Analysis of policy measures and feedback effects on industry transformation towards carbon neutrality

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Extended Abstract:

The German industry faces major challenges in complying with the Federal Climate Protection Act (BMVU, 2021) and the Paris Climate Agreement (UNFCCC, 2015). By 2045, the sector must achieve carbon neutrality that is in line with the 1.5-degree target of the Paris Agreement. While, according to recent numbers, industry emissions continued to fall in 2023, and met the legal requirements (Umweltbundesamt, 2024a), this can be mainly attributed to declines in production due to a weak economic development (Umweltbundesamt, 2024b). If the industrial sector continues to invest in emission reduction measures as before, it is highly likely that the Paris Climate Agreement and the legal requirements cannot be met (Holz et al., 2018).

The EU's Emissions Trading Scheme (ETS) and Germany's carbon pricing system can be considered the most important policies used to date to steer investments in emission reduction measures. In response to the developments observed so far, policymakers are discussing strengthening these measures and introducing further levers, such as offering low-interest loans or changing corporate tax rates. However, it remains unclear how these incentives will affect the industry. Therefore, the following research questions arise: What levers can politicians use to encourage industry to make further investments in climate protection measures? What impact do the political measures have on economic factors of industrial sectors? Do they help or hinder the transformation?

We develop a qualitative System Dynamics model to analyse policy measures and their feedback effects on the industry's transition to carbon neutrality. The model focuses on a specific industry sector and groups together companies with similar energy consumption and technology profiles. It integrates data from the literature, facts and data from specialised reports and newspaper articles as well as the authors' understanding of the system to identify causal relationships and feedback loops (Jalali and Beaulieu, 2023).

In the model, we focus on the energy consumption and energy supply of the production facilities. We assume that the electrical energy is initially purchased from the grid and that the carbon emissions are equal to the national electricity mix. Thermal energy is supplied by the natural gas grid. The investment decision is driven by the deviation from an emission target and the remaining carbon budget. A decision can be made between the photovoltaic system, a heat pump and an increase in electrical or thermal energy efficiency. This decision is influenced by the legal and economic pressure to reduce emissions, the mitigation potential of the available measures, the specific abatement costs of the measures, the available financial resources, and the industry's willingness to act. The financial resources are provided by both internal and external financing. External financing is provided through conventional bank debt or green bonds.

The model underlines the crucial role of the carbon target deviation in encouraging companies to invest in environmental measures. High deviations increase industry's willingness to invest, leading to increased capacity in photovoltaic systems and heat pumps and improved energy efficiency. The use of subsidised debt could reduce interest rates and financing costs, and thus increase profits and the investment budget. Lower corporate tax rates also increase profits and the investment budget. Increasing carbon or energy costs could boost investment in mitigation measures, but they could also increase operating costs, reducing profits and the investment budget. Energy subsidies could also discourage proactive investments and potentially increase carbon emissions because reducing operating costs leads to lower prices and thus higher demand and sales. To solve these problems, subsidies could be linked to compliance with carbon regulations to ensure effective utilisation.

This paper presents a qualitative system dynamics model to analyse policies and feedback effects influencing the industry's transition to carbon neutrality from both technological and economic perspectives. The model captures the complex interactions between carbon reduction investments, regulatory compliance pressures, the economic success of the industry and the availability of finance. While this qualitative analysis provides valuable insights into the transformation dynamics of the industry, it is essential to develop a quantitative version of the model. This would allow for a detailed case study of a specific industry, assessing different investment strategies as well as the effectiveness of policy levers to promote industrial transformation.

A full paper on this topic can be found here: Ahlfs, S. & Kieckhäfer, K. (2024): Analysis of policy measures and feedback effects on industry transformation towards carbon neutrality, in: Systems Research and Behavioral Science,1–17. DOI: https://doi.org/10.1002/sres.3059.

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