Developing a Circularity Cost Approach for the Wood Products Industry

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Abstract

The paper approaches the topic of costs when transitioning from a classical manufacturing approach to a circular model in the wood products industry. The purpose of the endeavor is to investigate the main cost categories and to establish their relations and connections, for establishing the basis needed for a detailed quantitative model. The methodology employed starts from a brief literature review, completed by the industry experience of the authors, leading to a theoretical framework that address the costs before and after the aforementioned transition. Our main findings consist in identifying four principal groups of cost items, which are then detailed for the wood products industry and related to the usual accounting practices. The understanding of these connections is important for defining in the future mathematical relations and creating formulas that can be easily applied to any manufacturing company, including from other sectors. The ultimate goals towards which we are working is to facilitate the transition to the circular economy, by reinforcing its environmental benefits and gains with clear arguments pertaining to the efficiency of operating within this paradigm.

Keywords

circular economy, cost analysis, wood products

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Introduction

The need to transition the current economic models from the existing linear and wasteful approach to a circular economy concept, in which both matter, and energy can be recovered and reused in one way or another, is one of the guiding imperatives of the present. The management of existing resources, the protection of the environment and the reduction of the carbon footprint are concrete steps that can be derived from the circular economy paradigm and the sooner the society and companies are ready to embrace it, the better for our continued survival and sustainable development.

In Romania, steps are being taken in this direction, as industry sectors struggle to keep in line with European guidelines and strategies, while other difficulties are coming up all the time. One of the most visible domains in which this solution can be of high value is the exploitation and processing of wood, including many other sub-domains such as forestry, timber and lumber production, fiberboard/ particleboard production, wood-based products, furniture, etc.

The present paper performs a cursory investigation about the costs and savings associated with having a wood products manufacturer adopt a circular economy approach. This follows our team's work in (Tofană, et al., 2022) and is aligned with scientific investigations in the field, such as those performed by (Lazaridou, Michailidis and Trigkas, 2021) and (Susanty, Tjahjono and Sulistyani, 2020). The proposal of the authors combines technical, economic and financial aspects in a qualitative model of understanding and managing the transformation project. The two main parts of the paper include the development of a Theoretical framework based on Literature review and a Discussion of the implications, followed by Conclusions.

Future work is needed to also develop a quantitative model that can relate the currently identified cost categories in a complete feasibility study.

1. Literature review

Although circular economy has become an important policy guideline and requirement in the past decade in the manufacturing industry, the focus of most companies, as many of the scientific studies, rest with the technical (Uemura Silva, 2021) and operational (Gigli, et al., 2019) aspects of the transition from current models, or the overall assessment of the investment opportunity (Kravchenko, Pigosso and McAloone, 2019). However, once the circular approach is up and running, the companies are face with new challenges related to determining the effectiveness and efficiency of their new manufacturing system, and problems only get more complicated with time, as the environmental benefits can remain intangible, while production difficulties can manifest in concrete ways, hampering the competitiveness of the enterprises.

By focusing on a deep transformation of the business model (Albastroiu Nastase et al. 2021), as part of a holistic approach at the national (Ungerman & Dědková, 2020), supply-chain or sectoral level effort (Pitti, Espinoza and Smith, 2020), the success prognostic can be increased significantly. The limiting factors and superfluous costs (e.g. red tape, administration, safeguarding, etc.) can be overcome more easily if the target markets can be convinced by economic efficiency arguments (Mellquist, Boyer and Williander, 2022) or policy interventions (Sikkema, et al., 2023) to facilitate the establishment of the circular economy.

In this context, the most adequate framework to deal with costs and externalities appears to be the lifecycle outlook that is used on a large scale for environmental impact assessment, but can be readily extended to include other cost features such as socio-economic characteristics (Jahan, et al., 2022) and or specific circular economy processes encountered in manufacturing (Wouterszoon Jansen et al. 2020). The methodology we present next divides the production system lifecycle into two zones: before and after transition, showcasing their commonalities and differences.

Theoretical framework

In order to properly distinguish the cost categories of the transition from a classic approach to a circular approach in the wood product industry, we propose the following methodical framework that takes into account the necessary transformations before, during and after the process is complete. This model is based on the understanding of the specificity of each of the paradigms that bring about both costs and savings in relation to each other (see Figure 1). Additionally, there is an important area of overlapping where the costs are similar, as well as an area of costs associated with the change itself.

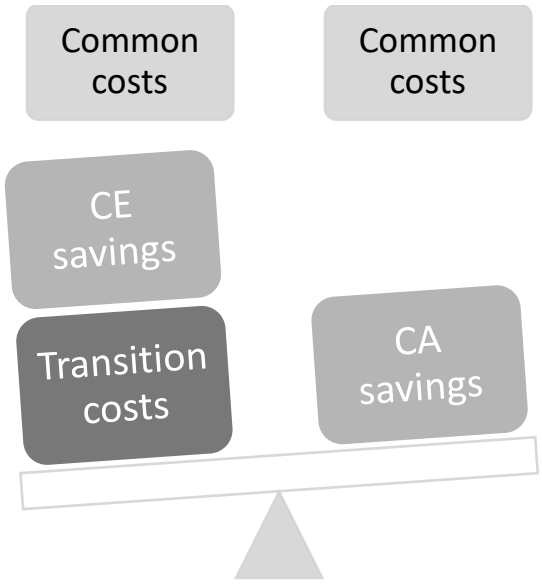

Figure no. 1. CECACM (Circular economy – Classic Approach – Cost Model)
Source: own work

When investigating the issues in more detail, these four main categories can be broken up into specific components, although there is constant dynamic between them until the final goal of establishing the full CE approach is accomplished. The table below presents a general overview of the situation, which can be further detailed depending on the level of accuracy targeted by the analysis (Table 1).

