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Research Article

From wood to food: Approaching stakeholder integration in forest-based biorefinery development

Vom Holz zum Lebensmittel: Ein Beitrag zur Integration von Stakeholdern bei der Entwicklung von Holz-Bioraffinerien

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Summary

The expansion of existing pulp mills with additional technology processing concepts to forest-based biorefineries implies high risks. A stakeholder-integrated strategy development is therefore more likely to open up such new business opportunities. Therefore, this paper aims to develop and verify a feasible approach. For this purpose, Porter's deliberate strategy was extended in context of a case study on the production of hemicelluloses for value-added food markets. Considering two different strategies based on technological approaches, the case of pre-extraction can be given preference considering the interests of involved stakeholders regarding food additive marketing.

The implementation process of a forest biorefinery remains widely case dependent, but nonetheless this paper provides some guidance concerning realization steps. The study proved that vast concordance between three different stakeholder groups can be achieved in case of two complex options. Hence, coordination of stakeholder interests is feasible in context of technology implementation strategy development.

Keywords: bioeconomy, stakeholder integration, bio-based industries, pulp and paper industry, biorefinery

Zusammenfassung

Die Erweiterung existierender Zellstofffabriken zu Bioraffinerien ist mit großen Risiken verbunden. Um diesen Herausforderungen entgegentreten zu können, ist die Einbeziehung relevanter Stakeholder in die Strategieentwicklung unersetzlich. Dieser Artikel beschäftigt sich daher mit der Entwicklung und Umsetzbarkeit eines entsprechenden Ansatzes. Dazu wurde Porters Konzept der generischen Strategieentwicklung adaptiert und im Sinne einer Fallstudie auf die Nutzung von Hemizellulosen für höherwertige Produkte im Lebensmittelbereich angewendet. Unter Berücksichtigung von zwei unterschiedlichen, auf Basis von technischen Ansätzen abgeleiteten Strategien, erzielt die Vorextraktion eine höhere Übereinstimmung der Interessen einbezogener Stakeholder bezüglich einer Vermarktung als Lebensmittelzusatz.

Die praktische Umsetzung von Holzbioraffinerien ist überwiegend fallabhängig jedoch bietet dieser Beitrag einige generelle Hinweise für Umsetzungsschritte. Die Ergebnisse zeigen, dass eine weitgehende Übereinstimmung zwischen drei unterschiedlichen Stakeholdergruppen im Falle zwei komplexer Optionen erzielt werden kann. Die Koordinierung von Stakeholderinteressen erscheint im Rahmen der Entwicklung von Strategien zur Technologieimplementierung umsetzbar.

Schlagworte: Bioökonomie, Stakeholderintegration, biobasierte Industrie, Zellstofffabriken, Bioraffinerie

1. Introduction

Recently, there has been a growing interest in the pulp and paper industry to develop new lines of business by utilizing side streams and creating innovative application fields (Mayr et al., 2015). The partly saturated market for pulp and paper products forces this industry to adopt a more diversified product portfolio and aim for growth through innovation (Hämäläinen et al., 2011). The sustainable synergetic processing of biomass into a spectrum of marketable food and feed ingredients, chemical and material products, and energy is defined by the term "biorefinery" (IEA Bioenergy, 2014). A detailed analysis of the markets provided profitable future perspectives for microencapsulation materials and food additives derived from hemicelluloses (Stern, 2009). Though research and development is highly promoted on a policy level, the large-scale implementation of biorefineries for pulp and paper industry is still lagging behind (Luguel et al., 2012). The implementation of biorefinery processes implies high financial risks. Risk sharing through partnerships is likely to open up new public funding opportunities and could represent a decisive factor for attracting additional investors (Näyhä and Pesonen, 2013). Improving the collaboration and cooperation partnerships of the main stakeholders of forest-based biorefineries suggest decisive advantages for the implementation of forest-based biorefineries (IEA Bioenergy, 2014). In contrast to the relevance of various stakeholder groups in relation to biorefineries, a very limited number of studies have used a stakeholder-oriented approach. However, a sound scientific basis for the conception, implementation, and evaluation of strategic planning approaches has been formed, predominantly on the basis of two controversial schools of thought. Porter's deliberate strategy suggests strategic top-down guidance (Porter, 1980). Mintzberg's emergent strategy development controversy offers a more flexible bottom-up approach (Mintzberg and Waters, 1985). Both methodological approaches include the analysis of stakeholders and environmental framework conditions while developing long-term business strategies. A stakeholder-oriented approach to strategy management emerged in the mid-1980s, and one evident framework in this movement was delivered by Freeman (Freeman and McVea, 2001). Within the scope of biorefinery in the pulp and paper industry, the integration of stakeholders' perspectives is considered as indispensable. Approaches in the scientific literature, however, are still lacking. Against this background, the central question that motivates this paper is: Is it feasible to integrate different stakeholders in forest-based biorefinery development?

