NERA
ECONOMIC CONSULTING

Can the steel industry pass through carbon costs without losing market shares?

Literature review and qualitative analysis

For EUROFER

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Executive Summary

The existing EU ETS Directive states that the indicator for the risk of carbon leakage is assessed by "the extent to which it is possible for the sector or subsector concerned, at the relevant level of disaggregation, to pass on the direct cost of the required allowances and the indirect costs from higher electricity prices resulting from the implementation of this Directive into product prices without significant loss of market share to less carbon efficient installations outside the Community".[1]

The issue of cost pass-through is thus a critical component of a proper understanding of exposure to the risk of carbon leakage, although it is at best an imperfect indicator. Bearing this in mind, the European Commission ("EC") released in July 2015 an Impact Assessment, which draws on existing literature, to assess the ability of several sectors to pass through costs, in the context of its Proposal to amend the EU ETS Directive to enhance cost-effective emission reductions and low carbon investments. The EC also commissioned a study by CE Delft / Oeko Institut, which was released in November 2015 and assesses the ability of several sectors to pass through costs.

In this context, EUROFER has asked NERA Economic Consulting to investigate, for the European steel industry, what conclusions can be drawn from the existing literature and the latest study commissioned by the EC, and how this relates to the conclusions of the EC in its Impact Assessment.

Where free allocation is used to protect sectors at risk of carbon leakage, there is a legitimate public interest in limiting the extent of any "windfall profit" from the allowances. However, in order to assess the risk of potential windfall profits, the ability to pass-through costs must be assessed *in conjunction with estimates of the impact on market share.* In contrast, our review of the existing literature shows that for the most part it does not address cost pass-through *in conjunction in market share* or that, when it does (Vivid 2014), it is misinterpreted in the Impact Assessment.

Furthermore, the (very limited) existing literature shows the pitfalls of trying to measure ex-post cost pass-through – even when ignoring potential impacts on market share. One should highlight that since CO2 costs as a share of product prices are low, small changes in key assumptions can drastically change the results. A good illustration is the sensitivity of the estimates from the CE Delft/ Oeko-Institut 2015 study, which can range from 26 to 419% by changing one single parameter value. In addition, we have identified major flaws in the data used in the study, which should lead to dismiss the results as inaccurate: the benchmark cost structure used by the authors to convert the results of their study into a cost pass-through corresponds to "*a notional producer - a typical size integrated BOF plant, 3m t/yr, <u>at a Japanese coastal site</u>"* in March 2015, which means that neither the geographical location nor the time period are coherent with the rest of the data (Europe, 2008-2014), and a further bias is introduced by the use of a cost to proxy a price, despite the availability of the latter. It would also be imprudent to assume that any cost pass-through relationship measured during an unprecedented economic crisis and its aftermath could reasonably be applied to the decade after 2020. Even if the modelling were sound it *should not* be used for policy purposes without an analysis of the robustness of the assumptions and the corresponding results.

[1] Source: COMMISSION DECISION of 24 December 2009 determining, pursuant to Directive 2003/87/EC of the European Parliament and of the Council, a list of sectors and subsectors which are deemed to be exposed to a significant risk of carbon leakage

A qualitative analysis using the criteria identified by the EC's impact assessment (trade exposure, market structure, elasticities) suggests that high cost pass-through would likely result in loss of market share and would likely be detrimental to the European steel industry (which already suffers from low margins, dumping behavior, most notably from Chinese steel producers, and fierce competition from other less environmentally stringent producers). Reducing carbon leakage protection based on poorly justified estimates of ability to pass through costs will also be contrary to the objective pursued by the ETS Directive of limiting CO2 emissions, which would merely be relocated and not reduced.

Contents

List of Exhibits

Synthesis

The European Commission published in July 2015 an Impact Assessment accompanying the Proposal for a Directive to amend the EU ETS Directive (Impact Assessment). Among other topics considered, the Impact Assessment (IA) presents information about the ability of different industries to pass through carbon costs, including the steel industry. The existing EU ETS Directive states that the indicator for the risk of carbon leakage is assessed by "*the extent to which it is possible for the sector or subsector concerned, at the relevant level of disaggregation, to pass on the direct cost of the required allowances and the indirect costs from higher electricity prices resulting from the implementation of this Directive into product prices without significant loss of market share to less carbon efficient installations outside the Community*".[2] In this context, the IA assesses options for using free allocation of allowances to protect exposed sectors against the risk of carbon leakage, taking into account their ability to pass-through costs.

In its Impact Assessment, the EC relies on three studies (McKinsey 2006, CE Delft 2010, Vivid 2014). Later on, the EC commissioned an "ex-post investigation of the cost-pass through in the EU ETS", analyzing six sectors among which the steel industry. This study was only published in November 2015, and does not appear in the bibliography of the EC's IA.

After analyzing the relevance and robustness of the existing literature, including the recent CE Delft / Oeko Institut study, this report considers market characteristics to comment on the steel sector's ability to pass-through costs without loss of market share.

An important feature of the EU ETS is that it imposes (opportunity) costs on EU producers, but not on foreign competitors. In this context, estimates of cost pass-through rates, and the analysis of cost pass-through, must refer to a situation in which the cost "shock" or cost increase is *asymmetric*.

All of the analysis we have performed in this report thus considers the specific situation of an asymmetric cost increase and its impact on EU steel producers' market share. Indeed, focusing only on general ability to pass-through cost, without taking into account the additional requirement set out in the Directive that market share be retained, may result in erroneous conclusions, as ability to pass through cost without loss of market share varies significantly depending on whether the cost increase affects all market players or not. Economic theory suggests that ignoring potential impacts on market share makes it impossible to assess accurately the effectiveness of policy instruments designed to limit the risk of carbon leakage.

As we discuss below, the analysis presented in the Impact Assessment failed to acknowledge that the level of cost pass-through alone is an imperfect indicator of exposure to carbon leakage. Only when impacts on market share (and resulting impacts on profitability) are taken into account can an accurate assessment of carbon leakage risk be made. The Impact Assessment, has completely ignored potential market share impacts when assessing literature estimates of cost pass-through and when applying these to its analysis. Its approach to calculating policy impacts and the potential for "windfall profits" from free allocation therefore does not accurately reflect the likely impacts on the sectors analyzed.

[2] Source: COMMISSION DECISION of 24 December 2009 determining, pursuant to Directive 2003/87/EC of the European Parliament and of the Council, a list of sectors and subsectors which are deemed to be exposed to a significant risk of carbon leakage

Similarly, the 2015 CE Delft / Oeko-Institut study does not address the issue of cost pass-through in conjunction with market share, rendering the analysis largely irrelevant from a policy perspective. Furthermore, the study suffers from serious shortcomings and is as such not robust enough to conclude on historical pass-through, even without taking market share impact under consideration.

The literature quoted or commissioned by the EC is either irrelevant to the current debate or misinterpreted: no evidence of cost pass-through without loss of market share is documented

The European Commission relies on the results of three studies in its Impact Assessment to assess the ability to pass through costs. While it recognizes that the results from the studies it quotes are not robust enough to draw definitive conclusion[3], it uses a weighted average of cost pass-through figures in these studies to calculate the net costs of compliance for a selection of energy intensive industries, and thus the risk of carbon leakage. Some of these studies suffer from serious methodological flaws, which we address in the next section. But even setting aside these concerns, none of the cost pass-through rates reported in the studies cited by the Commission are relevant to the question implied by the Directive, which is how much cost pass-through is possible ***without*** loss of market share.

One study, performed in 2006 by McKinsey, suggests that the steel industry can pass through costs at rates ranging from just 6% (for basic oxygen furnaces) to 66% (for electric arc furnaces), based on expert opinion. The study does not provide any details of the underlying data and hypothesis, so we are unable to comment on the validity of the methodology. **The report does not specifically address the issue of loss of market share associated with cost pass-through.**

The CE Delft study from 2010 reports cost pass-through values of up to 120% for the steel industry based on an ex-post econometric model. We believe there are very significant flaws in the methodology of this study, which we discuss below. Setting these aside, however, even by its own admission, the CE Delft (2010) study does not provide the type of evidence that is required by the Commission in its Impact Assessment. The CE Delft (2010) report notes that: "*the higher prices on the EU markets may have stimulated imports from non-EU producers* ***but this was not quantitatively assessed in this study***". **As such, this study omits a critical aspect of the analysis of cost pass-through as it is relevant to the question of carbon leakage, and therefore its results are not relevant for the purpose of the impact assessment, which should identify the share of costs than the industry can pass through *without* loss of market share**

The Vivid study (2014), in contrast, *does* consider market share impacts, and concludes that a high rate of cost pass-through (assumed at a rate of 75-80%) for the steel industry would result in significant loss of market share (the Vivid case study, published at the same time as the Vivid study quoted by the EC, based on the same data, concludes on a loss of market share of 21-22% for a CO_2 cost of 30€/ton in 2020). The results of this study therefore cannot be applied directly to estimates of the ability to pass costs through *without* loss of market share. It appears that the authors of the Impact Assessment have misinterpreted the Vivid study and used these figures as though they were

[3] *"The values from this table must be interpreted with caution. They provide a range of average expected cost pass rates through based on a review of the literature. In this literature both ex-ante and ex-post estimates have been treated as a single observation from which an average has been calculated. No attempt has been made to correct for the number of regression estimates in the literature."* Impact Assessment, page 202

estimates of the ability to pass through costs without loss of market share. Overall, our assessment that full cost pass-through of carbon costs by the steel sector could result in significant loss of market share is consistent with the correct interpretation of the Vivid study.

