Analysis of the macro-economic and production network implications of decarbonisation pathways

Deliverable 5.1

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2020-10-05

Abstract

The purpose of this report is to discuss how a decarbonising the steel, plastic, and paper industries may affect economic growth, wages and employment in the European Union (EU). We approach the issue from two different angles. First, we discuss how a decarbonization of the three industries may affect the rest of the economy. Second, we discuss how a decarbonization of the three industries may affect their future growth potential.

We conclude that the macroeconomic effects of a decarbonisation are likely to be relatively small but could under certain conditions still be economically significant. The main factor determining the size of any macroeconomic effect is whether the decarbonization will lead to higher costs of materials elsewhere in the economy. The industries most likely to be affected by higher material costs are the manufacturing, utility and construction industries. How they respond depends on the level of competition and their ability to innovate. Industries that are characterized by a high degree of competition and product innovation are likely to respond by investing in new more efficient production technologies and to develop new products to increase their value added. Sectors where competitive pressures are low and the scope for product innovation limited are most likely to increase prices and reduce their output and employment levels.

The steel, plastic and paper industries future growth potential is partially linked to their ability to use modern technologies to increase efficiency and for product innovation. Based on recent data from the European Union we find that investment in new technology such as information and communication technologies have enhanced productivity in these three sectors without having increased their greenhouse gas emissions. Some economic growth of this kind is likely to take place in the future and can be used to help to finance investments in low carbon technologies. It should a policy aim to encourage both decarbonization and modernization at the same time.

1. Introduction

The purpose of this report is to discuss how a decarbonising the steel, plastic, and paper industries may affect economic growth, wages and employment in the European Union (EU).[1] We approach the issue from two different angles. First, we explore how a decarbonisation of the three industries affect the rest of the economy. Second, we explore how a decarbonisation of the three industries affect their future growth potential. Here we consider their ability to increase their produced economic value through e.g. new products and technology without increasing greenhouse gas emissions.

The three sectors themselves are relatively small compared to the overall size of the economy.[2] But they account for a large share of all industrial greenhouse gas emissions. They are so called upstream industries that produces materials that other so called downstream industries use as intermediate goods in their production. Close to 90 percent of all their output are used as intermediate goods by other industries, and only 10 percent is consumed directly by end-users. Their biggest customers are the manufacturing, construction and utility industries (for details see Andersson, 2020a). Any direct macroeconomic effect from a decarbonization of these sectors are likely to be small. However, they may cause relatively large indirect effects by affecting the behaviour of the downstream industries. The first part of this report is devoted to discussing and quantifying the size of any such indirect effects.

The second part of the report focuses on the three industries future economic growth potential. Once upon a time during the first and to some extent second industrial revolutions these industries were essential drivers of economic growth (Andersson, 2017). Their importance has since declined. In a future sustainable economy, production of virgin raw materials may have to fall irrespective of production technology, e.g. through a shift towards a more circular economy. However, economic growth is measured as the value these sectors produce. While their physical production levels remain stagnant of even decline, their economic value may still increase ceteris paribus due to new technology or products. In the second part of the report we

[1] Here we have excluded the meat/dairy industry as it is significantly different compared to these three industries.
[2] The exact size of the sector depends on how they are defined. They account for only a few percentage points of total output in the European economy even if we use a broadly based industrial definition.

focus on these industries ability to generate higher economic values without increasing greenhouse gas emissions in the future.

The discussion in this report is a summary of the research published in Andersson (2019) and Andersson (2020a, b, c). The reader is referred to those publications for more details including details on data and methodology.

2. Potential macroeconomic effects from upstream decarbonisation

The steel, plastic and paper industries are primarily upstream industries. Almost all of their output are consumed by downstream manufacturing industries, utilities and construction firms. Less than 10 percent are directly consumed by consumers. They are themselves relatively small in economic terms compared to the overall economy, but they may still cause relatively large macroeconomic effects through their impact on downstream industries in their value-chain.

Andersson (2020a) studies how the steel, plastic and paper industries have affected their respective downstream industries in Europe between 1998 and 2016. The focus is on technological change and relative price changes for materials and how these cause changes down streams in the value chain. Based on these results Andersson discusses the potential effects of a decarbonization of the three industries on the wider macro-economy.

Theory provides no certain answer to how a decarbonization of the upstream industries will affect downstream industries: it depends on a wide range of different factors. One such factor is whether the upstream and the downstream industries are technologically integrated. Technical collaborations across the value chain are often used to share knowledge, skills and experience (Bayona, Garcia-Marco and Huerta, 2001; Miotti and Sachwald, 2003), and to reduce the risk involved in the innovation process (Tether, 2002; Belderbos, Carree and Lokshin, 2004; Naghavi and Ottaviano, 2010). It is often stressed that collaborations are essential when it comes to environmental innovation as the risks are commonly higher, the innovation process more complex, and the economic benefits often smaller compared to other technological and product innovations (see, e.g., Green, 2012).