The main objective of the study is to develop a feasible approach for stakeholder integration in the strategic decision-making process in the forest biorefinery business development. An exemplified implementation is carried out as a case study. For this purpose, the production of hemicelluloses for food additives and microencapsulation materials market was selected (Höher, 2013). The application of hemicellulose has an increasing potential to open up new sources of income (Stern, 2009). In this context, the study aims to extend the multiple literature-based and empirically tested approach of Porter's deliberate strategy (1980) to a stakeholder-assessed development. The contribution of this paper is the development of a stakeholder-oriented approach on creating or selecting business strategies in the forest-based biorefinery context.

Section 2 describes the research approach and the steps carried out for the case study. Section 3 reveals the exemplary results achieved by the approach in the selected case study. Subsequently, the applied approach is discussed in the conclusions.

2. Methodology

The approach to create a stakeholder-assessed business strategy derives from the concept of strategy plan development created by Porter (1980). In order to explicitly involve the relevant stakeholders' perspectives into the business development process, the selected approach aims at extending Porter's strategic plan development. The research approach therefore consists of two pillars, the technology assessment and the stakeholder survey, which are finally merged for a stakeholder-integrated evaluation (see Figure 1).

For the purpose of technology assessment in our case study, two different strategies are derived from literature (see Section 2.1). Thereafter three different groups of stakeholders are defined in context of the case study (see Section 2.2). The development of an evaluation scheme (see Section 2.3) uses Porter's five forces model as a base to derive key factors. The key factors are rated according to their individual investment relevance by the stakeholders through an online survey. In a similar manner, the strategies are assessed regarding their performance with respect to the same key factors. By pursuing this approach, an objectified valuation including the investment preferences of the relevant

stakeholder is provided. Subsequently, general guidelines for the implementation of the most preferable strategy can be summarized. The focus of this paper rests on the case study based development and validation of a stakeholder-oriented business development approach. Therefore, we assume no need for universal validity for our results but we do believe that we have been able to spot relevant propensities in the field (Brudermann et al., 2015).

2.1 Deriving base strategies

Starting from the strategic plan development of Porter (1980), two different business strategies are developed, which depict a selection of visionary outcomes. The definition of a vision for each business strategy is based on a content analysis of relevant industrial development studies and strategy papers of the European Union, member states, and forest-based biorefinery related associations (e.g. CEPI, 2011; CEPI, 2012; Luguel et al., 2012; Edelmann et al., 2013). This ensures that all goals and aligned objectives are recorded and subsequently can be summarized in an integrative vision.

For the case study selected, two contrary but techno-economically feasible business strategies were identified.

The green strategy named after the source of hemicelluloses is based on a fully integrated pre-extraction step and produces high-purity hemicelluloses suitable for producing food additives (Van Heiningen, 2006). Hemicelluloses are extracted from woodchips through adapted green liquors. The pretreatment, separation, and concentration can be fully integrated into energy and material flows of an already existing kraft pulp mill. Great future challenges are technical and financial barriers, adequate legal frameworks, and targeted market requires additional approvals and registration. Adequate strategic partnerships might help to overcome the technical challenges of a fully integrated biorefinery and pave the way to the targeted market (Menrad et al., 2009).

