

The Steel Industry in the European Union: Composition and drivers of energy prices and costs

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No. 80/December 2013

This report was prepared as a contribution to the European Council on Energy with the financial support of Eurofer, which we gratefully acknowledge. The content and the analysis shall be attributed only to CEPS' independent research.

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ISBN 978-94-6138-372-3

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CEPS SPECIAL REPORT No. 80 / 17 DECEMBER 2013

PREPARED FOR EUROFER AND THE EUROPEAN COMMISSION

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Abstract

This report assesses the energy costs borne by the steel industry in the EU between 2010 and 2012, and compares the energy costs, including both the energy components and other regulatory costs, to production costs, turnover and margins of steel-makers. The estimates of energy costs are based on primary sources, i.e. is on information provided by steel-makers through a written questionnaire. This information was validated by the research team by checking annual energy bills, when available, and other public sources. In this respect, this exercise represents a unique fact-based investigation into the costs of energy for steel-makers in Europe, whereas most of the information currently available in the public domain is based on secondary or statistical information.

In 2012, the median EU steel plant pays about €33/MWh for gas, up from €26/MWh in 2010. As for electricity, in 2012 the EU median plant pays €62/MWh, up from €59/MWh in 2010. The report also includes a comparison with the prices of energy carriers paid by producers based in the US.

Main Findings

This report assesses the energy costs borne by the steel industry in the EU between 2010 and 2012, and compares the energy costs, including both the energy components and other regulatory costs, to production costs, turnover and margins of steel-makers. The estimates of energy costs are based on primary sources, i.e. is on information provided by steel-makers through a written questionnaire. This information was validated by the research team by checking annual energy bills, when available, and other public sources. In this respect, this exercise represents a unique fact-based document on the costs of energy for steel-makers in Europe, whereas most of the information currently available in the public domain is based on secondary or statistical information. Information for production costs and margins has been retrieved from industry databases and the analysis of public accounts.

Some 17 respondents, including both steel-making companies and national federations, participated in this exercise. The sample of plants is diversified in geographical terms, as it is widespread across the regions: north-western, southern and central and eastern Europe. The sample also includes different steel making technologies, namely BOF (basic oxygen furnaces) integrated sites, EAF (electric arc furnaces) plants and rolling mills.

In 2012, the median EU steel plant pays about €33/MWh for gas, up from €26/MWh in 2010. Price of gas is much higher in southern Europe (€47/MWh), while central and eastern producers are close to the average, and north-western producers enjoy a cost advantage compared to the rest of the EU.

As for electricity, in 2012 the EU median plant pays €62/MWh, up from €59/MWh in 2010. The cost of electricity is the highest in central and eastern Europe; in southern Europe, it is still higher than the EU average. North-western producers enjoy again a cost advantage from lower electricity prices.

For natural gas, the energy component is the main driver of total costs, as it represents about 90% of the final price. While taxes and levies are almost negligible, network costs represent between 7% and 8% of the final price; they are the highest in central and eastern Europe and the lowest in southern Europe.

When it comes to electricity, the energy component is again the main cost driver but it represents a lower share of total costs – between 74% and 81%. Network costs represent between 8% and 9% – up to 13% for central and eastern Europe – and are fairly stable. Other taxes and levies are also stable, between 4% and 5% of the electricity price. RES (renewable energy sources) levies in 2012 represent 12% of electricity costs, up from 7% in 2010 (up to 14% in central and eastern Europe).

The report also includes a comparison with the prices of energy carriers paid by producers based in the US. Although the international comparison cannot be as representative as the analysis on European prices, it shows striking differences. American steel-makers are enjoying a significant cost advantage due to electricity and natural gas prices. As for the former, electricity prices for US steel-makers are constantly around half that paid by EU producers. As for the latter natural-gas prices in the US have plummeted, and now US steel companies pay only 25% of that borne by the EU counterparts.

In 2012, energy costs represent 13% of production costs for the production of EAF wire rods, 2.3% of which consists of regulatory costs (network costs, RES levies, other levies and taxes). For BOF hot-rolled coils, energy costs represent 5.1% of production costs, of which 1.2% is due to regulatory costs.

If regulatory costs of energy are compared with the EBITDA, they represent 19.2% of this margin for EAF wire rods, and 38.6% for BOF hot-rolled coils. As for electricity, the ETS (emissions trading system) indirect costs, which are part of the energy component, represent 0.6% of production costs and 5.0% of EBITDA for EAF wire rods; and 0.2% and 2.5% for BOF hot-rolled coils. Regardless of how margins may vary among different financial years, the impact of energy costs remains similar also in 2010 and 2011.

1. Description and production

1.1 The industry value chain

The steel industry value chain includes all the processes required to transform raw materials (mainly coal, iron ore, electricity and scrap) into finished steel products. Generally, the following infrastructures are required to produce steel (EPA, 1995):

- Coke ovens
- Sinter and pellet plants
- Blast furnaces
- Steel furnaces
- Rolling and finishing mills

Based on the degree of vertical integration, steel-making plants can be broadly classified in two different groups, i.e. **integrated plants** and **minimills** (secondary steel producer). The former group includes fully integrated plants, where all the production stages are performed (from coke-making to product finishing), and partially integrated plants, where coke ovens are not installed and coke-making is outsourced. Integrated plants use blast furnaces (BFs) and basic oxygen furnaces (BOFs) to transform iron ore and coke into steel. The minimills group mostly includes plants comprising only steel furnaces and rolling and finishing facilities. The minimills mostly utilise electric arc furnaces (EAFs) to produce steel, and mainly rely on scrap, and only partially on raw iron, which is usually purchased as processed input.

A broader definition of the industry value chain would include upstream the suppliers of raw materials and, downstream, intermediaries (service centres, stockholding companies, etc.) and final customers (producers of steel end products).

1.1.1 The steel industry value chain and production technologies

1.1.1.1 Coke-making

Coke-making is the first production stage in fully integrated plants. Coke is the fuel and the carbon source adopted in iron-making and is produced by processing low-ash low-sulphur bituminous coal. Pulverised coal is added in the coke oven through an opening located in the top of the oven. When the ports are sealed, the coal is heated, in the absence of oxygen, at high temperatures (1200-1300°C). The necessary heat is provided by external combustion of fuels and recovered gases. Coke is the solid material remaining in the oven. Coke-making is an energy-intensive process. Despite coke being still essential in the production process, to increase cost effectiveness steel-makers are adopting new technologies that aim at reducing the quantity of coke required. In particular, pulverised coal can be directly injected in blast furnaces rather than in the coke oven; according to technical sources, “pulverised coal injection can replace about 25 to 40 per cent of coke in the blast furnace, reducing the amount of coke required and the associated emissions” (EPA, 1995: 16-17). In some facilities also waste plastic or other fuels,

such as natural gas or oil, are injected (Ogaki *et al.*, 2001). Furthermore, new processes are progressively adopted to produce iron using gas or coal rather than coke.

1.1.1.2 Iron-making

In partially integrated plants, coke is purchased as a processed input and steel-making starts with the production of raw iron in blast furnaces. These furnaces are vertical cylindrical vessels (up to 35 meters high and up to 15 meters wide) where iron ore, coke (the fuel), and limestone (the flux) are charged at the top and are subject to a smelting process mainly aiming at removing impurities from iron ore as well as oxides resulting from the reduction. Hot air, usually heated through recovered exhaust gases, is blown into the base of the vessel, thus supplying heat and oxygen for combustion. At the bottom of the furnace, molten iron and slag are collected as outputs. Molten iron may either be casted into ingots (the so-called pigs) or transferred directly to a connected steel furnace. Iron-making in a blast furnace is a continuous production process that requires the progressive addition of raw materials at the top of the vessel. Modern blast furnaces have between 2,000 and 6,000 cubic meter capacities. The production of iron accounts for about 55% of the total cost per tonne of steel and constitutes the largest cost category (Madar, 2009).

Also new technologies are being adopted for iron-making. The Direct Reduction Iron-making (DRI) is a new process, using gas rather than coke as a fuel, being particularly cheap in countries with access to low-cost natural gas. DRI facilities are less capital intensive than traditional integrated plants, and are efficient at smaller production volumes.¹ A slightly different technology, known as smelting reduction, replaces coal for coke. DRI and similar processes can be used both in integrated plants² and in minimills to substitute scrap. For minimills, DRI and similar processes represent the only viable technology to reduce their dependency on high-quality scrap or pig iron made by integrated producers.³ Nonetheless, there are still some factors limiting the adoption of this technology: i) DRI needs particular iron ores as an input, ii) its output (the so-called sponge iron) requires further processing to completely remove slag and iii) production costs, and thus profitability, are highly dependent on the price of gas (BCG, 2013).

In any case, blast furnaces are still deemed the best solution for integrated facilities, considering both their efficiency improvement and their significant economies of scale. Furthermore, the availability of miniblast furnaces (whose capital investments is about only \$17-19 million rather than \$400-900 million for traditional vessels) constitute a viable alternative to DRI plants to contain capital expenditures (Madar, 2009).

¹ At larger volume, BOF installations are cheaper in term of capital cost per unit of output.

² The use of DRI in integrated plants to substitute scrap as a cooling agent in the converter is very limited in Europe.

³ As mentioned in the next paragraph, to improve the quality of their production, EAFs have to rely on high-purity input, i.e. high-quality scrap, molten (or solid) pig iron, and/or DRI.

In integrated mills, sinter and pellet plants may also be installed, and this equipment is relatively common in Europe. Sintering is a process to agglomerate iron ore fines with other small particles (pollution control dusts, coke breeze, flux et cet.) at high temperature into a porous mass (sinter agglomerates) that can be added in the blast furnace. A sinter plant enables recycling of iron-rich material, otherwise disposed as production waste (EPA, 1995). Pelletising is a process to transform iron ore into pellets by processing iron ore with additional substances. Pellets are hard spheres which are preferred to lump ore in blast furnaces because hot air can circulate more freely, thus improving the efficiency of the iron-making process.

1.1.1.3 Steel-making

Steel-making basically consists of a process to transform raw iron in steel by removing impurities (mainly carbon, phosphorus and sulphur). The remaining quantity of carbon is crucial to determine the hardness of the steel. During the steel-making process, other metals (manganese, nickel, chromium, and vanadium) may be added to create alloys, thus obtaining specific qualities of steel.

In steel-making, the more production stages are integrated, the more production costs per tonne are reduced; therefore, the industry is moving towards a full automation and continuous production flow.

Molten iron from blast furnaces is traditionally refined in Basic Oxygen Furnaces (BOF), which are cylindrical vessels lined with refractories where high-purity oxygen is blown under pressure. To eliminate impurities, limestone and other flux are added in the BOF process, thus producing slag that is removed from molten steel. In BOFs, up to 30% of scrap iron and steel can be combined with molten iron. Modern BOFs can take a charge of iron up to 350 tonnes per cycle (Ecorys, 2008).⁴

The Electric Arc Furnace (EAF) is a completely different technology for steel-making; it is usually adopted in minimills. The main inputs for the EAF are scrap and electricity. Electrodes installed within the furnace melt scrap through the heat created by an electric arc. Limestone and other flux are added in the EAF to remove impurities from molten steel. When the quantity of other metal residuals (the so-called ‘tramp metals’) contained in scrap is incompatible with the steel quality envisaged, pig or sponge iron is also charged in the furnace to dilute them. Tramp metals usually lower the metallurgical quality of steel produced in minimills. The EAF has a cycle time of about 50 minutes to one hour. The size of EAFs ranges from very small units of 50 tonnes of capacity per cycle, to large facilities that can charge up to 200 tonnes (Ecorys, 2008). An EAF processing only scrap uses 10% of the energy needed by blast furnaces and BOFs, not accounting for the different inputs used in the two routes. New technologies are enabling further reduction in energy consumption by pre-heating scrap with recovered hot gases.

⁴ A different and older production process adopts Open-Hearth Furnaces (OHF) where impurities are removed from molten iron by blowing flames and heated air in alternating sequence on a pool of molten iron. The OHF process has been progressively abandoned since the 1950s, when BOF technology was introduced, as it is more efficient at all levels of production.

EAFs are economic and efficient at relatively small volumes of production compared to BOFs, in particular because they can be easily shut down and restarted.

In the 1950s, the continuous casting technology was introduced. Through this technology, molten steel is directly and continuously formed into blooms, billets, and slabs.⁵ Molten steel is poured into a container (the so-called ‘tundish’) from which it is released into the water-cooled moulds of the casting machine. The metal is cooled as it descends through the moulds, thus forming a thick solid shell. Progressively, on the run-out table, which operates at a constant speed and is cooled by water, the centre also solidifies, thus allowing cutting the cast shape into lengths (EPA, 1995). In terms of efficiency improvements, continuous casting has been second only to BOF. In the 1980s, thin slab continuous casting was introduced, thus also eliminating several stages in the hot rolling process. This technology eased the entry of minimills in the hot-rolled product business, even though metal quality is still a limitation, as high-quality coiled sheets have to be free of tramp metals.

1.1.1.4 Rolling and finishing

Blooms, billets and slabs are transformed into finished steel products in rolling facilities. A traditional distinction is made between ‘long’ and ‘flat’ products. Long products are rolled from blooms and billets. Blooms (characterised by a rectangular cross-section of 16cm or more) are rolled into structural beams. Billets (characterised by a square cross-section of 4 to 14 cm) are rolled into bars, rods and wire. Long products for the construction market represent the bulk of the production. They have relatively limited production costs and are intended to comply with lower standards (mainly strength requirements); hence, they are considered low added-value products.

Slabs (flat cross-section) are rolled into steel plates and coiled sheets, the latter being produced in rolls. Coiled sheets are the most-used steel product, automotive and appliance producers being the bigger customers. Rolling facilities form these products in a succession of stages where the steel passes through rollers characterised by narrower and narrower clearances. Two different types of rolling are possible: i) hot rolling (heated steel), producing coiled sheet with a rough surface; and ii) cold rolling (unheated steel), adding strength to the metal and making the surface smooth and shiny. Flat products have relatively higher production costs and comply with higher standards (e.g. in terms of lightness, strength, corrosion resistance, flawless surface, special coatings etc.) required by more demanding customers, thus being high added-value products.

One of the most crucial aspects of a finished product is the quality of the surface. In particular, to avoid corrosion, a protective coating has to be applied. Common coating processes include: galvanising (zinc coating), tin coating, chromium coating, aluminising, and terne coating (lead and tin). Coated products may also be painted to further prevent corrosion (EPA, 1995).

⁵ Previously, the steel-making process needed an additional intermediate stage (the so-called ‘ingot teeming’), where molten steel was poured into ingot moulds, thus allowing steel to cool and solidify. Ingots were then transformed in primary mills into blooms, billets, and slabs.

Finished products also include tubes and pipes. The pipe and tube industry includes two main production processes: i) seamless pipes, which are made through hot rolling starting from billets; and ii) welded pipes, which are made through cold rolling starting from plates (large pipes) or coiled sheet (small pipes). Seamless pipes require special billets as inputs; hence, they are usually made in vertically integrated plants, comprising either an EAF or, less frequently, a BOF (mostly in central and eastern Europe). In contrast, welded pipes are usually made by companies buying steel on the market.

1.1.2 The upstream and downstream value chain

1.1.2.1 Upstream

The production of steel relies on the supply of three specific raw materials: iron ore, coking coal (or coke) and scrap. Two energy carriers are used for the production of steel: natural gas and electricity, the latter being especially significant for EAF plants.

The iron ore industry is highly concentrated. Some 60% of production originates from Australia, Brazil and China. Three global companies dominate the mining industry: Vale SA (Brazil), Rio Tinto PLC (UK/Australia) and BHP Billiton Limited & PLC (UK/Australia). These players control about the 75% of the world trade (Ecorys, 2008).

Iron ore is sold to steel-makers on the basis of long-term contracts based on quarterly prices (Datamonitor, 2011). Price of iron ore was historically influenced by Japanese contracts; however, the industry has repeatedly reported that now Chinese transactions are becoming the benchmark. Customarily, the price negotiated by Japanese steel-makers was the benchmark for contracts worldwide. Since the second quarter of 2012, contract pricing has been reportedly shifting towards an index-based mechanism (based on spot pricing in China). Consequently, a growing tendency toward monthly pricing mechanisms would be unfolding. European steel-makers depend exclusively on overseas supply. Costs for iron ore are a relevant share of variable costs of production; hence, being independent of the iron ore global cartel can be crucial. As a result, upstream vertical integration and pursuing of mining investments have a pivotal role in growth strategies of steel-makers, albeit this strategy is difficult to implement under the current economic and financial conditions (Madar, 2009; Datamonitor, 2011; Ernst and Young, 2012).

European steel-makers rely heavily on coal imports too. Although Germany and Poland have reserves of coking coal amounting to 5% and 6% of the total world reserves (Ecorys, 2008), the European coal production is expected to cease due to the termination of subsidies. Coal prices are negotiated but the price set between Japanese steel-makers and Australian coal suppliers is the beacon for all other contracts. Steel-makers are starting to follow expansion strategies aiming at purchasing coal mines and processing facilities (Madar, 2009; Ernst and Young, 2012).

Scrap may have three different sources: i) 'home scrap', that are leftovers from steel making process; ii) 'new scrap' from steel processing industries and from steel-based manufacturing processes; and iii) 'old scrap' from recycling of steel end products (Ecorys, 2008). Prices of scrap are increasing due to a growing demand (growth in production by EAFs) and a decreasing supply (both end product manufacturers and steel-

makers are becoming more efficient, thus reducing leftovers), albeit the price level has become more stable since 2011.

While electricity prices affect traditional integrated producers only to a small extent, they are the largest variable cost category for non-integrated steel-makers adopting EAF. Hence, the access to a stable supply of low-cost electricity becomes a crucial locational factor for minimills.

1.1.2.2 Downstream

Steel is an intermediate good, characterised by a derived demand which is inelastic in the short run, so that changes in price affect only marginally the overall amount of steel that can be sold worldwide. Nonetheless, the demand for end products which contain steel strongly affects demand for steel and fluctuations in demand can have significant effects on prices and on profit margins of steel-makers, whose individual demand is very elastic, with steel to a large extent being a commodity. The end markets for steel products mainly comprise automotive, construction, packaging, durable consumer goods and mechanical engineering industries (Ecorys, 2008). While it is unlikely that steel buyers can undertake upstream vertical integration, some steel-makers may integrate downstream; for instance, Nippon Steel operates also in the mechanical engineering and construction business (Datamonitor, 2011).

High-volume end users, such as automakers, usually purchase steel directly from steel-makers on the basis of negotiated contracts. These large buyers demand high added-value steel (mostly cold-rolling products) for their production processes and may have enough bargaining power to obtain price discounts (Ernst and Young, 2012), due to their dimensions, the competition intensity in their industries and the importance for steel-makers of preserving long-term relations with these customers. Nonetheless, steel-makers and large buyers have reciprocal incentives to cooperate in new product development and to coordinate production schedule and supply chains. Thus, the location of steel making facilities – in terms of both proximity to the customers' plants and worldwide production to supply global customers in several markets – becomes a competitive advantage factor.

In contrast, low-volume customers buy from steel intermediaries based on spot prices. While small buyers do not benefit from bargaining power, they may take advantage from a stronger competition among producers of standardised low added-value steel products (Datamonitor, 2011).

Intermediaries operate in the value chain between rolling mills and end users. In the EU, steel distribution includes different operational models, grouped into two main categories: i) typical steel stocking (beam and profile centres and general stockists, reinforcing services, distribution of tubular products, stainless steel service centres and high carbon and alloy steel stockists); and ii) flat steel services centres (strip mill products service centres, plate processors and stockists).

Several mismatches exist between producers and customers of steel. Steel-makers produce in big volumes and long runs to achieve economies of scale. Customers want small orders, short lead times and additional processing. Intermediaries work as matchmak-

ers, thus creating value for the industry. On the one hand, vis-à-vis the steel mills, they cluster and simplify orders, absorb mill lead times and receive deliveries by rails or boats. On the other, vis-à-vis customers, steel distributors ensure availability of a wide range of products, accept multi-product orders and provide further processing and fast deliveries (the average lead time of distribution is between 24 to 48 hours). It is worth noticing that the distribution chain has been affected by the current economic crisis, thus re-shaping relationships among players. In particular, since 2008, while several intermediaries have been facing financial problems and poor liquidity, the EU demand for steel product has been weak and less predictable; hence, a tendency towards reducing stock levels and buying smaller lots has been registered. Hence, steel-makers have reported that the supply risk has been increasingly shifted to them.

In the EU, about two-thirds of the steel sales are direct to intermediaries (Ecorys, 2008; Eurometal, 2013). Most of large steel-makers (such as ThyssenKrupp, Tata, Voestalpine, ArcelorMittal and Ssab) are integrated downstream in steel distribution.

1.2 The economics of steel

1.2.1 Players

Boston Consulting Group (2007) classifies three different categories of players in the steel industry:

1. Global players, which own a global network of facilities, provide a full range of steel products, are vertically integrated (even in the mining sector), and produce more than 50 million tonnes per year (the only example being ArcelorMittal).
2. Regional champions, which produce between 5 to 50 million tonnes per year, have a strong regional presence, and can be divided into two sub-categories:
Type 1 includes companies which have access to low-cost countries and provide high added value products (technology leaders, such as ThyssenKrupp and Riva);
and
Type 2 includes companies which are based in low-cost countries and provide steel commodities (for instance steel-makers located in new member states).
3. Niche specialists, which provide only a narrow range of products, usually very specialised, are present in few locations, and produce less than 5 million tonnes.

The 25 largest steel companies in 2010 is reported in Table 1 (EU companies in bold).

Table 1. World's largest steel companies

#	Company Logo	Company Name	Country	Crude Steel Output in 2010 year (tonnes)	#	Company Logo	Company Name	Country	Crude Steel Output in 2010 year (tonnes)
1		ArcelorMittal	Luxembourg	97,200,000	14		Gerdau	Brazil	20,500,000
2		Hebei Group	China	44,400,000	15		Nucor	USA	19,900,000
3		Baosteel	China	43,300,000	16		Thyssenkrupp	Germany	17,900,000
4		Posco	South Korea	39,100,000	17		Evrz Group	Russia	16,800,000
5		Wuhan Iron & Steel Group (Wisco)	China	37,700,000	18		Maanshan	China	16,700,000
6		Nippon Steel	Japan	33,400,000	19		Benxi	China	16,500,000
7		Jiangsu Shagang Group	China	31,900,000	20		Hyundai Steel (HSC)	South Korea	16,300,000
8		Shougang Group	China	30,000,000	21		Gruppo Riva	Italy	16,100,000
9		JFE Holdings	Japan	29,900,000	22		Valin Group	China	15,900,000
10		Anshan Iron & Steel Group (Ansteel)	China	29,800,000	23		Severstal	Russia	15,300,000
11		Shandong Group	China	24,000,000	24		Metinvest	Ukraine	14,400,000
12		Tata Steel	India	23,200,000	25		China Steel Corporation	Taiwan	14,000,000
13		U.S. Steel	USA	22,000,000					

Source: World Steel, 2012.

1.2.2 High capital requirements and fixed costs

Facilities required to produce steel, from coke ovens to rolling mills, are large, highly specialised, complex and durable assets which require huge capital outlays leading to significant fixed production costs. As a result, break-even point is achieved only at very high-capacity utilisation. In particular, integrated plants need to produce more than 2 million tonnes per year to be profitable (Ecorys, 2008).

The introduction of new technologies had a two-fold effect:

- Capital requirements for integrated mills increased, due to larger minimum efficient scale (MES) and to the rising complexity and indivisibility stemming from

the higher level of automation and integration among the infrastructures included in the value chain.⁶

- Continuous casting facilities, and, to a greater extent, EAFs lessened capital expenditures.
- Hence, cost structures vary broadly between integrated plants and minimills, as well as among larger plants with different degrees of vertical integration. Capital expenditures for an integrated plant can reach up to \$10 billion, while a minimill can be installed for about \$350 million (Madar, 2009).

1.2.3 Scale economies and minimum efficient scale

The steel industry is characterised by significant economies of scale, i.e. production costs per unit fall as capacity increases. From an engineering standpoint, all the vessels required for coke making, iron making and steel making comply with the so-called “square-cube law” (Carlton & Perloff, 2005). As the volume of these facilities grows faster than their surface, capacity grows faster than investment costs. This rule applies also to maintenance costs such as re-lining of refractories. Furthermore, efficiency gains (in particular savings generated by lower energy consumption for re-heating molten iron and molten steel) can be achieved through a stronger integration of all production stages in a single plant, thus enlarging the overall production scale because of the combination of adjoining facilities. From an organisational perspective, a single company is better suited to manage such a complex and continuous production flow and to exploit synergies.

The effect of scale economies and high fixed costs – indeed saturation of the installed capacity enables spreading fixed costs over a larger quantity of output, thus cutting total costs per tonnes as production grows – results in very large MES in steel-making. While BOFs are characterised by a MES between 3 and 5 million tonnes per year, EAFs can be efficient at a scale ranging between 0.3 and 3.0 million tonnes. In integrated facilities, the overall MES is determined by the component with the highest MES. While cost efficiency in continuous casting facilities is achieved at 0.5 million tonnes per year (thus being compatible with minimill production), rolling mills require processing between 2 and 5 million tonnes to be efficient. In integrated plants, traditional blast furnaces for iron making set the MES between 3 and 7 tonnes, even if in new mills MES can reach up to 10 million tonnes per year (Barnett & Crandall, 1986; O’Brien, 1992; Madar, 2009; Sato, 2009).

1.2.4 Product substitutability

When excluding highly specialised finished products, steel is a commodity complying with common global standards. Therefore, analogous steel products of different companies are almost perfect substitutes. Some quality differences still exist between steel

⁶ In particular, new investments to modernise parts of existing facilities often require costly changes to the adjoining infrastructures.

produced by BOFs and steel produced by EAFs, due to the presence of tramp metals in the scrap processed by the latter, even if technology improvements are progressively bridging this gap.

Focusing on products of other industries, for instance aluminium and fibreglass (or other plastic materials) might substitute steel in motor vehicles and appliance production. Although substitutability is possible in the long run, switching costs might be very high due to the changes required in the downstream production process (Datamonitor, 2011). Furthermore, the steel industry is following an innovation path aiming at meeting the new production needs of end users in order to retain customers. In a green economy, the threat from substitute products is also lowered by the particular environmental sustainability of steel, being 100% recyclable.

1.2.5 Barriers to entry and barriers to exit

High capital requirements to invest in a new installation or to add new facilities to existing plants constitute a structural barrier to entry, for all technologies and especially for BOF. As mentioned above, formidable capital expenditures are required of steel-makers and the break-even point is achieved only at considerable production levels. Hence, a strong financial effort is required from potential newcomers, and this is of course particularly risky when price fluctuations are marked. Scale economies may further discourage entrance because the minimum yearly output to compete on the market can be even higher than the break-even quantity, larger competitors having a significant cost advantage. Technology specialisation may also prevent the entry in a different product range by incumbents, due to technical limitation in shifting part of mill facilities from one production to another.

Strategic barriers raised by incumbents are even higher, thus constituting a strong deterrence to entry. First, an increase in demand for steel can be easily met by existing facilities due to worldwide excess capacity, thus narrowing the room for new entries. Then, the strategy of expansion in terms of both horizontal and vertical integration increases entry costs. Indeed, to serve global customers, new competitors may have to enter multiple regional markets; besides, the access to mining is increasingly becoming a competitive advantage factor, thus penalising newcomers that have to purchase raw materials in an oligopolistic market.

Capital intensity is also the main barrier to exit, considering that investment in steel-making facilities cannot be converted into any different use, and that scaling back of the output volume is not always economically sustainable in integrated plants using blast furnaces and BOFs. As a result, capital outlays results in very high sunk costs. Furthermore, in this industry the salvage value might also be negative, due to considerable dismantling costs. Also national policies aiming at protecting employment can result in institutional barriers to exit, discouraging plant shutdowns.

Both barriers to entry and to exit are considerably lowered by new technologies, whose impact can possibly advantage newcomers two-fold:

- Some technologies, such as EAFs adopted in minimills, may require smaller capital expenditures, be efficient at a smaller scale and enable a more flexible management of the production volume.
- Other technologies, such as BOF and continuous casting, when compared to older processes such as OHF and ingot teeming, have led to a formidable reduction in production costs, thus allowing newcomers to benefit from a competitive advantage, being more efficient than incumbents, which were tied to sunk costs and depreciation time of existing plants.

1.2.6 Intra-sectoral competitive dynamics

As mentioned above, steel is an intermediate good whose market demand is quite inelastic, especially in the short run when the threat from substitute products is not significant. Hence, as demand grows, producers can increase output volume and prices, benefiting from the existing barriers to entry. Conversely, each steel firm's demand curve is usually very elastic due to high substitutability of steel products belonging to the same category. Therefore, rivalry among competitors become fierce during downturns, and steel-makers are compelled to cut price rather than to scale back production, due to high barriers to exit. In particular, to cover high fixed costs (which become sunk costs in case of shutdown) steel-makers keep on producing until prices are higher than variable costs, thus bearing losses. This issue is of key importance in this industry, where variable costs are significantly lower than average costs, due to huge capital outlays. Inevitably, as demand declines, less-efficient producers with weaker financial positions are progressively expelled from the industry and consolidation occurs.

BOF plants are also facing a growing competition from more flexible EAF facilities, in particular in long product markets. As new technologies will provide efficient alternatives to blast furnaces, reducing minimill dependency on iron-makers and scrap supply and increasing the quality of scrap-based molten iron, EAF producers will increase competitive pressure across the whole steel market.