Although there are strong arguments for industries collaborating the enhance the innovation, such collaborations are not always successful. Differences in expectations and communication difficulties across firms and industries are two factors that make collaboration difficult (Skippari, Laukkanen and Salo, 2017). Moreover, firms only engage in collaborations across the value-chain when the expected gains are expected to be high (Menon and Menon, 1997; Bowen et al., 2001). For most environmental innovations, the expected gains are relatively small (Carter and Carter, 1998; Bowen et al., 2001), so we should not expect a high level of collaborations around green innovations. Yet, a decarbonization of the upstream industries may still affect downstream industries through markets and prices.

According to some studies, upstream production costs are likely to increase when they decarbonize (Palm, Nilsson and Åhman, 2016; Åhman, Nilsson and Johansson, 2017; Vogl, Åhman and Nilsson, 2018). A large share of this production cost is likely to passed on to the downstream industries as the upstream industries ability to carry the cost is limited. The price increase will trigger a downstream response. That response can either be i) passing on the higher cost to their own customers, ii) reduce other production costs and reduce waste, iii) invest in new and more efficient production methods, iv) innovate new production methods, v) innovate new products with a higher value added that can carry higher production costs.

Based on data from the last twenty years from the European Union, Andersson finds the following direct and indirect effects of upstream technological change and relative price changes on the manufacturing, utilities and construction industries.

Direct effect: technological integration

There is little evidence of direct evidence of technological integration between the steel, plastic and paper industries and their respective downstream industries. At least when it comes carbon technology.[3] A change in the upstream carbon technology is not followed by any similar change downstream. This suggest that technological collaborations and innovation collaborations are relatively weak. We should not expect at change in the carbon technology among steel, plastic and paper industries to have any major direct on downstream industries.

[3] At the aggregate level carbon technology is measured as the amount of CO2 emissions per unit of output.

Indirect effect: price signals

As expected market signals have a strong impact on the behaviour of downstream industries, but the effect vary from industry to industry. The downstream response is summarized in Table 1. Six possible downstream responses are considered:

- they may invest in new more efficient production capital
- they may enhance their total factor productivity, which is a joint measure of the economic efficiency of capital and labour, and of product innovation.
- they may change their prices.
- they may reduce other production costs here measured by real wages in the industry.
- they may improve their own carbon technology by cutting waste in the production process or coming from new production capital.
- they may reduce cost by reducing employment levels.

The downstream response is illustrated for the three major downstream industries: manufacturing, utilities, and the construction industries. A plus sign (+) implies that an upstream price increase from the steel, plastic or paper industry increases the respective variables. A minus sign (-) implies that the effect is negative. Only significant effects are shown. All other fields in the table are left empty.

Downstream *manufacturing industries* respond to higher production costs coming from the upstream sectors by investing in new production capital that is both more economically efficient and more carbon efficient. These investments lowers the cost of production and helps the industries to pay for higher material costs. There is also some evidence of that they are innovating to increase the value of the products they produce such that they can carry the higher material cost.

Capital	Capital	TFP	Relative price	Real wage	Carbon technology	Employment
Manufacturing	+	+	+		-	
Utilities			+	-		-
Construction			+	-	-	

Table 1: Estimated effects of a five percent relative price increase in the steel, plastic and paper industries.

Source: Andersson (2020a)

The downstream *utilities* on the other hand pass on the cost to their consumers through higher prices, and reduces wage costs by both cutting real wages and reducing overall employment. There is no evidence of new capital investments or technological/product innovation. The downstream *construction* industry also reduce wages and increase prices. Again there is no evidence of any major investment or innovation activities.

There are three potential factors that may explain the differences in the way in which the manufacturing industries respond compared with the utilities and construction industries. First, we are studying a relatively short time period. In particular, utilities tend to have relatively long investment cycles compared with manufacturing firms. It is possible that utilities invest in new capital and enhance their productivity, but the effect first occurs several years into the future. Second, the market conditions, not least competitive pressures, are likely to have an effect. Higher levels of competition in the manufacturing sector prevent manufacturing firms from pushing on the cost increase to their consumers. Instead, the firms innovate and invest to make themselves even more productive when the material costs increase. Utilities and construction firms commonly face less competition and can, to a higher degree, pass on the cost increase to their consumers without losing too many customers. However, we should not ignore the third potential factor, which is the ability to innovate. The products of utilities, and to some extent construction firms, are more standardized than those of manufacturing firms, and the scope for either innovating or updating the product to increase its value is more limited for utilities and construction firms than for manufacturing firms.