Furthermore, the EC commissioned a study by CE Delft and Oeko Institut, which was published in 2015[4], after the Impact Assessment, and which finds evidence of cost pass-through for the steel industry ranging from 55% to more than 100%. Like the earlier (2010) CE Delft study, the latest study does not address the issue of cost pass-through in conjunction with market share. The authors are very transparent about this, stating that they "*have not further investigated the extent to which cost pass-through has resulted in a loss in market share or has (negatively or positively) impacted on the profitability of firms*"[5].

As pointed out by the CE Delft/ Oeko Institut study, "**if costs are passed through there is potential leakage through the trade channel**, and if costs are not passed through there is potential leakage through the investment channel"[6]. It identifies, correctly, that a high cost pass-through rate can in fact be associated with a high risk of carbon leakage, especially if there is available spare capacity in foreign countries and if the product is easily substitutable by foreign ones, both of which are true for the steel industry.

So from the very literature that it has quoted (or commissioned), the EC should come to the conclusion that

- there is no consensus surrounding the ability of the steel sector to pass through carbon costs (6% to 120%) and

- the rates reported in this literature are not directly related to carbon leakage except if studied in conjunction with the impact on market share.

As stated by the 2015 CE Delft/ Oeko-Institut study commissioned by the EC: "*it is important to note that evidence of carbon cost pass-through is not in itself an indicator of carbon leakage risk*"[7]. This is also the position adopted by Vivid Economics: **"Consequently, while the cost pass-through rate is certainly of interest, it should not be the focus of attention for policy makers: it represents an intermediate step to the calculation of the variables that actually reflect the impact on the sector, such as the proportional change in production"[8]**

Literature on cost pass-through suffers from insufficient robustness

The McKinsey (2006) report does not detail the methodology used, beyond the fact that it seems to be an ex-ante model (which thus didn't measure historical cost pass-through) and the numbers published are thus the result of a "black box" model on which we cannot reasonably comment.

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[4] Ex-post investigation of cost pass-through in the EU ETS, CE Delft – Oeko-Institut 2015
[5] Ex-post investigation of cost pass-through in the EU ETS, CE Delft 2015, page 10

[6] Page 33 of the 2015 "ex-post investigation of cost pass-through in the EU ETS" by CE Delft

[7] Page 10 of the 2015 "ex-post investigation of cost pass-through in the EU ETS" by CE Delft

[8] Vivid Economics: carbon leakage prospects under phase III EU ETS and beyond, page 70

As for the Vivid (2014) study, which is based on ex-ante modelling, it should be noted that data sources are also not provided, but that it relies on strong assumptions, for which no justification seems to be brought forward. For instance, one key assumption in the Vivid model is the value of the price elasticity of demand, which has a strong influence on cost pass-through rate: Vivid Economics has assumed it to be identical to the one of cement (-0.3) **based on a single non peer-reviewed study[9] by a student at Duke University**[10], and which was actually **not dealing with the price elasticity of steel but with the price elasticity of <u>iron ore</u>**. This is illustrative of the weakness of the data used to determine key parameters, and strongly suggests that the results as they stand cannot be taken at face value.

It is also worthwhile to note that the Vivid study focuses only on the UK market, and then extrapolates to draw conclusions for the EU28, thereby ignoring the specificities of the UK market. It also focuses only on a subset of products, from which one cannot draw conclusions for a sector as a whole (which the EC also does). Critically, according to Vivid, "***the model does not take into account the production of semi-finished steel,*** *owing to difficulties in correctly accounting for intra-company transfers. However, two plants in the UK produce only semi-finished steel, and semi-finished steel is observed to be more highly trade exposed than finished steel products (British Steel, 2013).* ***This analysis may thus be understating the trade exposure of the steel sector***"[11].

Regarding the CE Delft 2010 study, its economic approach had been reviewed by NERA, which had identified a number of concerns. Among others, NERA had uncovered an important omitted variable bias: many relevant variables in the determination of steel prices, such as the price of iron ore or of scrap metal, were excluded in the modelling, seriously biasing the cost pass-through estimates (as these variables were shown to be correlated with CO2 prices). Furthermore, the authors failed to recognize data limitations that seriously undermined the strength of the estimates, for example by failing to find a significant long-term relationship ("cointegration") between European and US prices for half of the products analyzed, even though the existence of such a relationship is the authors' main reason for following their approach. Some concerns appear to have been taken on board, as the more recent study by CE Delft and Oeko Institute (2015) for instance incorporated variables for other input prices (iron ore, scrap, coke).

However, the more recent CE Delft / Oeko-Institut study, which also does not address impact on market share, also suffers from significant methodological issues.

As a result of the modelling, the authors of the study conclude that "[…] indicative CO2 cost pass-through rates in North Europe range from 75% for hot rolled coil to 85% for cold rolled coil. In Southern Europe a larger differential can be found where the cost pass-through of hot rolled coil would surpass 100% and for cold rolled coil would equate to 55%".[12] The actual figure for hot rolled coil in Southern Europe, which the authors refer to as surpassing 100%, is in fact 155%.[13] These results are very counterintuitive given that, during the period of observation (2008-2014), margins of steel makers have declined to a historical low, even reaching negative territory, which is an indication

[9] Vivid Economics, 2014, case studies, page 91

[10] ZHU, 2012 (graduate thesis), Identifying Supply and Demand Elasticities of Iron Ore

[11] Vivid Economics, 2014, case studies, page 94

[12] Ex-post investigation of cost pass-through in the EU ETS, CE Delft – Oeko-Institut 2015, page 92

[13] This has been obtained by applying the methodology described in the study. Small differences can arise due to rounding, whether published (rounded) numbers or calculated (raw) numbers are used. By using non-rounded figures, the pass-through amounts 152%, while by using published numbers it equals 155%.

that they are in fact struggling to pass through their costs. It is even more surprising given that the sector has suffered (and is suffering) from dumping behavior [14] from producers located in several countries [15] for different steel products, and unfair competition by foreign competitors in the steel sector in general. If foreign competitors are selling at prices below their costs, it is difficult to see how domestic producers would be able to pass through costs that the foreign competitors do not even face themselves. In consequence, a 155% pass-through for an asymmetric opportunity cost (i.e., one that has not been incurred in cash flow or accounting terms) seems implausible in this context.

Upon further examination, the CE Delft / Oeko Institut study suffers from three critical flaws, which should lead to dismiss its results:

- The authors determine the cost pass-through rate by comparing the production costs of a Japanese plant in March 2015 (which is used as a proxy of European product prices) with the average carbon price in the period 2008-2014. Firstly, using Japanese production costs as a proxy of European product prices is not appropriate. Secondly, the time-line of the comparison is not consistent, as two different periods are considered (2008-2014 vs. 2015). Thirdly, the average carbon price of the period 2008-2014 is considered as constant, which does not take into account the significant variations over the period (from 3.5 to 23.5 EUR/ton CO2). Finally, a crude estimate of the emission factor is used, to which the model is very sensitive. A simple sensitivity analysis of the choice of parameter values for carbon intensity, the price of carbon emissions and the price of output using available data or data suggested by CE Delft / Oeko-Institut results in values for carbon cost pass-through ranging from **26% to 419% by simply changing one parameter within the range suggested by the authors, and up to 570% when combining different values**. When correcting the input data, the CO2 cost as a share of total cost falls at a critical level, which according to the authors should have led to a different approach given that the results would be too sensitive to be considered robust. **The use of poor data for this stage of the approach leads to imprecise estimates and is in itself sufficient to dismiss the conclusions for the steel industry.**

- The final sample period chosen by the authors (August 2008 – December 2014) is a very particular period as it includes a 50% drop in output prices due to an unprecedented economic crisis, but omits a significant increase in prices that immediately preceded the sharp decline. In addition to reducing the number of observations to a critical level, **this calls into question the appropriateness of applying the resulting ex-post cost pass-through relationship to subsequent (non-crisis) periods, and thus seriously weakens the case for generalizing the results to subsequent ETS phases**. Furthermore, the theoretical model estimated in the study assumes that input cost shares are constant, which is simply untrue for steel when the sample period includes an

[14] The economic definition of dumping refers to a situation where foreign producers are selling below their production costs in a given market. As production costs in foreign countries could be unobservable, the definition from the EC rather uses product prices (i.e. not production costs), as the EC specifies that: *"A product is considered as being dumped if its export price to the EU is less than its normal value. The normal value is usually the market price for the product in the exporting country."* (EC Anti-dumping measures conditions – URL: http://trade.ec.europa.eu/doclib/docs/2013/april/tradoc_151016.pdf) . In order to receive compensation, producers should also demonstrate material injury (Condition 2), a causal link (Condition 3) and the Community interest (Condition 4).