1.3 The European steel market

1.3.1 Industry definition

According to the NACE (rev.2.0) statistical classification of economic activities in the European Community, steel-makers are included in the class 24.10, comprising manufacturers of iron and steel and ferro-alloys (see Table 2).

Table 2. Production of iron and steel, NACE rev.2.0 classification*

Sub-sector	NACE	Definition
Manufacture of iron and steel and ferro-alloys	Section: C Division: 24 Group: 24.1 Class: 24.10	<p>This class includes:</p> <ul style="list-style-type: none"> • operation of blast furnaces, steel converters, rolling and finishing mills • production of pig iron and spiegeleisen in pigs, blocks or other primary forms • production of ferro-alloys • production of ferrous products by direct reduction of iron and other spongy ferrous products • production of iron of exceptional purity by electrolysis or other chemical processes • re-melting of scrap ingots of iron or steel • production of granular iron and iron powder • production of steel in ingots or other primary forms • production of semi-finished products of steel • manufacture of hot-rolled and cold-rolled flat-rolled products of steel • manufacture of hot-rolled bars and rods of steel • manufacture of hot-rolled open sections of steel • manufacture of sheet piling of steel and welded open sections of steel • manufacture of railway track materials (unassembled rails) of steel <p>This class excludes:</p> <ul style="list-style-type: none"> • cold drawing of bars (included in NACE rev2.0 24.31)

* Manufacture of tubes, pipes, hollow profiles and related fittings, of steel (NACEv2 24.20) is also considered, as long as integrated pipes producers are concerned (i.e. those producing crude steel as well).

Source: EUROSTAT, 2008.

1.3.2 Supply

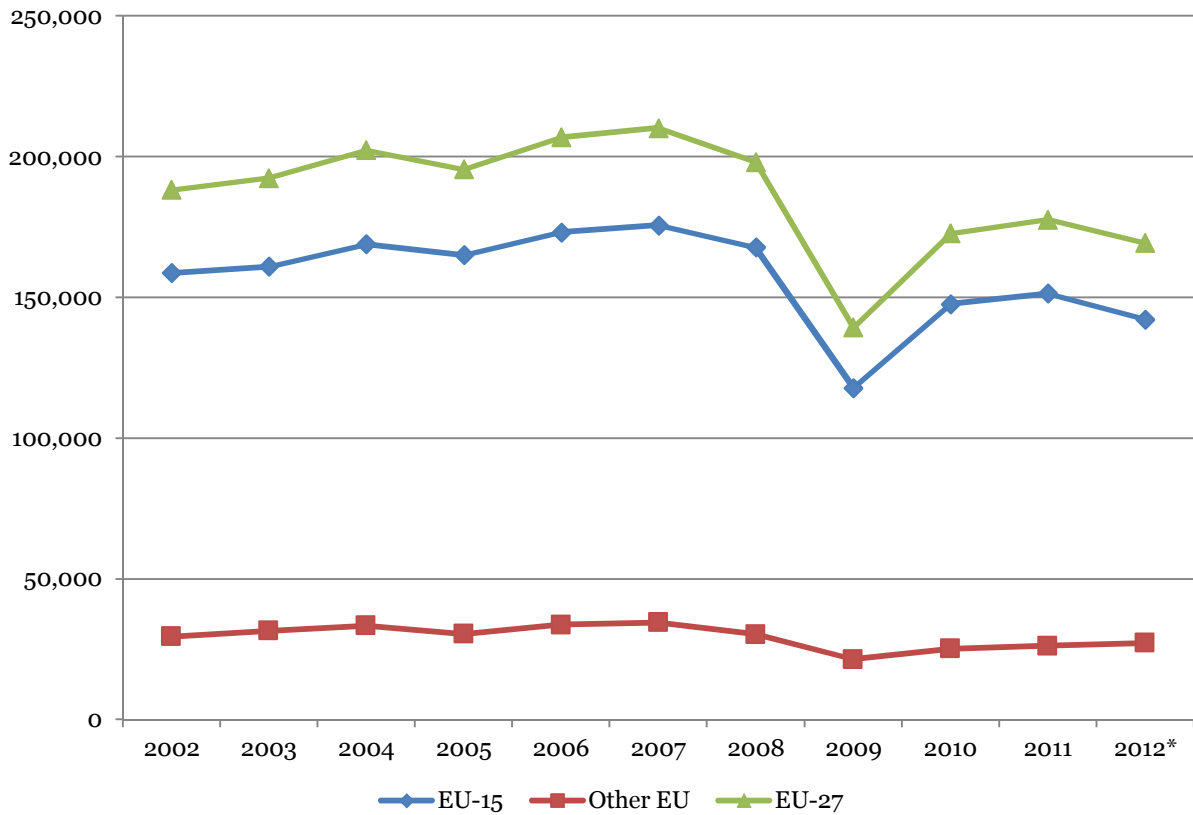
1.3.2.1 Production of crude steel

After a steady growth between 2002 and 2007 (+12%), over the period 2007-2009, the production of crude steel in the EU fell by 34% (see Figure 1). The partial recovery shown in 2010 (+24%) and in 2011 (+3%) is threatened by a new reduction recorded in 2012 (-5%). The Compound Annual Growth Rate (CAGR) over a 10-year period (2002-2012) amounts to -1%. Trends are similar in both EU-15 countries and new EU member states, with a 10-year CAGR respectively of -1.1% and -0.8%.

Crude steel production is concentrated in a relatively limited number of EU countries. In 2012, nine countries – Germany, Italy, France, Spain, the United Kingdom, Poland, Belgium, Austria and the Netherlands – accounted for 82% of the total EU production (see Figure 2). Among these countries, Austria (CAGR +1.8%), Italy (CAGR +0.4%), and the Netherlands (CAGR +1.2%) experienced a production growth between 2002 and

2012, while Belgium (CAGR -4.2%), France (CAGR -2.6%), Poland (CAGR -0.003%), and the United Kingdom (CAGR -1.7%) recorded a decline (see Figure 3).

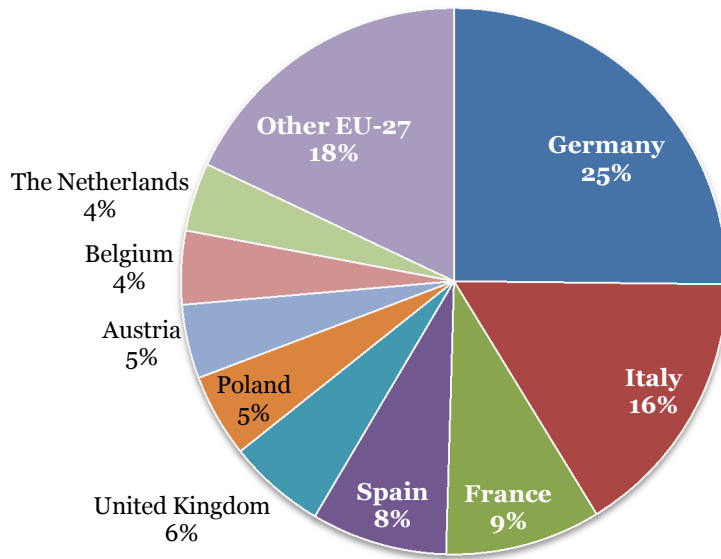
Figure 1. Production of crude steel in the EU, 2002-2012 (thousand tonnes)*



*Missing value for DK, LV, and PT; estimated value for GR, LU, NL, RO, and other EU.

Source: Authors' elaboration on World Steel (2012, 2013).

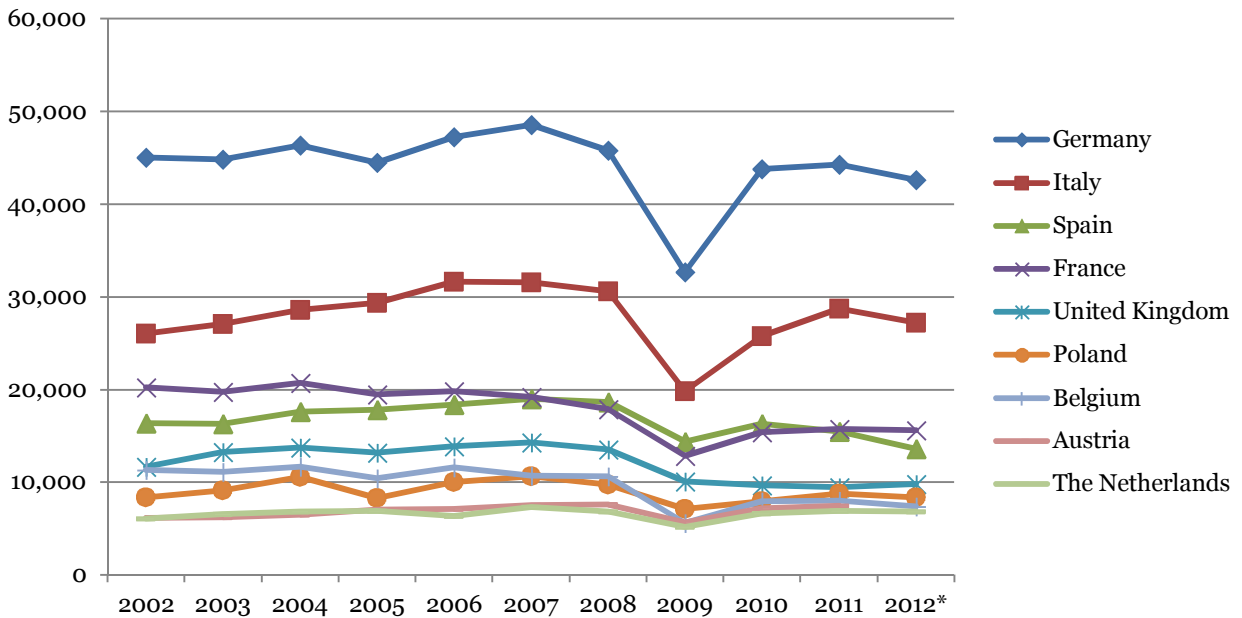
Figure 2. Share of crude steel production in the EU by member state, 2012*



*Estimated value for NL.

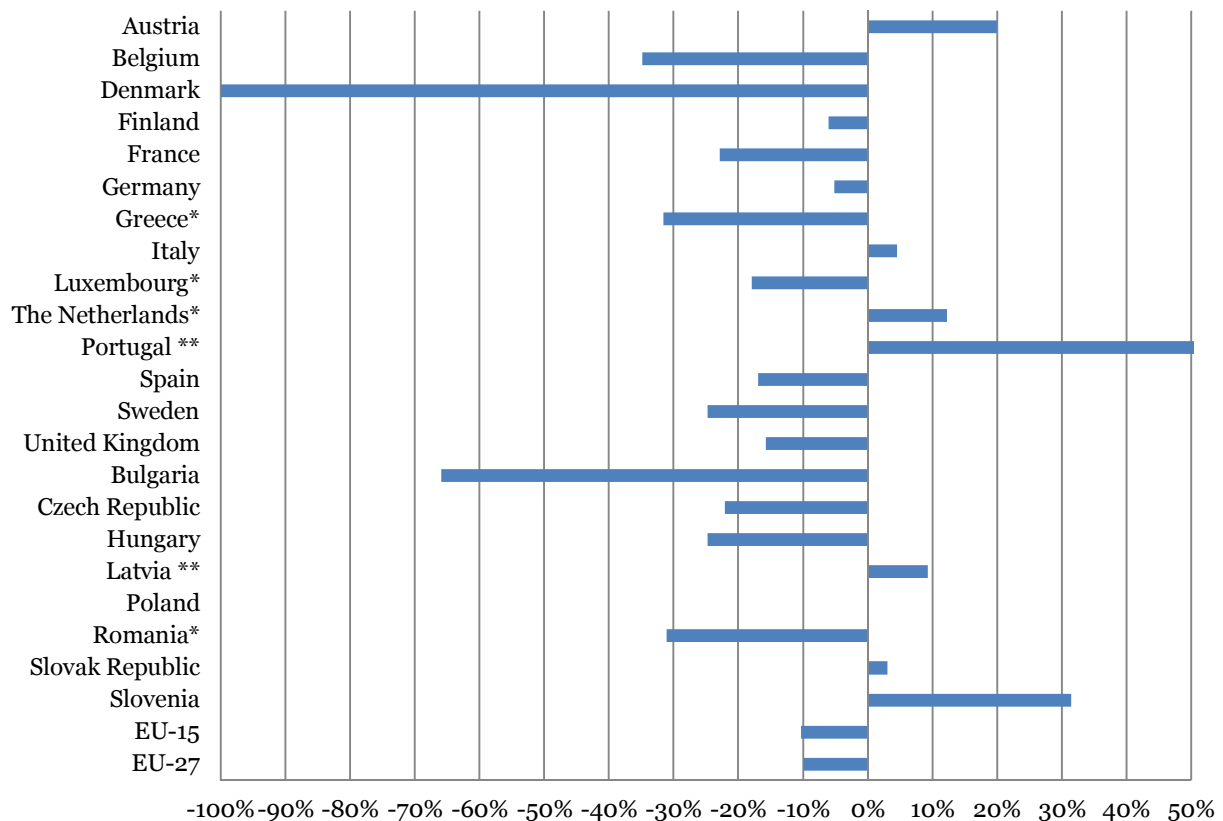
Source: Authors' elaboration on World Steel, 2013.

Figure 3. Production of crude steel in selected member states, 2002-2012 (thousand tonnes)*



*Estimated value for NL.

Source: Authors' elaboration on World Steel, 2012, 2013.

Figure 4. Variation in production of crude steel, 2002-2012*

*Estimated value in 2012 for GR, LU, NL, and RO.

**Variation over the period 2002-2011 for LV and PT.

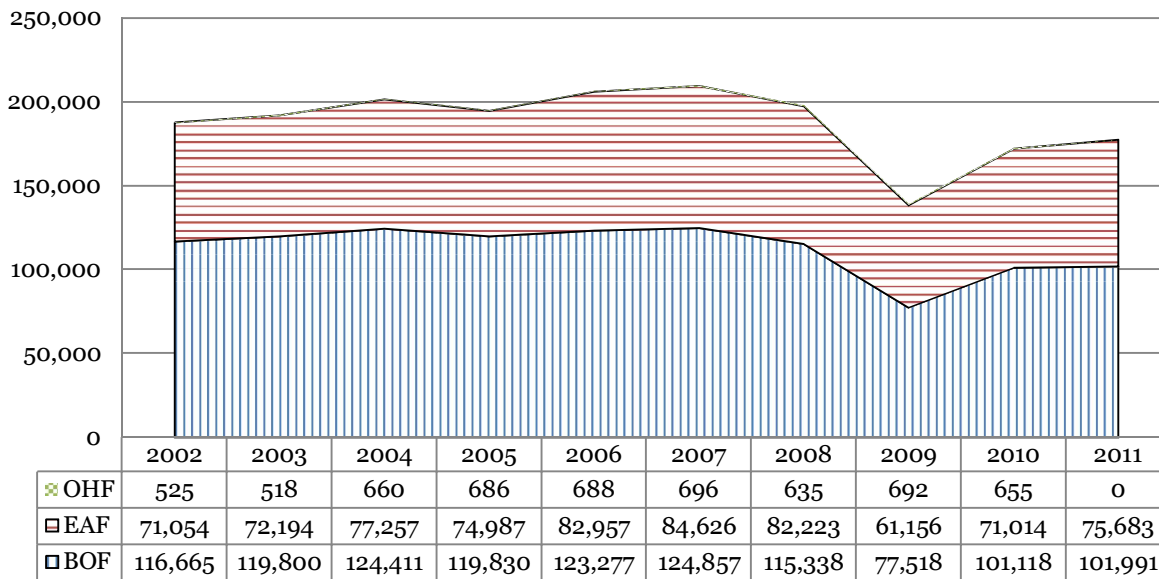
Source: Authors' elaboration on World Steel, 2012, 2013.

1.3.2.2 Steel-making technology and casting process

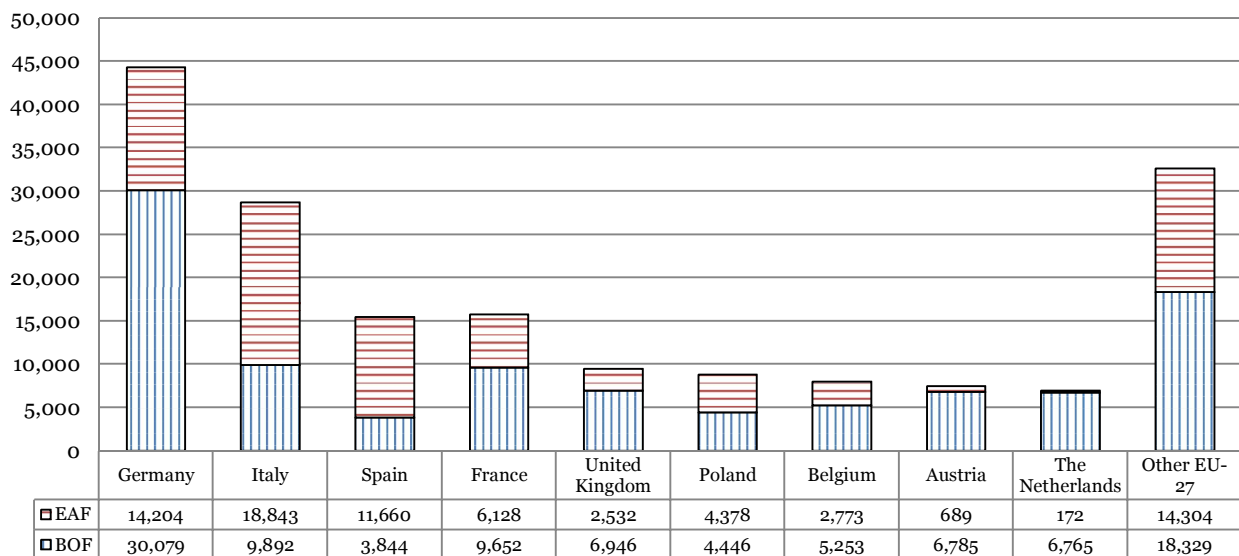
In the EU, a growing share of crude steel is produced in electric furnaces (see Figure 5). In 2002, about 62% of total production was carried out in BOFs, 37.7% in EAFs, and less than 0.3% in Open Heart Furnaces (OHF); in 2011, EAFs accounted for about 42.6% of steel produced and BOFs for 57.4%. As a consequence of the overall downturn registered in 2008, several integrated plants have been shut down either permanently or temporarily, resulting in a decline in BOF production between 2007 and 2009, comparatively steeper than the one registered by minimills (-47 million tonnes for BOFs against -23 million tonnes for EAFs).

Among the EU member states where the overall production is concentrated, in 2011 EAF technology has the lion's share in Spain (75%) and Italy (66%) and accounts for almost half of the total output in Poland (49.6%); it is less widespread in France (39%), Belgium (35%), Germany (32%), and United Kingdom (27%); and it has a modest role in Austria (9%) and the Netherlands (3%) (see Figure 6).

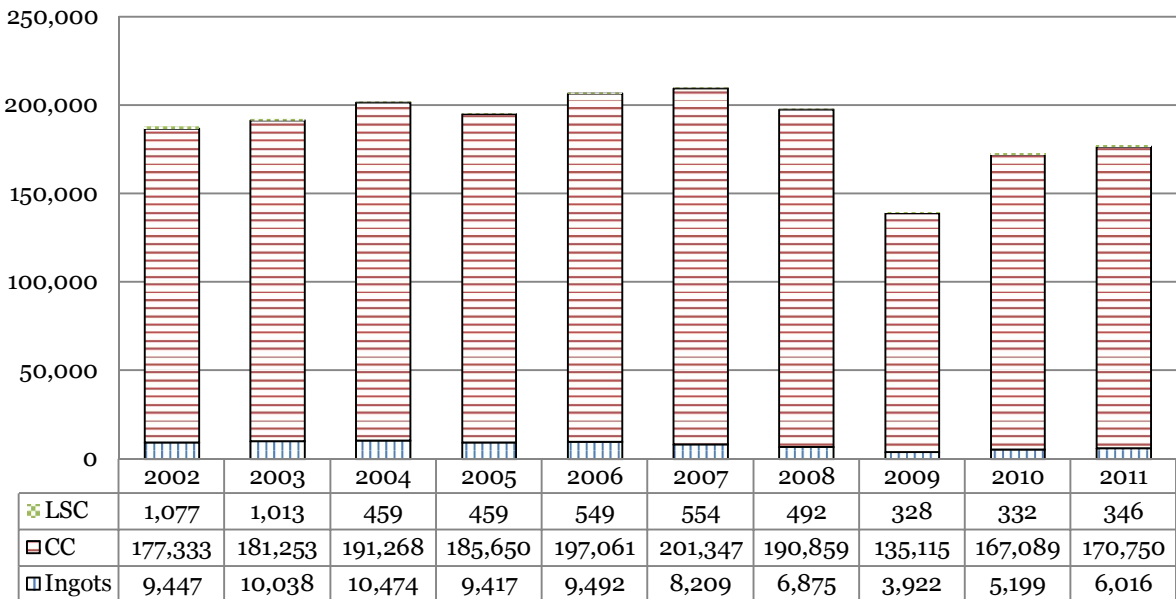
Continuous casting is the predominant casting process all over the EU, accounting for more than 94% of the total output in 2002 and for about 96% in 2011 (see Figure 7). When considering the larger producers, the share of continuous casting production goes from 95% for Italy and France to 100% for Belgium (see Figure 8). Indeed, the EU steel-makers have completed the transition to the most cost efficient casting process.

Figure 5. Production of crude steel by steel-making technology, 2002-2011 (thousand tonnes)

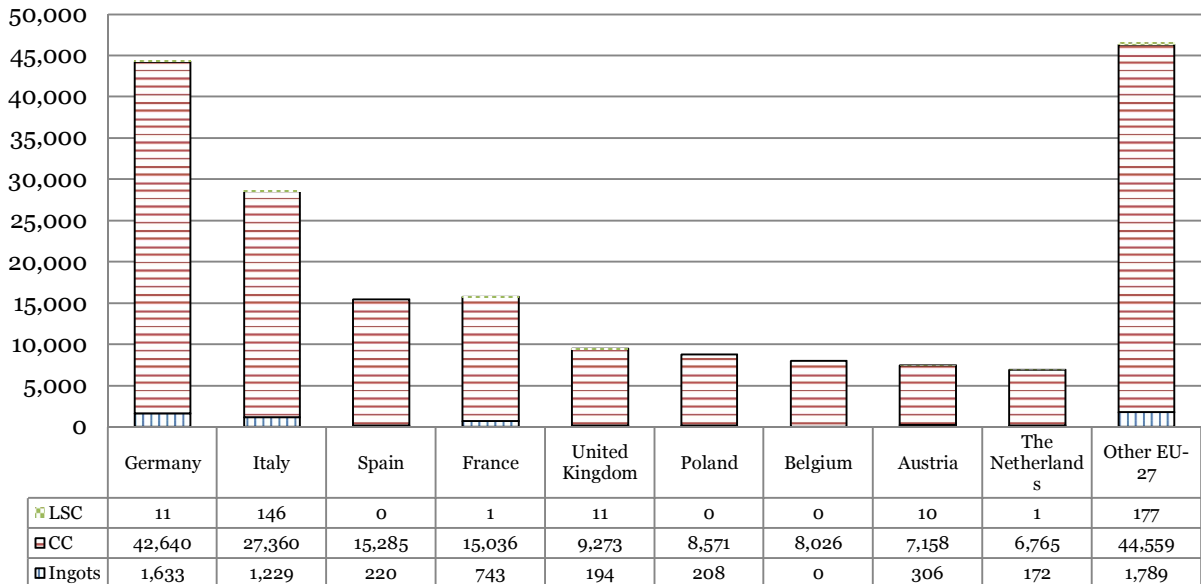
Source: Authors' elaboration on World Steel, 2012.

Figure 6. Production of crude steel by steel-making technology in selected member states, 2011 (thousand tonnes)

Source: Authors' elaboration on World Steel, 2012.

Figure 7. Production of crude steel by casting process, 2002-2011(thousand tonnes)

Source: Authors' elaboration on World Steel, 2012.

Figure 8. Production of crude steel by casting process in selected member states, 2011 (thousand tonnes)

Source: Authors' elaboration on World Steel, 2012.

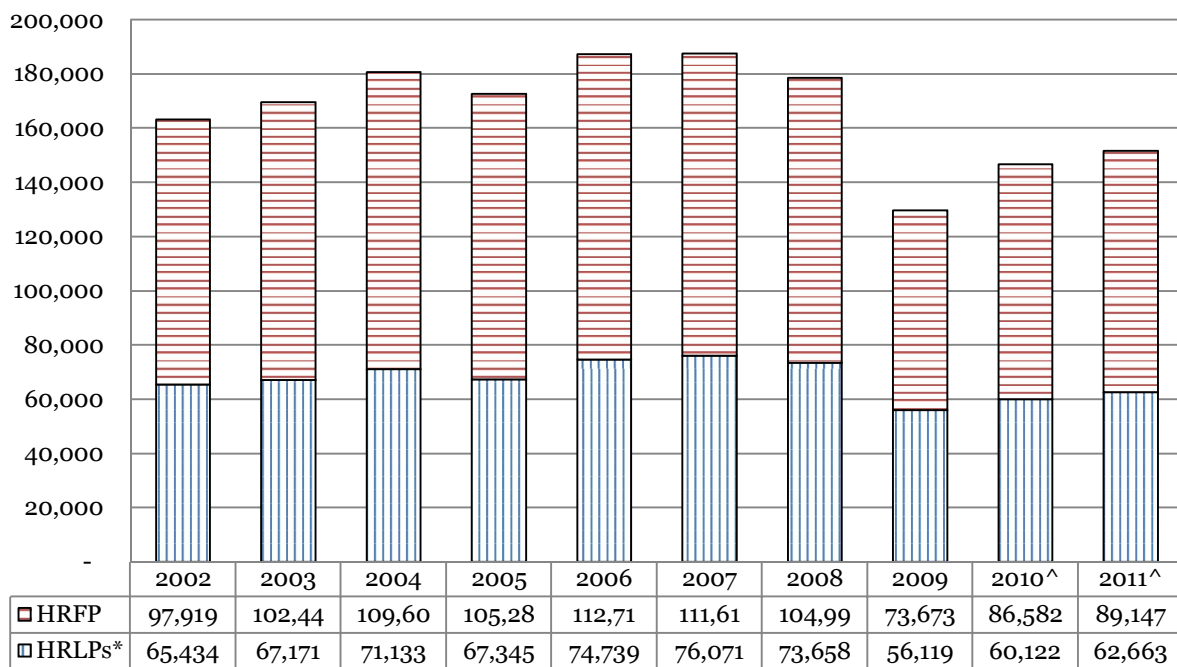
1.3.2.3 Steel Products

Flat products represent approximately 60% of the EU hot rolled steel output; this proportion was constant over the period 2002-2011, meaning that EU countries maintained their solid position in the high added-value portion of the steel market (see Figure 9). In 2011, in Austria (78%), Belgium (90%), France (69%), Germany (66%), and the Nether-

lands (97%), flat products had the lion's share. In Italy about half of the market (53%) is represented by flat products, while in Poland (35%) and Spain (32%) a higher share of long products was processed (see Figure 10). This uneven distribution reflects a different combination of production technologies, as Poland, Spain and Italy also produce a large percentage of crude steel in EAFs, whose output is usually less suitable for flat products.

Focusing on steel products of second transformation (see Figure 11), in 2009 coated sheet and strip (tinmill, other metallic, and non-metallic) accounted for more than one-third of the total EU production, followed by wire rod (22%), concrete reinforcing bars (21%), other hot rolled bars (10%), and heavy sections (10%).

Figure 9. Production of hot rolled products in the EU, 2002-2012 (thousand tonnes)

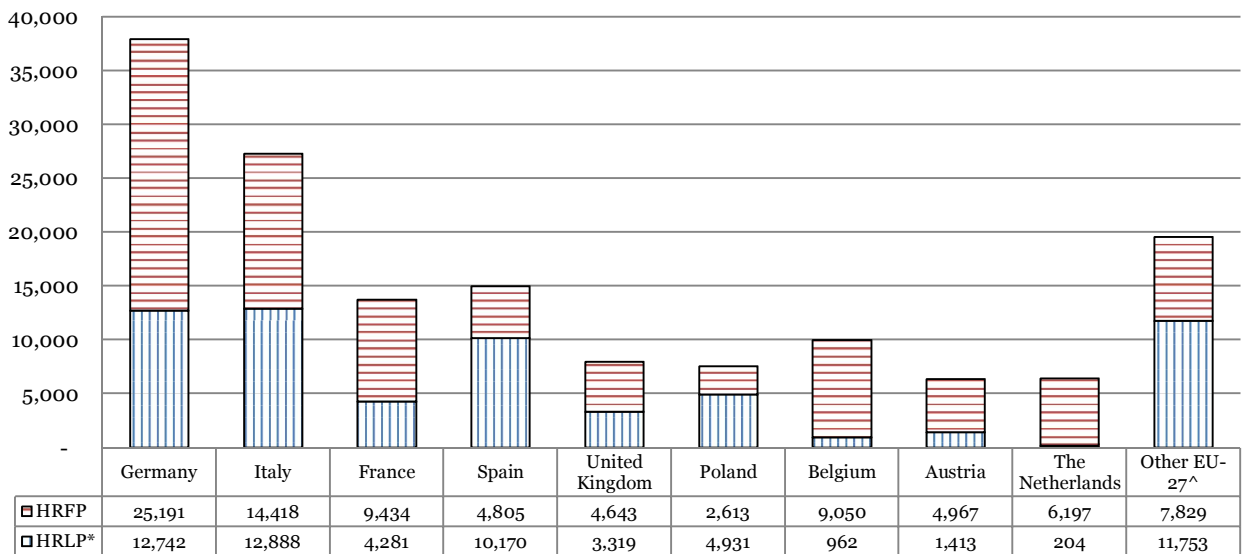


*Seamless tubes excluded;

[^]Data on hot rolled long products are missing for SE and SI; data for hot rolled flat products are missing for GR, SE, SK and SI.