The black strategy again named after the source of hemicelluloses is based on black liquor refining, which is fully integrated and converts this residue into a wide range of novel products while a separate combined heat and power generation provides sufficient heat and power (CEPI, 2011). The suggested key technology is thermo-chemical

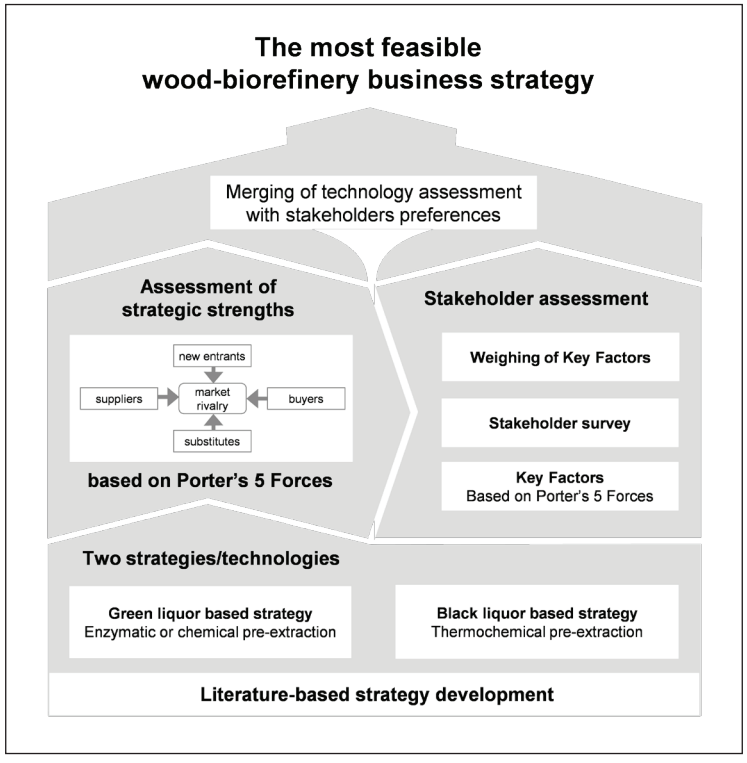

Figure 1. Research approach of the study
Abbildung 1. Forschungsansatz der Studie

gasification, which aims at decomposing polymers into smaller molecules (Sousa, 2010). Within pulping, up to 50% of the processed biomass ends in the black liquor, an underestimated source for added value applications (Fengel and Wegener, 1983; Bajpai, 2013). Thermo-chemical conversion technologies are already operational for biofuels and are expected to have high potential to satisfy the European demand (Molino et al., 2016). The large scale might have considerable impacts on surroundings and cause considerable resistance from local stakeholder groups (Luguel et al., 2012).

2.2 Defining stakeholder groups

The large-scale implementation of biorefineries affects several stakeholder groups. However, within the scope of this paper, the focus is set on the three most relevant stakeholders considering the evaluation of new business strategies. The stakeholder groups are introduced below.

The pulp and paper industry (PPI) accesses and processes large quantity of biomass, is technologically advanced, and has a long experience in the fractionation and separation of wood components. It can provide a sufficient amount of raw material and economies of scale for biorefining and is furthermore strongly connected to the rural economy. Due to the saturated markets for pulp and paper products, this industry sector is under pressure to diversify and to develop new value chains. Most production facilities are located in North and Central Europe and the leading countries in terms of quantities are Germany (23.9%), Finland (11.9%), and Sweden (11.9%) (CEPI, 2012). Consequently, the survey has primarily focused on these countries.

Public and private funding (PPF) will play a decisive role to overcome the technically and economically risky startup phase. Mainly two groups of potential investors can be identified: institutional investors and public funding agencies. Forest-based biorefining is still in the development stage and might not be the most obvious future investment. It is therefore essential to survey attitudes and prior knowledge of potential investors. To understand and meet their requirements is the prerequisite for additional co-financing.

