholder satisfaction	Customer satisfaction
	Satisfaction of the supply chain collaboration
	Supply chain visibility / transparency
Process Perspective	
Aim	**Performance Measurement**
Improvement of processes which are important for the customers	Lead time of the reverse logistics
	Quality of the products
Innovations and Growth Perspective	
Aim	**Performance Measurement**
Ensure competitiveness sustainably	Investment for trainings for reverse logistics
	Investment for reverse logistics
Flexibility Perspective	
Aim	**Performance Measurement**
Increase the flexibility	Number of flexible employees
	Volume flexibility

The perspective citizenship and legislation was added under consideration of the reverse supply chain driver corporate citizenship and legislation. For comparison, Guimaraes et al. added the perspective legal program and citizenship program [8]. Guimaraes suggests to measure the number of offenses of public restrictions [8]. Moreover, Luger and Hermann point out, that the carbon footprint and the regeneration rate should be considered [27].

The goal of the financial perspective is the maximization of the profit and the reduction of costs. The consideration of costs is recommended by several authors, for example Shaik and Abdul-Kader [8]. The potential of taxes is pointed out by Janse et al. [5] and Verweij [22]. The third performance measurement considers the value of the products in the reverse supply chain against the value of the products in the forward supply chain.

Shaik and Abdul-Kader criticized the primary BSC not to consider all stakeholders in the customer perspective [32]. Therefore, the perspective was adapted to the needs of international reverse supply chains, and thus extended to the stakeholder perspective. The consideration of all stakeholders leads to increased transparency and visibility, which again leads to increasing collaboration. This is useful to face the uncertainties of international reverse supply chains [15, 33]. Nevertheless, the satisfaction of customers is crucial for performance measurement systems [8, 12, 30].

The process perspective aims to assess the important processes within companies. To measure this perspective, the lead time of the reverse logistics is common in literature [27, 32, 34, 35a, 35b]. The second performance measurement within the process perspective is the quality of the products, which is influenced by the processes and has a significant influence to the processes as well.

The innovation and growth perception is measured by the investment for reverse logistics and the investment in trainings for reverse logistics. Both ensures the future competitiveness of the companies.

The flexibility perspective was added to consider the increased uncertainty within international reverse supply chains. Flexibility enables to react on uncertainty [36]. The number of flexible employees and the volume flexibility measures the flexibility perspective. The volume flexibility is defined as the scale of variations, which a company can manage without profitability losses [37].

7. Conclusion and Outlook

The paper described the development of a performance measurement system to assess international reverse supply chains. The development was done based on an intense literature review and usage of the balanced scorecard approach.

Six perspectives were defined to holistically assess international supply chains.

The development of a performance measurement system is the first step of the development of a holistic approach to assess international reverse supply chains. In future research, the second step respectively part of the holistic approach to assess international reverse supply chains will be developed. It will be the calculation of the performance index, based on the Analytical Hierarchy Process (AHP).

Furthermore, the holistic approach will be verified by performing simulation studies.

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