Source: Authors' elaboration on World Steel, 2012.

Figure 10. Production of hot rolled products in selected member states, 2011 (thousand tonnes)

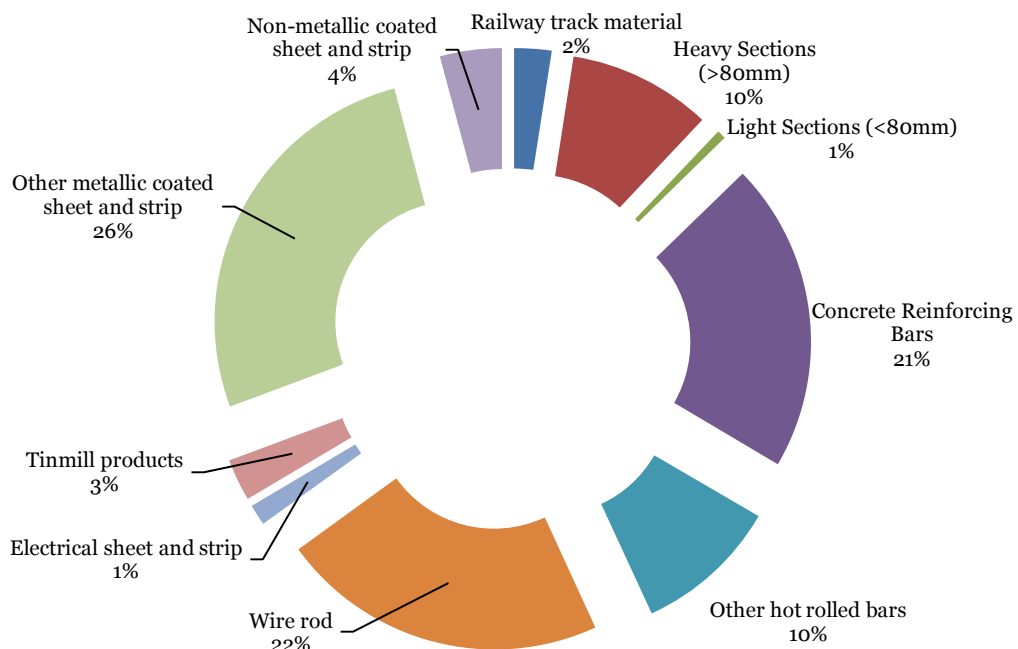


*Seamless tubes excluded;

[^]Data on hot rolled long products are missing for SE and SI; data for hot rolled flat products are missing for GR, SE, SK and SI.

Source: Authors' elaboration on World Steel, 2012.

Figure 11. Production of steel products of second transformation in the EU, 2009 (thousand tonnes)⁷



Source: Authors' elaboration on World Steel, 2012.

⁷ Data for 2010 and 2011 are scattered and fragmented.

1.3.2.4 Turnover, production value, value added and gross operating surplus

The turnover of the EU steel industry experienced a sharp increase between 2002 and 2008 (+104% in absolute terms, CAGR +12.6%), followed by a dramatic decline between 2008 and 2009 (-41%) and by a partial recovery in 2010 (+27%) (see Figure 12). In particular, over the period 2002-2007, revenues grew faster than production (+101% in absolute terms against +12% registered in production of crude steel); revenues slightly grew also in 2009 (+1.8%) although output already started to decline. Analogously, the 2008-2009 downturn of turnover was steeper than in terms of output, thus signalling the high volatility of steel prices. The impressive growth in revenues, which was largely determined by a sharp increase in steel prices, did not lead to the expected positive effect in term of economic results for steel-makers. It is worth stressing that national turnover of the steel industry has a crucial role in the economic system of several EU member states, even when quantity produced are limited in absolute value (see Figure 13). In 2010, steel-maker turnover accounted for 6.0% of GDP in Slovakia, 3.7% in Luxembourg, 3.2% in Latvia, 3% in Czech Republic, 2.9% in Finland and 2.6% in Belgium. As a back-of-the-envelope estimate, considering that in the same year valued-added over sales for the EU steel industry was about 15%, steel-making is worth 1 percentage point of GDP in Slovakia and about 0.5 in the other mentioned countries.

Valued added⁸ over sales went from 20% in 2002 to 22.3% in 2007, then falling in 2008 (18.6%) and reaching 15.3% in 2010 (see Figure 14). Considering that the difference between turnover and value added is mainly explained by the cost of goods and services, variable production costs (raw materials and energy) sharply increased over the period 2002-2010. According to Crompton & Lesourd (2004, cited in Ecorys, 2008), price of iron ore are the main driver of variable production costs (in BOF). Therefore, it can be supposed that raw material suppliers, which benefit from a strong bargaining power, drained a significant share of the value generated in the industry. Indeed, iron ore price went from \$12.68 per dry tonne in January 2002 to \$125.91 in January 2010 (+893% in absolute terms, CAGR +33%).⁹

The ratio between gross operating surplus¹⁰ (an indicator that is comparable to the EBITDA) and sales experienced a sharper fluctuation, swinging from 4.5% in 2002 to 13% in 2007 and back to 4.3% in 2010 (with a minimum of 0.4% in 2009). This trend,

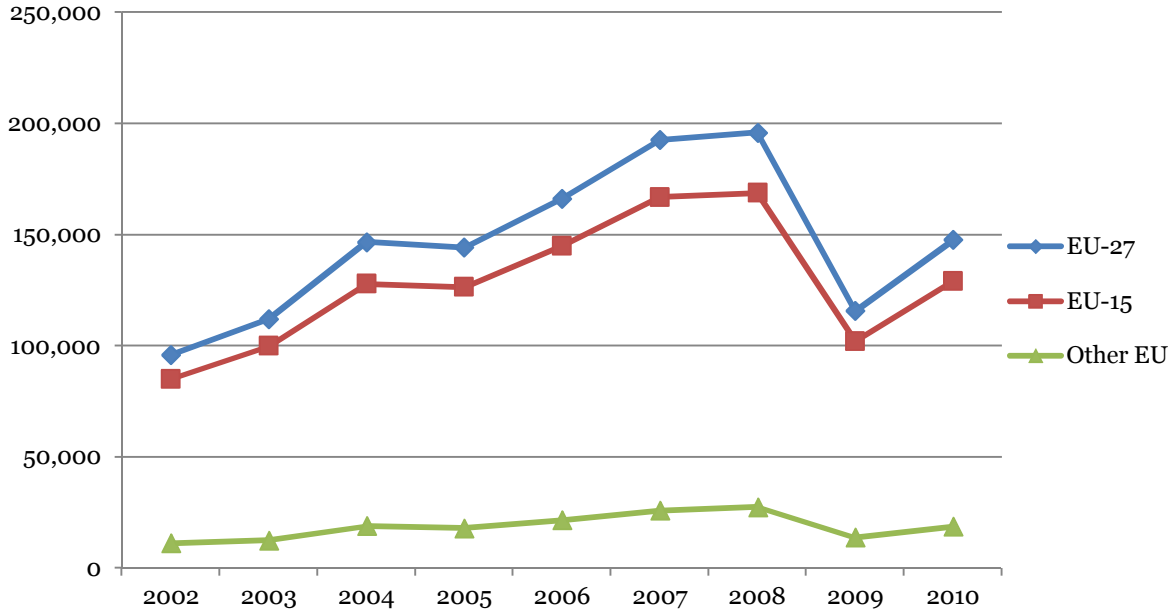
⁸ "Value added at factor cost is the gross income from operating activities after adjusting for operating subsidies and indirect taxes. It can be calculated as the total sum of items to be added (+) or subtracted (-): turnover (+); capitalised production (+); other operating income (+); increases (+) or decreases (-) of stocks; purchases of goods and services (-); other taxes on products which are linked to turnover but not deductible (-); duties and taxes linked to production (-)" (EUROSTAT, Glossary, 2013, http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Glossary:Value_added_at_factor_cost).

⁹ Index Mundi, Iron ore monthly price (<http://www.indexmundi.com/commodities/?commodity=iron-ore&months=180>).

¹⁰ Gross operating surplus is calculated from the value added at factor costs by subtracting personnel costs.

when compared to the one registered in value added over sales, indicates a certain degree of rigidity in labour costs in the EU steel industry.

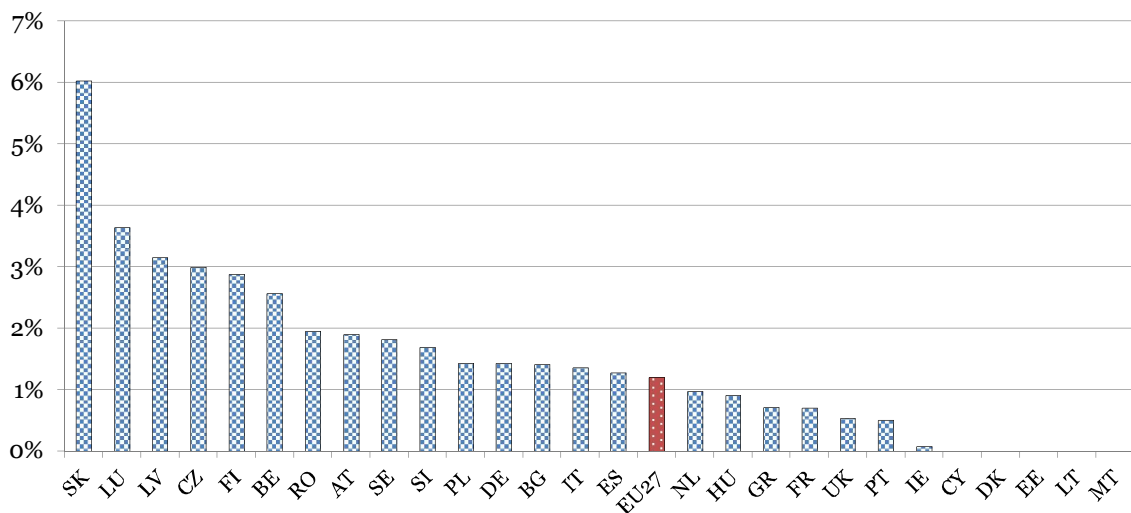
Figure 12. Aggregate turnover in the EU iron and steel industry, 2002-2010, NACE rev.2 24.1 (€ mil)



Note: Data estimated for BE in 2002; for CZ in 2002, 2005, and 2007-2010; for DK over the whole period; for GR in 2002, 2008, and 2010; for IE in 2002; for LV over the whole period; for LT in 2002 and 2005-2008; for LU in 2005-2010; for MT in 2002-2004, 2006, and 2008-2010; for PT in 2004 and 2007; for RO in 2008; for SK over the whole period; for SI in 2003 and 2004; for NL in 2002-2008 and 2010.

Source: Authors' elaboration on EUROSTAT.

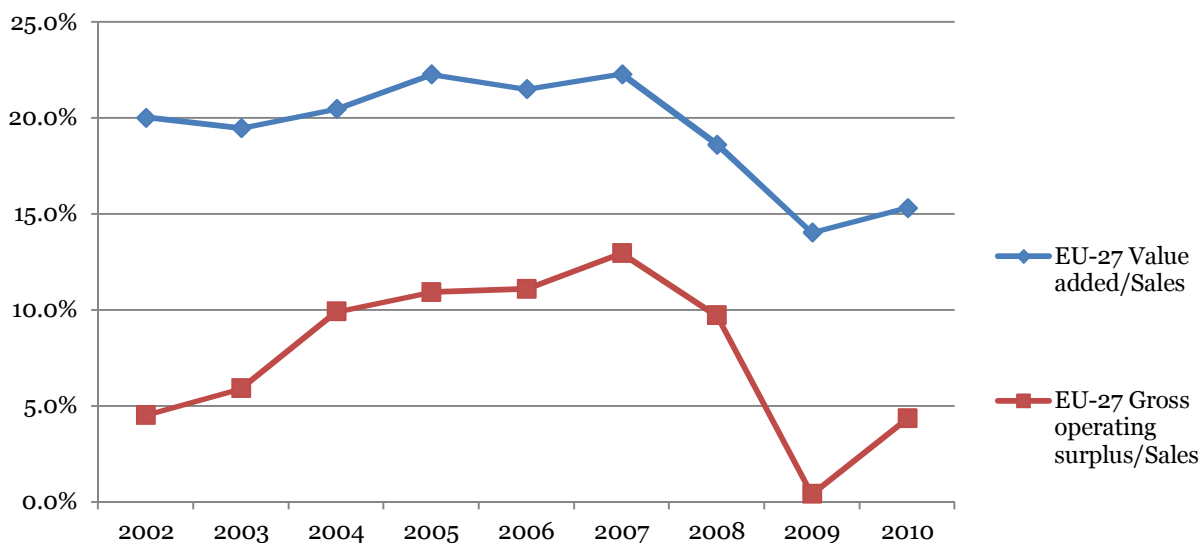
Figure 13. Turnover of the steel and iron industry over GDP – NACE rev.2 24.1



Note: Data estimated for CZ, DK, GR, LT, LU, MT, NL, and SK; GDP at current prices.

Source: Authors' elaboration on EUROSTAT.

Figure 14. Value added over sales and gross operating surplus over sales value in the EU iron and steel industry, 2002-2010, NACE rev.2 24.1



Notes: Value added is measured at factor costs. Data for BE are missing for 2002; data for CZ are missing for 2002, 2005, and 2007-2010; data for DK are missing for the whole period; data for GR are missing in 2002, 2008, and 2010; data for IE are missing for 2002; data for LV are missing for the whole period; data for LT are missing for 2002 and 2005-2008; data for LU are missing for 2005-2010; data for MT are missing for 2002-2004, 2006, and 2008-2010; data for PT are missing for 2004 and 2007; data for RO are missing for 2008; data for SK are missing for the whole period; data for SI are missing for 2003 and 2004; data for NL are missing for 2002-2008 and 2010.

Source: Authors' elaboration on EUROSTAT.

1.3.2.5 Employment and labour cost

EUROSTAT data on employment in the EU iron and steel industry are very fragmented. In 2010, based on the available information, 290,639 persons were employed in this industry. Germany (77,997) and Italy (42,751) accounted for the majority of jobs; in Spain, France, Poland, and Romania employment levels were higher than 20,000 units. In these member states, employment experienced a decline over the period 2002-2010: modest in Spain (-0.7%, -177 units), Germany (-2.9%, -2,351 units) and Italy (-4.0%, -1,759); dramatic in Poland (-20.2%, -6,108 units), France (-35.5%; -14,057 units) and Romania (-59.8%, -32,545 units). In contrast, growth was registered in Finland (+13.4%, +1,291 units), Austria (+9.5%, +1,291 units) and Sweden (+8.6%, +1,269 units). A general negative trend for employment in the EU steel industry is registered, and it is steeper in Eastern Europe, probably due to a progressive conversion towards less labour-intensive production technologies.

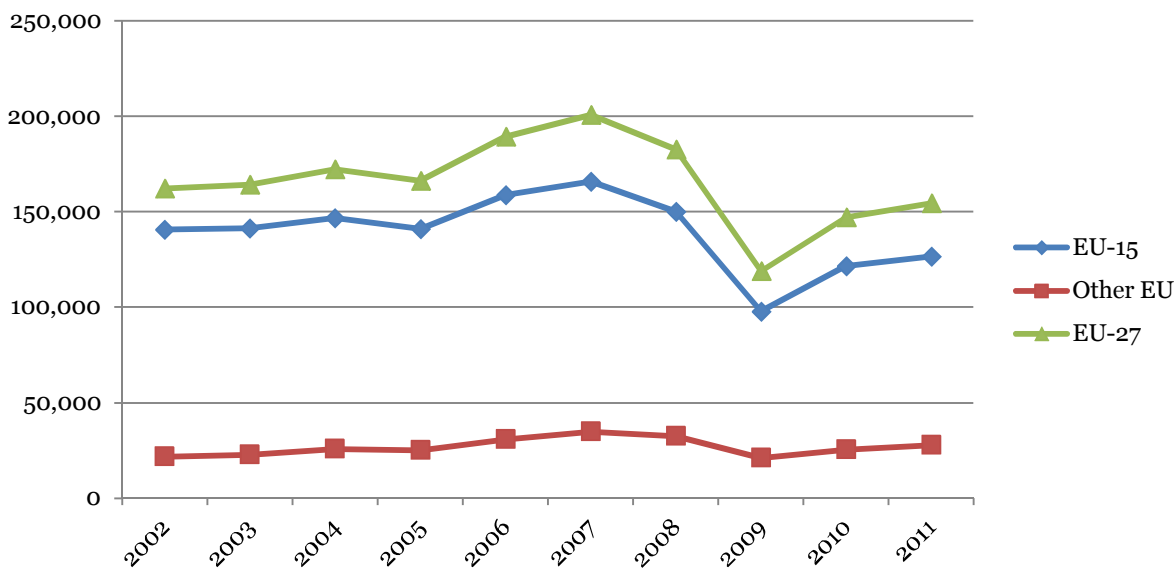
1.3.3 Demand

1.3.3.1 Demand for steel finished products

Demand for finished steel products in the EU (see Figure 15) fell between 2007 and 2009 by 41% after a remarkable growth experienced over the period 2005-2007 (+21%), which in turn followed a period of relative stability in 2002-2005 (+2%). Signs of recovery were registered in 2010 (+24% on yearly basis) and 2011 (+5%), but total demand is still below the 2007 level (about 50 million tonnes lower). Overall, trends registered in the EU-15 member states are comparable to those registered across new member states. Nevertheless, between 2002 and 2011, demand in EU-15 slightly decreased (CAGR -1.2%; -14 million tonnes), while a growth was registered in the new member states (CAGR +2.9%; +6 million tonnes).

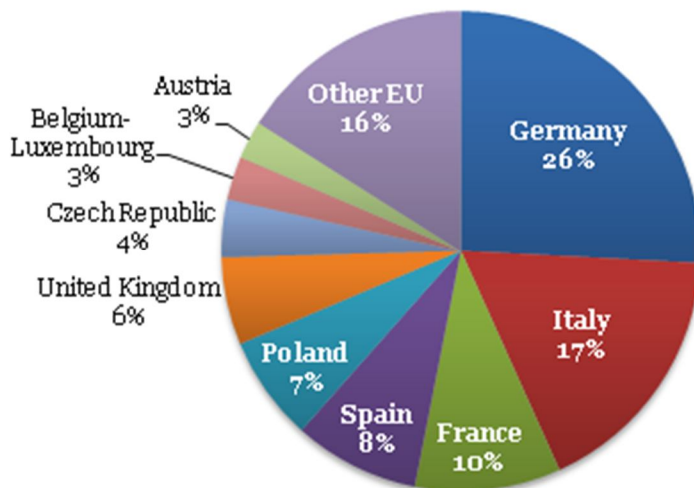
In 2011, demand for finished steel products in the EU was geographically concentrated: Germany, Italy, France, Spain, Poland, the United Kingdom, Czech Republic, Belgium (including data for Luxembourg) and Austria accounted for more than 84% of the total demand (see Figure 16). Demand variation diverged across EU member states over the period 2002-2011. Eleven countries out of 27 experienced an increase in demand (see Figure 17), namely Austria (+823,000 tonnes), Belgium and Luxembourg (+40,000 tonnes), Germany (+4.6 million tonnes), Sweden (+596,000 tonnes), Czech Republic (+1.8 million tonnes), Estonia (+8,000 tonnes), Latvia (+330,000 tonnes), Lithuania (+102,000 tonnes), Poland (+3.2 million tonnes), Romania (+460,000 tonnes) and Slovak Republic (+473,000 tonnes). A strong decline in absolute terms was registered in Spain (-6.5 million tonnes), the United Kingdom (-3.5 million tonnes), Italy (-2.5 million tonnes), Greece (-2 million tonnes) and France (-2 million tonnes).

Between 2002 and 2011, crude steel production in the EU was always higher than the entire demand for steel finished products (see Figure 18). The quantity produced did not experience the same sharp increase which characterised demand between 2005 and 2007, growing only by 11% in the period 2002-2007. In contrast, a comparable and sharp decline was registered both for supply and demand between 2007 and 2009.

Figure 15. Apparent steel use in the EU, 2002-2011 (thousand tonnes)

Note: Apparent steel use of finished steel products is expressed in volume terms as deliveries of finished steel minus net exports of steel industry goods.

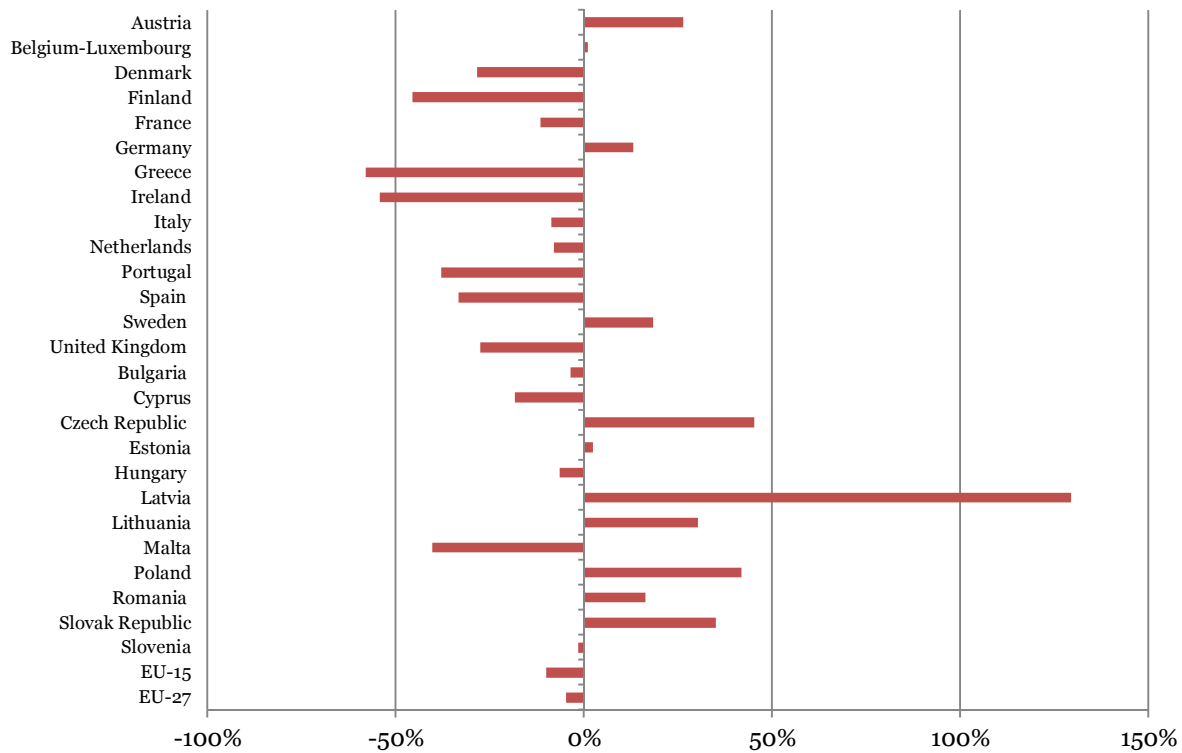
Source: Authors' elaboration on World Steel, 2012.

Figure 16. Country share of total European apparent steel use – 2011

Note: Apparent steel use of finished steel products is expressed in volume terms as deliveries of finished steel minus net exports of steel industry goods.

Source: Authors' elaboration on World Steel, 2012.

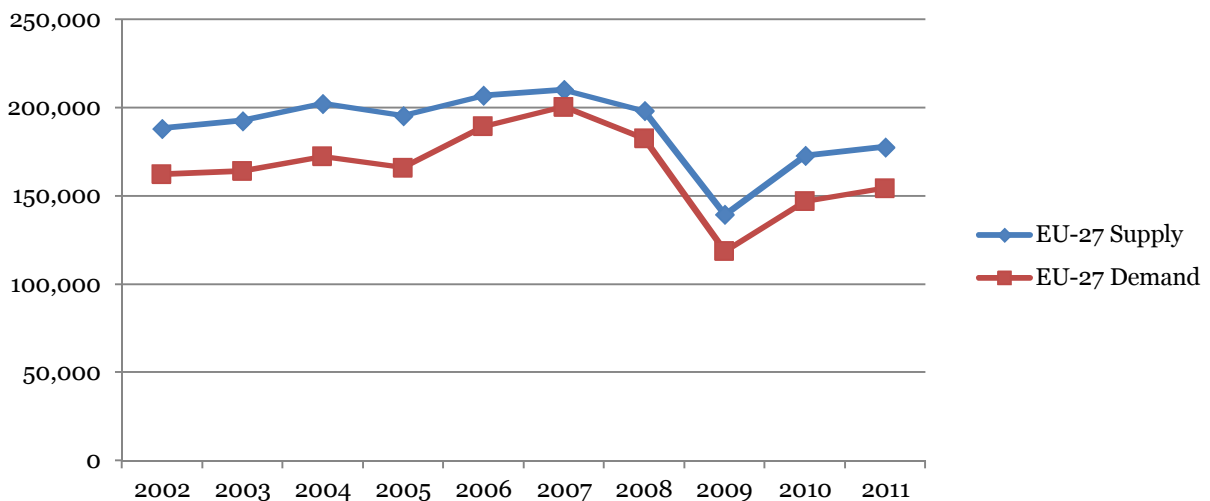
Figure 17. Variation in apparent steel use, 2002-2011



Note: Apparent steel use of finished steel products is expressed in volume terms as deliveries of finished steel minus net exports of steel industry goods.

Source: Authors' elaboration on World Steel, 2012.

Figure 18. Apparent steel use and production of crude steel in the EU, 2002-2011 (thousand tonnes)



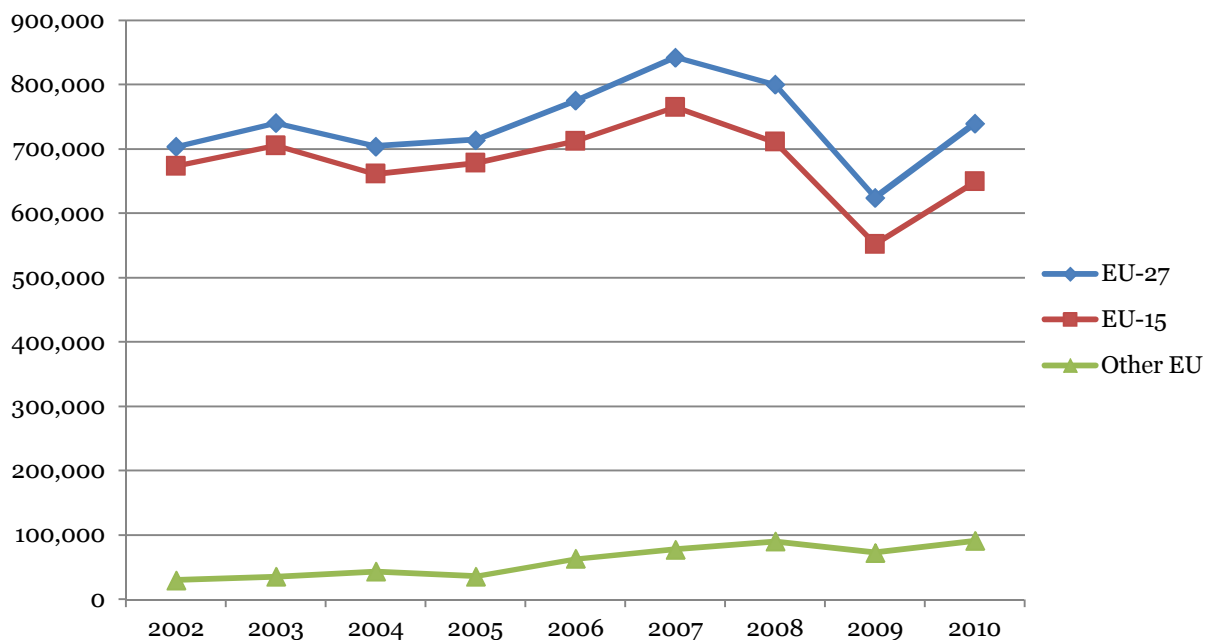
Note: Demand measures apparent steel use of finished steel products, expressed in volume terms as deliveries of finished steel minus net exports of steel industry goods; supply measures total production of crude steel.

Source: Authors' elaboration on World Steel, 2012.

1.3.3.2 Demand for steel end products

Automotive and construction sectors have usually been the two largest steel end users. Therefore, fluctuations in turnover in these industries significantly affect steel demand. As expected, trend in the EU motor vehicle industry revenues are comparable to the one registered in demand for finished steel products (see Figure 19). A strong growth between 2005 and 2007 (+18%), preceded by a more stable period between 2002 and 2005 (+1.5%), was followed by a remarkable decline by 25% over the period 2007-2009. As for steel demand, a new increase was registered in 2010 (+18% on a yearly basis). Analogous fluctuations affected the construction sector (see Figure 20), where a comparable downturn was experienced one year later and no sign of recovery could be noticed in 2010.

