Eurasian Journal of Economics and Finance, 6(1), 2018, 35-46
DOI: 10.15604/ejef.2018.06.01.004

EURASIAN JOURNAL OF ECONOMICS AND FINANCE

www.eurasianpublications.com

WORKING CAPITAL FINANCING IN REVERSE SUPPLY CHAINS – NEW PERSPECTIVES (AUTO-FINANCING)

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Abstract

Competition among Global Supply Chains has been studied intensively in recent years. While forward supply chains strategies such as supply chain or operational redesign were studied often, for reverse logistics most development strategies represented a new direction of research, especially regarding Supply Chain Finance domain. This paper explains how a reverse supply chain can obtain finances for its daily activities in its sorting phase by using a linear model based on penalties for the working capital issue. Here, traditional working capital financing (obtained normally from a financial institution) is replaced by a new production model, resulting in daily activities financing from another actor of the reverse logistics. In this case, the working capital provider is no longer a financial institution, but the original raw material provider. This approach gives a new perspective about finances in a supply chain hence it does not add more financial constraints for companies, and helps in the same time the whole supply chain from an operational point of view. As a result, the manufacture company has less financial constraints, the sorting process improves significantly both in financial and non-financial terms, and the overall supply chain is more competitive on the market.

Keywords: Global Supply Chains, Reverse Supply Chains, Single Equation Model, Sorting Process, Supply Chain Finance, Working Capital

JEL Classifications: C2, C5, G0

1. Introduction

In recent years, there have been severe disruptions on all strategic levels of numerous global supply chains (redesign of the whole supply chain, tactical decisions or operational activities) for many major companies in both financial and non-financial terms due to global economic crisis and increased competitiveness on both national and international levels. The shift has changed from a cost minimization perspective to a revenue maximization view not only for firm-against-firm competition, but also for supply chain versus supply chain competition.

Added governmental and environmental constraints and regulations, different interests for all stakeholders involved in a supply chain or short-term versus long-term strategies decisions have increased supply chain complexity in general, and made long-term survival and development harder than before these measurements have been applied in practice. If non-financial strategies have been covered by a series of research articles, which focused their studies in finding best operational solutions to help on the survival and development of different supply

chains and industries, working capital strategies have not been actively debated until recently where few studies from the Supply Chain Finance perspective have been made.

Supply Chain Finance seeks to describe various working capital financing methods in order to help improve supply chains operability and lease financial constraints that can lead to supply chain shutdown if alternative solutions are not applied. Most affected parts of the logistics chains are small and medium sized enterprises (SME) which need external funding very often in order to support their optimal activity levels (production levels, transportation methods) in a larger proportion than big corporations (where bargaining power is higher on the market and credit options are more variate). Stonkutė and Vveinhardt (2016) present the key success factors for SME in global supply chains that can overcome the disadvantage of lower bargaining power in the development of these global networks. On SME individual level, Asikhia (2016, p. 128) highlights the fact that "SMEs' Innovation and creativity, licensed intellectual property, degree of customers and employees involvement, and Network and Collaboration are positively related with SMEs' Wealth Creation", statement which focuses on operational and social attributes related to SME success (or failure) in the long run.

Unfortunately, in practice, these SME encounter more constrains and limitations regarding the amount of capital borrowed or in terms of obtaining a credit from a financial institution despite continuous efforts of the national governments, institutions which seek to support all types of businesses in general, but which can also influence some industries based on countries and natural resources needs.

While forward supply chains analyze working capital as a regular focus issue, in reverse logistics this topic did not received considerable attention until recently because green logistics is still a new area of research for many studies compared to traditional supply chains. According to Pokharel and Mutha (2009), Reverse Logistics and various aspects of this new form of supply chain have been actively debated after 2005.

The Reverse logistics principle (or Reverse Supply Chains) handles returns of used products and studies the whole logistics process from the original delivery of used products to their end-of-life disposal. There are two alternative strategies: destruction of the original product (for those end-of-life products that require permanent removal from the market) and recycling of at least one component coming from the returned products in order to be used on the secondary market (for those finished products that are returned to reverse supply chains in order to extract and use at least one recycled component from the used products).