Table no. 1. Details relating to cost categories

Cost category	Cost elements (examples)
Common costs	Overhead costs related to location, management, administration, etc. Production costs associated with design and manufacturing Marketing/distribution costs for promoting and selling the new products Costs of financial and business services need for the company Personnel costs related to the workforce employed by the company
Transition costs (temporary and permanent)	Change of production equipment/software to accommodate CE Re-training of personnel to use the new equipment/software Additional logistics costs to use the new type of recycled materials Cost of new consumables used in the CE specific processes
CE savings	Reduced costs of raw materials by re-use/re-cycling Reduced environmental compliance costs Increased sales of the current product lines Sales of new types of products and solutions
CA savings	Use of existing infrastructure, knowledge and solutions

Source: own work

In turn, if we study the accounting approach used by most Romanian companies, there are several elements that show the possible connections between the CECACM and the records that are usually maintained (Table 2). The symbols in the table matrix below show the degree of correlation among the analyzed categories, going from very low to very high, and using five steps.

Table no. 2. Determining the relationship between CECACM and accounting practices

	Wages and contributions	Raw materials	Energy and utilities	Transport and services	Depreciation and interests	Misc.
Common costs	❺	❺	❹	❸	❷	❶
Transition costs	❸	❹	❶	❺	❺	❶
CA savings		❶	❶	❶		
CE savings		❹	❸	❸		❺

Source: own work

Legend (relationship strength): 1 - very low, 2 - low, 3 - average, 4 - high, 5 - very high

Raw materials and wages represent the largest categories for common costs, and they apply in similar proportions to both models. For the transition costs, the most significant elements are the transport and services (especially for recovering wood) and the depreciation and banking interests associated with purchasing new equipment. Most CA savings are small, while the CE saving are high for raw material and very high in the miscellaneous category due to the new possible sales.

2. Discussion

When analyzing the cost categories proposed in the model above, we must recognize the following important aspects in relation to their definition and possible means of collection of data:

- Both approaches will generate costs related to using equipment and workforce, as well as capital and services to create and sell products, however the technical and competence content of these elements might differ considerably (e.g. replacing tree trunk peeler with a de-varnishing machine, replacing a primary saw worker with a CNC specialized worker, etc.);

- Transition costs incurred in the conversion from the classical to the circular model are either temporary or one-off costs (e.g. buying a new machine, setting up a collection system) or they can become permanent in the new production system (e.g. using enzymes to breakdown lignin or water-based coatings instead of solvent-based coatings);

- The savings brought about the CE approach are either easily quantifiable (e.g. quantity of replaced wood material) or difficult and vague to assess (e.g. image impact on the market niches of becoming a circular manufacturer);

- The savings of CA are mostly related to well-known economic effects related to scale, know-how or shared externalities.

The relationship between these categories is not yet fully defined, one of the reasons being the possibility of some cost elements migrating from one area to another. Especially the permanent transition costs can turn into common costs, as they are accrued and produce the expected changes within the production system and the company staff. Also, the CA savings will become also CE savings as soon as the circular economy approach is adopted on a large scale, as the new external costs (e.g. for transportation or energy, or support services) will become refocused themselves on realizing additional economic benefits. Another pattern that emerges and constitutes an advantage of the new way of doing things is the prosumer paradigm, as the company can use considerable amount of wood waste from the first processing or from additional ones to generate energy for electricity and heating.

Of course, the focus of the company we approached for realizing the case study is on the large technology costs associated with implementing the new model and increasing its sales to the existing customer base, but also on finding and new customers and new opportunities, specifically due to the circular economy model. These categories are perceived as being at least one order of magnitude more significant than all the other included in the framework (full categories or even some of the sub-categories, such as the training costs). The other categories are also acknowledged but their evaluation is not considered a priority in the market place (although it might be interesting for researchers). This aspect leads us to believe that there should be a form of weighing or prioritizing the costs and savings, and not simply treat them as factors in a mathematical formula. Thus, a complete CECACM should also take into account the time dynamic of when the costs become important and what data is available to estimate them.

Conclusions

Based on our investigation, we can conclude that Romanian wood products manufacturers are in the early stages of planning and implementing circular economy models, as they come to assess the magnitude of the necessary changes from an operational and economic point of view. Many times, the focus is on the required investments in equipment and software, but we came to the conclusion that the long-term operation of the approach also bears other significant costs, that should be however offset by the magnitude of savings generated by the possibility of use of recovered wood. Nonetheless, the classical approach also has some important savings for which there is no substitute yet, including the use of existing business channels, the learning effect produced by generation of wood manufacturing and the possibility to leverage the current infrastructure (e.g. production facilities, pollutant treatment stations, classic transportation options etc.). Also, it is worth noting that the transition is difficult if it does not happen as part of a coherent ecosystem in which as many partners as possible in the value creation chain undergo the same process, thus pointing for the need to support this industrial conversion through proper incentives and funding.

Our future work will focus on further developing this cost model through testing and validation in the real world (at a company performing the changeover), collecting additional data to refine it and the establishment of the mathematical formulas and relations that cand quickly produce the desired results for decision makers.

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