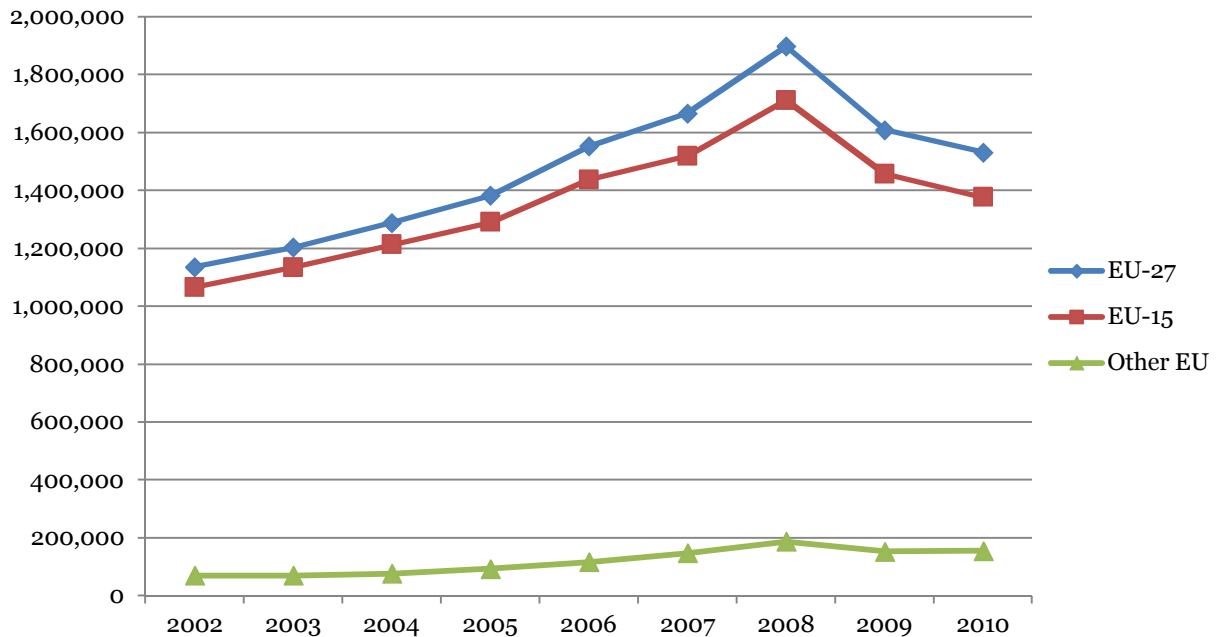
Figure 19. Total turnover in the EU motor vehicle industry – enterprises included in NACE rev.2 Division 29 (€ mil)



Notes: Data for BE are missing for 2002; data for GR are missing for 2002, 2008, and 2010; data for LU are missing for the whole period; data for MT are missing for 2006 and 2008-2010; data for PT are missing for 2006 and 2007.

Source: Authors' elaboration on EUROSTAT.

Figure 20. Total turnover in the EU construction sector, 2002-2010 – enterprises included in NACE rev.2 Section F (€ mil)



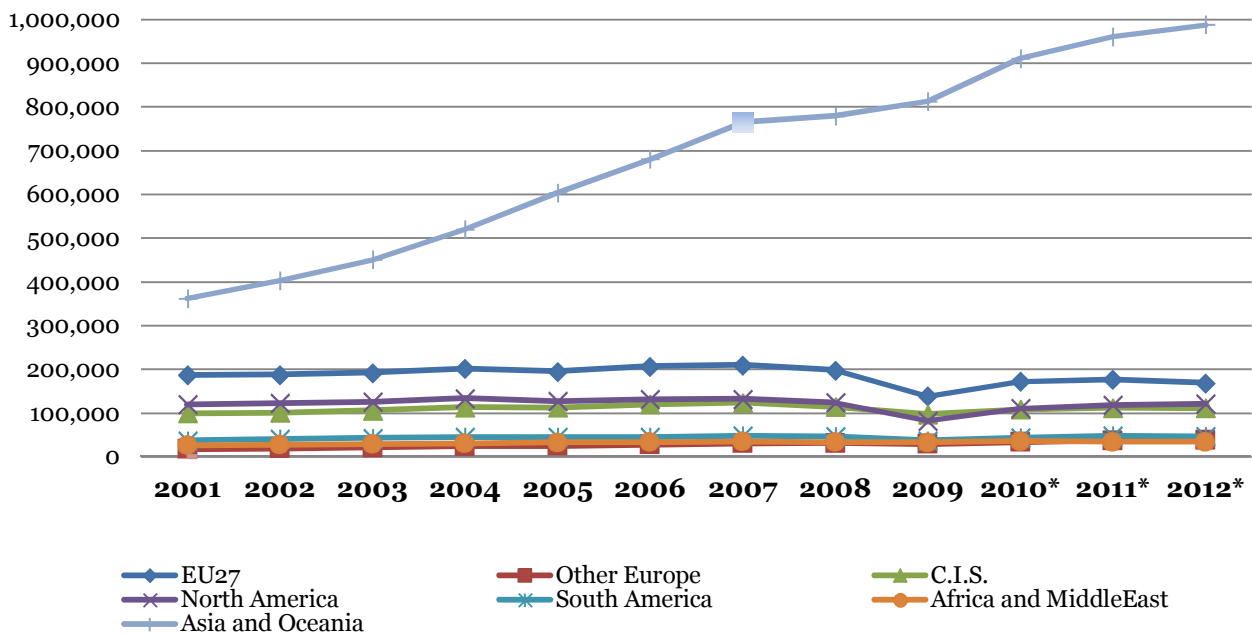
Notes: Data for BE are missing for 2002; data for GR are missing for 2002, 2008, and 2010; data for MT are missing for 2006 and 2008-2010.

Source: Authors' elaboration on EUROSTAT.

1.4 International trade of steel

1.4.1 World production and trade flows

The production trend of the steel industry has been subject to structural change over the last 12 years, mainly due to the increase in the Asian production. As this section will show, this shift in relative market shares, together with the economic crisis, has modified the directions and volumes of trade flows. Figure 21 shows that, against a flat trend characterising the production of crude steel in the historical locations such as the EU and the US, production of Asia and Oceania has increased at a steep pace, reaching almost 1 billion tonnes in 2012. The upward trend is led by the Chinese performance, fuelled by growing internal consumption and external demand of cheaper steel products. Beside the Asian position as global leader, the EU-27 is the second biggest player, followed by North America and CIS, with an average of 200 million tonnes until 2008. In 2009, the production dropped by 24% in the EU-27, North America and CIS, and underwent a weak recovery in the three following years. These three regions, together with Asian countries, cover more than 90% of the world production.

Figure 21. Crude steel production, 2001-2012 (thousand tonnes)

*Estimates by World Steel Association.

Source: Authors' elaboration on World Steel (2013).

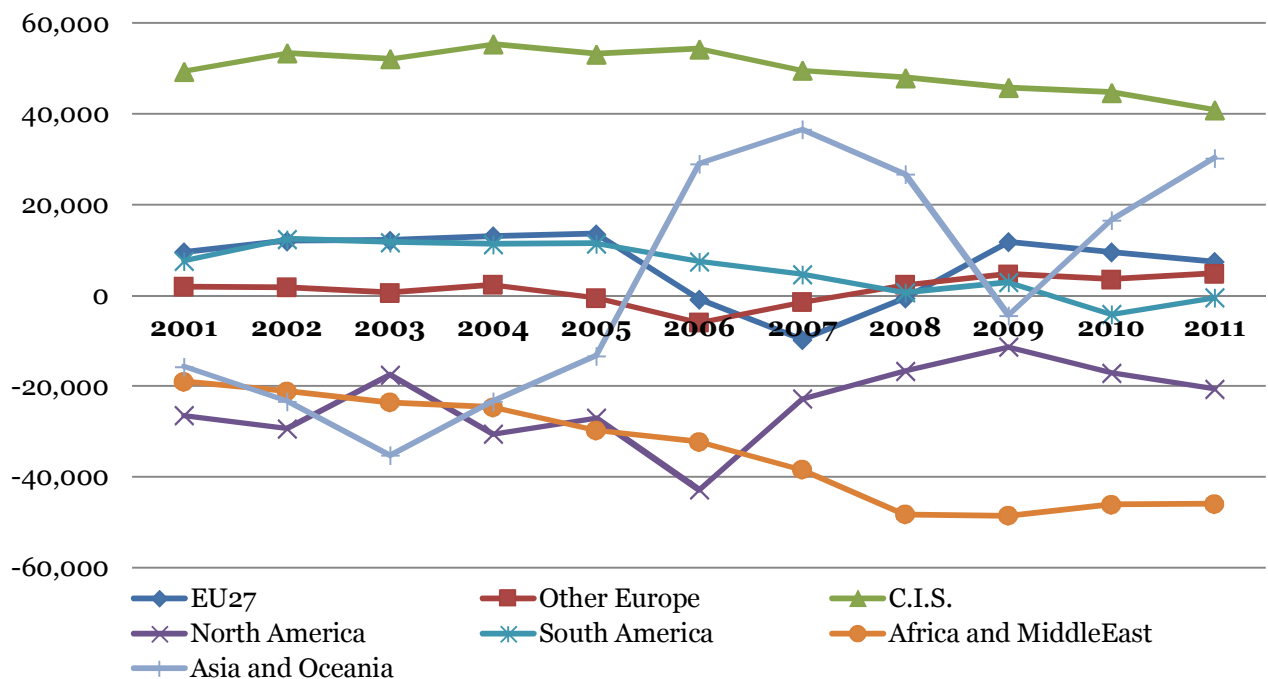
The dynamics of the global steel production provides the background to analyse the net positions of semi-finished and finished products. As shown by Figure 22, EU-27, that used to be a net exporter, has turned into a net importer from 2006 to 2009 due to a marked increase of the imports volume; finally, the EU-27 turned back into a net exporter in 2010 and 2011. Since 2006, while the European countries reduced their steel production, Asian countries, mostly China, increased enormously their capacity, to satisfy both the internal and external demand. As a result,

Figure 23 shows that exports market shares of semi-finished and finished steel products shift mainly from EU27 to Asia. From 2001 to 2011, the EU export share¹¹ decreased from 41% to 35% while for Asia and Oceania increased from 24% to 36%. Again, China played the lion's share in this shift, by increasing its exports share from 2%, in 2001, to 12% in 2011. Export shares for Japan, for instance, remained unchanged (10%), while for South Korea increased by 2% (from 5% to 7%).

¹¹ It is worth observing that these data also include intra-EU trade. This could lead in Figure 25 to an overestimation of the EU export share compared to other exporting countries. However, this should not cause any problems in Figure 24, where intra-EU flows (imports and exports) balance each other out.

The CIS, led by Russia and Ukraine, has been a net exporter of semi-finished and finished steel products over the whole period, with a net balance slightly decreasing over time, on average equal to about 50 million tonnes, and an extremely low level of imports. As for Africa and Middle East, they are increasingly becoming net importers, mainly due to the rising dependence from production of Iran, Saudi Arabia and UAE. North America is on the contrary switching from its position of net importer due to a reduction of imports since 2006 (from 64 million tonnes in 2006 to around 29 million in 2009) and to a slow improvement of the export (the level of export was 25.5 million tonnes in 2011 compared to 15.3 in 2001). In 2010, South America (mainly Brazil, Argentina and Venezuela) turned into a net importer due to lower imports and higher exports in almost all the countries (although Brazil remained a net exporter). Its negative balance was equal to -442,000 tonnes in 2011. Finally, Other Europe, mainly due to increasing exports volume of Turkey, has improved its net position by reporting a surplus of around 4.8 million tonnes in 2011.

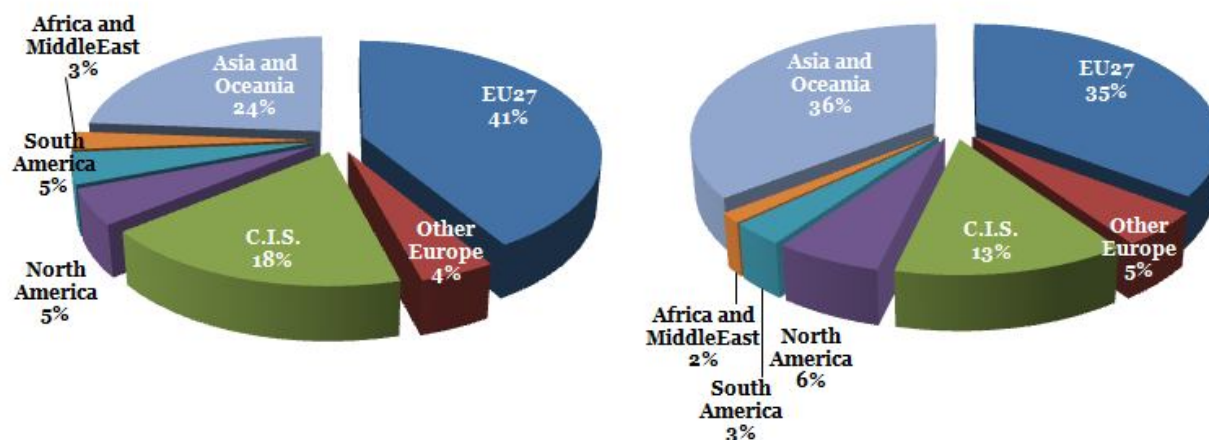
Figure 22. Net flows of semi-finished and finished steel products, 2001-2011 (thousand tonnes)



Note: Data for 2010: estimates by World Steel Association.

Source: Authors' elaboration on World Steel 2011 and 2012.

Figure 23. Market shares of exports of semi-finished and finished steel products, 2001 and 2011



Source: Authors' elaboration on World Steel (2013).

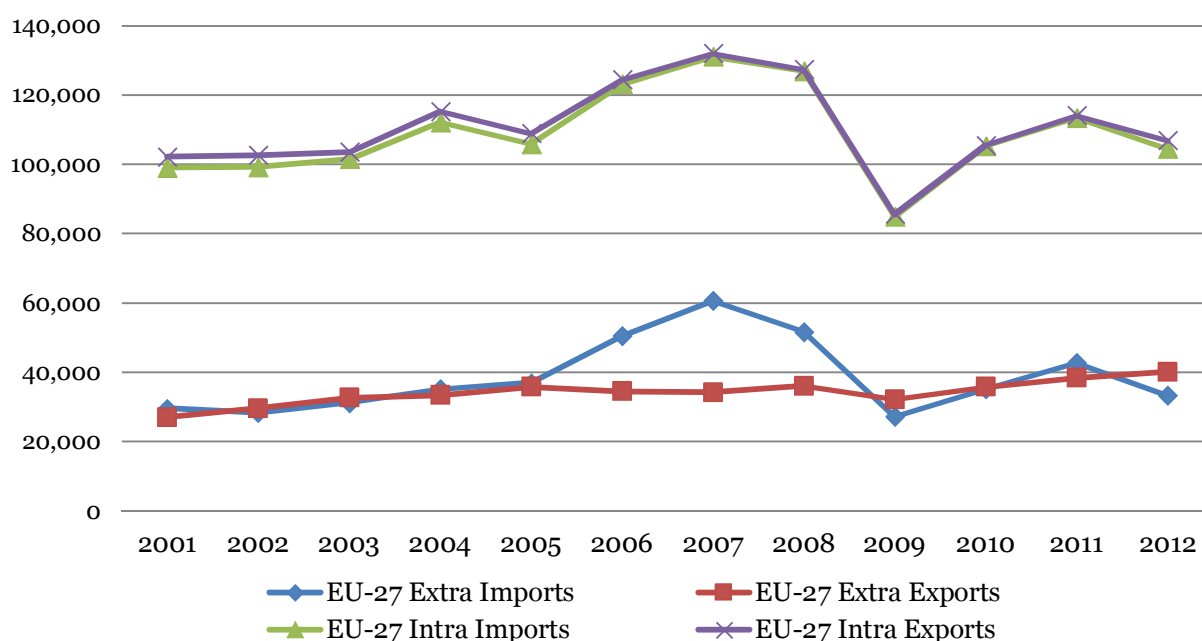
1.4.2 EU trade flows

The European market for iron and steel¹² is mainly represented by intra-EU flows, as confirmed by Figure 24. Indeed, in 2012, intra-EU trade accounted for 72% of the total, while only 28% of trade was directed towards extra-EU economies. The same can be observed for imports, where 74% has come from EU member states and 26% from outside EU borders. Based on COMEXT data, which disentangle between intra- and extra-EU trade, the EU was a net importer of iron and steel from 2004 to 2008 and again in 2011. Finally, in 2012, EU recorded a positive net balance of 66.8 million tonnes.¹³

The relative weight of intra- and extra-EU trades did not change substantially across the decade. In 2001 intra-EU imports and exports accounted for 78% and extra-EU for 21% of the trade flows; in 2012, intra-EU imports and exports accounted for 75% and 73%, respectively, while extra-EU imports and exports accounted for roughly 24% and 27%, respectively. It is evident from Figure 24 that, intra-EU trade flows and extra-EU imports dramatically dropped in 2009 (the former by about one-third, and the latter by almost one-half on a year-to-year basis), while extra-EU exports showed a slow but steady increase throughout the decade.

¹² Iron and steel are here defined according to the category 67, SITC Rev. 3. The category includes: Pig-iron, spiegeleisen, sponge iron, iron or steel granules and powders and ferro-alloys (671); Ingots and other primary forms, of iron or steel; semi-finished products of iron or steel (672); Flat-rolled products of iron or non-alloy steel, not clad, plated or coated (673); Flat-rolled products of iron or non-alloy steel, clad, plated or coated (674); Flat-rolled products of alloy steel (675); Iron and steel bars, rods, angles, shapes and sections (including sheet piling) (676); Rails or railway track construction material, of iron or steel (677); Wire of iron or steel (678); Tubes, pipes and hollow profiles, and tube or pipe fittings, of iron or steel (678).

¹³ However, according to the data reported by ECORYS (2008), which take into account a smaller range of products, in particular, semi-finished and finished steel products, EU extra-regional imports overtook the exports in 2006, turning the EU into a net importer back then.

Figure 24. Intra and extra-EU Trade of iron and steel, 2001-2012 (thousand tonnes)

Source: COMEXT, 2013.

Table 3. EU-27 exports, imports and net positions in iron and steel by selected destination countries, 2001 and 2012 (thousand tonnes)

Destination Countries	2001			2012		
	Export	Import	Net	Export	Import	Net
Total Extra-EU	27,048	29,573	-2,525	40,150	33,341	6,809
Turkey	1,741	3,326	-1,584	5,284	1,830	3,454
USA	6,312	334	5,978	5,237	509	4,728
Algeria	562	133	429	4,603	34	4,569
Switzerland	2,179	1,051	1,128	2,478	1,251	1,228
India	449	326	123	1,432	1,585	-154
Russia	438	6,644	-6,207	1,299	8,322	-7,023
China	758	449	309	1,160	3,502	-2,342
Mexico	668	307	362	1,142	31	1,111
Morocco	689	15	674	1,035	38	997
Norway	1,120	1,656	-536	891	1,118	-227
Canada	939	168	771	812	130	682
Brazil	435	1,302	-867	791	1,388	-597
South Korea	300	737	-437	462	1,331	-869
South Africa	178	2,181	-2,003	423	1,332	-910
Ukraine	115	4,190	-4,075	350	6,084	-5,734
Japan	123	433	-310	152	316	-164

Source: Authors' elaboration on COMEXT, 2013.

The destinations of extra-EU flows are diversified geographically, showing that the EU is fairly integrated in the global trade dynamics. Table 3, selects the top 16 destination

economies of EU steel exports in 2012. It can be observed that in 2012 almost 45% of EU exports were directed to Turkey, the US, Algeria and Switzerland. The same year, 53% of total imports came from Russia (8.3 million tonnes), Ukraine (6 million) and China (3.5 million). Top origin and destination countries are quite similar compared to 2001, where more than 55% of total extra-EU exports were directed to the US, Switzerland, Turkey and Norway, while almost 63% of extra-EU imports come from Russia (6.6 million tonnes), Ukraine (4.2 million), Turkey (3.3 million) and South Africa (2.2 million).

Compared to 2001, when US and Russia were the first markets for EU exports and imports respectively, it is worth observing the new prominent role acquired by China and India. In particular, Chinese exports to Europe grew eight-fold in 12 years, and India's five-fold. Remarkably, South Korea doubled its exports to Europe, overcoming Switzerland despite proximity, while Russia and Ukraine increased their export volumes by about 50%. In the same period, the EU's imports from Turkey, Norway and South Africa decreased by about one-third to one-half in terms of volume. As for EU exports, the most remarkable spike is in trade flows towards Algeria, which increased eight-fold from 2001 to 2012, making it the second-largest importer of European steel. Exports towards India, Russia and Turkey almost trebled, while exports towards China 'only' increased by 50%.

2. Selection of the sample and sample statistics

2.1 The selection of facilities

The facilities have not been chosen by the authors of this report. The sample is based on the companies and plants that voluntarily decided to take part in this study at the request of Eurofer. However, the plants admitted to be part of the study represent a fairly accurate approximation of the steel industry in Europe, according to the following criteria:

- Geographical coverage
- Capacity of plants
- Ownership
- Production technology

A total of 15 steel plants took part in this exercise. Furthermore, two national federations provided substantiating information about national typical facilities, bringing the sample to 17 plants.¹⁴

2.1.1 Geographical coverage

In this case, the following criteria were applied:

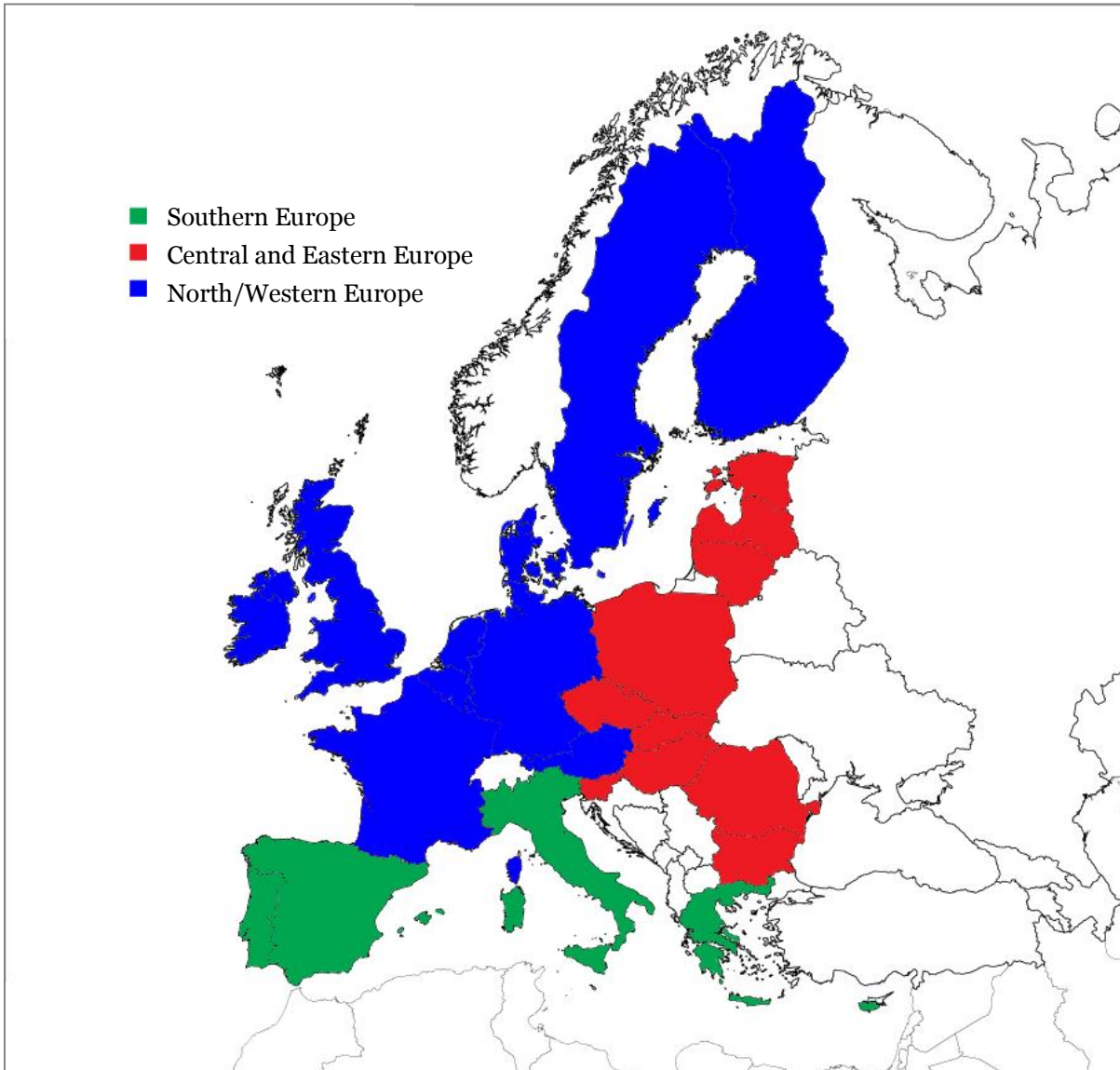
- **Production per member state:** Nine member states (Germany, Italy, Spain, France, the United Kingdom, Poland, Belgium, Austria and the Netherlands) represented 82% of EU steel production in 2012. This study covers six out of these nine countries, and five out of the first six producing countries.
- **Heterogeneity:** To the extent possible, the sample ensures the geographical heterogeneity, as it includes different member states in terms of i) regional location, ii) country size and iii) date of accession to the EU. The sampled facilities have been attributed to three geographical areas (as illustrated by Figure 25).
- **North-western Europe (NW)** (France, Belgium, Luxembourg, the Netherlands, Ireland, United Kingdom, Germany, Austria, Denmark, Finland and Sweden). It represents 59% of EU crude steel production in 2012. Nine plants in the sample belong to this area.
- **Central and eastern Europe (CEE)** (Poland, Slovenia, Hungary, Romania, Bulgaria, Czech Republic, Slovak Republic, Estonia, Latvia and Lithuania). It rep-

¹⁴ National federations have sent data to CEPS concerning a typical plant representative of the national steel industry in terms of location, capacity, technology and production. Cost components provided have been validated and adjusted where needed by double-checking with national energy prices and the cost of regulatory components as provided by national laws and regulations. Further interviews were held when values did not coincide, and CEPS retained the right to adjust values based on third-party information.

resents 15% of EU crude steel production in 2012. Three plants in the sample belong to this area.

- **Southern Europe** (Italy, Spain, Portugal, Greece, Malta, Cyprus). It represents 26% of EU crude steel production in 2012. Five plants in the sample belong to this area.

Figure 25. Steel - division by regions



Source: Own illustration.

2.1.1.1 Production technology

The following technologies should be covered if representativeness is to be ensured: BOF and EAF. In 2011, BOF plants produced 57% of crude steel in Europe, while EAF

plants accounted for 43%. However, given the different average size, few BOF facilities exist compared to EAFs: 40 vs. 182.¹⁵

In the sample, both technologies are represented, as four BOF and nine EAFs are included.¹⁶ Hence, EAFs are over-represented in terms of output; but this is a more accurate reflection of the numbers of the two classes of plants. In any case, EAF plants, given their higher electricity intensity per tonne of steel and the fact that do not own self-generation facilities running on waste gases, are mostly exposed to the costs of energy, and hence had a larger incentive to take part in this study. The sample also includes three rolling mills (one aggregated with two BOF plants, and two on a standalone basis).

2.1.1.2 Capacity of plants

For each technology, plants may have different capacity. The sample is then to reflect a distribution of capacity similar to that of the steel-making universe (as retrieved from Steel Business Briefing & EuroStrategy Consultants, 2010 and other sources).

BOF plants included in the sample range from smaller ones, with a capacity of 2MMT and higher, to medium ones, with a capacity of up to 4.5 MMT. Very large BOF plants are not covered by this study.

EAF plants taking part in this study are highly diversified in terms of capacity, ranging from small installations with less than 400,000 tonnes of capacity, to large installations with more than 1.3MMT of capacity.

2.1.1.3 Ownership

The sample will include facilities from global players, regional champions and niche specialists. SMEs are not relevant among steel-making facilities.

2.2 Methodology

As previously described, the data sample consists of 17 plants, which have been split into three different regions. For each plants, cost and consumption data are available, i.e. annual and specific costs for the total amount of electricity and the natural gas consumed. Yearly energy bills are available for six out of 17 plants, enabling CEPS researchers to validate the information specified in the questionnaires.

2.2.1 Data collection

The analysis of the energy prices and costs for the sector of steel was based on questionnaires received from Eurofer. All participants provided detailed data about their energy prices, structure of energy bills and energy consumption.

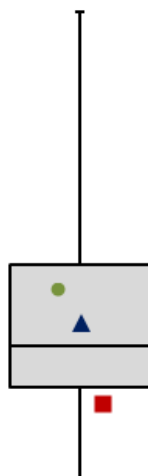
¹⁵ Steel Business Briefing & EuroStrategy Consultants (2010).

¹⁶ The two national representative facilities mostly refer to EAF producers. In addition, two rolling mills are also included in the sample.