The two fundamental questions behind reverse logistics are "Does it pay to be green?" (King and Lenox (2001)) and "Pay to be sustainable?" (Hoffman and Bazerman (2007)). The recycling rate in Reverse Logistics (used products in Forward Supply Chains) strongly depends on the "Green" degree of each actor involved in the recycling process. Unfortunately, for SME the dimension of being green strongly depends on their financial and human resources.

This research suggests an alternative working capital model as a financial solution for reverse supply chains in the sorting phase of the recycling process, solution which is designed in a non-Supply Chain Finance traditional way. The model suggests a new method of obtaining working capital from another actor of the supply chain, namely the raw material provider (all companies that deliver used goods to the sorting facility in the supply chains). This new approach differs from the original Supply Chain Finance methods because working capital financing is not obtained from a financial institution that would automatically involve financial capital return with an eventual interest rate, but from an existent member of the Reverse Supply Chain.

The novelty of the model is that the working capital provider in the reverse supply chain will not only offer the needed capital for daily activities, but will also contribute to a better sorting degree of the goods which are originally delivered. Another important aspect is that the financial institution which delivers working capital becomes one of the stakeholders involved in the recycling process, with strong financial (working capital provider) and non-financial (higher sorting degree for raw materials in the reverse logistics supply chain) implications.

The paper is organized as it follows: Section 2 contains a brief description of the existing research literature about global supply chains, Supply Chain Finance, Reverse Logistics and Working Capital; Section 3 describes working capital model's design and methodology starting points; Section 4 presents the penalty system as an alternative sorting model in the reverse

logistics, and Section 5 presents author's conclusions regarding model's improvement for the recycling business in particular, and supply chains in general in both financial and non-financial terms.

2. Literature Review

Working capital has been a major issue for many supply chains (both forward and reverse supply chains) in recent years due to stronger regulations and laws towards single entities (companies) of the logistics chain. Obtaining a financial credit from a financial institution has become an obstacle for small and medium sized enterprises, which seek to remain on the market in the long run. The process of obtaining working capital has thus expanded from traditional finance solutions (in Supply Chain Finance way) to newer and more complex methods of obtaining capital advantages for daily activities in a competitive market.

Global Supply Chains was firstly suggested in the research literature in the consulting area, in early 1980, and refers to the "management across a network of upstream and downstream organizations of materials, information and resource flows that lead to the creation of value in the form of products and/or services" according to Mangan *et al.* (2008, p. 11). In a study about outstanding supply chains, Waters (2010, p. 9) emphasizes MIT study about best supply chains which combine "a clear business strategy supported by supply chain strategy and a complementary operational mode, which enables the perfect realization of strategy", highlighting once more the importance of operability strategy for a durable supply chain.

The competition focus has shifted from brand versus brand or store versus store to suppliers-brand-store versus suppliers-brand-store or supply chain versus supply chain (Lambert and Cooper (2000) or in terms of moving cost minimization strategy to return maximization approach (Ballou (2007)). While several disruptions (such as demand-side, supply chain and catastrophic risks) and vulnerabilities (customer and supplier dependence, single sourcing, supplier concentration, single and global sourcing) have been signalized by Wagner and Bode (2006), the global market has become more unstable and competitive while supply chains have expanded to a global scale.

One of the main challenges in Global Supply Chains has become "Green Logistics" implementation concept in many companies, which try to adapt their strategies to long-term sustainability target. As parts of this environmental approach, reverse logistics and waste management are among the most relevant contributors when choosing a green strategy. Min and Galle (2001) underlined, on the other hand, green logistics implications in terms of costs and investments in a research concerning successful implementation of green purchasing on various US companies. Cluster formation has expanded once with global supply chain formation, providing a better framework for the business environment in terms of purchasing power, obtaining working capital or credibility on the market. Moosavi and Noorizadegan (2009) designed a simplified cluster structure which includes government, financial institutions and SME enterprises. Once again, the financial component is included in the core cluster-framework.

Burgess *et al.* (2006) has provided a general research framework for Supply Chain Management literature review in order to highlight future directions of research. While analyzing publications for period 1985 – 2003 from ABI/Inform Global Proquest's journals (approx. 100 papers), the authors were unable to find any article with main theme "Finance" as an industry of applicability for Supply Chain Management. However, their findings showed that approx. 10% of the total number of articles included finance and economy in Supply Chain Management researches, whereas the rest were debating larger areas like *Logistics* or *Operations*.