Food additive industry (FAI) is the third stakeholder group and consists of potential customers. This group includes the food additive industry in general and furthermore food additive producers with experiences in microencapsulation. Their experiences in processing food additives, their market power, and access to target markets are of crucial importance for the success of novel products (Stern, 2009). The analysis was limited on the development of strategies within the European Union (plus Norway and Switzerland) with an evident focus on regions with considerable pulp production, in particular North and Central Europe (CEPI, 2012). Nevertheless, the developed evaluation approach assumed to be transferred to other geographical regions as well.

2.3 Evaluation Scheme

The evaluation scheme used in this study is based on Porter's five forces model, which attempts to evaluate the competitive forces within existing business environments (Porter, 1980). With regard to the research scope of the present paper, the focus of the competitive environment of an existing business has to be transferred to the specific case of entering new markets (Stern, 2009). Therefore, an examination of the competitive environment is carried out from the entrepreneurial perspective entirely focusing on the influence of key factors on business performance. In contrast to Porter's model, the adapted version evaluates the expected business environment from the management perspective of a potential partner and investor. This potential partner has to rate potential threats to entering the market, and even after a successful implementation of a forest-based biorefinery, the management has to permanently cope with existing competitors and influences from suppliers and buyers.

The main objective of the evaluation scheme is to link the stakeholder's investment preferences with the characteristic properties of the strategy by standardized key factors.

Therefore, the construction of the stakeholder survey was setup in order to generate adequate numeric assessment values. The selection of the decision criteria, hereinafter referred to as key factors, derives from the adaption of Porter's five forces model. The questionnaire essentially consists of five-point Likert scales for the rating of the specific influence of the key factors regarding the stakeholder's investment preferences. The respondents can propose their level of acceptance by choosing a category ranging from "strong influence" represented by "1" down to "zero influence," which is represented by "0." In order to reduce the amount of invalid replies, the survey is constructed to give participants the opportunity to refuse the answer. Additionally, replies to the questions are voluntary. At the end of each questionnaire sequence, an open question is envisaged, which allows the beneficiary to indicate any other relevant influence factors relating to the topic. The main

part of the questionnaire is accompanied by supporting information, demographic questions, and general questions about knowledge and attitudes.

To ensure data comparability of the differing stakeholder groups, the weighted average influence factor $\bar{x}$ was calculated for each factor and stakeholder group. A "zero influence" rating contributed 0% (respectively 0.00) to the weighted influence whereas a "strong influence" factor had 100% (respectively 1.00) potential to seriously jeopardize the future business performance. The weighted average influence factor consists of the average linear combination of the total number of observed assessments for each Likert-scale rating x_i and the appropriate weighting w_i:

$$\bar{x} = \frac{1}{n} \sum_{i=1}^{n} x_i \times w_i$$

The corresponding result is the comparable weighted assessment of the potential competitive influence of every key factor in each stakeholder group (see Table 1). An additional advantage of compiling the single ratings to one assessment is to avoid biased assessments based on the number of participants per stakeholder group.

A large set of potential participants and organizations (n=268) of the three stakeholder groups throughout Europe were identified via desk research. The stakeholder groups were invited to participate in March 2013. A rather short period of 14 days was set to submit their responses after invitation. The number of valid replies amounted for 23 reliable datasets, which have been used for further analysis. The responses can be allocated to all analysed stakeholder groups, although at varying levels: pulp and paper industry (n=9 or 25%), the investment and consulting group (n=10 or 8%), and the food additive and microencapsulation industry (n=4 or 4%). It is important to note that the obvious and indeed low response rate has a very limited practical impact. First of all, the purpose of the study, the development of a feasible approach for stakeholder integration, has to be kept in mind. Therefore, the empirical results refer only to the case study presented while other cases may use the same approach but perceive other results.