2.2.2 Data analysis and presentation

Box plots are used to display the cost ranges and to give an indication of the distribution among the units in the sample. An exemplary box plot is illustrated in Figure 26. The whiskers below and above the box represent the minimum and maximum values of the sample. The box itself is divided into two parts by a horizontal line. This line indicates the median of the sample, i.e. the numerical value separating the higher half of the data sample from the lower half. The lower border of the box represents the first (lower) quartile of the sample. It splits off the lowest 25% of the data sample from the highest 75%. Correspondingly, the upper border of the box indicates the third (upper) quartile of the sample, thus separating the highest 25% of data from the lowest 75%. Put differently, the box contains exactly the middle half of the data. The height of the box is also referred to as inter-quartile range (IQR). It is a robust way of showing the variability of a data sample without having to make an assumption on the underlying statistical distribution.

Figure 26. Exemplary box plot



Source: Own illustration.

In order to ensure that no data are attributable to any specific plant, box plots are not created for the regional subsets of the sample, as some of them consist of only 3-5 plants. Instead, weighted average values are calculated and displayed next to or inside the box plots (see Figure 26). As weighting factor, the 2012 crude steel production of the plant is applied.¹⁷

¹⁷ For the stand-alone rolling mill, the production of semi-manufactured steel products is used instead of crude steel. For national representative facilities, the following parameters have been considered: crude steel capacity 1MMT, crude steel production 700,000 tonnes.

2.2.3 Validation of information

All sampled participants provided detailed figures on the level and structure of energy prices as well as on energy consumption. The data were assessed, e.g. through a plausibility check, and then evaluated. Table 4 presents the number of questionnaires received, selected in the sample and used in the analysis of each section.

The research team conducted a validation of the collected data through EU energy statistics publications.¹⁸ To further assess consistencies in the responses, the researchers conducted targeted interviews with some of the national associations. The researchers were not able to validate the energy price data, for example, through external sources of information about the costs borne by EU producers at plant level.

Table 4. Number of questionnaires used in each section

Total number received	Number selected in the sample	Energy prices trends	Energy bill components	Energy intensity	International comparison	Production costs and margins
17	17	15 (gas) 17 (elec.)	14 (gas) 17 (elec.)	11 (gas) 14 (elec.)	3	n/a*

*Taken from the Cumulated Cost Assessment Study.

It is worth noting that all of the figures presented in the following chapters include possible exemptions from taxes, levies or transmission costs. The researchers asked the producers to communicate the prices they paid for energy carriers between 2010 and 2012. Therefore, their answers include exemptions/reductions if these are applicable, i.e. the net prices are reported.

2.3 Energy prices trends

2.3.1 Natural gas

Most steel-makers are large gas consumers. BOF integrated plants producing flat products included in the sample consume between 1 and 1.5 million MWh of natural gas per year, most of it in the rolling facilities. EAF and rolling facilities included in the sample consume between 60,000 and 450,000 MWh of natural gas per year.

¹⁸ Validation was conducted through the EU Statistical Pocketbook 2013 (European Commission, 2013) and the EU Market Observatory & Statistics.

2.3.1.1 General trends

As shown by the median in Figure 27, the prices of natural gas paid by the sampled steel producers¹⁹ were on the rise throughout the entire observation period. In 2010, the median EU price of natural gas paid by a steel producer was of €26.4/MWh. By 2012, the price rose by 34% to a level of €32.7/MWh. Weighted average values are lower, respectively €24.4/MWh in 2010 and €32.2/MWh in 2012 (+34.7%).²⁰

Furthermore, since 2010, the price differences between the three regions kept growing. The increasing inter-quartile range, i.e. the difference between the lower and upper quartile, which represents the middle half of the data, also reflects this trend, as it goes from €6.8/MWh in 2010 (26% of the median value) to €13/MWh in 2012 (32%). Moreover, the total range of prices has also been increasing since 2010, as indicated by the whiskers of the box plot, from €17.6/MWh in 2010 to €32.5/MWh in 2012.

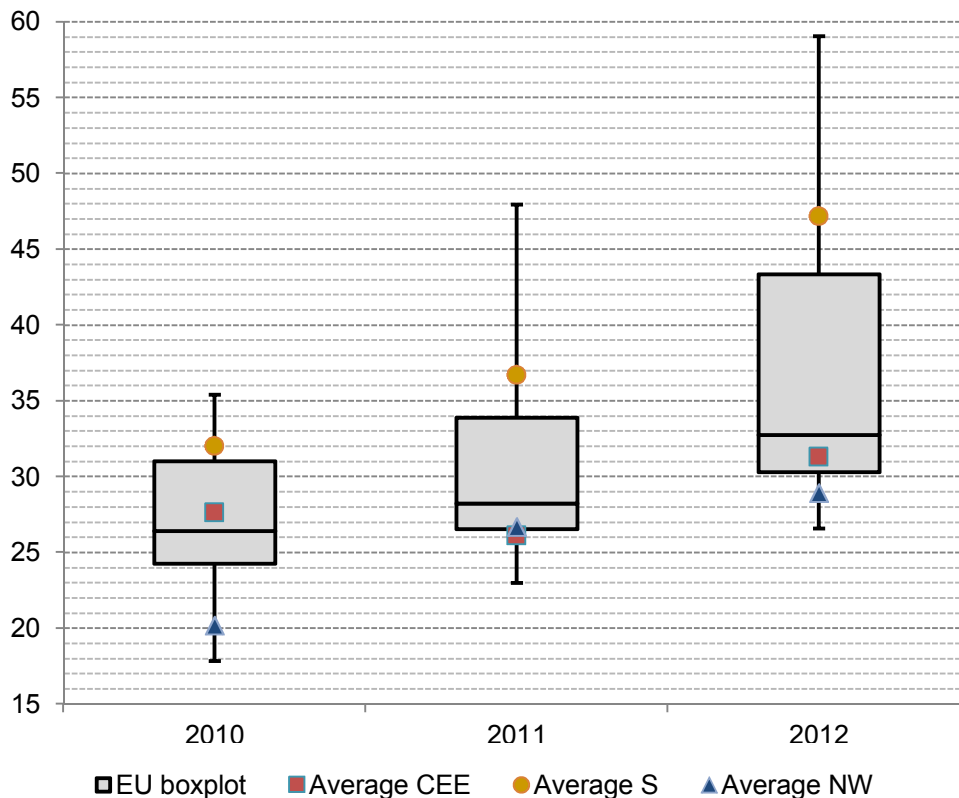
2.3.1.2 Regional differences

Figure 27 also illustrates the average price of natural gas paid by European producers operating in different geographical regions.

North-western European steel-makers face a comparably lower natural gas price; however, they had to bear an increase of 43% in two years. Their price is constantly below the median; the distance from the EU average decreased from €4.2/MWh in 2010 to €3.3/MWh in 2012. Southern producers faced an even harsher trend, as natural gas price increased by 47% and from a much higher level. The mean gas price for southern European steel-makers is constantly above the third quartile, meaning that, on average, they pay more for natural gas than 75% of all European producers, or 47% more than the EU average. Central and eastern European producers faced the most stable gas price, as it increased only by 13% in three years.

¹⁹ For natural gas, the sample is composed of 13 plants and two national representative plants. Two plants use other fuels than natural gas and therefore could not be compared.

²⁰ Values for 2011: median €28.2/MWh; average €27.8/MWh.

Figure 27. Prices of natural gas paid by sampled EU producers, 2010-2012 (€/MWh)

Source: Authors' elaboration on questionnaires.

Table 5. Descriptive statistics for natural gas prices paid by sampled EU producers (€/MWh)

	2010	2011	2012
<i>EU (average)</i>	24.4	27.8	32.2
<i>EU (median)</i>	26.4	28.2	32.7
<i>EU (IQR)</i>	6.8	7.3	13.0
<i>EU (minimum)</i>	17.8	23.0	26.6
<i>EU (maximum)</i>	35.4	47.9	59.1
<i>Central and Eastern EU (average)</i>	27.6	26.1	31.3
<i>Southern EU (average)</i>	32.0	36.7	47.2
<i>North-Western EU (av)</i>	20.2	26.7	28.9
<i>BOF average*</i>	24.4	26.2	30.8
<i>EAF average</i>	24.0	28.6	32.6

* It is worth noting that data show a high variation of costs for BOF and EAF due to the fact that the plants are unevenly distributed across different EU regions.

Source: Authors' elaboration on questionnaire.

2.3.2 Electricity

Consumption of electricity for steel-making is very different between BOFs and EAFs. Electricity intensity of the BOF process is about one-third of EAF; furthermore, BOF installations usually include a self-generation facility, where electricity is produced out of recycled waste gases from the furnaces. This means that, on average, sampled BOF producers procure electricity from external sources for about 60% of their total electricity consumption. Once these factors are accounted for, it comes as no surprise that much smaller EAF installations consumes as much electricity as larger BOF ones.

Consumption levels for EAF plants in the sample range between 150 and 600 GWh per year; as for BOF plants, the range is between 350 and 750 GWh per year. Given that the production process is standardised, the biggest determinants of electricity consumption are plant capacity and the presence of hot- or cold-rolling facilities within the plant premises.

2.3.2.1 General trends

Compared to natural gas, both EU average and EU median power prices are more stable (see Figure 28). Between 2010 and 2012, median costs of electricity increased by 6%, from €58.7/MWh to €62.3/MWh; mean costs of electricity increased slightly more, by 7%, from €66.8/MWh to €71.3/MWh.²¹ The cost increase is about 20% lower than in the case of natural gas.

In 2012, 25% of sampled plants faced electricity costs lower than €56.6/MWh, while the top quartile faced costs higher than €73.2. This resulted in an inter-quartile range of €16.6/MWh, that is 27% of the median value; in relative terms, the variance of electricity prices is smaller than for gas. The inter-quartile range decreased from 2010 to 2012, signalling a price convergence; in 2010, it amounted to €21.5/MWh, that is 36% of the median value. Instead, the max-min spread increased from €37.8/MWh to €57.9/MWh. This increase is due to an increasing maximum value (from €89.6 to €104.4/MWh) coupled with a stable minimum value.

2.3.2.2 Regional differences

Similar to natural gas, steel-makers in north-western Europe face more advantageous prices than producers in other regions. Across three years, their average electricity price is constantly below the EU average price, and in 2011 and 2012 is also below the median, implying that a steel producer located in this region on average pays less than 50% of EU producers. Between 2010 and 2012, the electricity price in north-western Europe slightly declined, by 2% in nominal terms.

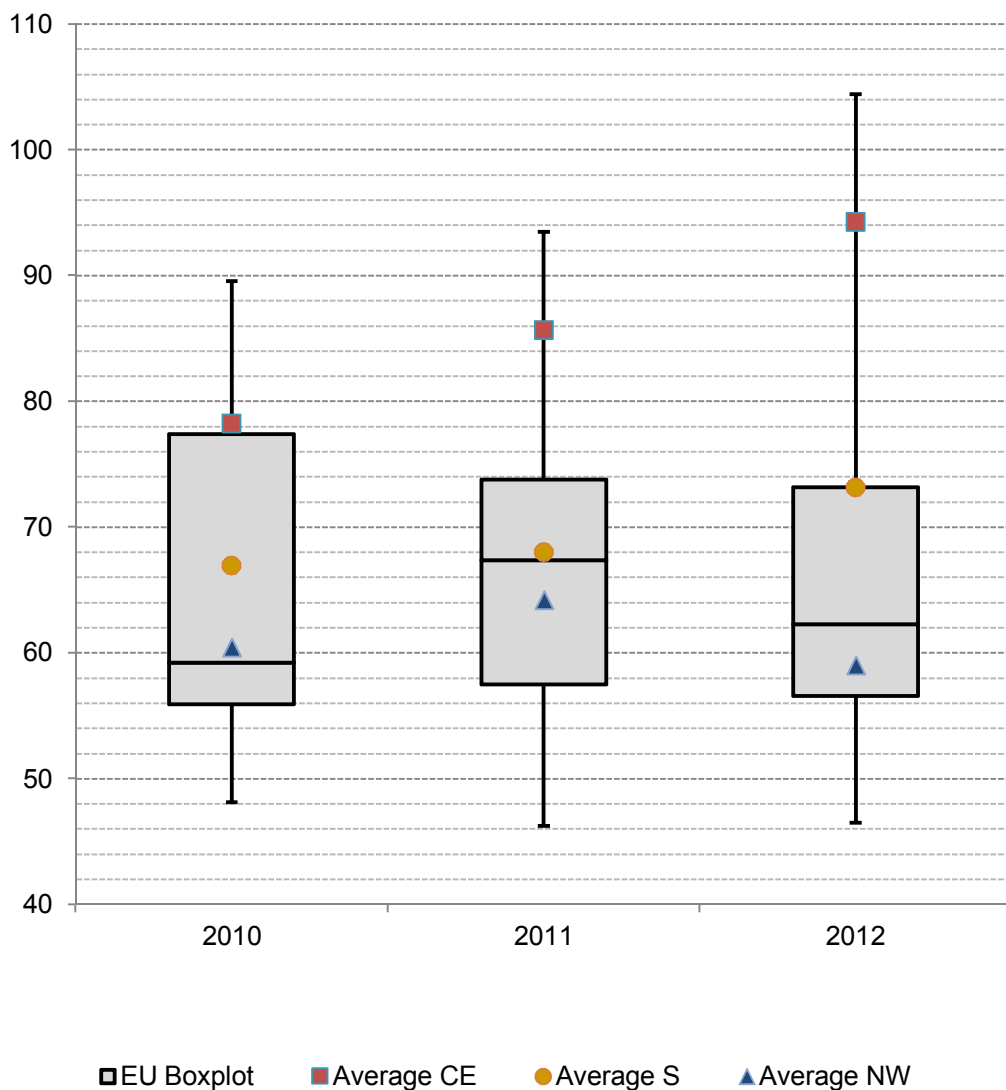
Average electricity costs for southern producers have been close to the average in these three years, albeit they are constantly higher than the median value. The cost differential with north-western Europe was between €4.5 and €7/MWh in 2010 and 2011, but

²¹ Values for 2011: median €67.4/MWh; average €71.1/MWh.

spiked to €14.8/MWh in 2012, due to the simultaneous decrease in northern Europe and increase in the south. Overall, the electricity price did not show a spike as high as the gas price, and in southern Europe it increased by 10% in nominal terms in two years.

Central and eastern steel-makers face the highest costs in the sample. Their average value is constantly above the third quartile, meaning that on average they pay more than 75% of the EU plants. The situation got worse between 2010 and 2012, as electricity prices have increased by about 19%, widening the gap with the EU average from €10.9 to €21.1/MWh.

Figure 28. Prices of electricity paid by sampled EU producers (2010-2012)



Source: Authors' elaboration on questionnaires.

Table 6. Descriptive statistics for electricity prices paid by sampled EU producers (€/MWh)

	2010	2011	2012
EU (average)	66.8	71.2	71.4
EU (median)	58.7	67.4	62.3
EU (IQR)	21.5	16.3	16.6
EU (minimum)	51.8	51.0	46.5
EU (maximum)	89.6	93.5	104.4
Central and eastern EU (average)	77.7	84.7	92.5
Southern EU (average)	67.7	68.8	74.2
North-western EU (average)	60.7	64.3	59.4
BOF average	67.5	73.9	73.9
EAF average	65.2	67.0	67.0

Source: Authors' elaboration on questionnaire.

2.4 Analysis of energy bill components

2.4.1 Introduction

In order to better understand the price developments, we now break down the total cost into its components. For natural gas, the following three components are relevant: i) the energy component, ii) the grid fees and iii) other levies and taxes (excluding VAT). For electricity, there is one additional component, the RES levies. It is worth noting that only net prices are reported, i.e. partial or full exemptions from certain fees, taxes or levies are already included.

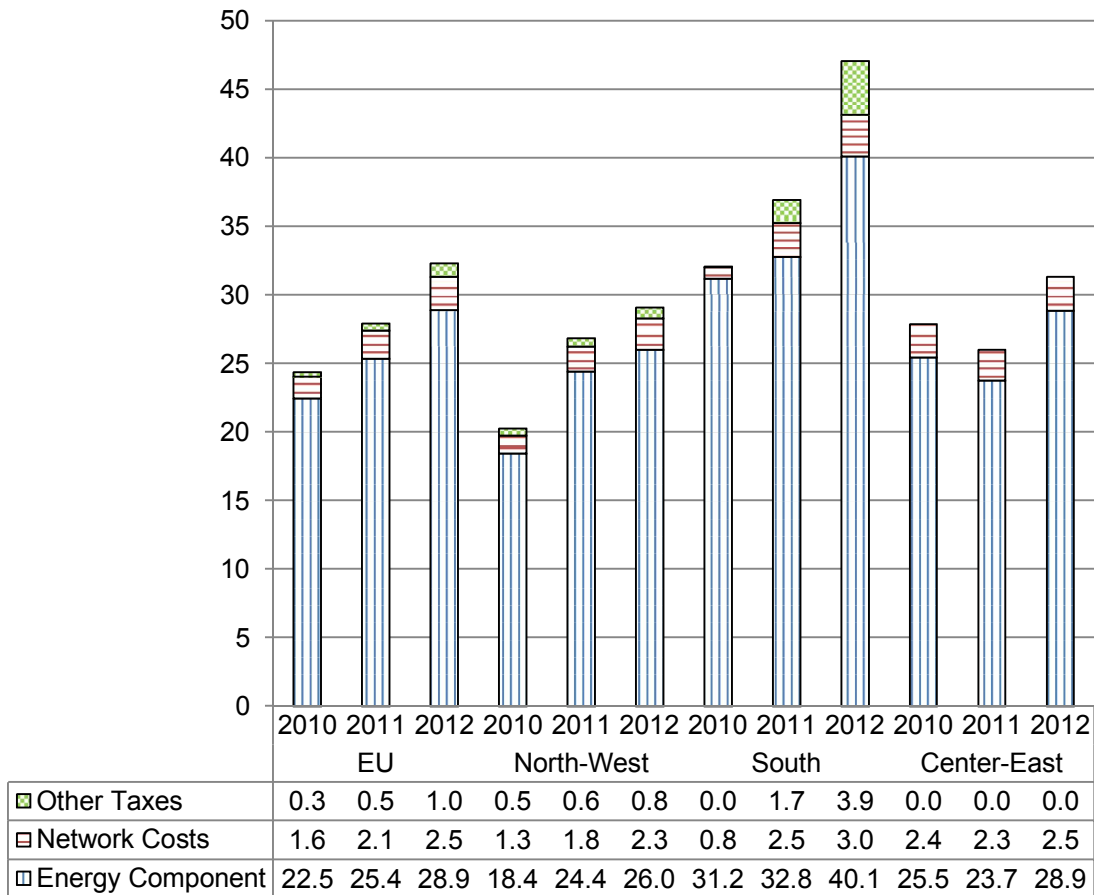
2.4.2 Natural gas

2.4.2.1 General trends

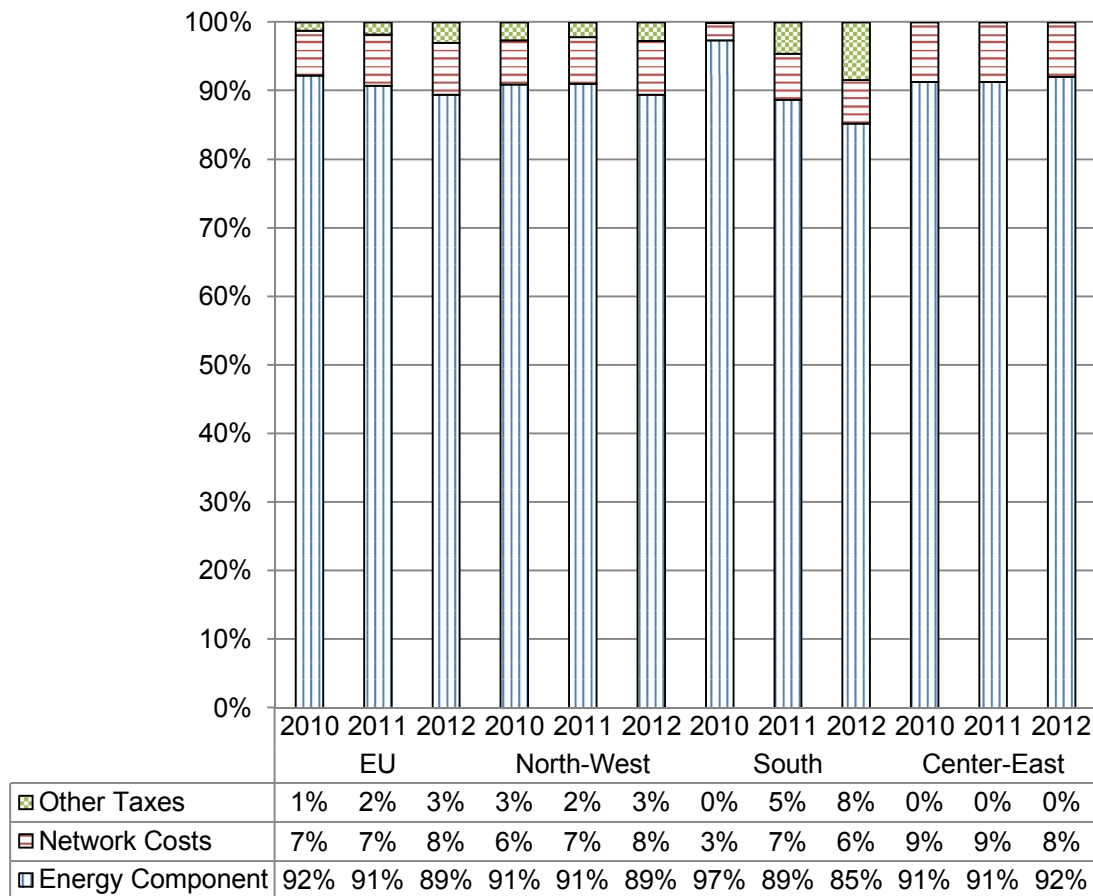
As shown by Figure 29 and Figure 30, the energy component is the major driver of natural gas prices for the sampled plants in Europe. In 2012, the latter accounted for 89% of the averaged price of gas. Due to the importance of the energy component, the impact of grid fees, taxes and other levies on the prices of natural gas was limited. In 2012, network costs accounted for 8% of the average price of gas. However low, they show a steep increase of 56% in only two years, from €1.6/MWh in 2010 to €2.5/MWh in 2012. Taxes and other levies represented only about 1 to 2% of total cost of gas for steel-makers in 2010 and 2011; however, in 2012 this value kept its increasing trend, reaching 3%, that is €1.0/MWh. The EU average for other taxes and levies has thus become close to the average network costs, representing its 40% in 2012 (18% of network costs in 2010). This increase is mainly attributable to a taxation spike in southern Europe.

Except for the recent spike in tax burden in southern Europe, the price structure of natural gas in north-west and southern Europe is very close to each other and to the EU average. The energy component ranges around 90%, and network costs around 6-8%. On the contrary, central and eastern European producers do not have to pay any tax on their gas bills, and as such network costs represent a higher share of the final price, between 8 and 9%.

Figure 29. Components of the natural gas bills paid by the sampled producers in Europe, 2010-2012 (€/MWh)



Source: Own calculation based on questionnaires.

Figure 30. Components of the natural gas bills paid by the sampled producers in Europe, 2010 (in %)

Source: Own calculation based on questionnaires.

2.4.2.2 Energy component

General trends

The EU average and median energy component of natural gas price increased significantly during the period 2010-2012. The changes were equal to +28% (both for EU average and median), respectively increasing from €22.5/MWh to €28.9/MWh and from €24.8/MWh to €31.9/MWh.

In 2012, 25% of sampled plants faced energy component costs lower than €26.2/MWh, while the top quartile faced costs higher than €38.3/MWh. This implies an inter-quartile range of €12.0/MWh, equal to 38% of the median value. In 2010 the inter-quartile range was equal to €8.5/MWh., or 34% of the 2010 median value. The increase of the inter-quartile range from 2010 to 2012 indicates a price divergence for the energy component. The min-max spread followed the same path, increasing from €18.8/MWh in 2010 to €28.5/MWh in 2012. This growth is mainly due to a step increase in the maximum value (from €35.4 to €52.9/MWh).

Regional differences

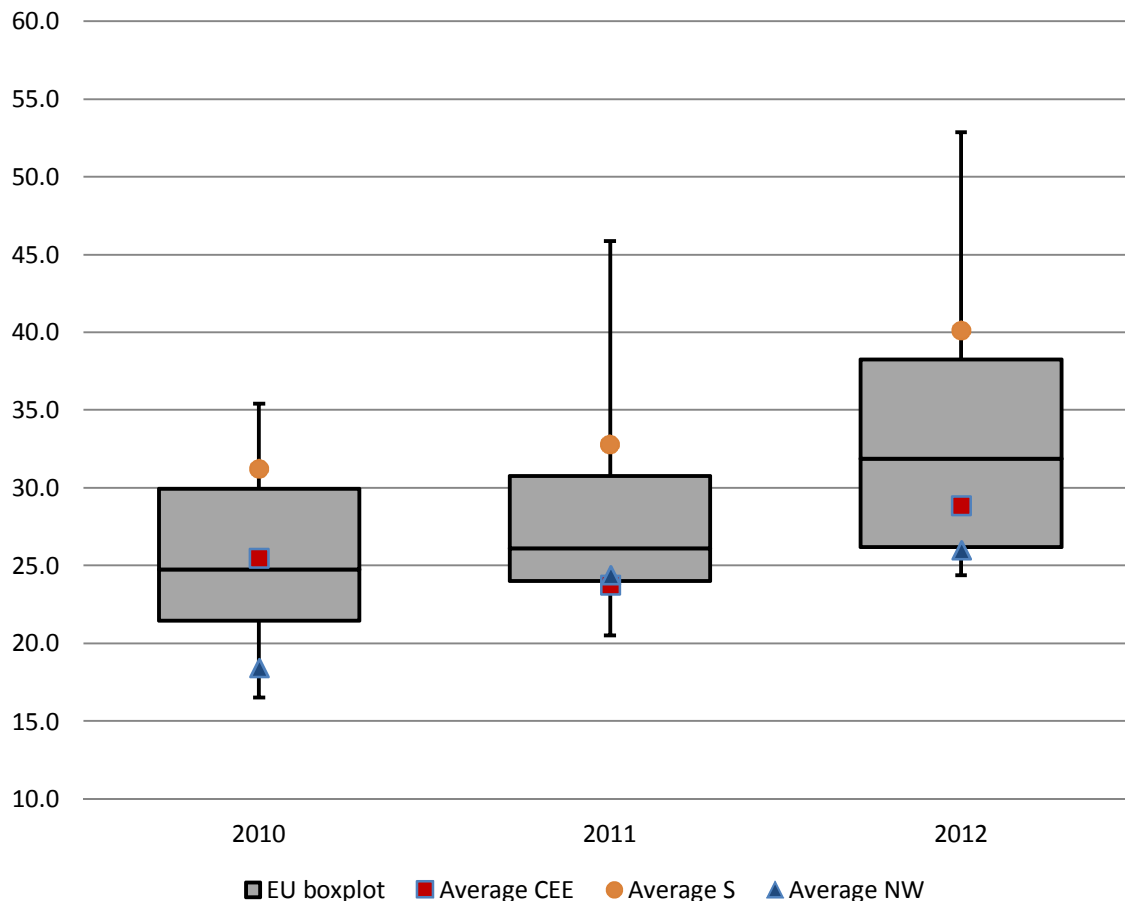
The aforementioned results only partially reflect diverse realities at a regional level.

north-western producers were the ones paying the lowest price for the energy component in 2012. The regional average price was below the EU first quartile both in 2010 and 2012, meaning that, in those years, north-western producers were paying on average less than 75% of EU producers. Between 2010 and 2012, the price paid for the energy component in north-western Europe faced a huge increase, equal to +41%.

Southern producers had to face the highest cost for the price paid for the energy component in the sample, equal to a cost gap with the Northern-Western ones equal to €14.1/MWh in 2012 (€12.8/MWh in 2010 and €8.4/MWh in 2011). Overall, the energy component cost increased in southern Europe by 29% during the period 2010-2012.

Central and eastern European steel-makers faced the lowest cost in the sample for 2011, being below the EU first quartile in 2011 and below the EU median in 2012, central and eastern European producers saw the energy component of natural gas price increasing by 13.3%.

Figure 31. Energy component of natural gas prices paid by sampled EU producers (2010-2012)



Source: Authors' elaboration on questionnaires.

Table 7. Descriptive statistics for the energy component of natural gas prices paid by sampled EU producers (€/MWh)

	2010	2011	2012
EU (average)	22.5	25.4	28.9
EU (median)	24.8	26.1	31.9
EU (IQR)	8.5	6.7	12.0
EU (minimum)	16.6	20.5	24.4
EU (maximum)	35.4	45.9	52.9
Central and eastern EU (average)	25.5	23.7	28.9
Southern EU (average)	31.2	32.8	40.1
North-western EU (average)	18.4	24.4	26.0
BOF average	22.2	23.6	27.5
EAF average	22.3	26.7	29.7

Source: Authors' elaboration on questionnaire.

2.4.2.3 Network costs

General trends

The EU average and median network costs for natural gas faced an increase during the period 2010-2012. In absolute terms, the change is less than €1.5/MWh in both cases (the percentage change is significant, being equal to +50% for the EU average and to +133% for the EU median). Respectively, they changed from €1.6/MWh to €2.5/MWh the former and from €0.9/MWh to €2.1/MWh the latter.