From the perspective of consumers, the increased cost in manufacturing output is likely to be of less concern as the product is likely to have improved as well. The price increase is thus at least partially a reflection of the product's higher value added. In fact, a decarbonization of the economy is unlikely to ca use any major changes in consumer prices and thus economic

welfare is the overall increase in costs for the consumer is small (Andersson, 2020c). Globally, European country's international competitiveness will growth if all countries decarbonize at the same time as the European economy is among the most carbon efficient in the world. However, exports will suffer if the decarbonization is unilateral without any protection of European industries (Andersson, 2018). This is especially important for highly competitive global markets as for steel.

In summation, we find that upstream and downstream industries are not technologically integrated. However, downstream industries respond to changes in the cost of materials. These results have two major implications. First, an increase in material costs are partially offset by the manufacturing industries through innovation. A decarbonization of the upstream industries are thus unlikely to cause any major negative macroeconomic effects. At least as long as the increased in costs is global. If the cost increase only occurs in Europe, industries will lose in competitiveness and that loss should be a concern. Second, the lack of technological integration among the upstream and downstream industries indicate i) that a shift towards a more circular economy will be easier to achieve than if upstream and downstream industries were technologically integrated, and ii) that the macroeconomic effects of a shift towards a more circular economy depends entirely on what happens to the price of materials.

3. Future economic growth

Is it possible to sustain economic growth rates in the future or is it necessary to reduce the level of economic activity to combat climate change? This is a question not only asked about the steel, plastic and paper industries but of the economy at large. Some argue that future economic growth is incompatible with a sustainable economy and calls for so called de-growth, i.e. a reduction is the size of the economy (for a review see e.g. van den Bergh and Kallis, 2012). The center of economic growth has already shifted away from the material producing sectors to the service industries. According to some estimates the level of physical output from the material producing industries may decline in the future. However, not all economic growth is linked to the physical level of production. Also the value and the productivity of the economy matters since economic growth is measured as the economic value an industry produces. Andersson

(2020c) asks the question if it is possible for the steel, plastic and paper industries to grow the value without growing their greenhouse gas emissions.

Economic growth is caused by many different factors. Often these factors are separated into two sets: intensive growth factors and extensive growth factors. Extensive growth is caused by greater use of production resources such as capital, labor, energy and natural resources. Intensive growth is caused by higher productivity or new products with a higher value added compared to previously produced products. The level of extensive growth an economy or an industry can achieve is of course limited in the long run. The level of intensive growth on the other hand is only limited by our ability to innovate.

Andersson (2020c) studies the steel, plastic and paper industries between 1998 and 2016. He divides the growth factors into intensive and extensive factors and studies how they correlate with greenhouse gas emissions and the use of other natural resources. Similar to Andersson and Karpestam (2013), he finds that they key growth driver linked to more greenhouse gas emissions is capital growth. More or larger production units more emissions. However, non-negligible levels of growth have come from intensive growth factors such as investments in productivity enhancing technologies such as information- and communication technologies without any increase in greenhouse gas emissions. Similarly an increase in total factor productivity (economic productivity and new products with a higher value added) does not cause more emissions. This result suggest that there is a limited possibility for growth in the future from e.g. productivity and product innovations ceteris paribus.

A future sustainable economy is likely to become more circular compared to the present economy. However, there is still likely a need for some new virgin materials. Investments in new carbon neutral production methods are likely to be costly. Encouraging intensive growth among the material producing sectors will enhance profit margins ceteris paribus, which may help financing some of the costs of decarbonization. Consequently, from a policy perspective, focus should not only be on decarbonization but also modernization through new productivity enhancing investments to increase the value produced to help finance the decarbonization.

4. Conclusions

The direct macroeconomic effects of a decarbonisation of the steel, plastic and diary industries are likely to relatively small given these industries relatively small economic importance in the European economy. But the effects of the decarbonization will affect other industries as well through the value-chain provided that the cost of materials increase. The steel, plastic and paper industries affect downstream industries primarily through market signals. A decarbonization of the three industries will spread to other industrial sectors if the decarbonization changes relative prices in the economy. How downstream industries respond depends on the characteristics of these industries. Higher costs for materials can have some positive effects on downstream industries provided that the levels of competition are high and that they have the ability to innovate both in terms of new production methods and new products. Overall there is no cause for alarm that a decarbonization will have any major negative macroeconomic effects. At least as long as the decarbonization takes place over a range of years. The lack of technological integration among upstream and downstream industries indicate that these results hold also for a more circular economy. The macroeconomic response to greater circularity depends on what happens to the cost of materials.