In terms of *financial flow optimization* inside a supply chain, Croom *et al.* (2000) explained how supply chain collaboration long-term goals are not sufficient for optimal financial flow definition and realization when trying to obtain supply chain performance as a whole. This new approach leads to a fundamental question regarding finances in a supply chain: what means financial optimization for supply chain management in practice?

There have been a series of definitions of this new concept, one of them belonging to the authors Pfohl and Gomm (2009, p. 151) which describe Supply Chain Finance as "the inter-company optimization of financing as well as the integration of financing processes with

customers, suppliers, and service providers in order to increase the value of all participating companies". In terms of financing conditions inside a supply chain, relevant levers for the stakeholders involved are: *amount of needed assets* (financing volume) for at least one of the companies involved, the *duration of financing* (loan period), and at which *capital cost rate* will the loan be obtained which represent the interest rate set by creditors. Scott *et al.* (2011, p. 28) refer to Sales and Operations (as strongly related to the financial middle-term strategy) as the "process of constantly realigning decisions in sales, marketing, demand and supply planning areas with the aim to synchronize with the strategic financial plans". Same authors emphasize in the same research one fundamental aspect when implementing a strategy or process, namely the people involved when making needed adjustments in order to meet a company's financial plans. Nevertheless, the people involved in applying a strategy are the most valuable and important resource a company has in terms of success or failure.

Reverse Logistics is another form of Supply Chain, which has a different structure than forward logistics in the way that it handles finished products that, for various reasons, have been taken out of the market to handling and sorting processes in order to either be disposed (destroyed) or used (recycled) further on the secondary market. Main processes inside this supply chain are (according to Ilgin and Gupta (2013)) direct reuse, repair, remanufacturing, recycling and disposal, which are used to handle unpredictable returns (due to the high variation in raw materials, both qualitative and quantitative).

Among the factors of using reverse logistics (or not) are the financial aspect and operational benefits while implementing this new strategy (Bowen *et al.* (2001)). Being green or sustainable is a permanent concern for more companies than ever before due to three criteria (social, environmental and economic responsibilities – Carter and Rogers (2008) which can hinder or increase companies' trust in the business they perform. Although the majority of the firms are actively seeking to implement green strategy, for small and medium-sized enterprises innovation can be a barrier for future development, among which can be found issues such as limited financial resources, organizational structure, short-term orientation towards profit or lack of relationships with external stakeholders according to Hervani *et al.* (2005).

An essential question comes when speaking of globalization and supply chain performance: Can forward and reverse supply chains cooperate in order to improve the efficiency of newly produced products and recycling materials as a common loop? Chouinard *et al.* (2005) conclude that reverse logistics is not a separate part of the supply chain, but it should be integrated in it in order to obtain efficiency and effectiveness of the entire logistics network in order to respond to governmental regulations or sustainable development. While there are many benefits of considering reverse logistics and regular supply chains as a whole and potential global supply chain, one issue is the unpredictability of processes, which can decrease overall performance dramatically.

3. Methodology

In the regular reverse supply chains, following processes are used to handle returns (Figure 1), based on the classic reverse logistics theory regarding the entire supply chain:

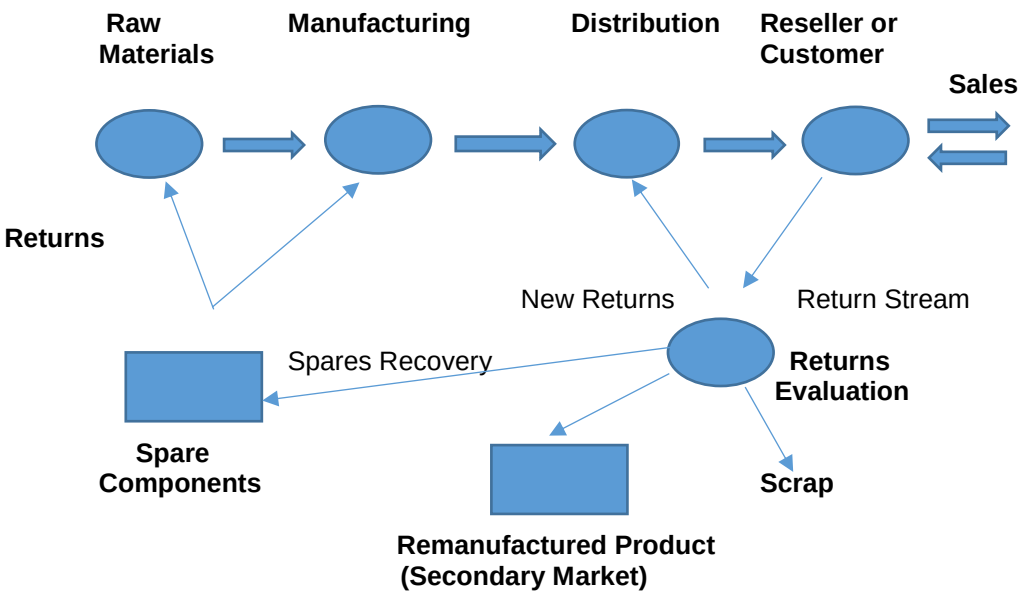

Figure 1. A reverse supply chain for product returns
Source: Blackburn *et al.* (2004, p. 8)

Chen and Hu (2011) configured a global design of the supply chain, which includes three types of flows (information, material and finance) that are present inside the loop. Added complexity to the whole supply chain is represented by the globalization phenomenon, which can increase the uncertainty level for short-term processes or can generate synchronization issues between involved firms. In the same research, Chen and Hu (2011, p. 112) designed a model based on two fundamental questions in Supply Chain Finance, such as „How to solve this grave problem of capital constraints in the supply chain in developing or developed economics?" or "How can optimality be increased in global supply chains, where complexity increases with network structure and international operability?" The authors make the following assumptions: there is one supplier *without capital constraint* (unlimited quantities of raw material), which produces a single product for the retailer (with the selling price noted *w)*, and one retailer (which might be capital-constrained) which has an *initial working capital* (noted B), and which sells the single product type coming from the supplier to its customers, choosing its forecast due to a random variable D, nonnegative and with finite mean. There are two situations: symmetric and asymmetric information. For the symmetric case, the initial capital B, the demand distribution D and the retail price (selling) price p are known. For the asymmetric information at least one of these two components (B or D) are unknown for one of the model participants. Quantity sub-optimality ordering depends on the initial capital B, and depends on the ordered quantity level from the supplier.

Kouvelis and Zhao (2012) have built a similar model, with only one retailer and one supplier (simple supply chain), and a bank as an intermediary actor for financing short-term needs. Moreover, authors described several cases, in which retailers are able to borrow bank loans, under the threat of bankruptcy costs or in which they can choose between a loan or an open trade account with various facilities. Their findings provide solutions for both bank and supplier alternatives of borrowing. General conditions of the model come from the Stackelberg game from "Game Theory" described by Kouvelis *et al.* (2012), where the supplier has a variable supply in terms of ordering and production costs and it acts as the leader due to its wholesale price setting, the retailer (newsvendor-type) is the follower in the game due to its order quantity setting, based on the supplier wholesale price and working capital which can be borrowed from the bank (if extra capital is needed, and if it can be obtained), and the financial "creditor" which is either a financial institution (bank in this case), or the supplier (as a facilitator for short-term

credits). Additional assumptions which authors introduce are related to *bankruptcy risks* (as a market imperfection), which are discussed for both bank and supplier funding.

In reverse logistics, roles for suppliers and manufacturing companies differ than those from forward supply chains, in both roles and ordering points. The actors involved in the production phase of a recycling process are the suppliers (as return-companies who deliver "raw materials" which are used goods in the regular supply chain), the manufacturers (as the sorting facilities, which collect used products, process them in order to define what type of handling they should have furthermore, and distribute them to downstream solutions), and downstream companies (all those companies which sell all the returns coming from the manufacturing companies, and which are ready to be sold on the second-products market). The requirements regarding sorting quality for each fraction for this market is imposed mainly by these firms which have a high standard regarding returns and allowed deliveries.

In the case of regular supply chains, ordered quantity is known and can be estimated, while in reverse logistics the quantity is stochastic and the sorting company (manufacturer) depends highly on the amount and quality of non-linear goods delivered since the quality of used products is not the same on its way into the plant. In addition, the sorting degree in which used products are delivered contribute to the manufacturing process while handling returns.