Table 1. Key factor based performance assessment of the green and the black strategy
Tabelle 1. Schlüsselfaktorenbasierte Leistungsbewertung der Grünen und Schwarzen Strategie

	Key factors	Green strategy	Black strategy
Entry barriers	Necessity to invest in a €10 million project	0.50	1.00
	Open up new distribution channels	0.50	0.50
	Defense reactions by established firms	0.25	0.25
	Restrictive legal frameworks for food and feed	0.50	0.50
Competitive factors	Competitors are highly different in size and power	0.25	0.75
	The growth rate attracts competitors	0.75	0.75
	Products are mainly used for high value applications	0.75	0.50
	High exit barriers for the competitors	0.75	0.50
	Production's fixed costs are between 30-40 %	0.25	1.00
Threat of supplier	Supply is regional limited to few (2-3) P&P companies	0.50	1.00
	Supplier's power to dictate terms and conditions	0.50	0.75
	Supplier's dependency on revenues from sold products	0.25	0.75
	Transportation costs	0.25	0.75
	Supplier's dependency on revenues to sold products	0.25	0.25
Threat of buyer	Buyer's power to dictate terms and conditions	1.00	0.50
	Buyer's switching costs	0.50	0.25
	Buyer's ability to integrate backward	0.25	0.25
	Buyer's share in expenses for raw materials	0.75	0.25
	Buyer's business profitability	0.75	0.25
∑ total	**Summarized ratings for both strategies**	**9.50**	**10.75**

Second, the lack of representativeness in this kind of expert survey is system immanent as there is no defined base population. Of the 268 companies/experts contacted, a very small share may be active in biorefinery development. Especially the food additives business and the investors may not even have thought about the topic before and can therefore not treat equal to those who responded. Hence, it is not possible to scale up any of our empirical results from the 23 respondents to the total number of companies contacted (268). Given the diversity of these companies, such an attempt to scale up would be anyway very difficult.

The descriptive analysis of the generated data points out general differences in the weights of each key factor for every stakeholder group. As the focus of this paper is set on the verification of the stakeholder assessed approach, a detailed discussion of these results is dispensed (see Table 2).

The evaluation scheme was furthermore applied to assess the performance of the two strategies (green and black) by consulting the appropriate literature (see Table 1). In this case, the results show differences in the performance of the strategies regarding the key factors. Even though one strategy outperforms the other in the overall assessment, it is necessary to consider the stakeholder related weight of each key factor to complete the assessment (see Table 3).

3. Results

The green and black strategies differ widely in technologies, size, impacts, and locations. The case study assesses their applicability for the involved stakeholder groups. First, the expected influence of the key factors on both strategies has been assessed to indicate their strengths and weaknesses (see Table 1). Practically the assessments range between low influence < 0.25, which means almost no limitation for the implementation, and strong influence > 0.75 referring to serious limitations.

According to Table 1, the green strategy provides a slightly better overall performance due to the lower influences of limitations for implementation. However, the overall difference between the strategies remains relatively small.

Table 2. Average weight of the key factors by stakeholder groups
Tabelle 2. Durchschnittliche Gewichtung der Schlüsselfaktoren nach Stakeholdergruppen

Category	Potential key success factors	PPI[1]	PPF[2]	FAI[3]
Entry Barriers	Necessity to invest in a 10 million € project	0.69	0.68	0.56
	Open up new distribution channels	0.56	0.53	0.63
	Defense reactions by established firms	0.53	0.80	0.50
Competitive Factors	Restrictive legal frameworks for food and feed	0.72	0.83	0.50
	Competitors are highly different in size and power	0.84	0.47	0.56
	The growth rate attracts competitors	0.58	0.61	0.38
	Products are mainly used for high value applications	0.64	0.53	0.56
	High exit barriers for the competitors	0.68	0.50	0.50
	Production's fixed costs are between 30 - 40 %	0.50	0.54	0.50
Threat of Supplier	Supply is regional limited to few (2-3) pulp mills	N/A	0.83	0.75
	Supplier's power to dictate terms and conditions	N/A	0.83	0.58
	Supplier's dependency on revenues from sold products	N/A	0.61	0.38
	Transportation costs	N/A	0.38	0.50
	Supplier's motivation to integrate forward	N/A	0.55	0.58
Threat of Buyer	Buyer's power to dictate terms and conditions	0.75	0.63	N/A
	Buyer's switching costs	0.66	0.61	N/A
	Buyer's ability to integrate backward	0.44	0.58	N/A
	Buyer's share in expenses for raw materials	0.63	0.58	N/A
	Buyer's business profitability	0.59	0.67	N/A