[15] Countries under antidumping measures and investigation as of December 2015 are: China, Japan, Russia, South Korea, Taiwan and the United States.

economic crisis with a corresponding drop in capacity utilization with major shifts in input cost shares.

- The choice of variables in the estimated equations for each product category is inconsistent. As an illustration, the price of iron ore for EU producers is measured by iron ore **from Brazil to the Netherlands** for 3 out of 4 product categories, but the authors appear to have used the **import price of ore to a port in China** for cold-rolled coil in Northern Europe (see Tables 15 and 16 of the report). The appropriateness of using a Chinese import price as a proxy for the EU import price requires justification, particularly given the use of another ore price for the three other regressions. Similarly, the timing of the effect of the price of scrap and of carbon emissions is allowed to differ across product categories: the results kept by the authors consider that the impact of an exogenous shock of scrap prices on the price of steel is felt with zero delay except in the case of hot rolled coil in Southern Europe. Similarly, a change in the price of CO2 is assumed to affect the price of steel with a one-period lag for cold rolled coil in Southern Europe, a two-period lag for cold rolled coil in Northern Europe, and a three-period lag for hot rolled coil in Northern and Southern Europe. Given that most of the steps in the BOF production process are identical between cold and hot rolled coil (up to the latter), it is hard to imagine any real-world specificities or idiosyncrasies that would justify such a different time span. The authors do not comment on this. **This highlights that the final specification across product categories is inconsistent and ad-hoc, and is not justified by any theoretical/factual argument.**

- The authors choose to simplify their model and to use only four dynamic variables to explain steel prices (price of iron ore, of scrap, of CO2 and of coke) by arbitrarily dismissing labour, and ignore the sector-specific nature of capital costs by using market-wide interest rates as proxy, which is (at best) very imperfect. **The model thus suffers from omitted variable bias as long as the correlation of the absent input prices with CO2 prices has not been ruled out.**

On top of these issues, the study neither presents key statistical tests of robustness nor any sensitivity analysis, so it is not possible to check the robustness of the analysis.

As a result, the CE Delft / Oeko Institut study cannot reasonably be used to frame the debate on cost pass-through as the results presented are unlikely to be an accurate reflection of actual cost pass-through of the steel industry in any way.

Factors identified by the Impact Assessment

The European Commission in its 2015 Impact Assessment (IA) identifies three main factors affecting how much a sector "may" pass through its costs: market structure, demand and supply elasticity and trade intensity.

Given that the existing literature does not provide robust and relevant conclusions regarding the steel sector's ability to pass-through carbon costs, we have reviewed the steel sector's ability to pass through costs in light of the three factors identified by the EC in its Impact Assessment (trade intensity, market structure, demand and supply elasticity), taking into account the specific features of steel markets.

While the analysis is based on the three broad criteria identified by the EC, it expands on these to include points missing from the Impact Assessment: for instance, when analyzing elasticities, we have also included Armington elasticities in addition to supply and demand elasticities. We have also tried to move beyond the sometimes simplified micro-economic framework used in the EC's reasoning to make it more relevant to the steel industry. Furthermore, our analysis systematically addresses pass-through ability of an *asymmetric* cost increase, in conjunction with the impact on market share.

Trade exposure

The steel sector has significant exposure to trade, which is recognized by the European Commission's analysis. Trade intensity for the manufacture of basic iron and steel and of ferro-alloys (NACE 24.10) reached 24% in 2014.

Exposure to international trade means that European steel producers compete directly with non-European producers, which operate outside the EU ETS and therefore do not bear the costs that it imposes. If a cost increase does not affect *all* suppliers in the market, those affected by the cost increase (i.e., the European producers) will pass through less of it than if the cost increase was common to all suppliers – and they may pass through none at all in competitive markets without capacity constraints. In fact, international trade flows in the steel industry seem particularly sensitive to environmental regulation. In a research working paper published by the World Bank in 2004, steel production was found to be the only industry in which the stringency of environmental regulation had a statistically significant, negative impact on net exports.[16]

Exposure to foreign competition is also likely to persist or even expand in the near future, since despite a glut of worldwide capacity, capacity is still being expanded in all markets (except the EU28).

This exposure to foreign imports has been recently aggravated by global overcapacities in the steel sector, resulting in fierce competition and often dumped imports, most notably from China. The European Commission has recognized the harm of this behavior on European producers.[17] In a context in which some producers are selling at below their variable cost, it is difficult to justify the conclusion from the Impact Assessment that steel producers are able to pass through costs without loss of market share, especially at a time when maritime shipping costs have reached an all-time low.[18]

Given the high exposure to trade of the steel industry, passing-through costs would likely result in loss of market shares.

Market structure

The ability to pass through cost with no significant loss of market share is related to the nature of competition at hand in the market, which impacts pricing strategies. In addition to relative bargaining power, analyzed through the concentration level of the steel industry and its upstream and downstream markets, industry characteristics are key to understand the ability to pass through costs without loss of market share: for instance economic theory indicates that fierce competition, which is associated with low margins, can be expected to lead to higher cost pass-through where all producers face the cost increase, as producers cannot afford to decrease their margins. However, the opposite

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16 Busse, M. (2004), "Trade, Environmental Regulations and the World Trade Organization, New empirical evidence", World Bank Policy Research Working Paper 3361

17 Anti-dumping and anti-subsidy measures list of EC Trade as of 31 October 2015

18 See Figure 20: Baltic Exchange Dry Index (BDI) – price index of shipping

is true, i.e. low pass-through levels, if the cost increase affects only some producers – as is the case with carbon costs – because fierce competition is associated with a high degree of contestability by producers who do not face the cost increase. Also, an analysis of the market structure at a given point in time is not sufficient to assess the ability to pass through costs without loss of market share: to be relevant, such an analysis must take into account future trends, as market structure can change rapidly over time.

Competition in the steel market is driven to a large extent by the search for economies of scale. This shared incentive to increase capacities has led to a lasting overcapacity situation worldwide: capacity utilization in Europe is on average 10 points lower over the past five years compared to the 2000-2008 period (given the economies of scale and competition based on capacity utilisation, it is rational for each producer to prefer volume over prices, resulting in overcapacity and limited pass-through) .[19] World overcapacity is estimated at 704 million tonnes of crude steel in 2014, which is more than four times the entire EU production estimated at 166 million tonnes.[20] In fact, overcapacity in China itself, at 379 million tonnes in 2014, could substitute the entire EU28 production for the same year (169 million tonnes) as it is more than 2.2 times larger.

This glut of capacity has led producers to decrease prices since steel pricing strategies are driven to a large extent by the willingness to maintain capacity utilization sufficiently high to remain competitive: as in many high fixed costs production processes, high capacity utilization allows to spread these costs over a larger number of units, thereby decreasing unit costs. Furthermore, capacity doesn't adjust quickly to downturns because of high exit barriers (dismantlement costs, environmental clean-up, labor costs, etc.) [21] and because steel producers do not have the option of shutting down a plant and reactivating it a few months or years later to drive up utilization at other units, since blast furnaces cannot be shut down temporarily (i.e. any capacity taken out of the market results in very substantial loss of the sunk investment).

Competition in the steel industry is global, and the market for steel products shows a low level of market concentration (the top 10 producers in the world accounted for just 27% of production in 2014). [22] This contrasts with the high concentration of upstream suppliers of the industry (4 companies account for 71% of the iron ore shipments in 2014).[23] The combination of fragmented steel producers, overcapacity resulting from a drive for economies of scale and very concentrated upstream suppliers has resulted in the steel industry globally seeing its share of profits within the steel value chain reduced significantly over the years, indicating a progressive but significant decrease in its bargaining power.[24] For European producers, this has been compounded by an inability to remain competitive on many markets relative to other steel producers: since 2000 the European steel industry has seen its share of worldwide production decrease from 23% to 10% in 2013: despite a growing global market, especially in traditional EU export markets, production of steel in the EU28 has

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19 See Figure 21: Evolution of EU steelmaking capacity and nominal capacity utilisation

20 See Figure 15: World steel capacity and demand (2002-2014) and Figure 7: EU27 and world crude steel production

21 OECD (2015), "Excess Capacity in the Global Steel Industry and the Implications of New Investment Projects", OECD Science, Technology and Industry Policy Papers, No. 18, OECD Publishing

22 See Figure 7: EU27 and world crude steel production

23 Mining Giants' Push for Iron Ore Tests Mettle of Smaller Miners, Wall Street Journal, July 22nd 2015

24 Competitiveness and challenges in the steel industry, McKinsey for the OECD Steel committee, 74th session, July 2013

decreased by 14% between 2000 and 2013[25] and while steelmaking capacity is still growing globally it is declining in the EU.[26]

Steel producers are in no position to enforce asymmetric cost pass-through in many of their markets as many clients have a worldwide sourcing organization, so the diverse uses of steel are faced with highly contested markets. Furthermore, the increase of indirect steel imports, with indirect trade of steel multiplied by six over the last decade, is a sign that Europeans consume more finished products containing steel that are fully produced outside Europe, which means the industry also faces the risk of indirect carbon leakage: carbon leakage can be assessed not only by looking at flows of steel, but also at the flows of products containing steel[27].