The model described further in this paper focuses on how the forward supply chain logistics – reverse logistics combination can be adjusted for both the financial and non-financial terms by using a production strategy which improves the end-of-life products original delivery in the reverse supply chains, and the sorting phase in the recycling system by adding value to the overall supply chain performance. The model aims to improve sorting time at the manufacturing stage of the reverse supply chain, to decrease manufacturer's own production costs, and to educate original raw material suppliers in their primary sorting phase.

4. The Penalty System - A Sorting Model for the Reverse Supply Chain

The model of this study is based on Chen and Hu model (2011) adapted to reverse logistics. The idea of the sorting model in the processing phase of returns collected comes from the need of decreasing sorting costs inside the manufacturing phase of the reverse supply chain.

The core idea is how to reach at least a minimum given sorting level for all goods delivered by the supplier (return companies) on their way into the production facility based on their original properties in order to deliver 100% sorted level after the manufacturing process at the sorting facility. This sorting level is established prior to delivery (fixed level), first between the manufacturer (retailer) and the downstream actor in the supply chain (next actor in the production model), and is noted *f,* and afterwards between the manufacturer and the supplier (used products company), level *w*.

In this case, the variable *w* in Chen and Hu model (2011) which comes from the supplier side is given by another actor of the reverse supply chain, namely from the downstream company, and from the manufacturer/sorting facility, which in both cases are not first actors in the supply chain. In order to achieve this minimum exogenous level, the manufacturer has two alternatives: either to finance the whole process for the aimed sorting level itself, or to obtain external financing. In the second case mentioned previously, the external financing company is the original customer (or raw materials deliver firm), as the raw material actor inside the supply chain.

The model has two variables that define the production model optimal values (see Figure 2 for new roles assigned in order to reach the optimal sorting level $w = f$).

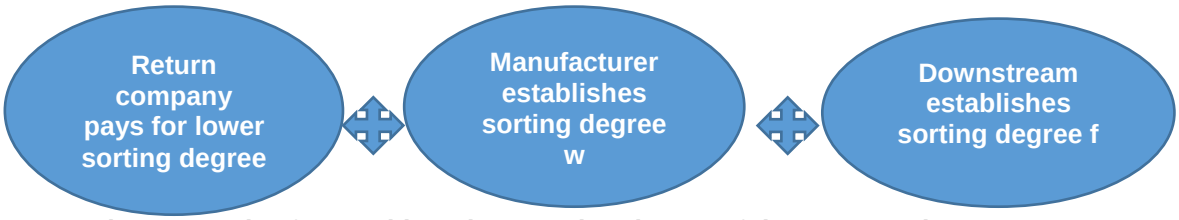

Figure 2. Roles for reaching given sorting degree of the new penalty system
Source: Nicolae (2018, p. 92)

Variables for the reverse logistics production model in the sorting phase of the reverse logistics process are:

W – Sorting level - established for every fraction delivered by the supplier (in regular supply chain, *w* is the wholesale price set by the raw material producer)

B – Manufacturer (sorting facility) original working capital**,** or the regular (normal) production working capital.

The penalty system has a set of prerequisites that need to be followed in order to obtain the optimal values for the working capital needed in the production phase of reverse logistics process, and the steps are explained in the following paragraphs.

First of all, establishing exogenous variables provides the same information related to the allowance sorting level to all the actors involved in the processing phase about the various fractions of the goods delivered after the sorting phase (at the manufacturer site) of the supply chain (noted *f*), and the allowance sorting level of the sorted fractions when the products come into the production/manufacturing company (*w*).

Next, achieving the imposed sorting levels (*w* and *f)* established by both the manufacturer and the downstream actors by covering working capital needs at the manufacturing point of the reverse supply chain leads to the optimal financing of the producer. This actor of the supply chain is the fundamental sorting area of the logistics process, since it has the capacity to handle and sort properly various fraction types.

