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An analysis of the economic determinants of energy efficiency in the European iron and steel industry

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A B S T R A C T

The iron and steel industry has some of the highest levels of carbon emissions and energy consumption in Europe. At the same time, this sector is of great economic importance for the European Union.

In this paper we investigate the technological, market and policy factors that are associated with a reduction in the specific energy consumption in iron and steel production. In addition, we analyze whether achieving more environmentally friendly production is accompanied by a decrease or an increase in production levels.

We base our analysis on technical information about cost factors of steel production routes, historical data for prices of energy carriers, on prices for the feedstock in the iron and steel sector, on political framework conditions, and the demand for steel.

As we find out, higher energy prices tend to raise energy efficiency (or tend to reduce specific energy consumption) in the steel sector. Yet, because lower specific energy consumption is related to higher total steel production, energy price increases might cause a kind of rebound effect, bringing about an increase in total production as a consequence of induced energy efficiency improvements. Taking this effect into account, the negative relation between input prices and total steel production is not very strong. In the short run, the wages of employees in the steel sector tend to have the biggest influence on total steel production. In the long run, GDP and investment climate exert the biggest influence.

1. Introduction

A reduction in CO_2 emissions and energy consumption are two of the main objectives of the EU's climate and energy policies. Highly ambitious objectives, such as an 80–95% reduction in CO_2 emissions by 2050 as set by the European Council (European Commission, 2011) and the German government (Bundesregierung, 2010), will have a significant impact on the energy supply system as well as on the economy as a whole. Particularly energy intensive sectors, like the iron and steel industry, will be affected by CO_2 reduction measures which may result in additional (cost) pressure. Taking into account high competition levels in national and international markets, increasing costs could result in lower domestic production. However, politicians seek not only to reduce CO_2 emissions but also to sustain the domestic value creation capabilities of these industries.

The iron and steel sector is an exemplary case for the impact of energy policy on industry because of its large contribution to European CO_2 emissions and its high level of energy demand (EEA, 2013; Eurostat, 2012).[2] European steel policy is currently highly topical. In June 2013, the European Commission proposed an action plan for the European steel industry (European Commission, 2013). This document is remarkable as it is the first time since the Davignon Plan of 1977 that the European Commission proposed a comprehensive action plan for steel.[3] The new action plan details

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[2] According to the EEA, the contribution of “Iron and Steel” to energy related greenhouse-emissions accounts for 22% of total industrial emissions in the EU 27 (EEA, 2013). The final energy consumption of this sector constitutes 18% of the energy consumption of the industry (Eurostat, 2012).

[3] In the Davignon Plan, the Commission pursued an increasingly interventionist policy in order to address the deep steel crisis in Europe between 1975 and the late 1980s (Dudley and Richardson, 1997).

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the need to stimulate growth in the EU steel sector, cut costs and increase innovative, sustainable steel production.

We ask which technological, market and policy factors are associated with a reduction in the specific energy consumption in iron and steel production. Specific energy consumption refers to the ratio of total energy consumption to production volume. In addition, we ask whether achieving more environmentally friendly production, i.e., production that is associated with lower specific energy consumption, is accompanied by a decrease or an increase in production levels. As outlined above these questions are of high relevance to policy makers deciding on particular actions of energy policy. Our research also links to a discussion recently opened by Acemoglu et al. (2012), namely to what extent technical progress and economic growth is fostered by moving towards more abundant input factors. As we explain later in more detail two production routes compete for output in the iron and steel making. One is more resource and energy intensive than the other, but may currently enjoy cost advantages over the more resource and energy efficient method. By analyzing the association between technological, market and policy factors and specific energy consumption as well as output we are able to shed more light on this discussion.

In several studies, the impacts of non-financial barriers on the deployment of energy-efficient technologies have been identified (e.g., ECORYS, 2008; Schleich, 2009; Trianni et al., 2013). Different aspects of energy efficiency in the iron and steel sector in Europe have been analyzed in several studies. Oda et al. (2012), for example, analyzed the specific energy consumption of different steel production routes in selected countries. The changes in the iron and steel sector's specific energy consumption, with a focus on the historical deployment of different steel production routes, have been described by, for example, Arens et al. (2012), Price et al. (2002), Liu et al. (1996), Schleich (2007) and Worrell et al. (2001). Dahlstrom and Ekins (2006) analyze the value chain of the UK iron and steel industry. A case study with information on the factors determining energy efficiency for a steel mill was carried out by Siitonen et al. (2010). In the studies by Hasanbeig et al. (2013), Hildalgo et al. (2005), Moya and Pardo (2013), Oda et al. (2007), and IEA (2012), information on the costs of different steel production techniques is used for creating scenarios on the future of the iron and steel industry's energy demand. Impacts made by cost changes on iron and steel demand and supply have been also analyzed by using top-down models. In these models, energy reduction and fuel substitution options are assessed (see e.g. Alexeeva-Talebi et al., 2012), typically using an aggregated production function with elasticities. Technological aspects are only taken into account in a very aggregated way (Schumacher and Sands, 2007).