The current low margins in the EU steel industry[28] are evidence of a very limited ability to pass-through asymmetric costs: if the industry is not in a position to achieve sufficient profitability without being faced with significant carbon costs, it is likely to be unable to increase its prices to pass on significant carbon costs without losing market shares. And an inability to pass-through the full cost would be a further drag on margins, which is also associated with investment leakage: if margins are insufficient new capacity investments are realized outside of the EU, while plant closures affect EU producers. If this leads to EU exports being replaced by domestic production in third countries or results in more steel being imported in the EU, the consequence of low margins is carbon leakage. In fact, the OECD expects the EU to be the only market in which capacity decreases between 2013 and 2017[29], while it is increasing in nearly every other market. An asymmetric increase in prices for EU producers would thus only amplify the phenomenon.

Given these features of the steel market structure, high pass-through would likely be associated with loss of market share.

Supply and demand elasticities

The EC impact assessment takes for granted that inelastic demand is a good indicator of a high ability to pass through costs. The economic literature usually states that the steel industry exhibits relatively inelastic demand in the short-run, given its relatively low product substitutability in the short term, which is a common feature for many industrial materials[30]. However, in the context of concerns about carbon leakage, these observations about demand elasticity are largely irrelevant. Indeed, demand elasticity faced by EU producers cannot be assessed without taking into account *cross price*

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25 See Figure 7: EU27 and world crude steel production

26 OECD (2015), "Excess Capacity in the Global Steel Industry and the Implications of New Investment Projects", OECD Science, Technology and Industry Policy Papers, No. 18, OECD Publishing

27 See 3.33.3Trade of products containing steel means its trade exposure is greater than indicated by analysing only trade of steel products

28 See Figure 23: EBIT of EU28 steel companies with NACE 2410 as their primary activity in Orbis, Figure 24: EBIT from Orbis and Gross Operating Surplus from Eurostat of EU steel companies for NACE 2410, and Figure 25: Profit or loss as a share of turnover of EU28 steel companies with NACE code 2410 as their primary activity in Orbis.

29 See Figure 22: Steelmaking capacity

30 See for instance CEPS special Report: the steel industry in the European Union, N.80, December 2013: "Steel is an intermediate good, characterized 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"

elasticity of competing products and producers. In the context of international trade, these elasticities are often referred to as “Armington elasticities”.[31]

Armington elasticities are a measure of the extent to which domestic production can be substituted by imports in case of a price increase. In both the short run and long run, Armington elasticities of steel products are relatively high (based on the studies we have reviewed, steel products have the highest elasticities compared to other products). This reflects the fact that steel is traded as a commodity complying with global standards, meaning demand can be served by either foreign or domestic producers.[32]

On the supply side, the impact assessment is correct when stating that supply elasticity can affect rates of pass-through – but its impact depends on the nature of the market. The market structure discussed above, including the significant global overcapacity (Chinese overcapacity is superior to the entire EU production), implies that supply is very elastic as production can be increased by simply increasing capacity utilization instead of requiring significant new investments. Moreover, asymmetric cost increases can be expected to change the shape of the supply curve, so conclusions based on historical supply elasticity are unlikely to be accurate.

When these elements are taken in conjunction, the third criterion of the Impact Assessment suggests that passing through CO2 costs would likely result in loss of market share.

Our assessment

The literature used by the Commission for the most part does not address cost pass-through in conjunction with market share, or when it does (e.g. Vivid 2014), it is misinterpreted by the European Commission.

One must not lose sight of the fact that the relationship between carbon leakage (direct and indirect) and cost pass-through depends critically on output levels and market share. Where free allocation is used to protect sectors at risk of carbon leakage, there is a legitimate public interest in limiting the extent of any “windfall profit”. But the extent of any windfall profit depends not on prices and cost pass-through *on their own*, but on the combination of these with impacts on output and market share. Thus, in order to guard against potential windfall profits from the free allocation of allowances, the ability to pass-through costs must be assessed *in conjunction with estimates of the impact on market share.*

Furthermore, the (limited) existing literature shows the pitfalls of trying to measure ex-post cost pass-through – even when ignoring potential impacts on market share. One should highlight that since CO2 costs as a share of product prices are low, small changes in key assumptions can drastically change the results. A good illustration is the sensitivity of the estimates from the CE Delft/ Oeko-Institut 2015 study, which can range from 26 to 419% by changing one single parameter value. In addition, we have identified major flaws in the data used in the study, which should lead to dismiss the results as inaccurate. For example, the benchmark cost structure corresponds to “*a notional producer - a typical size integrated BOF plant, 3m t/yr, at a Japanese coastal site”* in March 2015, i.e. neither the geographical location nor the time period corresponds to the producers covered in the study. It would

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[31] Armington, Paul, 1969, "A Theory of Demand for Products Distinguished by Place of Production", International Monetary Fund Staff Papers, XVI (1969), 159-78

[32] See Figure 26: Armington elasticities for the steel products in the economic literature

also be imprudent to assume that any cost pass-through relationship measured during an unprecedented economic crisis and its aftermath could reasonably be applied to the decade after 2020. Even if the modelling were sound it *should not* be used for policy purposes without an analysis of the robustness of the assumptions and the corresponding results.

The qualitative analysis using the criteria identified by the EC (trade exposure, market structure, elasticities) carried out in this paper suggests that high cost pass-through would likely result in loss of market share and would likely be detrimental to the European steel industry (which already suffers from low margins, dumping from China and competition from other less environmentally stringent producers). Reducing carbon leakage protection based on poorly justified estimates of ability to pass through costs will also be contrary to the objective pursued by the ETS Directive of limiting CO2 emissions, which would merely be relocated and not reduced.

1. Introduction

The aim of the EU ETS Directive is to provide companies with incentives to reduce greenhouse gas emissions by putting a price on these emissions. As with the costs of any input, the more producers are able to drive down their carbon costs while holding other things equal, the more profitable their operations will be.

A major concern that has arisen since the start of the EU ETS is the threat of "carbon leakage". Carbon leakage can occur when consumers have the option of buying products that do not face a carbon price: instead of paying more for products whose costs are higher as a result of carbon emissions abatement, consumers instead switch to foreign producers who are not exposed to the carbon price or EU ETS compliance costs. Carbon leakage is a threat to the industrial and wider economic competitiveness of the EU. It is also a threat to the environmental integrity of the EU ETS, as it can result in higher emissions than would have occurred in the absence of the policy.

To avoid carbon leakage, the EU ETS Directive has defined a category of EU sectors "deemed to be at risk of carbon leakage". These sectors benefit from a larger share of free allowances, which – it is hoped – will allow them to remain competitive.

Without some form of protection from foreign competitors who do not face carbon costs, EU producers in sectors at risk of carbon leakage face two possibilities[33]:

- EU producers pass on extra CO2 costs to customers, but this leads to a reduction in market share. Profitability per unit of output is maintained, but volume of profits (and sales) is reduced and CO2 emissions are displaced to third countries. Investment returns and the attractiveness of new investments in the EU also decline.

- EU producers do not pass on costs to defend their market share. There is no carbon leakage in the short term (only profitability of the EU industry is affected), but in the long run carbon leakage materializes through investment leakage or plant closures in Europe, their capacity being replaced by imports. Because industrial plants are typically long-lived assets, once a decision has been made to invest in a non-EU country to serve EU markets, the impact may be felt for a long time.

The risk of carbon leakage is therefore reflected in the inability to pass through cost without losing significant market shares. More specifically, "*the extent to which it is possible for the sector or subsector concerned, at the relevant level of disaggregation, to pass on the direct cost of the required allowances and the indirect costs from higher electricity prices resulting from the implementation of this Directive into product prices without significant loss of market share to less carbon efficient installations outside the Community*[34]*"* is a key test of whether a sector is protected from the risk of carbon leakage.