In terms of operational and financial regular activities, this highly-effective sorting process means that, besides the fixed production costs (salaries, rent or tools), the manufacturer (sorting facility) should cover all variable costs directly related to sorting activities, such as dangerous waste costs (or the extra sorting costs (for other fractions than allowed found in the original deliveries)), the costs for sorting and packing of the wrongly-sorted materials in order to deliver them to downstream solutions for those products that were not declared and paid by the customers in the load originally, extra workforce – all human resources hired in order to work in addition to the normal sorting activity, due to a higher sorting processing of the original goods delivered than if the products had an original sorting degree equal to at least *w*.

There are two situations: one coming from the manufacturer (which covers all production costs (auto-financing), regardless of the sorting degree of goods delivered on the way inside the sorting facility). In this phase, original working capital (***B***) of the sorting company might be exceeded if the sorting degree of goods shipped to the sorting facility does not meet the minimum sorting level imposed by the manufacturer (noted ***w***). As a result, there will be a sub-optimality problem. The other one is provided by another actor/part of the supply chain which should cover these extra expenses in the case of a lower sorting degree than w (given) (external financing). This actor is the supplier in the reverse supply chain. The extra working capital obtained from this actor should include all extra costs for wrongly-sorted original returns.

Since the sorting level *w* is given, but the degree of sorted waste that comes inside the plant is variable, needed working capital is variable. Based on the assumption that the sorting degree of the original products is lower than w, the author has designed an initial model in the case of the supplier financing (which includes a logistics, operational and financial solution in the same time) in order to cover all the additional costs that will come continuously in the sorting phase of the reverse logistics process.

The production (or sorting) model is defined like a penalty system, having main objectives as :to cover needed working capital in the sorting phase of the recycling process, to cover all extra costs of the products/returns delivered originally (both declared and undeclared) associated with downstream solution allowance level on the way out/shipping process, to decrease sorting time at the manufacturer site (higher efficiency), and to educate the supplier at the original sorting point (supplier/collecting raw materials site) in order to deliver original goods in accordance to at least the minimum sorting level *w*.

The penalty system has the following characteristics: there are three penalty categories (small, medium and large), every wrong classification of the original product (wrong information of the original return) is penalized, and if there is an additional time used in order to sort wrongly-

delivered returns, it is added an hourly penalty rate to the model too. The penalty model for each wrongly-sorted load is (*equation 1*):

$$A = K + p_s * \sum_{i=1}^{m} s_i + p_m * \sum_{i=1}^{n} m_i + p_l * \sum_{i=1}^{o} l_i + r + p_{sorting} * s \quad (1)$$

where

A - penalty total value

K - base (penalty fixed amount – or the fee in order to start the penalty control)

p_s - represents the small penalty value (price)

p_m - represents the medium penalty value (price)

p_l - represents the large penalty value (price)

$\sum_{i=1}^{m} s_i$ - represents the total amount for small penalties

$\sum_{i=1}^{n} m_i$ - represents the total amount for medium penalties

$\sum_{i=1}^{o} l_i$ - represents the total amount for large penalties

r –fixed value regardless of the reclassified material value or amount

$p_{sorting}$ – represents the sorting penalty value (price per hour)

s – Calculated on an hourly basis (every 15 minutes).

This linear equation is integrated in the optimal working capital needs in order to reach the established sorting degree w. The optimization model is a maximization problem of the total needed working capital, as a combination between the original working capital and the extra working capital associated to extra sorting activities (*equation 2*):

$$\mathrm{Max}(B + \sum_{i=1}^{p} A_i) \quad (2)$$

where

W = sorting degree (given)

$B \geq 0$, original working capital related to normal sorting activities (given)

$\sum_{i=1}^{p} A_i \geq 0$, which is the sum of all penalties found at the sorting area in a given period

The penalty system has the following component structure for each penalty total value (Figure 3):