In 2012, 25% of sampled plants faced network costs lower than €1.1/MWh, while the top quartile faced costs higher than €2.9/MWh. This meant an inter-quartile range of €1.8/MWh. The inter-quartile range remained stable from 2010 to 2012 (€1.5/MWh in 2010). The min-max spread increased, more than doubling its original value, from €3.3/MWh in 2010 to €6.8/MWh in 2012. This is completely due to the change in the maximum value, as the minimum value remained equal to 0.

Regional differences

During the period analysed, growth in the price related to network costs is widespread over the three regions, having different intensities depending on the geographical area, and levelling regional disparities.

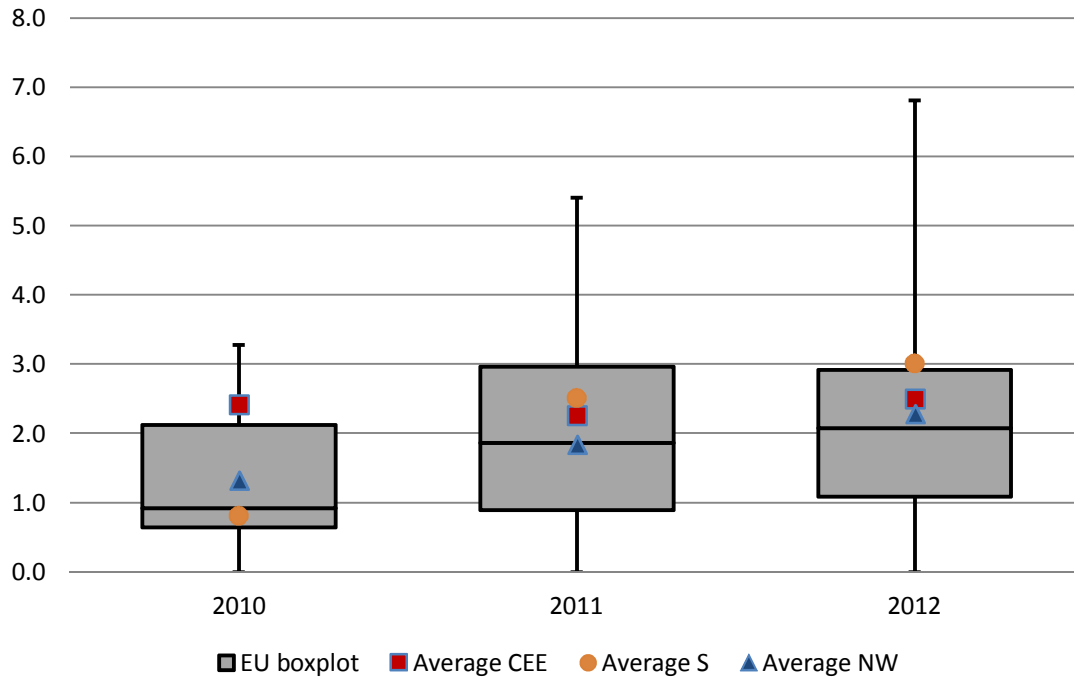
North-western producers saw their average price increase from €1.3/MWh (2010) to €2.3/MWh (2012). The north-western average was slightly above the EU median in 2012. This implies that a steel producer located in this region paid, during 2012, on average slightly more than 50% that of EU producers.

The evolution of southern producers' network costs is peculiar, being below the EU median in 2010, above the EU median in 2011 and above the EU third quartile in 2012. This implies that a steel producer located in this region paid on average less than 50% of EU producers in 2010, more than 50% of EU producers in 2011 and more than 75% of

EU producers in 2012. Overall, the price attached to network costs increased from €0.8/MWh to €3.0/MWh.

Central and eastern producers had to face the highest price for the network component in the sample for 2010, being above the EU third quartile. In 2012, instead, the price paid (€2.5/MWh) was not very distant from the lowest regional average price, i.e. the North-western one (€2.3/MWh).

Figure 32. Network costs component of natural gas prices paid by sampled EU producers (2010-2012)



Source: Authors' elaboration on questionnaires.

Table 8. Descriptive statistics for the network costs component of natural gas prices paid by sampled EU producers (€/MWh)

	2010	2011	2012
EU (average)	1.6	2.1	2.5
EU (median)	0.9	1.9	2.1
EU (IQR)	1.5	2.1	1.8
EU (minimum)	0.0	0.0	0.0
EU (maximum)	3.3	5.4	6.8
Central and eastern EU (average)	2.4	2.3	2.5
Southern EU (average)	0.8	2.5	3.0
North-western EU (average)	1.3	1.8	2.3
BOF average	2.1	2.5	3.0
EAF average	1.0	1.6	1.8

Source: Authors' elaboration on questionnaire.

2.4.2.4 Other taxes and levies

General trends

The EU median value for other taxes and levies on natural gas grew during the period 2010-2012 from €0.3/MWh to €0.7/MWh. The EU average increased from €0.3/MWh to €1.0/MWh.

In 2012, 25% of sampled plants faced other taxes and levies for less than €0.4/MWh, while the top quartile faced costs higher than €4.6/MWh. This meant an inter-quartile range of €4.2/MWh, that is four times the average value. The inter-quartile range increased by ten times from 2010 to 2012 (from €0.4/MWh to €4.2/MWh), indicating a diverging trend. The min-max spread also registered a large increase, from €1.3/MWh in 2010 to €6.0/MWh in 2012.

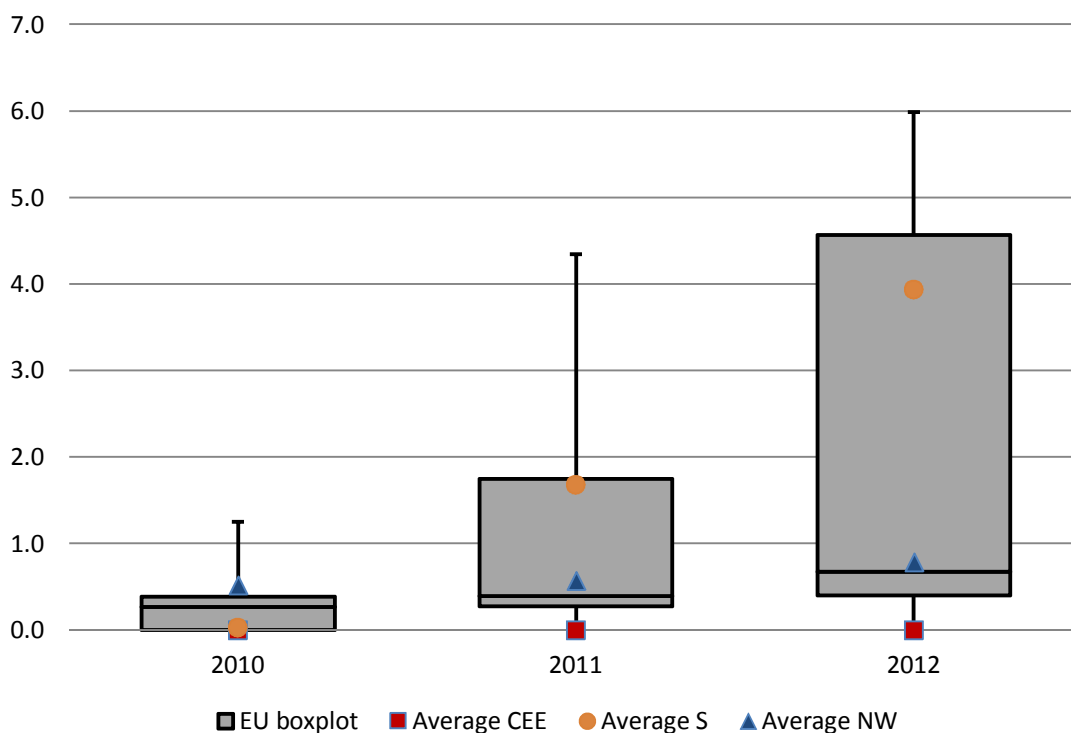
Regional differences

Regional disparities were almost insignificant in 2010. During the period the differences widened staggeringly. Northern-western producers saw their average price going from €0.5 to €0.8/MWh, being almost in line with EU median in 2012.

Southern producers' other taxes and levies increased steadily, from 0 to €3.9/MWh, in line with the fiscal tightening taking place in this region.

Central and eastern producers had to face the lowest amount in the sample for other taxes and levies, being approximately equal to 0 for the whole period considered.

Figure 33. Other taxes and levies' component of natural gas prices paid by sampled EU producers (2010-2012)



Source: Authors' elaboration on questionnaires.

Table 9. Descriptive statistics for the “other taxes and levies” component of natural gas prices paid by sampled EU producers (€/MWh)

	2010	2011	2012
EU (average)	0.3	0.5	1.0
EU (median)	0.3	0.4	0.7
EU (IQR)	0.4	1.5	4.2
EU (minimum)	0.0	0.0	0.0
EU (maximum)	1.3	4.3	6.0
Central and eastern EU (average)	0.0	0.0	0.0
Southern EU (average)	0.0	1.7	3.9
North-western EU (average)	0.5	0.6	0.8
BOF average	0.1	0.1	0.2
EAF average	0.5	0.9	1.6

Source: Authors' elaboration on questionnaires.

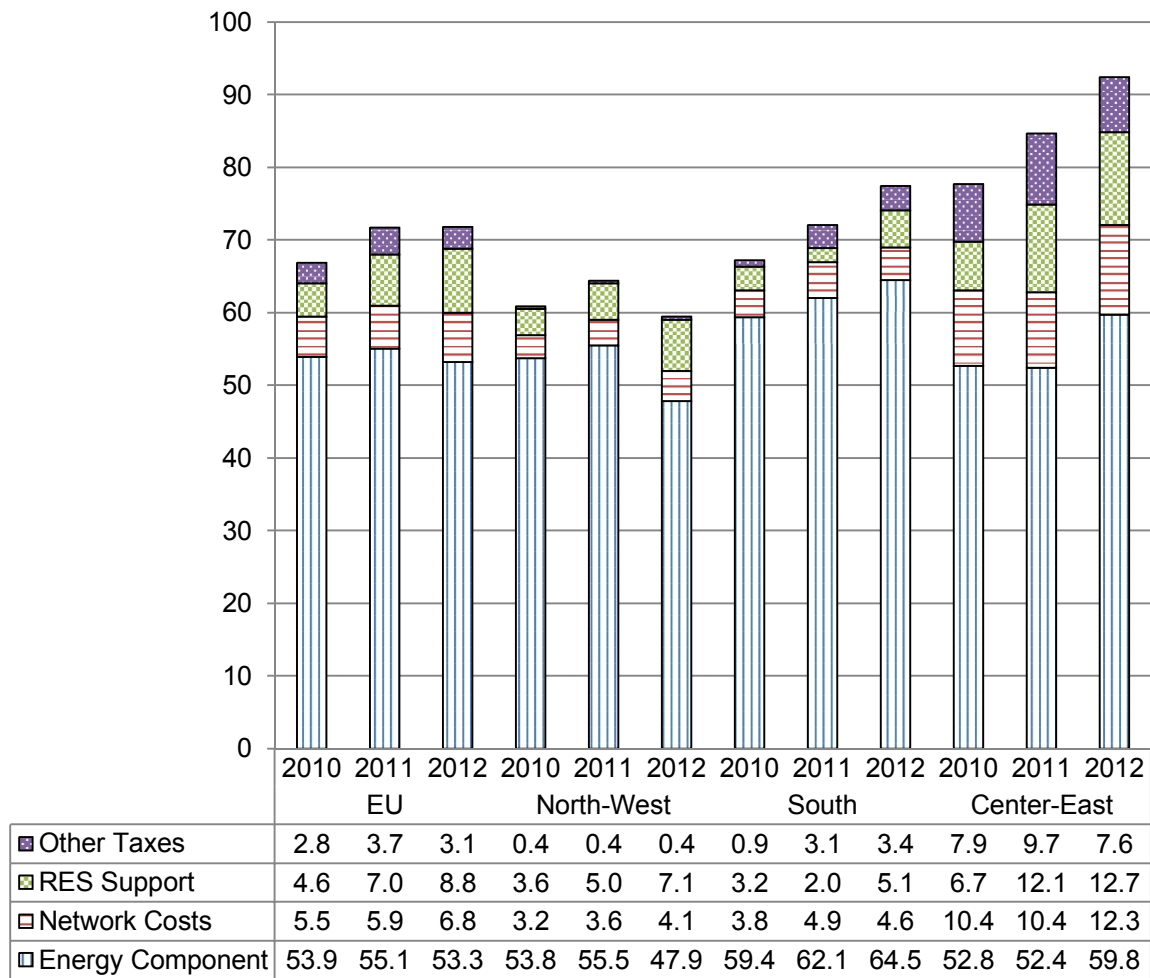
2.4.3 Electricity

2.4.3.1 General trends

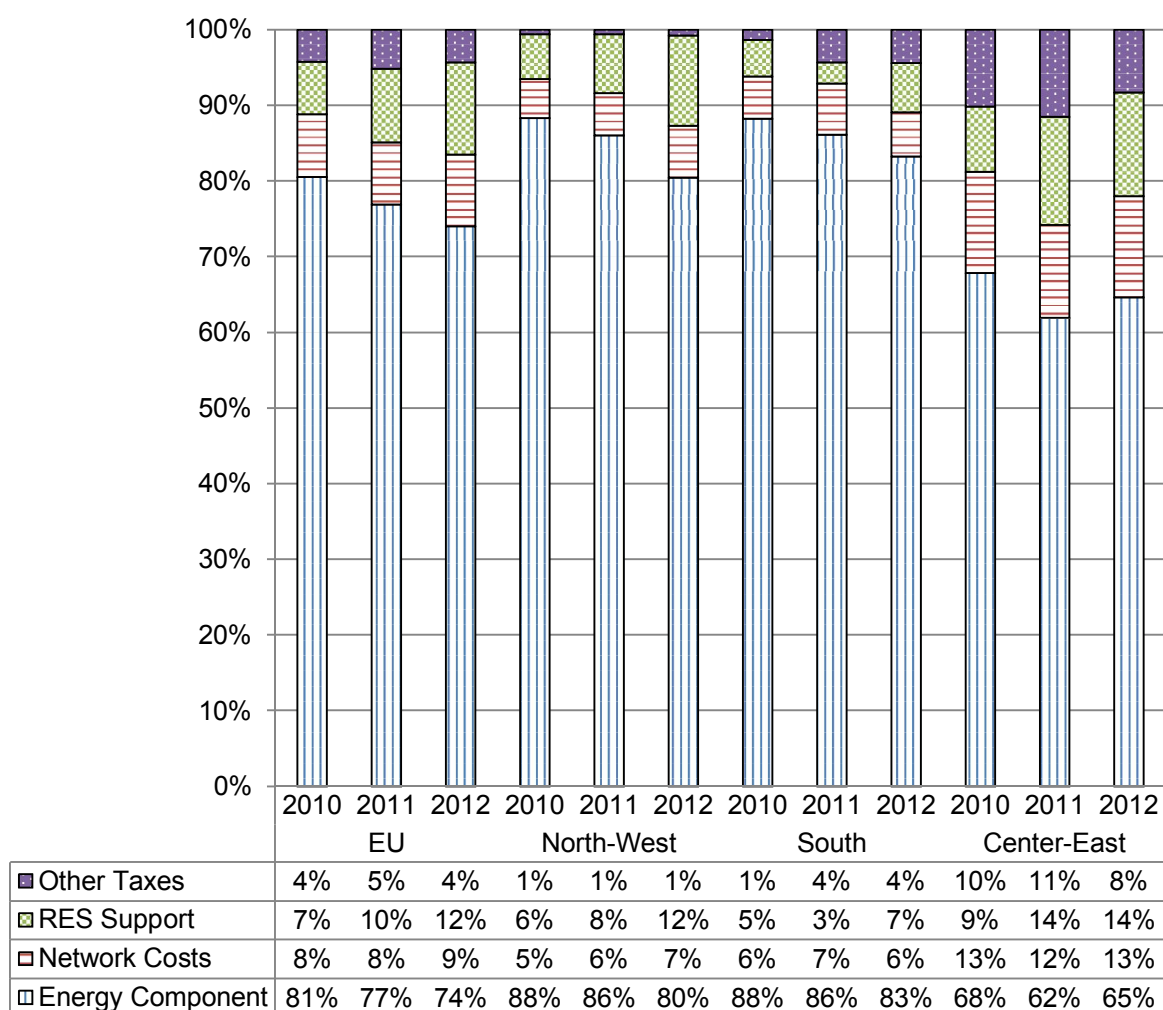
As for the structure of natural gas prices, the energy component is the most significant component of the electricity price paid by the sampled production facilities in Europe (see Figure 34 and Figure 35). However, in comparison to natural gas, this component is less dominant, and other components play a larger role in the final price. In 2010, the energy component amounted to €53.9/MWh, that is 81% of the final cost. In the same year, grid fees amounted to €5.5/MWh (8%), RES levies to €4.6/MWh (7%) and other levies and taxes (excluding VAT) to €2.8/MWh (4%).

The energy component has slightly decreased to €53.3/MWh in 2012 (-0.1%), and the relative weight also kept fairly stable. However, its share over the total costs shrank from 81% to 74% due to the increase of the other components, mostly RES levies. RES levies reached €8.8/MWh (+91%), and in 2012 they represented 12% of the final electricity bill. Network costs increased by 22%, and other taxes and levies by 9%.

The weight of the different components is quite different among the three regions. The energy component is the major cost driver in all regions. In southern and north-western Europe, the energy component has the lion share of total cost, over 80%, while in Central and eastern Europe this component only accounts for 62-68%. This is mainly due to higher taxes in the latter region; in the northern-western Europe these are almost negligible, while they went from 1% to 4% of the total bill in southern Europe. In 2012, RES levies, network costs and other taxes represented more than one-third of the total bill for producers based in central and eastern Europe. The share of RES levies reached up to 14% of total costs.

Figure 34. Components of the electricity bills paid by the sampled producers in Europe (€/MWh)

Source: Own calculation based on questionnaires.

Figure 35. Components of the electricity bills paid by the sampled producers in Europe (%)

Source: Own calculation based on questionnaires.

2.4.3.2 Energy component

General trends

The EU average and median price of the energy component has been very stable between 2010 and 2012. The change is circumscribed approximately to -1% (EU average) and -3% (EU median), respectively decreasing from €53.9/MWh to €53.3/MWh the former and from €51.1/MWh to €49.4/MWh the latter.

In 2012, 25% of sampled plants faced energy component costs lower than €47.2/MWh, while the top quartile faced costs higher than €57.3/MWh. This meant an inter-quartile range of €10.1/MWh, equal to 20% of the median value. In 2010 the inter-quartile range was equal to roughly the half of its equivalent in 2012, i.e. €5.4/MWh or 11% of the 2010 median value. The inter-quartile range increased significantly from 2010 to 2012, indicating a price divergence. The min-max spread followed the same path, increasing from €26.9 in 2010 to €37.7 in 2012. This growth is due both to an increasing maximum value (from €71.6 to €78.8/MWh) and a diminishing minimum value (from €44.7 to €41.1/MWh).

Regional differences

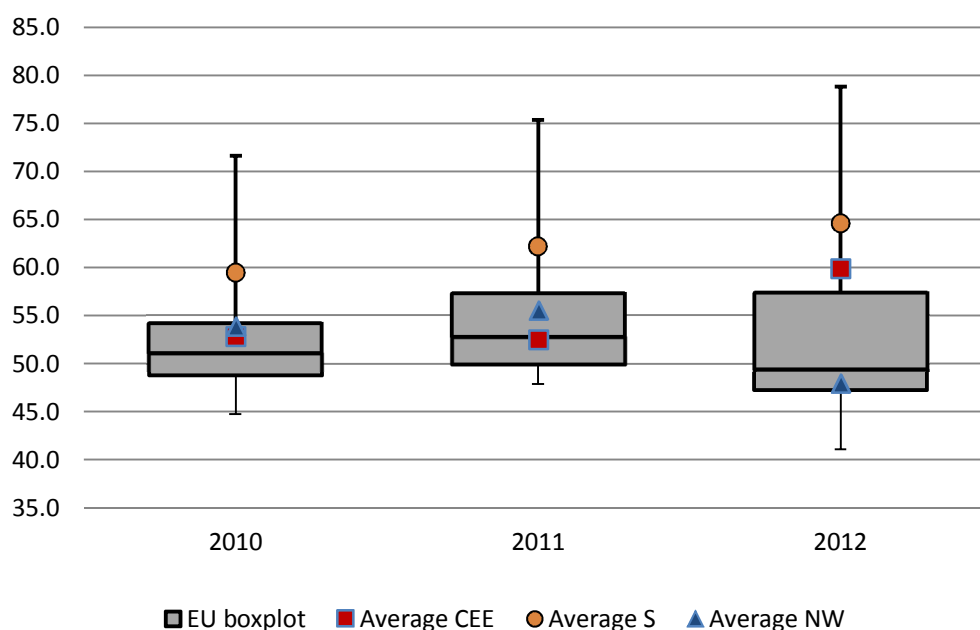
The aforementioned results only partially reflect the diverging realities at regional level, which are the core reason for the inter-quartile range increase.

During the period analysed, northern-western producers increased their advantage with respect to the other regions for the price paid on the energy component. Their average price was in line with the EU average price and slightly above the EU median in 2010 and 2011. In 2012 instead, it was below both the EU average and median in 2012. This implies that a steel producer located in this region paid, during 2012, on average 50% less than EU producers. Between 2010 and 2012, the price paid for the energy component in north-western Europe significantly declined, by 11% in nominal terms.

Southern producers had to face the highest costs for the energy component in the sample, equal to a cost gap with the north-western ones between €5.6 and €6.6/MWh in 2010 and 2011; however, the cost differentials spiked to €16.6/MWh in 2012, due to the simultaneous decrease in north-western Europe and the increase in the South. Overall, it increased in southern Europe by 9% in two years.

Central and eastern steel-makers faced the lowest cost in the sample for 2010, but after two years only (2012) their average was significantly closer to the southern European average (high costs, €-4.7/MWh gap), rather than the northern-western one (low costs, €+11.9/MWh gap). Their average value was below the EU average for 2010 and 2011, but jumped above the EU third quartile in 2012, meaning that, during the last year surveyed, on average they paid more than 75% of the EU plants. The situation deteriorated between 2010 and 2012, as the energy component price has increased by about 13%.

Figure 36. Energy component of electricity prices paid by sampled EU producers (2010-2012)



Source: Authors' elaboration on questionnaires.

Table 10. Descriptive statistics for the energy component of electricity prices paid by sampled EU producers (€/MWh)

	2010	2011	2012
EU (average)	53.9	55.1	53.3
EU (median)	51.1	52.8	49.4
EU (IQR)	5.4	7.3	10.1
EU (minimum)	44.7	47.8	41.1
EU (maximum)	71.6	75.4	78.8
Central and eastern EU (average)	52.8	52.4	59.8
Southern EU (average)	59.4	62.1	64.5
North-western EU (average)	53.8	55.5	47.9
BOF average	53.0	54.3	52.5
EAF average	55.5	56.0	53.6

Source: Authors' elaboration on questionnaire.

2.4.3.3 Network costs

General trends

Between 2010 and 2012, the EU average and median network costs included in the electricity price were on the rise. Nominally, the change is circumscribed to less than €1.5/MWh in both cases (the percentage change is significant being equal to +24% for the EU average and to 17% for the EU median). Respectively, they changed from €5.5/MWh to €6.8/MWh the former and from €4.8/MWh to €5.6/MWh the latter.

In 2012, 25% of sampled plants faced network costs lower than €3/MWh, while the top quartile faced costs higher than €10.2/MWh. This meant an inter-quartile range of €7.2/MWh, greater than the median value. In 2010 the inter-quartile range was lower, i.e. equal to €5.7/MWh, also greater than the median value. The inter-quartile range increased from 2010 to 2012, indicating a divergence in the price attached to network costs. The min-max spread marginally diminished, from €15.4/MWh in 2010 to €14.5/MWh in 2012. This is due to a minimal change in maximum value (from €15.4 to €14.7/MWh) and a practical stability in minimum value (from €0 to €0.2/MWh).

Regional differences

During the period analysed, growth in the price related to network costs is widespread over the three regions, having different intensities depending on the geographical area, and maintaining huge regional disparities.

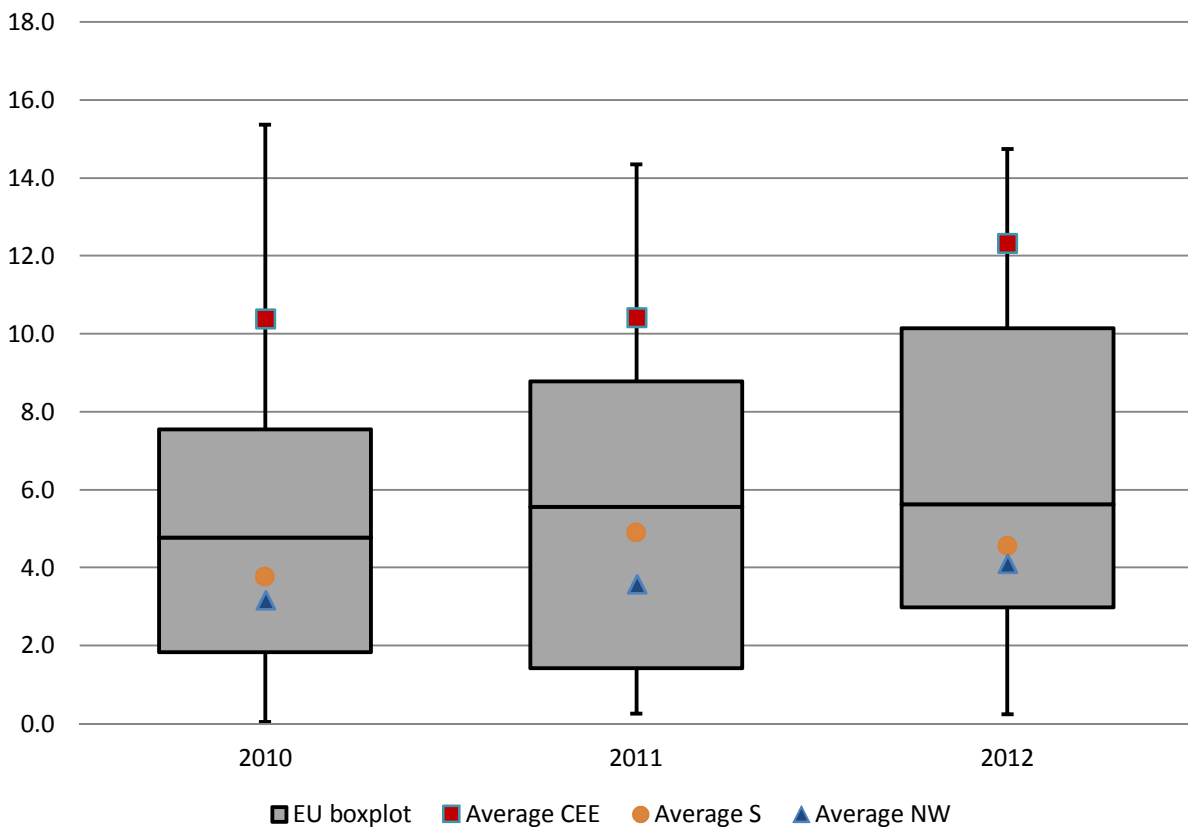
North-western producers saw their average price increasing in line with the EU average price in percentage terms, the former staying steadily below the latter during the whole period 2010-2012. The north-western average was also steadily below the EU median. Between 2010 and 2012, the price paid for network costs in North-western Europe increased from €3.2/MWh to €4.1/MWh.

The evolution of network costs paid by producers operating in southern Europe is in line with the one of the steel-makers based in north-western Europe. For the whole period,

network costs stayed between north-western and EU average, and below the EU median. The latter implies that in 2012, an average steel producer located in this geographical region paid 50% lower network costs than the sampled EU producers. Overall, network costs increased from €3.8/MWh to €4.6/MWh, reaching its peak in 2011 (€4.9/MWh).

Producers based in central and eastern Europe had to face the highest price for the network component in the sample, up to (more than) twice the EU average (median), and approximately three times the north-western and southern average. Their average value was also constantly and significantly above the EU third quartile, meaning that on average they paid more than 75% of EU plants.

Figure 37. Network costs component of electricity prices paid by sampled EU producers (2010-2012)



Source: Authors' elaboration on questionnaires.

Table 11. Descriptive statistics for the network costs component of electricity prices paid by sampled EU producers (€/MWh)

	2010	2011	2012
EU (average)	5.5	5.9	6.8
EU (median)	4.8	5.6	5.6
EU (IQR)	5.7	7.3	7.2
EU (minimum)	0.0	0.3	0.2
EU (maximum)	15.4	14.4	14.7
Central and eastern EU (average)	10.4	10.4	12.3
Southern EU (average)	3.8	4.9	4.6
North-western EU (average)	3.2	3.6	4.1
BOF average	5.9	6.3	8.0
EAF average	5.0	4.9	4.8

Source: Authors' elaboration on questionnaire.

2.4.3.4 RES levies

General trends

The EU average and median price paid for RES levies increased markedly during the period 2010-2012. EU average increased from €4.6/MWh to €8.8/MWh (+91%) and EU median from €3.2/MWh to €5.2/MWh (+63%).