The impacts of climate change policy on the steel industry have been analyzed in several studies (e.g., ECORYS, 2008; Santamaría et al., 2014; Okereke and McDaniels, 2012; CEPS, 2013). In these studies it is stressed that in recent years, the steel industry has managed to limit burdens resulting from energy and climate policy, e.g., by pointing to the fierce competition on the international markets. In particular, the free allocation of CO_2 allowances to the iron and steel industry and the classification of the iron and steel industry as a privileged electricity consumer are mentioned as examples of why the sector has not been significantly harmed. However, such favorable treatment may be discontinued in the future.

Based on technical information about cost factors of steel production routes, historical data for prices of energy carriers, on prices for the feedstock in the iron and steel sector, on political framework conditions, and the demand for steel, we analyze the impacts of these factors on the specific energy consumption of the industry as well as on overall steel production. We do not assume perfect markets as is often the case in forecast models and we do not limit the analysis to technical aspects as is done in many bottom-up studies. Rather, we intentionally restrict our analysis to the five major steel producing countries in the EU, namely Germany, Italy, France, Spain and the United Kingdom, to lessen complications that may arise from unobserved heterogeneity and simultaneity of supply and demand. These five EU countries face fairly similar conditions in the market for steel given the EU's internal market, which allows for a comparison of fairly homogeneous countries. Based on information about production cost, crude steel production, overcapacities, consumption of iron ore, coking coal and other inputs, we assume that the steel producers from these countries can be regarded as price takers with respect to input and output prices.[4] According to CEPS (2013), McKinskey&Company (2013a), WSD (2012) and Grimmond (2011), the steel companies in Western Europe are among the highest-cost producers in the world. There are overcapacities not only in Europe but also in other regions (McKinskey&Company, 2013b), which foster competition on national and international levels. Taking into account market shares of less than 3% for each of the selected countries in the global production of crude steel (World Steel Association, 2013a) and low transportation costs, it is very likely that these countries cannot significantly influence the price of crude steel (CEPS, 2013), even if differences in steel quality are taken into consideration. This assumption is supported by studies on the effects of changes in the cost for raw materials on the profitability of the European steel industry which show that increasing cost resulted in lower profits (see e.g. ECORYS (2008), McKinskey&Company (2013a,b), CEPS (2013)).[5]

Our analysis focuses on countries and not on international companies like ArcelorMittal, which may have more market power than 'small' countries. The assumption with respect to the feedback on the prices of inputs is based on statistics about the share of the selected countries in the overall consumption of the corresponding inputs. The demand for iron ore and coking coal can be used as examples: The steel sectors in the selected countries consume less than 1.5% of the coking coal (IEA, 2013) and less than 2.5% of the iron ore (World Steel Association, 2013b) consumed worldwide. Our approach thus allows studying possible influences of differences in prices for inputs to steel production among countries that are otherwise fairly similar.

The paper is structured as follows: In Section 2, we provide some information on iron and steel production. In Section 3, we describe the approach chosen for this study, in Section 4 we discuss the data used, and in Section 5 the results. Section 6 puts the results into a broader context and draws conclusions.

2. Technologies, costs and efficiency

For the assessment of specific energy consumption in the iron and steel sector it is necessary to take a closer look on the techniques and production processes in use. An overview of the main production routes is presented in Fig. 1.

In the recent years nearly 70% of the crude steel supplied worldwide has been produced by using the blast furnace/basic oxygen (BF/BOF) production route (World Steel Association, 2013b). This route comprises the steps "raw material preparation", "iron

[4] 'Price takers' refers to firms that take prices as given and do not take into account how their production decisions influence world market prices.

[5] Morfeldt et al. (2015) highlighted that in Europe there are some steel plants which produce high quality steel for niche markets and which have some market power. According to CEPS (2013) the production of niche specialists are comparable low in comparison to the production of the main player in the countries we selected for our study. So, the market power of niche specialists does not play an important role and can be ignored in a first step.