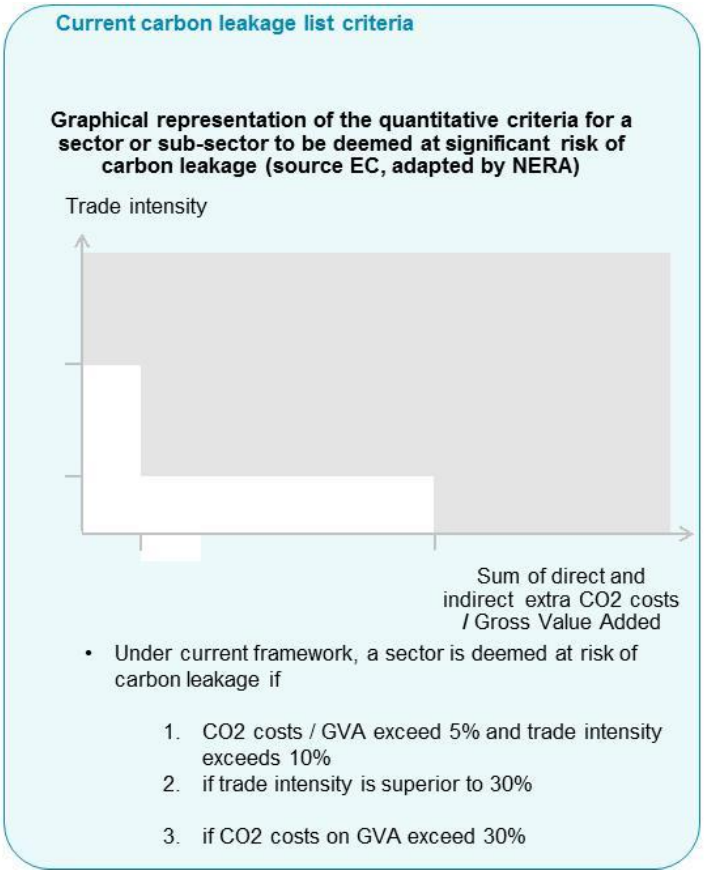
As it is difficult to accurately measure this carbon leakage risk, the three carbon leakage criteria (based on CO2 costs as a share of GVA and trade intensity – see graph below) set out by the EC

[33] In fact a range of possible outcomes between these two simplified situations

[34] COMMISSION DECISION of 24 December 2009 determining, pursuant to Directive 2003/87/EC of the European Parliament and of the Council, a list of sectors and subsectors which are deemed to be exposed to a significant risk of carbon leakage

were deemed to provide an approximation of the ability to pass through carbon costs, and in general of the exposure to the risk of carbon leakage.

Figure 1: Current carbon leakage criteria



In July 2015, the European Commission published a proposal to reform the EU ETS by amending the EU ETS Directive (2015/148(COD)). One of its main objectives is to better target the list of sectors deemed to be exposed to the potential risk of carbon leakage.

The Commission proposal states that "While some sectors (…) can be deemed at a higher risk of carbon leakage, others are able to pass on a considerable share of the costs of allowances to cover their emissions in product prices without losing market share (…) so that they are at a low risk of carbon leakage".

The European Commission published in July 2015 its Impact Assessment ("IA") accompanying the Proposal of a Directive to enhance cost-effective emission reductions and low carbon investments (Impact Assessment). The Impact Assessment (IA) assesses the ability to pass through carbon costs for different industries, including the steel industry. The IA assesses policy options which tie the level of free allowances issued to protect against the risk of carbon leakage to the ability to pass-through costs.

In this context, EUROFER has asked NERA to investigate, for the European steel industry, what can be drawn from the existing literature on cost pass-through in the steel industry in light of the main features and market characteristics of the European steel industry and to assess the characteristics identified by the EC as relevant to carbon cost pass-through.

This report considers the economic literature and market characteristics to comment on the values of cost pass-through in the steel industry. An important feature of the EU ETS is that it imposes costs on EU producers, but not on foreign competitors. In this context, estimates of cost pass-through rates, and the analysis of cost pass-through, must refer to a situation in which the cost "shock" or cost increase is *asymmetric*.

To assess the specific cost pass-through of the steel industry, the EC has relied on three studies. The table below shows the cost pass-through estimates for the steel sector, drawn from these studies according to the EC.

Figure 2: Studies on which the Impact Assessment relies

Study	Method	Products	Cost pass-through
McKinsey (2006)	Expert judgment	Basic oxygen furnace (BOF, mainly flat)	6%
		Electric Arc Furnace (EAF, mainly long)	66%
CE Delft (2010)	Ex-post econometric	Hot rolled coil	120%
		Cold rolled coil	110%
Vivid (2014)	Ex-ante market model	Flat steel	80%
		Long steel	75%

Furthermore, the EC commissioned a study to CE Delft / Oeko-Institut, which was published in 2015[35], after the Impact Assessment, and which finds evidence of cost pass-through for the steel industry (but without assessing impact on market share) ranging from 55% to 155%.

Our agreed scope of work focuses on the manufacture of basic iron and steel and of ferro-alloys (NACE 24.10) and is mainly qualitative.

Our findings are summarized in this report. We first examine in detail the three studies used by the EC to determine the cost pass-through without loss of market share, and the more recent study published by CE Delft / Oeko-Institut in 2015.

Then, after a brief overview of the steel industry and of its economic and operational environment, we discuss the three main factors affecting cost pass-through according to the EC, before drawing our own conclusions on the steel sector's ability to pass-through an asymmetric cost increase without loss of market share.

[35] Ex-post investigation of cost pass-through in the EU ETS, CE Delft 2015

2. Assessment of EC literature on pass-through

2.1. Neither the literature used by the EC in its impact assessment, nor the more recent CE delft / Oeko-Institut study address pass-through rates without loss of market share

The EC Impact Assessment relies on cost pass through rates from three studies in its Impact Assessment: by McKinsey (2006)[36], CE Delft (2010)[37] and Vivid Economics (2014)[38].

Sector	Product	Minimum	Maximum	# *of studies*	Estimated in
Iron and steel sector	Flat products	60%	100%	3	McKinsey(2006); Vivid Economics (2014); CE Delft (2010)
	Long products	66%	80%	2	McKinsey(2006); Vivid Economics (2014)

Source: EC impact assessment, Table 33, page 202

First of all, it is important to mention that the number reported by the EC in its impact assessment do not match those found in the aforementioned studies, as the EC has chosen to present "*a weighted average of cost pass-through rates from ex-ante and ex-post literature*"[39], which give the mistaken impression of a relative consensus for a cost pass-through range of between 60% and 100% for the steel industry. In fact:

- the cost pass-through estimate in the McKinsey ranges from 6% for BOF to 66% for EAF

- the 2010 CE Delft study analyzes the monthly change in steel price based on different regressors, including the change in CO2 price the month before. The coefficient for the delta CO2 is explained as follows in the study: "*These estimates show that a 1 Euro higher price for EUAs is transferred to a higher price of € 2.19 for hot rolled coil and € 2.20 for cold rolled coil*." This translates into cost pass-through rate of approximately 120%[40].

The range of values which can be derived from the literature presented by the EC can be found in the graph below:

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[36] Vivid Economic (2014), Carbon leakage prospects under Phase III of the EU ETS and beyond

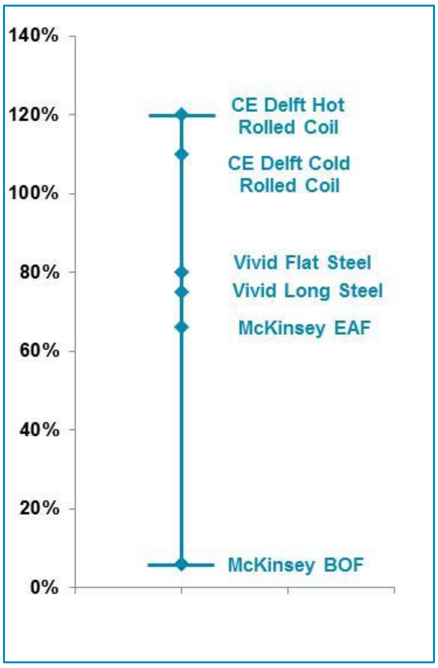
[37] CE Delft (2010a), Does the energy intensive industry obtain windfall profits through the EU ETS?

[38] McKinsey(2006), EU ETS Review: Report on international competitiveness

[39] Impact assessment, page 201

[40] Calculated based on the CE Delft estimate of emission intensity assumed per tonne of steel.

Figure 3: cost pass through values in the studies selected by EC impact assessment



Given the very wide range (from 6% to 120%) it is difficult to understand how one could make a robust assessment of the ability to pass-through costs based only on these studies, but it appears that this is what the Commission has attempted to do.

