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Real Option-Based Evaluation of Eco-Oriented Investment Using the Example of Closed-Loop Supply Chains

Markus Weskamp[a]*, Anja-Tatjana Braun[a], Thomas Bauernhansl[a,b]

[a]*Fraunhofer Institute for Manufacturing Engineering and Automation IPA, 70569 Stuttgart, Germany*
[b]*Institute of Industrial Manufacturing and Management, University of Stuttgart, 70569 Stuttgart, Germany*

* Corresponding author. Tel.: +049-711-970-1149 ; fax: +049-711-970-1927. *E-mail address:* markus.weskamp@ipa.fraunhofer.de

Abstract

Natural resources should be used as effectively as possible along the entire supply chain. One approach to keep the resources on a high value-added level is the extension of classical supply chains to closed-loop supply chains, covering the whole product life cycle. This requires innovations in products and technologies as well as changes in existing value-added processes. Thus, the required redesign process comes along with extensive investment and a high level of uncertainty and flexibility and can have a significant impact on the success of the company.
This paper presents a model, based on the real options theory with a closed-loop supply chain which complements the classic investment approach with ecological aspects of the evaluation. The model allows a qualitative and quantitative assessment of investment decisions associated with uncertainty. Additionally, the possible options for action and the inherent risks are demonstrated. The expansion of the net present value method to real options with external environmental factors and entrepreneurial aspects of design enable in this case the calculation of an extended net present value for realistic evaluation of strategic investments.

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1. Introduction

Global growth and a rising living standard for current and future generations can be realized only with sustainable management [1]. In order to meet the required change towards a sustainable added value in companies, they have to deal with strategic investment decisions which have a significant influence on the business success.

Therefore, a decision model has been developed that considers environmental influences. A basic requirement of the decision model is the systematic evaluation of the real options within the investment process as well as the consideration of external environmental factors. A methodical approach for the identification and evaluation of optimization potential and investment needs enables investors to manage the investment process. It offers a guideline for a constructive arrangement of eco-oriented investment projects. Due to the complexity of the evaluation and calculation of investment costs, the presented approach will be implemented in a software prototype. The decision model is able to evaluate investment-related options and flexibility in advance and assure the decision process. It offers a basis for managing the scope for designing the respective investment process. Moreover, the model enhances the acceptance of sustainable business models and contributes to sustainability.

2. The change to eco-effectiveness

Eco-effectiveness follows the example of nature and strives to construct biological or technical cycles. Only decoupling the consumption of resources from economic growth allows the required sustainable growth. The decoupling can be realized only through innovation effort into

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new products, technologies and new business models. The implementation of such purposeful innovation is associated with strategically deliberate investment decisions. Therefore, the alignment to more sustainability requires a change in corporate culture and also innovative product design and product engineering. In this case, the existing added-value structures need to be completely revised.

2.1. Finite resources require closed value networks

As part of an eco-effective approach, especially for the established products, the added-value structures of both intra-company and an entire supply chain is to be questioned critically. As shown in Fig. 1. closed material cycles increasingly enable the conservation of natural resources and reduction of waste through the development from a one way economy to a circular economy.

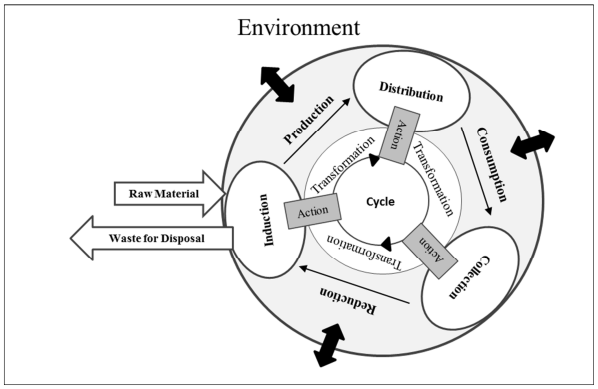

Fig. 1. Simple model of a closed value network [2]

The change towards a recirculated economy, based on the approach of "sustainable development" has extensive implications on the company and its surrounding environment. An increase of economic growth is sought through improved resource productivity while maintaining the quality and quantity of natural resources. A sustainable strategy of the production system includes the efficient use of available resources considering a target balance of economy, ecology and social responsibility [3]. In this context, legislation is required, that specifies that only the consumption of goods is allowed which are detectable and completely ecologically degradable. With the Cradle-to-Cradle concept Braungart and McDonough describe eco-effective products which can be either recycled as biological nutrients in biological cycles or go as technical fabrics continuously through technical circuits [4].

2.2. Closed-loop supply chain

The further development of existing supply chains to closed-loop supply chains provides a possibility to close material cycles and thus to increase the eco-effectiveness significantly. The term "closed-loop supply chain" is based on the environmental management research in the field of recycling economy and is considered as a further development of supply chain management. Following Guide and van Wassenhove, closed-loop supply chain management can be described as the design, control and operation of a maximum value-added system over the entire product life cycle including dynamic recovery of different types and quantities of material return flows over a certain period [5]. Complementary to this, the description of Minner and Kiesmueller considers closed-loop supply chains as related and dynamic processes at the end of the product life cycle [6]. Thus, closed-loop supply chains achieve an essential contribution to the sustainability of entrepreneurial activities. The objective in closed-loop supply chains is the design of products and processes which enable to keep their primary materials long-term at the same value level or even run an up-cycling of materials [7].

However, while integrating material recovery to the closed-loop systems, additional environmental and economic objectives have to be considered. Environmental legislation and market strategic aspects are promoters of an efficient recycling economy. Particular benefits for companies are reduced material costs, less waste production, output optimization with a reduced use of resources and a higher responsibility of the manufacturer. Also an important contribution is made to the enterprises eco-balance. The therefore needed changes are combined with a high degree of uncertainty. In addition, the implementation of innovations in the value chain assumes investment decisions. This investment decisions usually lead to long-term fixed capital commitments and have high influence on the company's success due to their strategic nature.

It is necessary to recognize and evaluate all relevant risks and chances related to the change process. Especially regarding eco-effectiveness these opportunities are often unknown in companies. The model aims to enable and to assure investment decisions oriented towards eco-effectiveness within the whole value chain. Thus, an evaluation model has to be developed supporting decision makers to consider opportunities and investment risks coming along with sustainable production.

3. The investment process

Investment decisions interact with many different departments of the company (interdependences). The affected fields include production processes, logistics, personnel and materials management. The consideration of these interdependences is important for investment planning. The available means of production, for example, influence the realizable range of products. The future market requirements, in turn, have an impact on the future production program and thus to the needed resources. Especially the company's interaction with the environment generates a dependence of investment decisions by external factors. These external factors can hardly be influenced by the company in general. External factors (e.g. demand behavior, social and political context condition) thus have an influence on the investment decision. The investment itself, however, also influences the business environment, for example by the consumption of primary materials or the emission of pollutants. Investments, therefore, should not be regarded isolated from the corporate