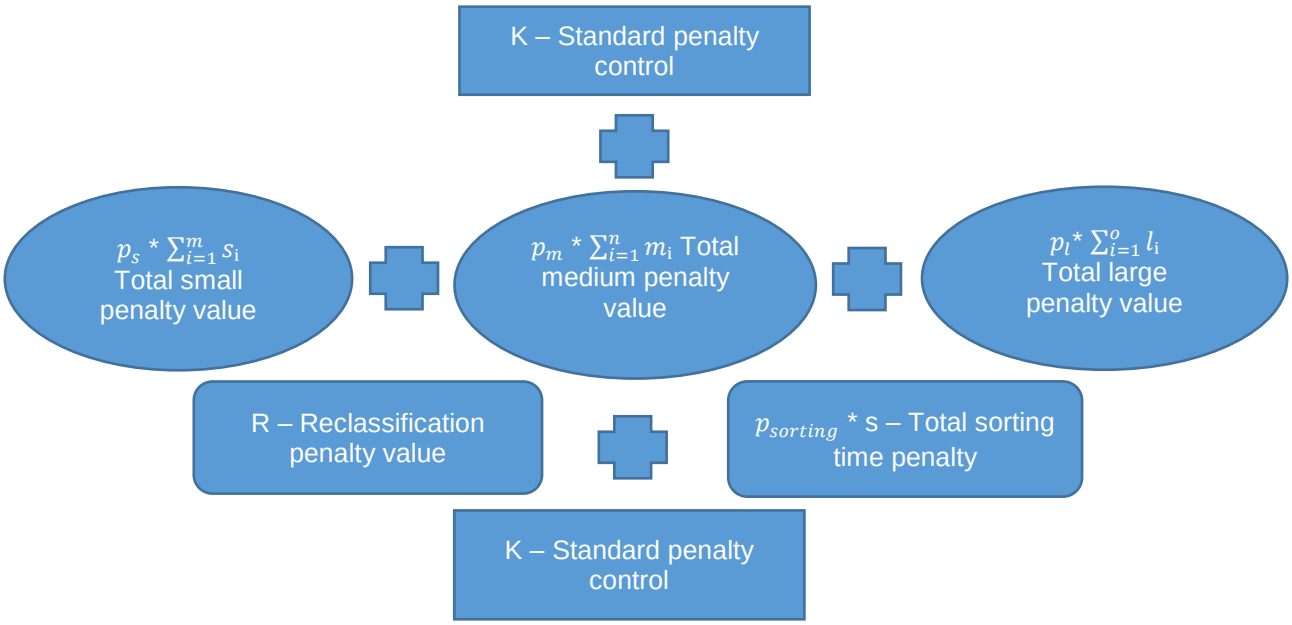

Figure 3. The Penalty System Component Structure
Source: Nicolae (2018, p. 96)

Adjusting the level of financing for total working capital according to real financial needs can be obtained by continuously improving the rates of the penalty components in order to reach optimal working capital. There are two situations: if the original level of financing is *too high* (the penalty system components have high levels), then the model will be adjusted to lower penalty rates, and if the original level of financing has *low values* – then the current charging penalty rates will be modified (higher levels) in order to meet the exogenous sorting level w.

Main characteristics of the model which might interfere in model's implementation phase are:

1. If all the suppliers (referred as raw material producers) have no financial limitations for waste disposal – then the financing of a desired sorting level *w* has no constraints.
2. If the suppliers have financial constraints, then the original financing method (penalty system) should be reconsidered. The suppliers are the ones who either accept this new model, or renegotiate the original model in order to get the original penalty level to an acceptable level. Alternative solutions can be applied by mutual agreement (supplier and manufacturer).
3. In practice, there are various and numerous actors which collect used products (known as raw material suppliers). As a result, the original model can be adjusted to a certain level (specific values) for all those suppliers that decide to renegotiate the financing terms if the sorting level is not the one implemented originally.
4. The small and medium-sized suppliers have a lower negotiation power which results in higher quota for them when applying the original penalty system.
5. If the penalty system that is not accepted by the suppliers which are raw material actors, and the manufacturer faces financing constraints for the total needed working capital that are not included in the normal operations level in the supply chain, all the actors involved in the sorting process of the reverse logistics will face sub-optimality, due to the fact that either the sorting level (w) cannot be reached, which decreases the overall supply chain performance; the sorting facility has lower working capital resources in order to process all estimated returns, or the supplier cannot deliver all raw materials (used products) due to the lack of capacity at the production site.

4.1. Benefits of the Penalty System

Among the benefits of implementing the penalty system in the sorting phase of the reverse logistics process are:

The new system can divide different loads based on their degree of sorting – which leads to lower penalty levels for those clients that sort their loads almost 100% correctly, and higher penalty levels for those return companies which do not sort properly their original deliveries, and which generate several amounts (items) of each penalty type (small, medium and large) and/or more expensive fraction quantities which will be fined with a higher total penalty value due to the accumulation of types and quantities.