Furthermore, and more importantly, when using the three studies by McKinsey (2006), CE Delft (2010) and Vivid Economics (2014) in its impact assessment, the EC interprets the cost pass-through values in these as meaning cost-pass through without loss of market share, which is plainly a mistaken reading of the studies. In fact, the pass-through rate reported in each of these studies is either a rate of pass-through **with** loss of market share (Vivid), and is thus not indicative of any protection against carbon leakage as such, or a rate estimated without any assessment the impact on market share (CE Delft, McKinsey) and can thus not be interpreted as the cost pass-through rate without loss of market share.

For instance, the CE Delft study states very clearly in its introduction that “The higher prices on the EU markets may have stimulated imports from non-EU producers but this was not quantitatively assessed in this study”[41]. In its concluding remarks, it even adds that “both theory and empirics point in this research at the same direction that companies will pass through their opportunity costs and accept an eventual reduction in market shares”[42].

The Vivid case study, published at the same time as the Vivid study quoted by the EC, concludes for its part that a cost shock of 15€/tCO2 would translate in a loss of EU market share of 11% for the EU steel industry and one of 30€/tCO2 by a loss of market share of 21-22% for long and flat products.

[41] CE Delft (2010a) ‘Does the energy intensive industry obtain windfall profits through the EU ETS?’, page 9

[42] CE Delft (2010a) ‘Does the energy intensive industry obtain windfall profits through the EU ETS?’, page 61

2020	*Cost shock (15€/ton)*	*EU Market Shares loss (15€/ton)*	*Cost shock (30€/ton)*	*EU Market Shares loss (30€/ton)*
Long Steel	3%	-11%	6%	-21%
Flat Steel	4%	-11%	8%	-22%

Source: Vivid Economics, 2014, case studies, page 95 and 96, extract.

The cost pass-through rate given by Vivid Economics is thus a cost pass-through **with** an associated loss of market share, and not without. But the Impact Assessment presents the study as though it is relevant for assessing cost pass-through *without* loss of market share.

As for the McKinsey studies, it never directly addresses the relationship between cost pass-through and market share, although it is difficult to gauge given that it relies on expert opinion and undisclosed data and methodologies.

In summary, we believe that the Impact Assessment mistakenly interprets the studies to which it refers when it states that:

"The ability to pass through carbon costs into product prices for final customers without losing market share has been assessed in preparation for the ETS revision. Based on an extensive literature review of theoretical and empirical studies (see Annex 9), it can be observed that the cost pass-through rates are not homogenous among different products. While it may be difficult to quantify these cost pass-through rates, it can be concluded, based on literature and stakeholders' views that most of the carbon-intensive sectors have been able to pass through at least part of their carbon costs."

The literature it refers to suggests that European energy intensive energy industries have been (or would be) able to pass-through their costs, **but not without loss of market share**. So the cost pass-through rate measured is not indicative of a sector's ability to resist to carbon leakage risk, quite the contrary.

As pointed out by a more recent study by CE Delft / Oeko-Institut, commissioned by the EC, "**If costs are passed through there is potential leakage through the trade channel**, and if costs are not passed through there is potential leakage through the investment channel"[43]. **It identifies, correctly, that a high cost pass-through rate can in fact be associated with a high risk of carbon leakage, especially if there is available spare capacity in foreign countries and if the product is easily substitutable by foreign ones, both of which are true for the steel industry.**

So from the very literature that it quotes, the EC should have come to the conclusion that there is no consensus of the cost pass-through ability of the steel sector (6% to 120%) and that it is not directly related to carbon leakage except if studied in conjunction with the impact on market share. As stated by the 2015 CE Delft / Oeko-Institut study commissioned by the EC: "*it is important to note that evidence of carbon cost pass-through is not in itself an indicator of carbon leakage risk*"[44]. This is also the position adopted by Vivid Economics: *"Consequently, while the cost pass-through rate is certainly of interest, it should not be the focus of attention for policy makers: it represents an intermediate step*

[43] Page 33 of the "ex-post investigation of cost pass-through in the EU ETS" by CE Delft

[44] Page 10 of the "ex-post investigation of cost pass-through in the EU ETS" by CE Delft

to the calculation of the variables that actually reflect the impact on the sector, such as the proportional change in production"[45]

Instead, the EC uses these pass-through rates to calculate the compliance costs of sectors to the ETS post-2020, assuming, incorrectly, that the "measured" pass-through is without loss of market share:

> *"The total cost of allowances to be purchased by sectors can be estimated based on the difference between emissions and free allocation as well as the expected carbon price.* ***The compliance costs borne by sectors are also affected by the share of costs passed through by sectors to their customers****.* ***In other words: the actual compliance cost for sectors is ultimately dependent on their ability to pass through carbon costs to their customers <u>without losing market share</u>****. Furthermore the ETS Directive already recognizes that the level of carbon leakage risk possibly faced by sectors depends on the extent to which it is possible for these sectors to pass through their costs without losing market share."*[46]

For the steel industry, using this inaccurate methodology, the IA concludes that **"**using the weighted average minimum cost pass-through rate identified in the literature for the sector, the sector is expected to be able to pass-through all its compliance costs to its customers"[47].

As demonstrated above, the cost pass-through rates from the literature used by the EC cannot be interpreted as being "without loss of market share" (on the contrary), and since according to the EC "***compliance cost for sectors is ultimately dependent on their ability to pass through carbon costs to their customers <u>without losing market share</u>*****"**, the only logical conclusion the EC could have correctly drawn is that there is no evidence of cost pass-through without loss of market share. The results presented in the IA should thus be dismissed.

As for the more recent study by CE Delft and Oeko Institut, it is not relevant to the current policy debate, because it does not address the issue of cost pass-through in conjunction with market share. The authors are very transparent about this, stating that they "*have not further investigated the extent to which cost pass-through has resulted in a loss in market share or has (negatively or positively) impacted on the profitability of firms*"[48].

In its impact assessment, the EC has lost sight of the fact that the relationship between carbon leakage, cost pass-through, and "windfall profit" also depends critically on output levels and market share. Thus, in order to guard against potential windfall profits from the free allocation of allowances, the ability to pass-through costs must be assessed *in conjunction with estimates of the impact on market share*. The Commission seems oblivious to this fact given that the more recent study it has commissioned to CE Delft / Oeko-Institut also does not address the issue of cost pass-through and is therefore also irrelevant in the current context.

Relying on the studies quoted in the Impact Assessment or the more recent CE Delft / Oeko-Institut study therefore risks seriously undermining the carbon leakage protection which the ETS Directive

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45 Vivid Economics: carbon leakage prospects under phase III EU ETS and beyond, page 70

46 EC impact Assessment, page 179

47 EC Impact Assessment, page 180

48 Ex-post investigation of cost pass-through in the EU ETS, CE Delft 2015, page 10

offers and which is essential in supporting the continued competitiveness of the EU energy intensive industries, and in achieving the intended reduction in CO_2 emissions.

2.2. Neither the literature used by the EC nor the 2015 CE Delft / Oeko Institut study are robust enough to draw policy conclusions

2.2.1. The three studies quoted by the EC in its impact assessment have serious weaknesses

Not only are the reports on which the EC is relying either not addressing the issue of cost pass-through in conjunction with market share (especially the two CE Delft reports), or are misinterpreted (Vivid report) and are thus not relevant to determine the exposure to the risk of carbon leakage, but most do not meet the necessary transparency and robustness requirements to be considered as a reasonable basis for a policy debate.

The McKinsey (2006) report does not detail the methodology used and the numbers published are thus the result of a "black box" model on which we cannot reasonably comment. This in itself means that it cannot be used as the basis of a policy discussion given that this makes peer review, to ensure that it is based on sound economic principles, relevant modelling and robust data, impossible.

As for the Vivid (2014) study, which is based on ex-ante modelling, it should be noted that data sources are also not provided, but also that it relies on strong assumptions, which have no justification. For instance, one key assumption in the Vivid model is the price elasticity of demand, which has a strong influence on cost pass-through rate: Vivid Economics has assumed this to be identical to the one of cement (-0.3), **based on a single non peer reviewed study[49] by a student at Duke University**[50]**.** , and which was actually **not dealing with the price elasticity of steel but with the price elasticity of <u>iron ore</u>**. This is illustrative of the weakness of the data used to determine key parameters, and strongly suggests that the results as they stand cannot be taken at face value.

Furthermore, one could question using the elasticity of demand and not Armington elasticities, as these are the most relevant to determine the impact of cost pass-through on market share (cf. 4.4). For these there is a significant difference between the steel and cement sector, which is well documented by reputable literature (cf Figure 26: Armington elasticities for the steel products in the economic literature).

It also worthwhile to note that the Vivid study focuses only on the UK market and then extrapolates to draw conclusions for the EU28, despite the specificities of the UK market, and focuses only on a subset of products, from which one cannot draw conclusions for the sector as a whole (which the EC does). Critically, according to Vivid, "***the model does not take into account the production of semi-finished steel,*** *owing to difficulties in correctly accounting for intra-company transfers. However, two plants in the UK produce only semi-finished steel, and semi-finished steel is observed to be more highly trade exposed than finished steel products (British Steel, 2013).* ***This analysis may thus be understating the trade exposure of the steel sector***"[51].