[1] pulp and paper industry, [2] public and private funding, [3] food additive industry

Table 3. Strategies' expected competitive influence on stakeholder groups.
Tabelle 3. Bewertung der Strategien auf Basis der erwarteten Einflüsse auf die Stakeholdergruppen.

	PPI[1]		PPF[2]		FAI[3]	
	Green strategy	**Black strategy**	**Green strategy**	**Black strategy**	**Green strategy**	**Black strategy**
Entry barriers	0.28	0.37	0.31	0.39	0.24	0.31
Competitive factors	0.25	0.35	0.25	0.31	0.21	0.28
Threat of suppliers	N/A	N/A	0.24	0.47	0.21	0.40
Threat of buyers	0.42	0.19	0.40	0.19	N/A	N/A

[1] pulp and paper industry, [2] public and private funding, [3] food additive industry

Table 2 presents the average weights that every key factor received by the different stakeholder groups. In case of the PPI, the supplier-related factors have not been applicable since PPI would act as supplier in the investigated case study themselves. The meaning of the ratings would therefore most likely not just been inverted but difficult to interpret. The same applies indeed for the FAI in case of the buyer-related key factors.
However, comparing the weights of key factors by stakeholder group, some similarities as well as some differences become visible. While the FAI is in general placing less importance to the factors provided (except limitation of suppliers), the PPF is facing several factors with strong influence (Table 2).
Merging the performance assessment of the strategies with the factor weights generated by the stakeholder survey creates the values provided in Table 3. This is the final result of the procedure. It indicates that the difference between the strategies is the smallest for the PPI (almost no difference) whereas the FAI perceives the green strategy as the most preferable. The result for the PPF is in-between the two industry groups, which is a seemingly logic result considering their practical role for the business development. The advantage of the green strategy is based on the assessment and perception of entry barriers, competitive factors as well as threats of suppliers. Only the threats of buyers are favoring the black strategy, which is reflecting for example, a potentially broader product portfolio.
The case study results indicate the difficulties for the development of a business to valorise hemicelluloses in the food additives and microencapsulation industry. While for the respondents of the FAI the number of potential suppliers is considered an important factor, the respondents of the PPI place a higher would give prefer a larger diversity of buyers. This divergence is the most segregating issue when it comes to technology or strategy selection. PPF respondents show less conflicting positions with the other two stakeholder groups. Convergence between all stakeholders can be observed regarding entry barriers, competitive factors, and threats of suppliers.

4. Discussion and conclusions

Stakeholders can be integrated in the strategic decision-making process in the forest biorefinery business development based on a multistep approach. The case study depicts the exemplified application of the method.
The implementation process of a forest-based biorefinery remains case dependent, but nonetheless this paper provides some guidance concerning realization steps. Chambost et al. (2008) suggested a step-wise implementation progress to reduce costs, increase revenues, and optimize margins. This paper presented a first approach to assess the feasibility of biorefining business opportunities and derive concluding strategies considering different technologies, framework conditions, and stakeholder groups. The rather small and convenient sample represented in the case study covered important parts of the relevant stakeholder groups and therefore an important market share of the relevant business. Other samples, constellations, and conditions may, of course, lead to other preferable strategies. Nevertheless, the study proved that concordance between three different stakeholder groups can be achieved in case of two complex options. Hence, coordination of stakeholder interests is feasible in context of technology implementation strategy development.
Further research could extend stakeholder groups, sample coverage, and technologies used. Furthermore, a route toward less detailed and complex technology implementation strategy development could apply multicriteria analytic methods (Ameseder et al., 2008; Brudermann et al., 2015).

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