Social consequences of replacing steel or aluminium in automotive applications

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EXTENDED ABSTRACT

Wood-based materials offer a promising lightweight alternative to conventional materials like steel or aluminium to reduce fuel consumption and thus the environmental impacts of vehicles [1,2]. So far, research has been carried out to investigate the environmental impacts using alternative lightweight materials as an eco-design measure [3,4], though little is known about the potential social consequences. In general, research on the modeling of social consequences has been sparse, with merely two case studies investigating this approach [5,6]. Consequences differ from impacts in that they not only examine the effects of a change within the product system itself but apply broader system boundaries to account for indirect and market-level effects (e.g., how the allocation of raw materials across industries in a region is affected). The aim of this study is to analyse the social consequences of using wood for automotive applications including potential side-effects on other forest-based industries in Austria. The social consequences of replacing conventional materials with wood in the Austrian automotive industry were analysed by linking 11 social indicators (e.g., fatal and non-fatal occupational injuries, women in managerial positions) with labour input in forest-based industries and material flows in the system dynamics model WOODSIM [7]. The WOODSIM model (Figure 1) depicts the Austrian wood utilization system and allows to simulate direct and indirect effects on the social performance of industries resulting from shifts in wood supply across the industries of the forest-based sector [7,8].
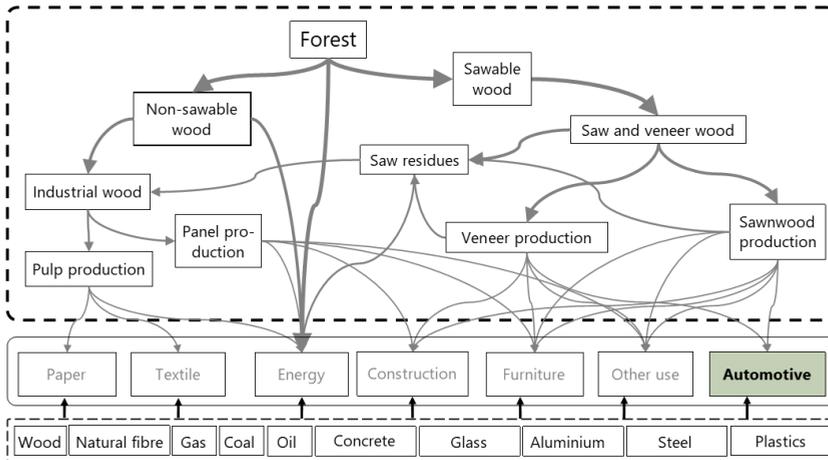
Figure 1: Schematic representation of the investigated system based on [7,8].

The sectoral performance of industries was calculated by using sectoral-specific data from official administrative bodies such as the Austrian Labor Market Service (AMS), the Austrian Chamber of Commerce (WKO), and Statistics Austria as well as more aggregated data from other sources (e.g., ILO, WHO) to depict social risks of global value chains. To illustrate the variability of effects depending on the specific application, two wood-based innovations were investigated: a wood-based side impact beam (SIB) for passenger cars replacing a steel-based SIB [2] and a wood-hybrid battery compartment for battery electric vehicles (WBC) replacing aluminium and steel [9,10]. In addition, these two innovations were compared to wood-based innovations in other sectors, namely in the construction and textile sector. To make the replacement scenarios comparable the same amount of additionally used wood for the SIB and the WBC was assumed (i.e., 25,000 m^3).

Modelling the system dynamics of social consequences showed that steel is connected with higher risks regarding fatal occupational injuries than aluminium, resulting in less social consequences for the WBC. The high-risk countries for this indicator are especially the Ukraine, the Russian Federation and Chile [8]. An improvement in the social performance can be thus achieved by taking measures improve the working conditions in the companies of the value chain or designing the value chain in a way that only suppliers from low-risk countries (e.g., Sweden, Greece) are chosen. Comparing innovations of different industries shows that the automotive industry has the potential to result in bigger improvements than the construction or textile industry. This is mainly due to the transition of value chains from globalized to primarily

regional ones. Hardly any effects can be observed if the replaced materials are largely sourced from Austria or neighbouring countries. Given the limited availability of wood, and assuming a consistently sufficient demand to clear the wood market, significant indirect effects on other wood-processing industries were observed. For example, the incorporation of wood in automotive applications leads to indirect consequences for the "other use" industry, as materials with greater social risks are being utilized to replace the wood that has transitioned to the automotive sector [8]. These findings can be used to identify optimization potentials in the Austrian wood utilization system in terms of its social performance. However, some of the results may be biased due to the poor data situation for the indicator of non-fatal occupational accidents [8]. Austria reports the highest number of non-fatal accidents, while countries that are transitioning or developing tend to have significantly lower figures. This discrepancy may be attributed to varying reporting practices across different regions of the world. This work offers a first attempt to model the social consequences of an innovation with system dynamics modelling which is essential to not overestimate positive effects when analysing consequences. Future studies may focus on optimizing systems with respect to various objectives, particularly aiming to reduce environmental and social impacts.

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