Regarding the CE Delft 2010 study, its economic approach had been reviewed by NERA, which had identified a number of concerns. Among others, NERA had uncovered an important omitted variable bias: many relevant variables in the determination of steel prices, such as the price of iron ore or of

[49] Vivid Economics, 2014, case studies, page 91

[50] ZHU, 2012 (graduate thesis), Identifying Supply and Demand Elasticities of Iron Ore

[51] Vivid Economics, 2014, case studies, page 94

scrap metal, were excluded in the modelling, seriously biasing the cost pass-through estimates (as these variables were shown to be correlated with CO2 prices). Furthermore, the authors failed to recognize data limitations that seriously undermined the strength of the estimates, for example by failing to find a significant long-term relationship ("cointegration") between European and US prices for half of the products analyzed, even though the existence of such a relationship is the authors' main reason for following their approach. CE Delft simply dismissed the concerns raised by NERA's review by stating that "*various of the econometric problems that NERA supposedly has identified can be regarded as extensions to the original framework of analysis of CE Delft. They would yield more information about the relationship between CO2 prices and product prices over time, but would not invalidate the results*."[52]. It is curious that CE Delft comes to the conclusion that significantly improving the framework (in fact changing the approach) would not change the conclusions without even testing this.

Some concerns appear to have been taken on board, as the more recent study by CE Delft and Oeko Institute (2015) for instance incorporated variables for other input prices (iron ore, scrap, coke).

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52 Did energy intensive companies really pass through costs of EU ETS?, a policy brief on interpreting the NERA critique from industry, CE Delft, October 21st 2010

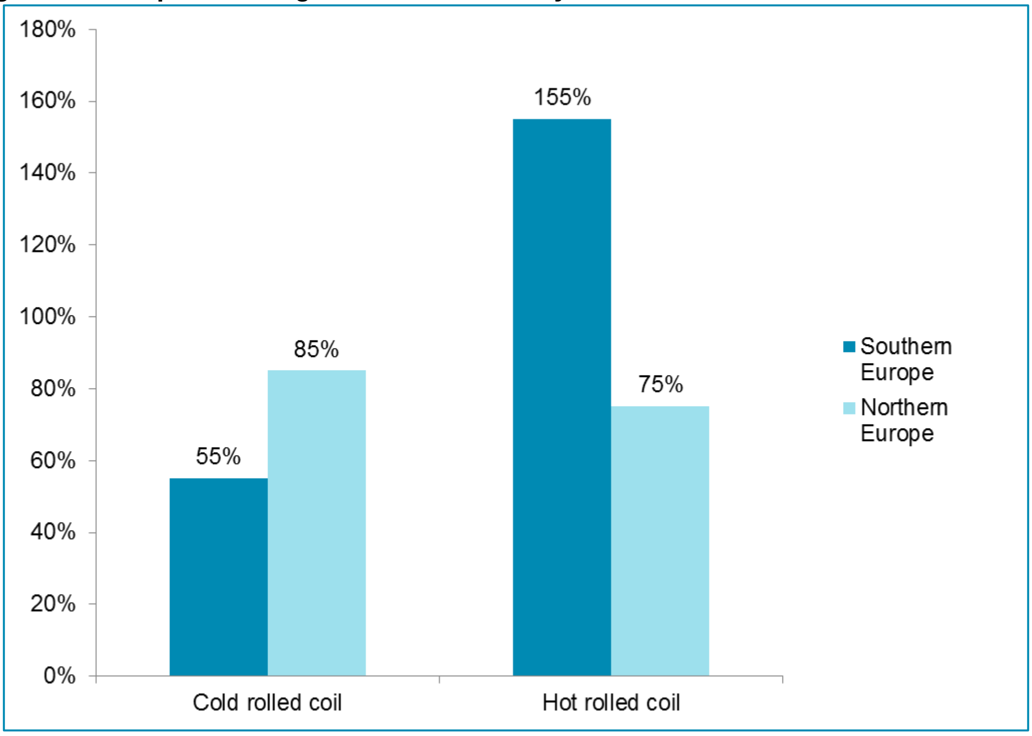
2.2.2. The 2015 CE Delft / Oeko Institut suffers from critical flaws

2.2.2.1. Implausible results

The more recent study by CE Delft, in partnership with Oeko institute, which also does not address impact on market share, also suffers from significant issues.

In the report the authors indicate that "[…] indicative CO2 cost pass-through rates in North Europe range from 75% for hot rolled coil to 85% for cold rolled coil. In Southern Europe a larger differential can be found where the cost pass-through of hot rolled coil would surpass 100% and for cold rolled coil would equate to 55%"[53]. The actual figure for hot rolled coil in Southern Europe, which the authors refer to as surpassing 100%, is in fact 155%.

Figure 4: Cost pass-through rates estimated by the 2015 CE Delft / Oeko-Institut study



These results are very counterintuitive given that, during the period of observation (2008-2014), margins of steel makers have declined to a historical low (see Figure 23, Figure 24 and Figure 25), even reaching negative territory, which is an indication that they are in fact struggling to pass through their costs. It is even more surprising given that the sector has suffered (and is suffering) from dumping behavior by foreign competitors, which means (by definition) selling below the foreign competitors' production costs. If foreign competitors are selling at prices below their costs, it is difficult to see how domestic producers would be able to pass through costs that the foreign competitors do not themselves even face. So a 155% pass-through for an asymmetric opportunity cost (i.e., one that has not been incurred in cash flow or accounting terms) seems implausible in this context.

[53] Ex-post investigation of cost pass-through in the EU ETS, CE Delft – Oeko-Institut 2015, page 92

The implausibility of the results is compounded by the fact that the cost pass-through ratios found for other inputs also seems implausible. It is also possible, using the methodology suggested by the CE Delft / Oeko report, to calculate a purported "pass-through rate" for the other three inputs used by the authors, This would be a natural "sense-check" to have performed on the estimation results, to test the plausibility of the models that they have estimated. But conducting this sense check reveals equally implausible results. For example, the implied "pass-through rate" for iron ore (which, according to the CE Delft / Oeko report, accounts for approximately 30% of steel production costs), applying their suggested methodology, ranges between just 13% and 52%, depending on the European region considered. It is extremely difficult to see how steelmaking could possibly remain profitable if it were not able to pass through most or all of the costs of iron ore.

When investigating how the authors come to such a conclusion, we have reviewed their assumptions and their modelling approach. It should be noted that we are limited in our assessment of the study by the fact that, surprisingly, the authors did not present any sensitivity analysis nor did they present all the standard statistical tests of robustness and relevance. We did not have access to the underlying data and did not replicate the model, as this was beyond our scope. As a result, the following assessment should not be considered exhaustive.

In the following sections we highlight the key points which call into question the findings of the study, without delving into the details of the econometric analysis (we explore in more detail the flaws of the study in Appendix B).

The four major issues we identify are the following:

- A major flaw in translating the econometric results into a cost pass-through ratio as a result of poor data which leads to inaccurate results
- An arbitrary choice of sample period (August 2008-December 2014), which reduces dramatically the sample size and limits the possibility to generalize results adequately to future ETS phases
- An arbitrary choice of variables and of timing of impacts, inconsistent across product categories
- A potential omitted variables bias which undermines the results of the econometric modelling

2.2.2.2. Major issues with the calculation of the cost pass-through ratio

The authors of the report are very transparent about the fact that the model is very sensitive to the input data and that any problem with the data used for the model would undermine the results they present in the study:

"Empirical estimations of cost pass-through are made on the basis of analysing price data, where the price of outputs (products) is tested for the significance of the price of inputs (including CO2) used in production. **As CO2 costs are relatively small, the results are very sensitive against the quality of the data**, especially regarding the price of outputs." [54]

[54] Ex-post investigation of cost pass-through in the EU ETS, CE Delft – Oeko-Institut 2015, page 60

Furthermore, the results (coefficients β1) of the complex econometric modelling undertaken by the authors are converted through a simple computation into a cost pass-through rate:[55]

$$\text{Cost pass through ratio} = \frac{Estimated\ coefficient\ \beta 1}{\frac{Emission\ factor * CO2\ price}{Product\ price}}$$

For this computation to be meaningful, even if coefficient β1 can be correctly interpreted as the extent to which CO2 prices directly influence the steel price (which we consider to be unlikely), the assumptions taken for the carbon emission factor, the product price and the carbon price must be correct, otherwise the result is inaccurate and potentially misleading.