In 2012, 25% of sampled plants faced RES levies costs lower than €3.3/MWh, while the top quartile faced costs higher than €10.2/MWh. This meant an inter-quartile range of €6.9/MWh. In 2010 the inter-quartile range was equal to roughly half of its equivalent in 2012, i.e. €3.6/MWh. The inter-quartile range increased significantly from 2010 to 2012, indicating a price divergence. The min-max spread followed the same path, increasing from €9/MWh in 2010 to €15.5/MWh in 2012. This growth is due to an increasing maximum value (from €9.3 to €15.8/MWh), while the minimum value kept constant (equal to €0.3/MWh).

Regional differences

Steel-makers face very different RES support regimes in the country in scope of this study. The amount paid by energy-intensive industries varies widely. Furthermore, in two countries among those investigated, RES levies are capped, a provision that is very favourable for energy-intensive industrial site. In one of the country in the scope of the report, RES levies are not regulated, but left to the market mechanisms, such as Green certificates.

Growth in the price paid for RES levies is widespread, but proportionate in the three regions, thus preserving the initial differences.

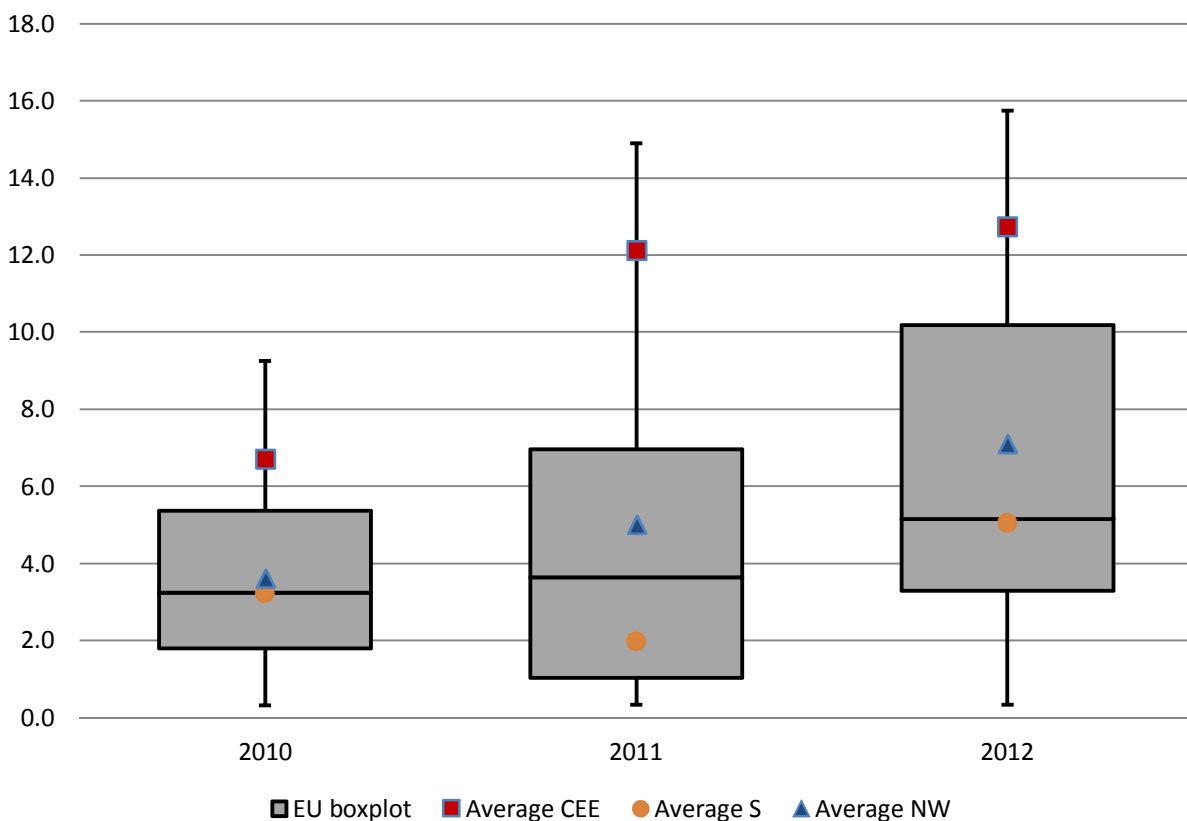
North-western producers saw their average price increasing in line with the EU average price in percentage terms, the former staying steadily below the latter during the whole period 2010-2012. Instead, the north-western average was above the EU median. This implies that a steel producer located in this region paid on average 50% more than EU

producers. Between 2010 and 2012, the price paid for the RES levies increased from €3.6/MWh to €7.1/MWh.

RES levies for southern producers have been the lowest of the sample during the whole period. In 2011 and 2012, they were below the EU median. This implies that a steel producer located in this region paid, during 2011-2012, on average 50% less than other EU producers for RES levies. Overall, the price attached to RES levies increased from €3.2/MWh to €5.1/MWh, reaching its minimum in 2011 (€2.0/MWh).

Central and eastern producers had to face the highest price for the RES levies component in the sample, up to (more than) twice the EU average (median), and approximately twice the north-western and southern averages. Their average value was also constantly and significantly above the EU third quartile, meaning that on average they paid more than 75% of the EU plants.

Figure 38. ‘RES levies’ component of electricity prices paid by sampled EU producers (2010-2012)



Source: Authors' elaboration on questionnaires.

Table 12. Descriptive statistics for the ‘RES levies’ component of electricity prices paid by sampled EU producers (€/MWh)

	2010	2011	2012
EU (average)	4.6	7.0	8.8
EU (median)	3.2	3.7	5.2
EU (IQR)	3.6	5.9	6.9
EU (minimum)	0.3	0.3	0.3
EU (maximum)	9.3	14.9	15.8
Central and eastern EU (average)	6.7	12.1	12.7
Southern EU (average)	3.2	2.0	5.1
North-western EU (average)	3.6	5.0	7.1
BOF average	4.8	8.3	9.6
EAF average	4.5	5.6	7.9

Source: Authors' elaboration on questionnaire.

2.4.3.5 Other taxes and levies

General trends

The EU median price paid for other taxes and levies grew during the period 2010-2012. EU average increased from €2.8/MWh to €3.1/MWh, having its peak at €3.7/MWh in 2011.

In 2012, 25% of sampled plants faced other taxes and levies lower than €0.3/MWh, while the top quartile faced costs higher than €4.4/MWh resulting into an inter-quartile range of €4.1/MWh. In 2010 the inter-quartile range was equal to roughly the half of its equivalent in 2012, i.e. €2.1/MWh. The inter-quartile range increased significantly from 2010 to 2012, indicating a price divergence. The min-max spread followed the same path, increasing from €9.6/MWh in 2010 to €12.3/MWh in 2012. This growth is due to an increasing maximum value (from €9.6 to €12.3/MWh) and a constant minimum value (equal to 0.0).

Regional differences

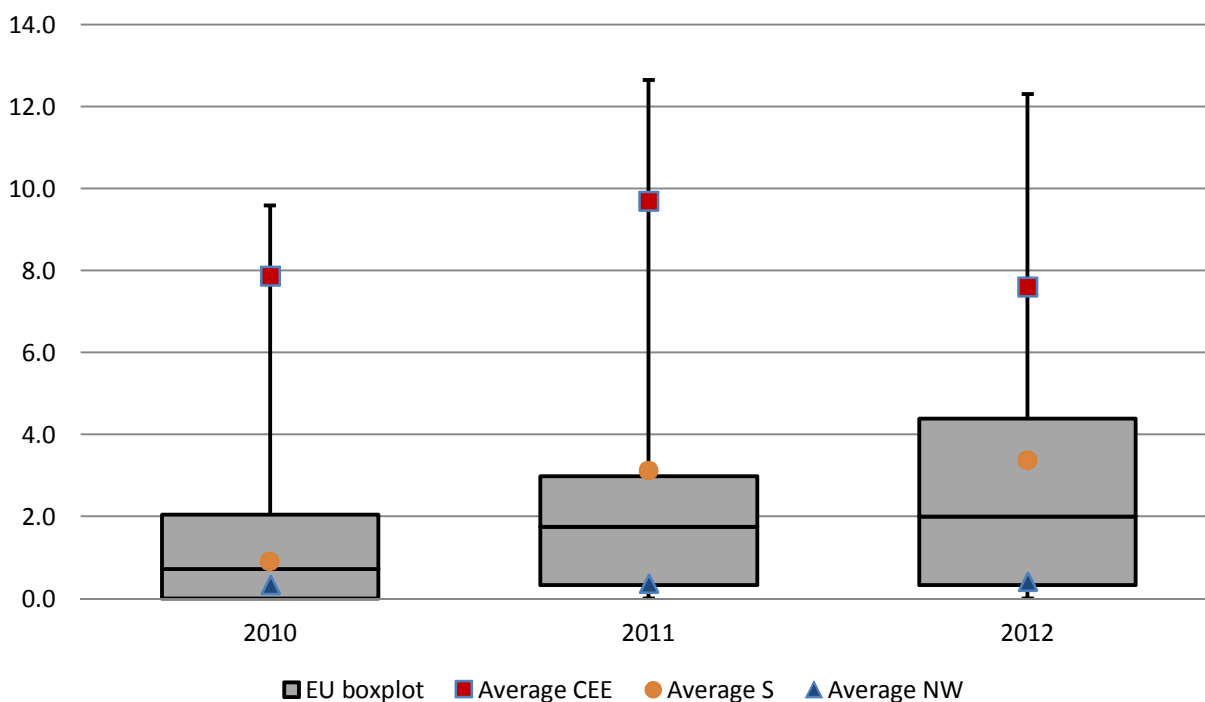
Regional disparities are high. North-western producers saw their average price staying approximately at €0.4/MWh during the whole period 2010-2012. Thus, it was below both EU average and EU median. The latter information implies that a steel producer located in this region paid on average 50% less than EU producers.

Southern producers' "other taxes and levies" in 2010 and 2012 increased steadily, from €0.9/MWh to €3.4/MWh, being always above the EU median. This implies that a steel producer located in this region paid, during the whole period, on average 50% more than EU producers for other taxes and levies.

Central and eastern producers had to face the highest costs in the sample for other taxes and levies, being approximately the double of the southern average in 2012. Their aver-

age value was also constantly and significantly above the EU third quartile, meaning that on average they paid more than 75% of the EU plants, peaking at €9.7/MWh in 2011.

Figure 39. ‘Other taxes and levies’ component of electricity prices paid by sampled EU producers (2010-2012)



Source: Authors' elaboration on questionnaires.

Table 13. Descriptive statistics for the “other taxes and levies” component of electricity prices paid by sampled EU producers (€/MWh)

	2010	2011	2012
EU (average)	2.8	3.7	3.1
EU (median)	0.7	1.8	2.0
EU (IQR)	2.1	2.7	4.1
EU (minimum)	0.0	0.0	0.0
EU (maximum)	9.6	12.7	12.3
Central and eastern EU (average)	7.9	9.7	7.6
Southern EU (average)	0.9	3.1	3.4
North-western EU (average)	0.4	0.4	0.4
BOF average	4.0	5.1	3.9
EAF average	1.1	1.4	1.5

Source: Authors' elaboration on questionnaires.

2.5 Energy intensity

2.5.1 General trends

The researchers asked the producers to provide information about the energy efficiency of their plants by disclosing figures on the energy intensity of their production processes. Intensity is measured in terms of physical output (unit: MWh/tonne). As several energy carriers are used in the production process, separate intensities should be calculated for each energy source (e.g. electricity, natural gas) to allow a correct interpretation of the data. Comparable figures could be retrieved for electricity and natural gas.

Electricity intensity should be computed differently for different steel products and processes. In the BOF route, steel-making requires a certain quantity of electricity (e.g. to operate equipment, in the sintering phase, to produce oxygen) and gas (e.g. for pre-heating). However, the BOF route is coal-based, and hence uses limited quantities of other energy sources. The production of semi-manufactured steel products, such as hot and cold rolled coils, in rolling mills requires a large quantity of natural gas, to re-heat crude steel. The EAF route is much more electricity-intensive than the BOF route, as steel scrap is melted through electric arcs. As for the BOF route, natural gas is mainly used for pre-heating, and in the rolling mill. Results for our sample are shown in Table 14 below, and are in line with the values used for the whole industry in the CEPS EA (2013) Cumulative Cost Assessment carried out for the European Commission.

Table 14. Descriptive statistics for the energy intensity (MWh/tonne)

		Electricity	Natural Gas
BOF	Crude Steel	0.175	0.135
	Hot-Rolled Coil	0.103	0.182
	Cold-Rolled Coil	0.164	0.122
EAF	Crude Steel	0.553	0.151
	Wire Rods	0.121	0.383

Note: In this table, the electricity intensity is reported per each step. Average is not weighted, given that energy intensity depends inversely on capacity utilisation, and hence weighting for the output would give a disproportionate weight to plant used closer to their technical optimum. Data points for each value: BOF Crude Steel – Electricity Intensity: 6; BOF HRC and CRC – Electricity Intensity: 5; BOF Crude Steel – Natural Gas Intensity: 4; BOF Crude Steel – Natural Gas Intensity: 3; EAF Crude Steel Electricity Intensity: 7; EAF WR Natural Gas Intensity: 4; EAF Crude Steel Natural Gas: 4; EAF WR Natural GAS: 6.

Source: Authors' elaboration on questionnaires.

2.6 International comparison: EU vs. US costs

The aim of this section is to compare the prices of energy carriers paid by producers based in the EU with the prices paid by steel-makers based the US. This section is based on data on energy costs in the US provided by one multinational company. Unlike for the European plants, the research team does not possess tools to validate data from the US; nor are we able to assess the representativeness of the selected plants as a sample of US steel-makers. Thus, the information reported in this section does not have the same degree of verifiability that the other parts of the report possess. However, a transatlantic comparison of real industrial prices for gas and energy can seldom be done through large samples; thus, the research team has decided to include it, despite a certain degree of spuriousness. The differences in costs are very significant, so that the results are relevant even accounting for possible spuriousness.

Electricity and natural gas costs are available from three plants located in the US: one BOF, one EAF, and one rolling mill.²² Prices have been converted into €/MWh using the annual exchange rate USD/EUR provided by the European Central Bank.²³

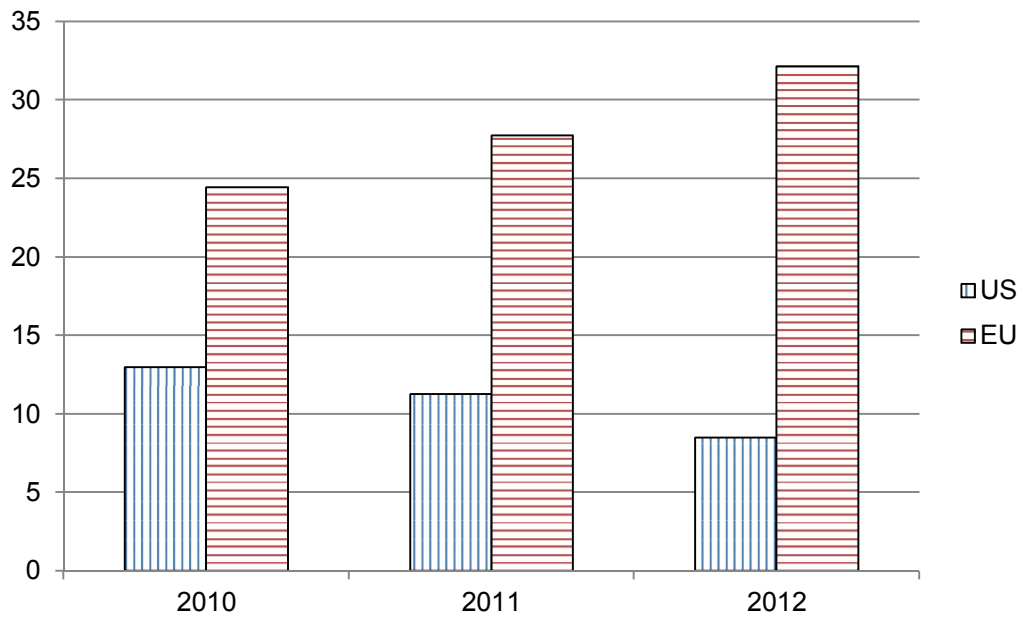
In the sub-sections below, detailed information on natural gas and electricity differentials are reported. In a nutshell, European steel-makers pay a price for electricity that is double that of their US counterparts. As for natural gas, the gap has widened so much that in 2012 the US steel-makers paid only one-quarter of the European price.

2.6.1 Natural gas

The cost of natural gas for EU and US plants belonging in the sample has been widely diverging. As reported in Figure 40 below, EU sample price went from €24.4 to €32.2/MWh, while the US sample price dropped from €13.0 to €8.5/MWh. This resulted in a price differential that has more than doubled in only two years, from €11.5 to €23.7/MWh. US producers included in the analysis pay for natural gas only one-quarter of the price estimated for EU steel-makers.

²² The costs of the electricity price components were not available for one plant. This explains why the differential in total electricity price reported in section 2.6.1 below does not coincide with the difference in electricity price components.

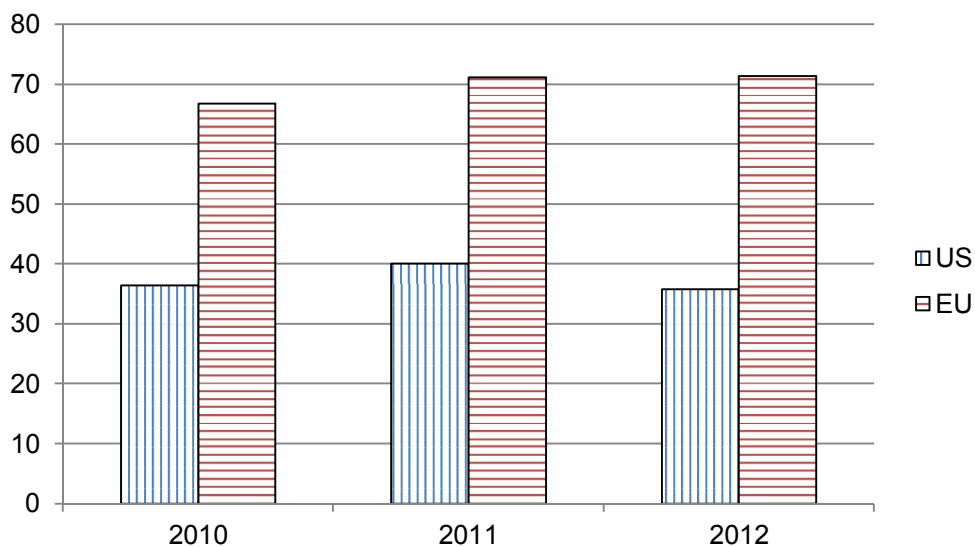
²³ 2010: 1.3257; 2011: 1.392; 2012: 1.2848.

Figure 40. Natural gas price in the EU and the US (€/MWh)

Source: Authors' elaboration on questionnaires.

2.6.2 Electricity

The selected American steel-makers enjoy a significant cost advantage compared to their EU counterparts. Between 2010 and 2012, electricity prices in the US varied between 50% and 56% of the European Price. The gap, in €/MWh is very large, in the area of €30-35/MWh. It has been widening, from €30.3 to €35.6/MWh, but the trend is much more stable compared with natural gas prices. As reported in Figure 41 below, the EU sample price went from €66.8 to €71.4/MWh, while US sample price slightly decreased from €36.5 to €35.8/MWh.

Figure 41. Electricity price in the EU and the US (€/MWh)

Source: Authors' elaboration on questionnaires.

2.7 Indirect ETS costs

ETS indirect costs are the increase of electricity prices due to the pass-on of the (opportunity) cost of European Union Allowances (EUAs) that electric generators have to surrender in order to emit CO₂. Indirect ETS (emission trading system) costs per MWh of electricity depends on:

- *The carbon intensity of the marginal plant.* This is retrieved from the Commission's Guidelines on State aid.²⁴
- *The price of EUAs, which is the price to emit one tonne of CO₂-equivalent.* This is retrieved from the European Environment Agency and is reported in Table 15.

Table 15. Average yearly prices per tonne of CO₂ (€)

Year	2010	2011	2012
CO ₂ Price	14.48	13.77	7.56

Source: European Environment Agency.

- *The pass-on rate.* Energy utilities have passed on a large proportion of their opportunity costs, that is of the value of the EUAs that they had to surrender rather than sell at market prices. Although the exact estimate of the pass-on rate is contested both in the literature and in the opinions of different operators along the electricity value chain, it seems clear that the pass-on rate is close to 1. Conservatively, we assume a pass-on rate of 0.8.

Given that carbon intensity of electricity depends on the generation mix of the electricity market and is kept constant throughout the period, diachronic variation of ETS indirect cost per MWh of electricity only depends on the price of CO₂. Geographical variation, on the contrary, depends on the different carbon intensity of the marginal electricity generator. The impact of ETS indirect costs in €/tonne, which also depend on the electricity intensity of each plant, is discussed in the section below. Descriptive statistics for the indirect cost of ETS are reported in Table 16 below.

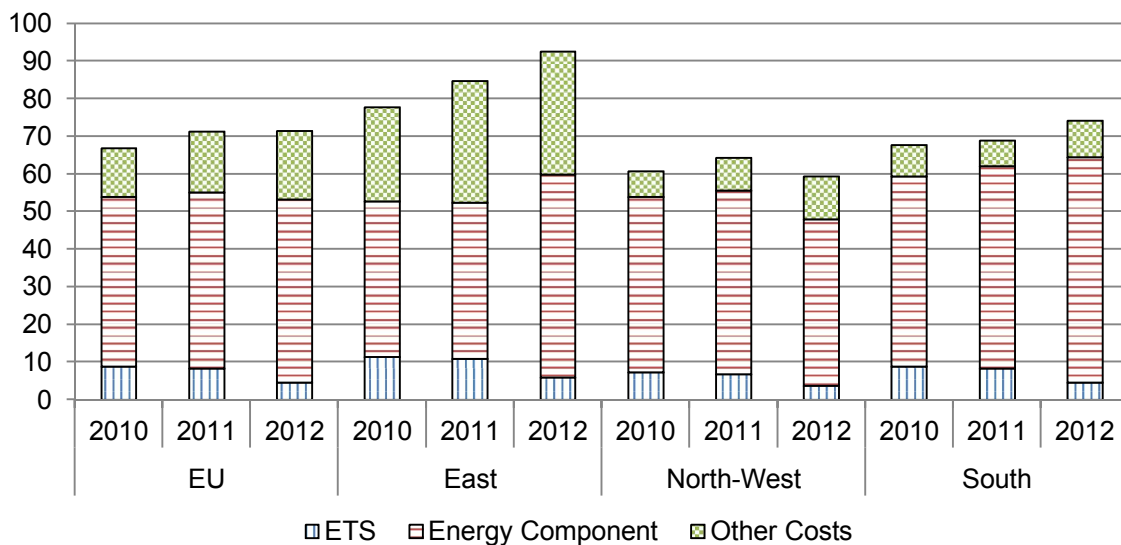
²⁴ Communication from the Commission: Guidelines on certain State aid measures in the context of the greenhouse gas emission allowance trading scheme post-2012 (2012/C 158/04)

Table 16. Descriptive statistics for the Indirect Cost of ETS component of electricity prices paid by sampled EU producers (€/MWh)

	2010	2011	2012
EU (average)	8.7	8.3	4.5
EU (median)	8.8	8.4	4.6
EU (IQR)	2.5	2.4	1.3
EU (minimum)	6.7	6.4	3.5
EU (maximum)	12.3	11.7	6.4
Central and eastern EU (average)	11.4	10.9	6.0
Southern EU (average)	8.7	8.3	4.5
North-western EU (average)	7.2	6.8	3.7

Source: Authors' elaboration on questionnaires

Figure 42 shows the weight of ETS indirect costs over the energy component of the electricity price and the total electricity cost from 2010 to 2012 in the three regions. In 2010 and 2011, indirect ETS costs represent between 12% and 17% of the total electricity cost across the three regions. This value dropped to 6% in 2012, due to the fall of CO₂ price.

Figure 42. ETS indirect costs over energy component of the electricity price and total electricity cost, 2010-2012 (€/MWh)

Source: Authors' elaboration on questionnaires

Table 17. Share of ETS costs over energy component and total cost of electricity

Region	Year	ETS / energy component	ETS / total cost
EU	2010	16%	13%
	2011	15%	12%
	2012	9%	6%
Eastern & central	2010	22%	15%
	2011	21%	13%
	2012	10%	6%
North-west	2010	13%	12%
	2011	13%	11%
	2012	8%	6%
South	2010	15%	13%
	2011	13%	12%
	2012	7%	6%

Source: Authors' elaboration on questionnaires

3. The impact of energy costs

3.1 Energy costs per tonne of output

To assess the impact of energy costs on firm competitiveness, costs of energy per MWh must first be translated into costs per tonne of finished product. This can be done through the energy intensity provided in the questionnaires. For plants for which electricity intensity could not be provided, the average electricity intensity of the sample is used.

There is no a thing such as “energy cost per tonne of steel”, as energy costs per tonne of steel products depend on at least two variables:

1. The production process, that is BOF vs. EAF.
2. The product.

The research team provides energy costs concerning EAF-made wire rods; BOF-made hot rolled-coils and cold-rolled coils. Moreover, energy costs per tonne of crude steel, either BOF- or EAF-made, are provided.

Segmenting the sample along these lines means that it is not possible to assess separately energy costs for the three different regions, as the number of plants per technology per region would be as low as to endanger anonymity. Furthermore, in some cases, data points could not be used for the following reasons.

1. Rolling mills, given that we only have two stand-alone mills in our sample;
2. BOFs producing long products;
3. In the case of natural gas costs, steel plants using other fuels than natural gas.

The number of data points for each segment is reported in Table 18 below.

Table 18. Sample numerosity for technology and product segmentation

	Electricity	Natural gas
EAF-CS	10	9
EAF-WR	10	9
BOF-CS	5	3
BOF-HRC	4	2
BOF-CRC	4	2

Source: Authors' elaboration on questionnaires

The following tables and graphs show the amount of energy costs for the various technologies and products represented in the sample between 2010 and 2012. They are calculated as the average of the costs for the plant per each segment, weighted by 2012 production. Electricity costs are decomposed into the four usual components: i) energy component, ii) network costs, iii) RES costs and iv) other taxes. Natural gas costs are decomposed into the three usual components: i) energy component, ii) network costs and iii) other taxes and levies.

