THE INFLUENCE OF UNCERTAINTY ON THE DECARBONISATION OF THE SPECIALTY CHEMICALS INDUSTRY

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Overview

Climate change mitigation demands a swift transition in the energy sector regarding both the supply and demand side. While investments on the supply side (e.g., into renewable power production) have been mainstreamed in Europe in the past two decades thanks to effective support policies, investments in clean industrial production technologies (i.e., the demand side) still lack a comparatively secure investment environment—especially as in today's globalized world, industrial production is much more exposed to the risk of carbon leakage than the power sector.

To steer emissions reductions towards net zero and to overcome the lack in investment security, the EU's most powerful tool is the emissions trading system (ETS). According to the latest political decisions from December 2022, the ETS cap is going to be reduced faster than previously planned—i.e., by 4.4% annually from 2028 on. This ambitious path would lead to the cap reaching zero by 2040 and a rapid increase in carbon prices (Pahle et al., 2023). It could, however, lead to political backlash resulting in a loosening of the policy regime—a major uncertainty for potential investments. On top, large uncertainties around energy prices and CO_2 transport infrastructure impose additional uncertainty for plant operators. With emissions and energy costs being a major determinant of production costs, such uncertainty impedes timely investments in mature clean production technologies and ultimately results in uncertainty for the energy system as a whole.

To no surprise, there is a lively debate among scholars, policy makers and industry representatives on policy mixes best suited to overcome existing uncertainties and create a business environment conducive to investments in clean technologies (see e.g. Edenhofer et al. (2019)). In 2022, this debate was further intensified by the introduction of the Inflation Reduction Act that heavily supports investments into clean technologies in the US. Policy options to reduce emissions costs uncertainties frequently discussed in literature are industry-agnostic emissions price floors or collars (Flachsland et al., 2018) and industry- or project-specific Carbon Contracts for Difference (CCfDs) that polluters and the state agree on and which fix the carbon price for a defined period (Chiappinelli & Neuhoff, 2020). In addition, CAPEX-focused instruments (like investment subsidies) are commonly considered for new technologies.

The chemicals industry is one of the most energy and emission intensive industrial sector in the EU. While the decarbonisation of chemical feedstock production—e.g., that of ethylene from naphtha in steam crackers—is (rightfully) in the focus of research, emissions from the remainder of the chemical and pharmaceutical industry—i.e., the production of fine and specialty chemicals—are less well studied. The decarbonisation of the latter can largely be achieved through cross-sectional technologies that are not specific to the chemical industry (e.g., high temperature heat pumps). The role of policy in accelerating the decarbonisation of this sector is an interesting case to study, as the technologies often are mature but simply not economically viable in the presence of uncertainty.

In this context, the conference contribution addresses the following questions: *How do uncertainties around carbon and energy prices influence clean investment decisions in the specialty chemicals industry, what is the role of policy in accelerating investments, and what are investments' implications for the energy system?*

Methods

We use real options valuation (more specifically the value of the "option to defer" investments (Amram & Kulatilaka, 1999; Dixit, 1994)) to study the effect of different policy interventions on investment decisions in the specialty chemicals industry given technological and price (ETS and energy) uncertainties. The option to defer is particularly suitable to model policy's role in accelerating investments in clean technologies as it—compared to regular NPV models—takes into account investors' preference for postponing investments in the presence of uncertainty. While many real options-based studies exist for power sector investments (see e.g. Blyth et al. (2007), Laurikka & Koljonen

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(2006), Reedman et al. (2006), and Yang et al. (2008)), much less work is available for clean technologies in the industrial sector (Agaton, 2021). Our analysis focusses on four cross-sectional decarbonisation options, namely carbon capture and storage (CCS, see e.g. Gardarsdottir et al. (2019) and Voldsund et al. (2019)), a fuel switch to biofuels, the combination of both, and direct electrification (e.g., via heat pumps) as these options allow for a full decarbonisation of specialty chemicals production in the near future. The model is implemented as a trinomial tree model in Python with a step length of five years and the option values being calculated recursively. We inform and triangulate this real options analysis by interviews with practitioners from the industry and technology providers. We further test how sensitive results are towards changes in different input parameters.

Results

Preliminary results show that accounting for option values changes expected investment decisions. Furthermore, we show that energy-related emissions are abated through direct electrification and the use of biomass depending on temperature levels and energy prices. Carbon capture and storage/utilization is only applied for few large point sources of difficult to abate process emissions and those from the incineration of industrial waste. Accordingly, the decarbonisation has mainly implications for the demand for natural gas and its replacements biomass and electricity. All tested instruments (CCfDs, a price floor, and investment subsidies) could significantly de-risk and accelerate investments in clean technologies. The extent to which investments can be expedited depends on the perceived price uncertainty, the policy intensity, and the assumed correlation between emissions costs and other input parameters.

Conclusions

The decarbonisation of specialty chemicals production in Europe is associated with a shift from gas to electricity, biomass and, in few cases, to carbon capture solutions. The technology choice is mainly influenced by technical specifications as well as energy prices, but**—**with exception of technology-specific subsidies**—**to a lesser extent by policy. The timing of investments, however, can be heavily influenced by all policies. By quantifying the influence of policy on investment decisions, our work helps to better understand implications for the energy system.

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