One reason we may expect downstream industries to be affected is because production costs will increase, which in turn is passed on to the downstream industries through higher prices. A complementary way of financing a decarbonization is to increase the economic value produced by the three upstream industries. Economic growth caused by intensive growth factors does not directly cause greater emissions of greenhouse gasses. Policies that encourages both decarbonization and modernization at the same time is more likely to succeed in reducing emissions while keeping the potential negative economic effects of the decarbonization to a minimum.

References

Andersson, F. N. G. (2020a). Effects on the manufacturing, utilities and construction industries of a decarbonization of the energy intensive and natural resource based industries. *Sustainable Production and Consumption* 21, 1-13.

Andersson, F.N.G. (2020b). Estimates of the inflationary effect of a global carbon price on consumer prices, investment prices, export prices and import prices. In Carbon dioxide: Past, present and future perspectives. *Nova Publisher*, forthcoming.

Andersson, F.N.G. (2020c). Industrial economic growth, energy and material consumption. Lund University mimeo.

Andersson, F. N. G. (2019). Perspectives on Climate Policies. *LSR Working Paper* 2019:1.

Andersson, F.N.G. (2018). International trade and carbon emissions. The role of Chinese institutional and policy reforms. *Journal of Environmental Management* 205(1), 29-39.

Andersson, F. N. G. (2017). Basindustrin och dess ekonomiska utveckling. In Johansson, B., and Nilsson, L.J. (eds). Nollutsläpp i basindustrin. Förutsättningar för en ny industripolitik. *Lund University Rapportnummer 101*.

Andersson, F.N.G., and Karpestam, P. (2013). CO_2 Emissions and Economic Activity: Short- and Long-Run Economic Determinants of Scale, Energy Intensity and Carbon Intensity. 2013. *Energy Policy,* 61, 1285-1294

Bayona, C., Garcia-Marco, T. and Huerta, E. (2001). Firms' motivation for cooperative R&D: An empirical analysis of Spanish firms. *Research Policy*, 30, 1289–1307.

Belderbos, R., Carree, M. and Lokshin, B. (2004). Cooperative R&D and firm performance. *Research Policy*, 33, pp. 1477-1492.

van den Bergh, J.C.J.M, Kallis, G. (2012). Growth, A-Growth or degrowth to stay within planetary boundaries? *Journal of Economic Issues* XLVI (4), 909-919.

Bowen, F.E., Cousins, P.D., Lamming, R.C. and Faruk A.C. (2001). Horses for courses: Explaining the gap between the theory and practice of green supply. *Greener Management International*, Autumn, pp. 41-61.

Carter, C.R. and Carter, J.R. (1998). Inter-organizational determinants of environmental purchasing: Initial evidence from the consumer products industries. *Decision Sciences*, 29(3), pp. 659-684.

Green, K. (2012). Green supply chain management practices: Impact on performance. *Supply Chain Management: An International Journal*, 17(3), pp. 290-305.

Menon, A. and Menon A. (1997). Environmental marketing strategy: The emergence of corporate environmentalism as marketing strategy. *Journal of Marketing*, 61, pp. 51-67.

Miotti, L. and Sachwald, F. (2003). Co-operative R&D: Why and with whom? An integrated framework analysis. *Research Policy*, 32, pp. 1481-1499.

Naghavi, A. and Ottaviano, G.I.P. (2010). Outsourcing, complementary innovations, and growth. *Industrial and Corporate Change*, 19(4), pp. 1009-1035.

Palm, E., Nilsson, L.J. and Åhman, M. (2016). Electricity-based plastics and their potential demand for electricity and carbon dioxide. *Journal of Cleaner Production*, 129, pp. 548-555.

Skippari, M., Laukkanen, M. and Salo, J. (2017). Cognitive barriers to collaborative innovation generation in supply chain relationships. *Industrial Marketing Management*, 62, 108-117.

Tether, B. (2002). Who co-operates for innovation, and why. An empirical analysis. *Research Policy*, p. 31.

Vogl, V., Åhman, M. and Nilsson, L.J. (2018). Assessment of hydrogen direct reduction for fossil-free steelmaking. *Journal of Cleaner Production*, 203, pp. 736-745.

Åhman, M., Nilsson, L.J. and Johansson, B. (2017). Global climate policy and deep decarbonisation of energy-intensive industries. *Climate Policy*, 17(5), pp. 634-649.