An improvement in the sorting degree for most of the return companies (as a consequence of higher sorting costs at the production area than at the original return companies' site) might be visible at the production site. Clients who have constant deliveries on a determined period of time will search to improve their original sorted delivers in order to minimize their overall sorting costs associated to a load.

Less manual work for the production workers – if all the production costs are covered due to the new penalty system, then the manufacturing company has the financial resources to hire external workforce in order to handle all the additional loads that do not meet the requirements (sorting level w) of the production firms.

Better product flow for the whole recycling process – due to better sorting quality of the loads delivered by the return companies to the sorting facilities, which in return will improve the sorting performance of all actors involved by decreasing the sorting time at the sorting plants that was higher before the new system implementation, and it will decrease the delivery times of the returns from the manufacturers further in the reverse supply chain.

The penalty system covers all the additional production costs associated with extra fraction handling costs and sorting activities. The manufacturer will directly benefit from the new system due to the fact that the entire working capital (fixed and variable) is covered without additional borrowing from a financial institution, and without any extra costs (such as interest rates or other constraints).

4.2. Risks associated to the Penalty System

Due to the fact that the new penalty system is a tool that helps mainly the sorting firms to decrease their own working capital costs by rebuilding the penalty fees and mechanism, there are various risks associated with the implementation of such a complex system. Among these risks can be found:

Bankruptcy risks – higher exposure of the return companies to bankruptcy due to the fact that their overall sorting costs will be (in most of the cases) higher than before. As a result, these companies might change the sorting firm, which will lead to lower raw material quantities delivered to the manufacturer, determining a lower volume of the handled goods for the same fixed working capital costs.

Sub-optimality over a long-term period might lead to bankruptcy not only for the return company, but for the manufacturer and the downstream company also.

Lack of understanding of the system for internal workers inside the sorting facilities (manufacturer) – which can hinder the system practical implementation.

Lack of understanding on the supplier behalf – on the operational level, risk similar to the first one mentioned above.

Overall, the penalty model brings a new perspective regarding financing of working capital inside a supply chain: the supplier in the reverse logistics case is not a financial credit institution in terms of Chen and Hu (2011) model, but a financial working capital provider.

In this case, the loan from the original financing model in the forward supply chain that replaced by a penalty system financed 100% by an internal actor of the reverse supply chain, namely the supplier itself. Moreover, the capital "borrowed" from the customers in the regular supply chain will not be paid back, since it is used as penalty for lower sorting level than *w*.

5. Conclusion

Working capital financing has become a recent concern in the supply chain area. Supply Chain Finance domain has treated issues such as financing different actors of the regular supply chains in order to reach supply chain optimality. Chen and Hu (2011) and Kouvelis and Zhao (2012) suggested two alternative models for working capital financing by involving both financial and non-financial decisions in order to get entire supply chain optimization.

This paper explains how working capital can be obtained in a reverse logistics structure in the sorting stage of the recycling process by using a penalty model (sorting system) inside the sorting area at the manufacturer site (which represents the raw material actor in the reverse supply chain). The model suggested is a multi-penalty mechanism that is applied in order to reach needed working capital for daily activities, namely a given sorting level ***w*** at both the manufacturer and the downstream actors in the reverse supply chain.

In this case, the working capital provider is not a financial institution (as described in the classic Supply Chain Finance theory), but one of the actors involved in the reverse supply chain, namely the supplier itself (the original return companies that deliver used products to the manufacturer). This new perspective adds value from the operational, logistics, sorting, financial and environmental points of view for the entire supply chain since it takes into account all stakeholders involved in the recycling process (among which can be found the suppliers, manufacturers, downstream solutions, or the environment).

The importance of the study is that this approach of a penalty system is different from a logistics and operational traditional perspective in the way that the new system represents a financial measure in order to improve the whole logistics of the reverse supply chain, whereas the majority of the studies in the Supply Chain Management focus on finding operational solutions for daily activities in order to improve financial results. But how does this new system work in practice?

New future directions of research for the author are the usage of this penalty system on data provided by one of the biggest recycling companies in Scandinavia in order to see how the system is used in practice and how it can be improved in order to achieve entire supply chain optimization without affecting the day-to-day business.

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