Table 19. Electricity costs (€/tonne)

	Energy component			Network costs			Total		
	2010	2011	2012	2010	2011	2012	2010	2011	2012
EAF-CS	30.66	30.92	29.64	2.74	2.73	2.63	36.38	37.35	37.28
EAF-WR	37.34	37.66	36.10	3.33	3.32	3.21	44.32	45.49	45.41
BOF-CS	9.25	9.49	9.17	1.03	1.09	1.40	11.82	12.93	12.93
BOF-HRC	13.33	13.54	13.36	1.62	1.70	2.12	17.26	18.80	18.97
BOF-CRC	15.99	16.18	16.09	2.00	2.10	2.59	20.80	22.62	22.89
	RES costs			Other taxes and levies					
	2010	2011	2012	2010	2011	2012			
EAF-CS	2.38	2.94	4.19	0.61	0.75	0.81			
EAF-WR	2.90	3.59	5.11	0.74	0.92	0.99			
BOF-CS	0.83	1.45	1.68	0.70	0.89	0.68			
BOF-HRC	1.18	2.13	2.39	1.13	1.43	1.10			
BOF-CRC	1.41	2.56	2.85	1.41	1.78	1.36			

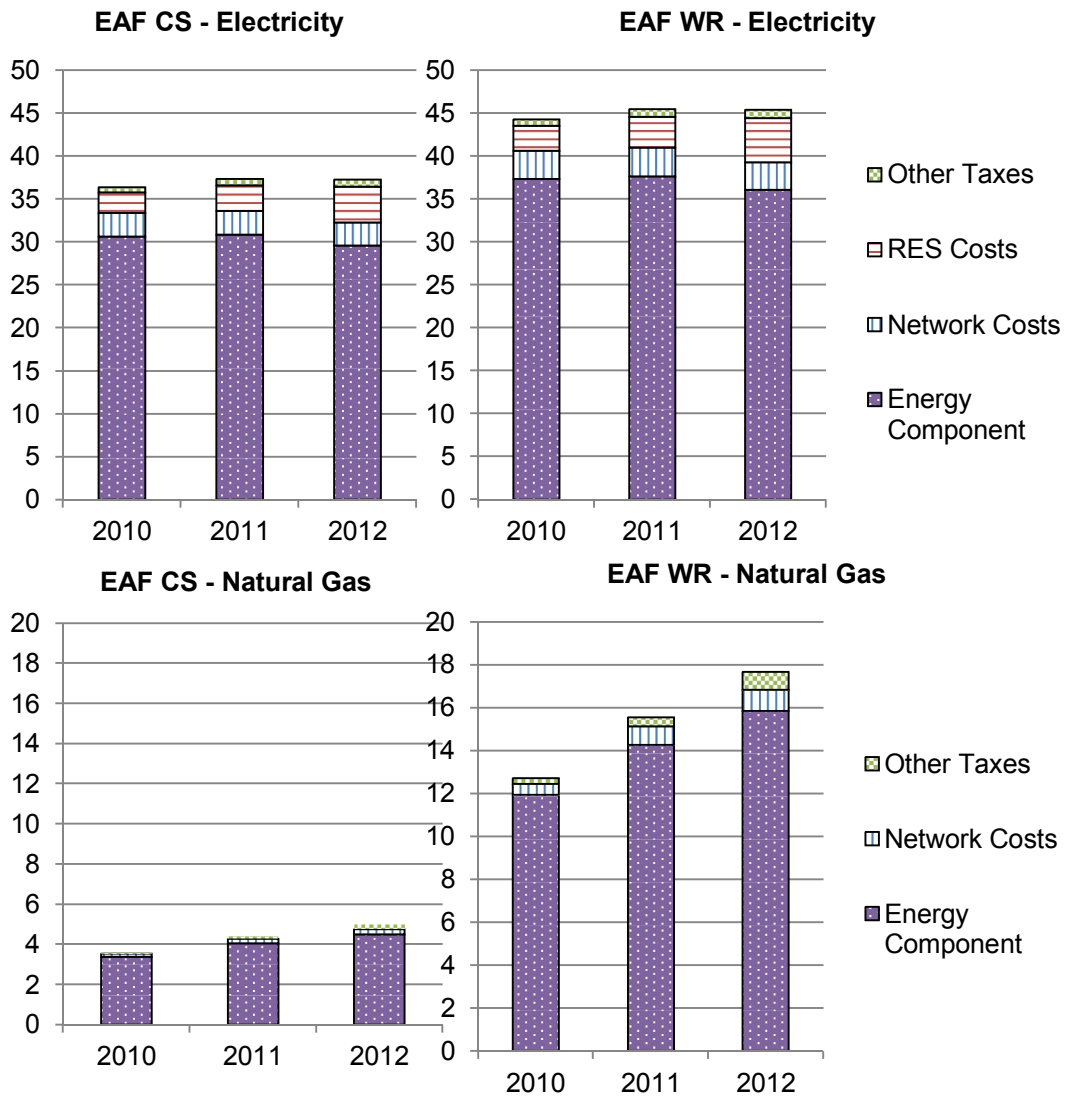
Source: Authors' elaboration on questionnaires

Table 20. Natural gas costs (€/tonne)

	Energy component			Network costs					
	2010	2011	2012	2010	2011	2012			
EAF-CS	3.38	4.05	4.50	0.15	0.24	0.27			
EAF-WR	11.94	14.29	15.87	0.53	0.85	0.97			
BOF-CS	2.98	3.18	3.70	0.28	0.33	0.41			
BOF-HRC	5.59	5.61	6.65	0.53	0.56	0.66			
BOF-CRC	5.25	5.79	6.62	0.33	0.41	0.46			
	Other taxes and tevies			Total					
	2010	2011	2012	2010	2011	2012			
EAF-CS	0.07	0.12	0.24	3.60	4.41	5.01			
EAF-WR	0.25	0.43	0.85	12.72	15.57	17.69			
BOF-CS	0.02	0.02	0.03	3.28	3.53	4.14			
BOF-HRC	0.02	0.02	0.03	6.14	6.19	7.35			
BOF-CRC	0.07	0.12	0.24	5.65	6.32	7.31			

Source: Authors' elaboration on questionnaires

Figure 43. Energy costs for EAF producers (€/tonne)



Source: Authors' elaboration on questionnaires

Figure 44. Energy costs for BOF producers (€/tonne)



Source: Authors' elaboration on questionnaires

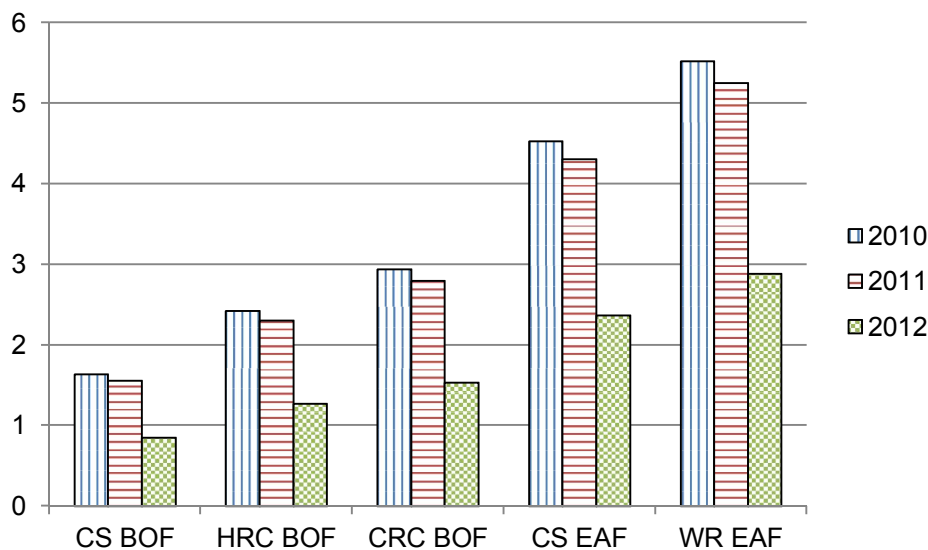
Further to the components illustrated above, the indirect costs of ETS incorporated in electricity prices have also been estimated. They should not be considered as an additional component; rather, they are included in the energy component. Costs per tonne of products are summarised in Table 21 and Figure 45 here below.

Table 21. ETS indirect costs (€/tonne)

	ETS Indirect Costs		
	2010	2011	2012
EAF-CS	4.53	4.31	2.36
EAF-WR	5.52	5.25	2.88
BOF-CS	1.63	1.55	0.85
BOF-HRC	2.43	2.31	1.27
BOF-CRC	2.94	2.80	1.54

Source: Authors' own elaboration.

Figure 45. ETS indirect costs (€/tonne)



Source: Authors' own elaboration.

3.2 Production costs and margins

To assess the impacts of energy costs, these have compared with production costs and margins of the steel industry. This requires estimating these figures for the different products and technologies. To do so, the research team has resorted to the extensive research on costs and margins which was carried out in relation to the Cumulative Cost Assessment. Indeed, the past experiences of the researchers have shown that most firms are not able to share margins on specific products and technologies, and hence that other sources need to be retrieved and complemented with plant information. This also en-

sures consistency with the assessment of costs already in the hands of the European Commission. The following cost and margin indicators could be estimated:

1. Production costs for EAF WR (wire rod) and BOF CRC (cold-rolled carbon) and HRC (hot-rolled carbon) for 2012,
2. Price-raw materials margin, EBITDA, EBIT, and price-cost margins for EAF WR and BOF CRC and HRC for 2012;
3. EBITDA for BOF and EAF plants for 2010 and 2011; and
4. Price-raw materials margins for BOF HRC for 2010 and 2011.

In each subsection below, the various sources and methods for estimation are detailed.

3.2.1 Production costs

Per-tonne production costs incurred by steel-makers in 2012 have been estimated by relying on data provided by World Steel Dynamics and updated to December 2012. In particular, EU average costs for EAF wire rods (WRs) and for HRC and CRC made in integrated plants have been detected. Costs have been converted into euro.²⁵

3.2.2 Margins

The assessment of margins registered by the EU steel industry is not an easy task. Indeed, it is very hard to retrieve meaningful information from companies' balance sheet data, since many companies – especially the largest ones accounting for a very high share of EU steel production – are involved in several business line, thereby making it difficult to single out balance sheet indicators such as profits/losses, EBIT or EBITDA representative of steel-making activities and, even worse, on particular production segments.

One way to estimate margins is to consider the price-cost mark-up, by computing the differential between market prices and production costs for finished products, differentiating between full production costs, capital costs, financial costs and the costs of raw materials. This could be done for the year 2012. Different production costs are retrieved from World Steel Dynamics. Average market prices per tonne of wire rod, HRC and CRC registered in 2012 are drawn from MEPS.²⁶ Table 22 shows a set of margin proxies calculated for each finished product covered in this section:

1. Price-cost margin, i.e. the difference between market price and overall production costs;
2. EBIT, i.e. the difference between market price and production costs, excluding interest and taxes;
3. EBITDA, i.e. the difference between market price and production costs, excluding interest and depreciation; and

²⁵ USD/EUR exchange rate: 1.285 (2012 annual exchange rate, source: ECB).

²⁶ MEPS EU Carbon steel prices with individual product forecasts (www.meps.co.uk/EU%20price.htm).

4. Margin over raw materials, i.e. the difference between market prices and the cost incurred by BOF producers to purchase the required amount of coal, coke, iron ore and scrap; and by EAF ones for scrap, pig iron and DRI.

Table 22. Production costs and margins of the EU steel industry, 2012 (€/tonne)

	Wire rod (EAF)	HRC (BOF)	CRC (BOF)
Price-cost margin	38	(3)	(34)
EBIT	43	9	(20)
EBITDA	58	50	30
Price-raw materials	203	179	240
Production costs	485	519	626

Source: Authors' elaboration on WSD, 2012; and MEPS, 2013.

For 2010 and 2011, the same data sources, in particular World Steel Dynamics (WSD), do not provide sufficient data. However, the research team was able to estimate the EBITDA also for 2010 and 2011 and the price-raw material margin for BOF HRC. Data on EBITDA per tonne of steel shipped by EU producers are reported in the "Global Steel Financial Reports" (GSFR) database, included in the GSIS platform compiled by WSD. GSFR include per-tonne EBITDA for a sample of producers accounting for 22% of the total production capacity installed in the EU in 2010 (34% of total BOF capacity and 4% of total EAF).²⁷ In order to increase the representativeness of the sample, balance sheet data for 69 European steel-makers – including both BOF and EAF producers and covering 17 member states – have been taken into account. Margins registered by these companies have been used to adjust the estimates provided by WSD, thus computing an average annual EBITDA for the EU steel industry. With regards to HRC, figures for margin over raw materials have been estimated on data provided by Eurometal.

Table 23. Margins of the EU steel industry (€/tonne at constant 2012 prices)

	2010	2011
EBITDA*	38	43
Price-Raw Materials (HRC)**	194	130

*Authors' elaboration on WSD, 2012.

**Eurometal, 2013.

3.3 Comparison of energy costs with financial indicators

This section presents the impact of the energy costs on the margins (2010-2012) and production costs (2012) of the industry. Figure 24, Table 25, and Table 26 report the comparison against costs and margins for 2012, respectively for electricity costs, natural gas costs and total energy costs. Table 27, Table 28 and Table 29 report the comparison

²⁷ Steel Business Briefing & EuroStrategy Consultants, 2010.

against margins for 2010-2011, respectively for electricity costs, natural gas costs and total energy costs.

The analysis included in this section, as the whole report, is a stocktaking fact-based exercise. Hence, energy costs and firms' financial indicators are those reported for 2010-2012. In this period, some factors depressed energy costs (i.e. the overall economic crisis and the relatively low CO₂ price), some others have increased them (e.g. the rising RES levies. At the same time, margins in these three years have been relatively lower compared to the last decade, and hence the impact of regulatory and energy costs over margins is far more prominent. However, the research team only intends to present costs and margins as they could be investigated, and makes no counterfactual claims concerning how much energy costs and margins would have been different had other drivers intervened.

3.3.1 2012

Energy costs vary among different types of production. They are relatively low compared to the overall cost of steel production for BOF, both for HRC (hot-rolled carbon) and CRC (cold-rolled carbon) producers, representing about 5% of total production costs in 2012. For EAF WR producers instead, they represent – for the same year – about 13% of total production costs.

As far as the price-raw materials margin is concerned, in 2012 energy costs represent 31% of this margin for EAF WR producers, 15% for BOF HRC producers and 13% for BOF CRC producers. Price-raw materials margins are important, and are customarily kept under control by both steel-makers and customers, and constitute a fair proxy of the value added generated by the industry. Raw materials costs are largely exogenous for European steel-makers, given that they have almost no grasp on raw materials worldwide resources and thus price.

Energy costs have a significant impact on the final firm profitability, especially during years in which margins are low, as shown by the share of energy costs over EBITDA. For EAF-WR producers, in 2012 energy costs are higher than their EBITDA (109%). For BOF CRC steel producers, energy costs are approximately equal to their EBITDA (101%), whereas for BOF HRC they represent about half of their EBITDA (53%). For smaller margins proxies (i.e. EBIT and price-cost margin), the weight of energy costs becomes correspondingly greater.

The relative contribution to total energy costs is higher for electricity than for natural gas. In 2012, the former accounts for 9% (EAF-WR producers) and 4% (both BOF HRC and BOF CRC producers) of total production costs. The latter, instead, accounts for 4% (EAF-WR producers) and 1% (both BOF HRC and BOF CRC producers) of total production costs.

The impact of energy costs on production costs and margins for 2012 are shown in Figure 46 (EAF-WR), Figure 47 (BOF-HRC) and Figure 48 (BOF-CRC) below.²⁸

Table 24. Impact of electricity costs on financial indicators, 2012

		Energy component	<i>of which: ETS indirect</i>	Network costs	RES	Other taxes and levies	Total
<i>EAF-WR</i>	<i>Price-Cost</i>	95.0%	7.6%	8.4%	13.4%	2.6%	119.5%
	<i>EBIT</i>	84.0%	6.7%	7.5%	11.9%	2.3%	105.6%
	<i>EBITDA</i>	62.2%	5.0%	5.5%	8.8%	1.7%	78.3%
	<i>Price-Raw</i>	17.8%	1.4%	1.6%	2.5%	0.5%	22.4%
	<i>Production Costs</i>	7.4%	0.6%	0.7%	1.1%	0.2%	9.4%
<i>BOF-HRC</i>	<i>Price-Cost</i>	-445.4%	-42.2%	-70.6%	-79.6%	-36.5%	-632.2%
	<i>EBIT</i>	148.5%	14.1%	23.5%	26.5%	12.2%	210.7%
	<i>EBITDA</i>	26.7%	2.5%	4.2%	4.8%	2.2%	37.9%
	<i>Price-Raw</i>	7.5%	0.7%	1.2%	1.3%	0.6%	10.6%
	<i>Production Costs</i>	2.6%	0.2%	0.4%	0.5%	0.2%	3.7%
<i>BOF-CRC</i>	<i>Price-Cost</i>	-47.3%	-4.5%	-7.6%	-8.4%	-4.0%	-67.3%
	<i>EBIT</i>	-80.4%	-7.7%	-12.9%	-14.3%	-6.8%	-114.5%
	<i>EBITDA</i>	53.6%	5.1%	8.6%	9.5%	4.5%	76.3%
	<i>Price-Raw</i>	6.7%	0.6%	1.1%	1.2%	0.6%	9.5%
	<i>Production Costs</i>	2.6%	0.2%	0.4%	0.5%	0.2%	3.7%

Source: Authors' own elaboration.

Table 25. Impact of natural gas costs on financial indicators, 2012

		Energy component	Network costs	Other taxes and levies	Total
<i>EAF-WR</i>	<i>Price-Cost</i>	41.8%	2.5%	2.2%	46.5%
	<i>EBIT</i>	36.9%	2.3%	2.0%	41.1%
	<i>EBITDA</i>	27.4%	1.7%	1.5%	30.5%
	<i>Price-Raw</i>	7.8%	0.5%	0.4%	8.7%
	<i>Production Costs</i>	3.3%	0.2%	0.2%	3.6%
<i>BOF-HRC</i>	<i>Price-Cost</i>	-221.8%	-22.2%	-1.1%	-245.0%
	<i>EBIT</i>	73.9%	7.4%	0.4%	81.7%
	<i>EBITDA</i>	13.3%	1.3%	0.1%	14.7%
	<i>Price-Raw</i>	3.7%	0.4%	0.0%	4.1%
	<i>Production Costs</i>	1.3%	0.1%	0.0%	1.4%
<i>BOF-CRC</i>	<i>Price-Cost</i>	-19.5%	-1.3%	-0.7%	-21.5%
	<i>EBIT</i>	-33.1%	-2.3%	-1.2%	-36.6%
	<i>EBITDA</i>	22.1%	1.5%	0.8%	24.4%
	<i>Price-Raw</i>	2.8%	0.2%	0.1%	3.0%
	<i>Production Costs</i>	1.1%	0.1%	0.0%	1.2%

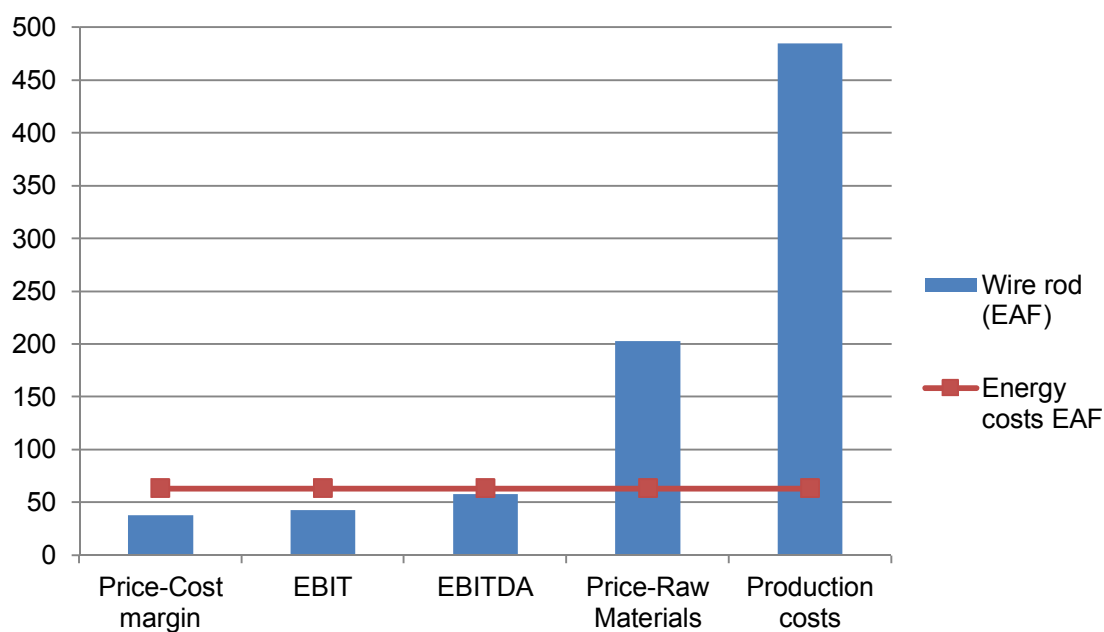
Source: Authors' own elaboration.

²⁸ In the table below, the share of total energy costs over margins and the share of energy components over margins have been reported. However, they only serve as a comparison metric, since production cannot take place, and hence margins cannot be gained, if energy costs are not sustained. On the other hand, the share of energy regulatory costs over margins can give an idea of how margins would have been, absent costs imposed by EU rules (under a *ceteris paribus* condition).

Table 26. impact of total energy costs on financial indicators

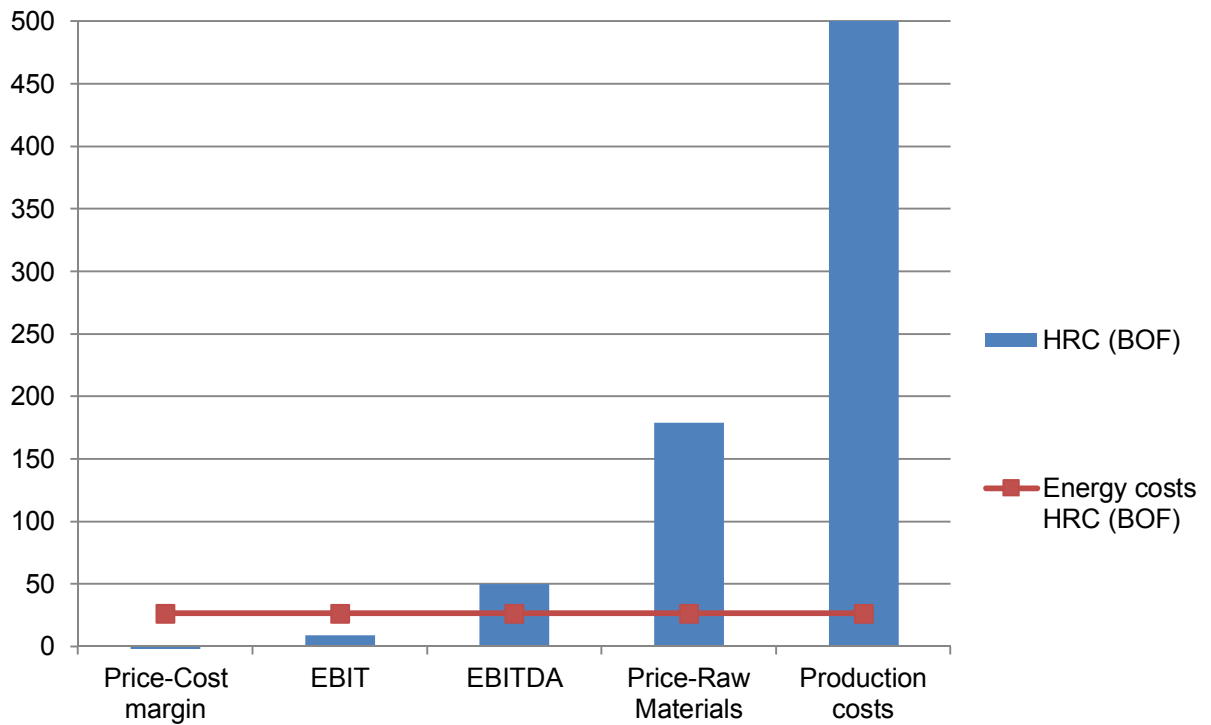
		Energy components	Other costs	Total energy costs
<i>EAF-WR</i>	<i>Price-Cost</i>	136.8%	29.3%	166.0%
	<i>EBIT</i>	120.9%	25.9%	146.7%
	<i>EBITDA</i>	89.6%	19.2%	108.8%
	<i>Price-Raw</i>	25.6%	5.5%	31.1%
	<i>Production Costs</i>	10.7%	2.3%	13.0%
<i>BOF-HRC</i>	<i>Price-Cost</i>	-667.2%	-210.0%	-877.2%
	<i>EBIT</i>	222.4%	70.0%	292.4%
	<i>EBITDA</i>	40.0%	12.6%	52.6%
	<i>Price-Raw</i>	11.2%	3.5%	14.7%
	<i>Production Costs</i>	3.9%	1.2%	5.1%
<i>BOF-CRC</i>	<i>Price-Cost</i>	-66.8%	-22.1%	-88.8%
	<i>EBIT</i>	-113.5%	-37.5%	-151.0%
	<i>EBITDA</i>	75.7%	25.0%	100.7%
	<i>Price-Raw</i>	9.5%	3.1%	12.6%
	<i>Production Costs</i>	3.6%	1.2%	4.8%

Source: Authors' own elaboration.

Figure 46. Energy costs vs. margins and production costs – EAF-WR (2012, €/tonne)

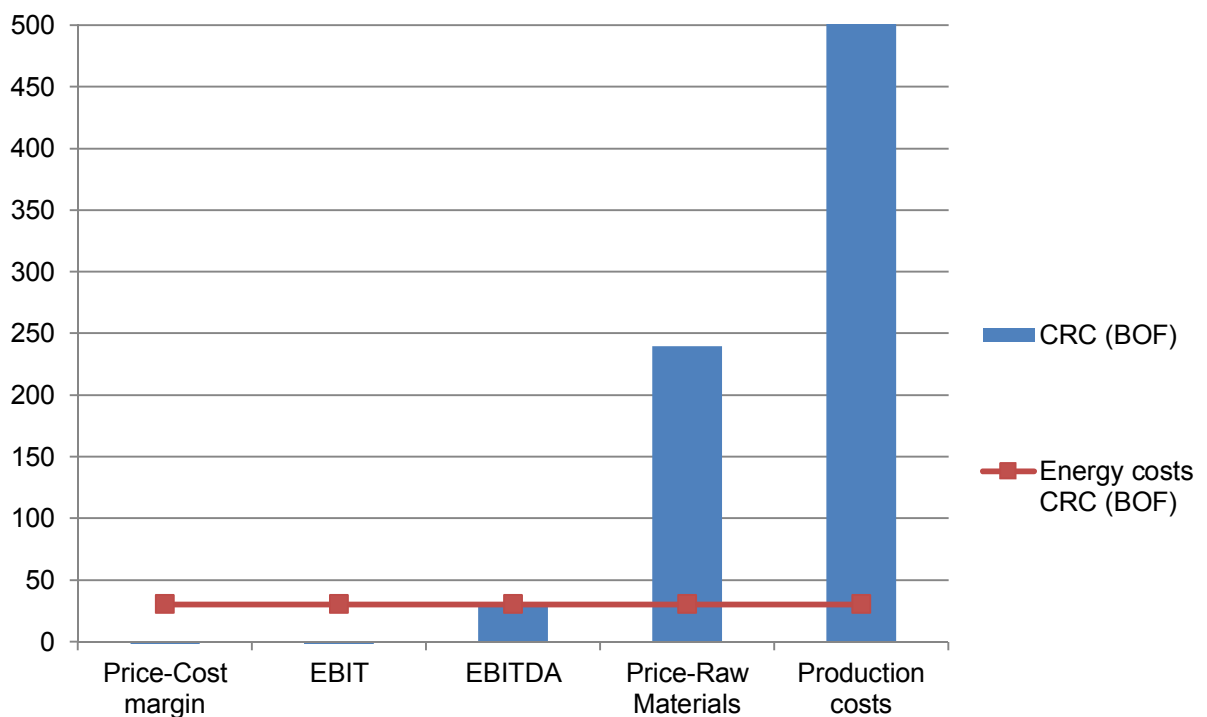
Source: Authors' own elaboration.

Figure 47. Energy costs vs. margins and production costs – BOF-HRC (2012, €/tonne)



Source: Authors' own elaboration.

Figure 48. Energy costs vs. margins and production costs – BOF-CRC (2012, €/tonne)



Authors' own elaboration.

3.3.2 2010 and 2011

Three trend in 2010 and 2011 does not differ significantly from the one described in 2012. The impacts of energy costs on margins in 2010 and 2011 are higher than in 2012, because lower energy costs are more than compensated for by even lower margins. The only exception concerns BOF HRC producers, whose margins are estimated to be lower in 2012.²⁹

In 2010-2011, both for EAF-WR and BOF-HRC producers, the impact of energy costs on profitability – using the impact on EBITDA as a proxy – is higher than 2012. It was equal to about 150% (2010) and 142% (2011) for EAF-WR producers, and to about 62% (2010) and 58% (2011) for BOF-HRC producers. As in 2012, the relative contribution to total energy costs is higher for electricity costs than for natural gas costs.

Table 27. Impact of electricity costs on financial indicators, 2010 and 2011

		Energy component		of which: ETS indirect		Network costs		RES		Other taxes and levies		Total	
		2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
EAF WR	EBITDA	98.3%	87.6%	14.5%	12.2%	8.8%	7.7%	7.6%	8.3%	1.9%	2.1%	116.6%	105.8%
BOF HRC	EBITDA	35.1%	31.5%	7.7%	6.5%	4.3%	4.0%	3.1%	4.9%	3.0%	3.3%	45.4%	43.7%
	Price-Raw	6.9%	10.3%	1.5%	2.2%	0.8%	1.3%	0.6%	1.6%	0.6%	1.1%	8.9%	14.5%

Source: Authors' own elaboration.

Table 28. Impact of natural gas costs on financial indicators, 2010 and 2011

		Energy component		Network costs		Other taxes and levies		Total	
		2010	2011	2010	2011	2010	2011	2010	2011
EAF-WR	EBITDA	31.4%	33.2%	1.4%	2.0%	0.7%	1.0%	33.5%	36.2%
BOF-HRC	EBITDA	14.7%	13.0%	1.4%	1.3%	0.1%	0.0%	16.2%	14.4%
	Price-Raw	2.9%	4.3%	0.3%	0.4%	0.0%	0.0%	3.2%	4.8%

Source: Authors' own elaboration.

²⁹ In the table below, the share of total energy costs over margins and the share of energy components over margins have been reported. However, they only serve as a comparison metric, since production cannot take place, and hence margins cannot be gained, if energy costs are not sustained. On the other hand, the share of energy regulatory costs over margins can give an idea of how margins would have been, absent costs imposed by EU rules (under a *ceteris paribus* condition).

Table 29. Impact of energy costs on financial indicators, 2010 and 2011

		Energy Component		Other Costs		Total	
		2010	2011	2010	2011	2010	2011
EAF-WR	EBITDA	129.7%	120.8%	20.4%	21.2%	150.1%	142.0%
BOF-HRC	EBITDA	49.8%	44.5%	11.8%	13.6%	61.6%	58.1%
	Price-Raw	9.8%	14.6%	2.3%	4.5%	12.1%	19.1%

Source: Authors' own elaboration.

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Glossary of Abbreviations

BF – Blast furnace

BOF – Basic oxygen furnace

CAGR – Compound annual growth rate

CRC – Cold rolled carbon (steel)

DRI – Direct Reduction Iron-making

EAF – Electric Arc Furnace

EBIT – Earnings before interest and taxes

EBITDA – Earnings before interest, taxes, depreciation, and amortisation

ETS – Emissions trading system (EU)

EUAs – EU Allowances (carbon credits or pollution permits traded in the EU ETS)

GSFR – Global steel financial reports

HRC – Hot rolled carbon (steel)

IQR – Inter-quartile range

MES – Minimum efficient scale

OHF – Open-hearth furnaces

RES – Renewable energy sources

WSD – World steel dynamics

WR – Wire rod



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