Regarding the product price

The methodological section of the report suggests using the product price to compute the cost pass-through (Equation c2, p.53 of the report). This means the logical step would have been to use the European price of the relevant steel products, which is widely available. Instead the authors have chosen to use the cost of an allegedly typical plant to reflect the product price. The assumption presented by the authors implies a non-carbon costs of 342.9€/t, the source of which is the website *steelonthenet*. The authors do not clarify that these data are for "*a notional producer - a typical size integrated BOF plant, 3m t/yr, at a **Japanese coastal site** with its own coke and sinter plant, using imported ore and coal purchased at international prices with third party transport. The blast furnace is assumed to have PCI. The steel plant is assumed to make **commodity grade carbon steel** for flat products with average labour productivity*" in **March 2015**.

- The fact that this is from a Japanese coastal plant and not a European plant is a first and obvious reason why this data source seems inappropriate.
- The data can be volatile over the years and the chosen data point is after the period considered in the study (which is a clear mismatch with the rest of the data, which covers 2008-2014)
- It is also not consistent with the price of CO2 taken (averaged over the observation period instead of taking an end of period point estimate) and does not capture the variance of the price of the products over the period (which have decreased by around 50%-60% since 2008 (see Figure 8 and Figure 9).
- It also assumes the same product price for hot and cold rolled coils and across both Southern and Northern Europe, which defeats the purpose of modelling two products across two different geographies.
- Finally, it proxies a product price with a production cost, which can introduce a significant bias. This choice is surprising given that price data is available for the products throughout the period, which would have avoided all the pitfalls mentioned above.

If we consider European production costs, specifically for the BOF route, and during the period estimated, publicly reported figures are very different from the ones used by CE Delft / Oeko-Institut in

[55] Ex-post investigation of cost pass-through in the EU ETS, CE Delft – Oeko-Institut 2015, page 53

2015. In the steel roadmap 2050, BCG & VDEh present cost of production for 2010 that vary between 599€/t **crude steel** (with retrofit BOF plant) and 871€/t of **crude steel** for greenfield BOF plant[56]. **As a result of this, the analysis of CE Delft / Oeko-Institut should not be relied upon for lack of accuracy and even plausibility**.

Regarding the emission factor

Despite recognizing the sensitivity of the model to input data, the authors do not present a sensitivity analysis, even when they acknowledge that they are uncertain about the data. This is the case for the CO2 intensity of the steel products: the authors acknowledge that it can range from 1.5 to 2.5t CO2 per tonne of steel[57] but simply use a value of 2t of CO2 per tonne of steel (for all products tested, across all geographies). As shown by the simple equation above, the estimated values for the carbon cost pass-through are sensitive to the level of the emission factor. The authors recognize this fact as they explain that "*uncertainty about the emission factor can result in biased estimates on the cost pass-through rate*"[58]. Indeed, the emission factor is subject to (i) the perimeter of the products studied, (ii) the date (it is not correct to assume it is constant over the period), (iii) the regions (the emission factor vary across steel producers within Europe). **The level of uncertainty on the emission factor translates directly on the uncertainty related to pass-through costs: in the steel case, the results are thus uncertain within a range larger than 50% (- 25%/+25%). Accordingly, estimates for the cost pass-through range between 46% and 200% when varying the emission factor between 1.5 and 2.5 t CO2 / t of steel.** Detailed figures are presented below and calculations are shown in Appendix B.

Regarding the price of CO2

Furthermore, regarding the price of CO2, the reference price of carbon is chosen at **10.31 € /t CO2**, a simple average over the sample period (and then rounded at 10€/t, which is inexplicable given that either values are not rounded to the full Euro). This reference value provides a very crude estimate, as the variance of the price of carbon has been large over the period: between August 2008 and December 2014, the price of carbon (spot price) varies between **3.51 and 23.52 €/t**. These upper/lower bounds would translate into pass-through estimates lying between **34% and 420%** depending on the product category**.**

In addition, there is no a priori reason to assume that carbon pass-through is a linear function of carbon prices. Interestingly, for other products studied, CE Delft / Oeko-Institut estimated the share of carbon cost among total costs for different carbon prices[59], but omits this for the steel sector.

The variance in carbon prices is also inconsistent with the underlying assumption of the study that the cost shares are constant through time. The estimated coefficient may not accurately reflect the average cost share over the sample period. The theoretical equation ignores that this share evolves through time, in particular when the price of carbon varies by a factor of seven within the period.

Conclusion on the flawed cost pass-through computation

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[56] Eurofer (2013),"A steel roadmap for a low carbon Europe 2050", pp. 36-37

[57] Ex-post investigation of cost pass-through in the EU ETS, CE Delft – Oeko-Institut 2015, page 81

[58] Ex-post investigation of cost pass-through in the EU ETS, CE Delft – Oeko-Institut 2015, page 53

[59] See for example Fertilizers on p. 108 of the report

Correcting the CE Delft / Oeko-Institut data, one can find results of carbon cost share estimates varying largely from the reported 5.5%. By only correcting the cost of production it falls to **between 2.3% and 3.3% and down to 1.5% if the lower value of the carbon intensity range is taken into account. As the authors acknowledge, for a carbon cost below 5% another approach would have been necessary for results to be reliable**:

> *"The formal test for our econometric study is therefore if this β coefficient is statistically significantly different from zero. If carbon costs are reasonably high (e.g. **above 5% of total costs**), it is clear that this is a good test. However, if carbon costs are very small (e.g. 1% of total costs) or if not all costs have been passed through into product prices, it becomes more difficult to discern whether this variable is statistically significantly from zero given the typical noise in the data."*[60]

One should note also, that as all results are not disclosed, there is possibility to verify if according to the econometric model, all costs have been pass-through.

Furthermore, the range of estimates obtained by modifying simple assumptions on parameter values is so large as to render the approach essentially useless for application to the relevant policy question. The cost pass-through estimates can vary from **26% to 419% by changing only one parameter within the range identified by the authors**. As an illustration, the figures below present a sensitivity analysis of cost pass-through for each category of steel product for different parameter values. Here, we present different scenarios, with the maximum and minimum value in the sample period for (i) carbon intensity (1.5 and 2.5 t CO_2 / t of steel), (ii) carbon prices (3.51 and 23.52 €/t CO_2)[61] and (iii) output prices (319 and 762 €/t of steel for HRC Northern Europe, 390 and 801 €/t of steel for CRC Northern Europe, 330 and 476 €/t of steel for HRC Southern Europe and 390 and 840 €/t of steel for CRC Southern Europe)[62]. This underlines the necessity to use coherent assumptions (time, geography, perimeter). Detailed calculations are presented in Appendix B.

For Hot rolled coil in Northern Europe, for instance, the cost pass-through reported is 75% (74% when taking not rounded numbers). By using the upper/lower bounds for carbon intensity, the estimates vary between **60 and 98%**. Similarly, by taking the highest/lowest values of carbon spot prices over the period under consideration, using the same reference as the CE Delft / Oeko-Institut report, the estimates vary from **34 to 204%.** When using the price of output to calculate the cost share of carbon (low output price/high output price), as suggested by Equation (c2) on page 53 of the report, the new estimates vary between **87 and 125%**. As noted above, these values beg the question "How can it be possible for the European steel sector to pass through carbon prices when they face dumping by foreign competitors at below production costs?" Given the flaws identified here, it seems clear that the results should be seriously questioned.

As can be seen, the range of estimates obtained by using different parameter values from the same references as used in the CE Delft / Oeko-Institut report is **too large to be reliable,** across all product categories. Given the unreliable data used by the authors to calculate the cost pass-through for the steel industry, the reported figures cannot be taken at face value.

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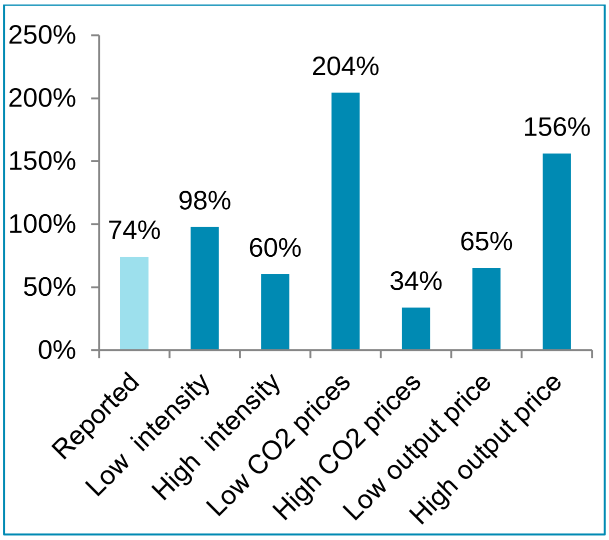
[60] Ex-post investigation of cost pass-through in the EU ETS, CE Delft – Oeko-Institut 2015, page 51

[61] Source : SendeCO2, EUA spot price (URL : http://www.sendeco2.com/it/prezzi-co2)

[62] Source: SBB Steel Prices

Figure 5: Cost pass-through rates, sensitivity analysis[63,64]

a) HRC – Northern Europe (b) CRC – Northern Europe



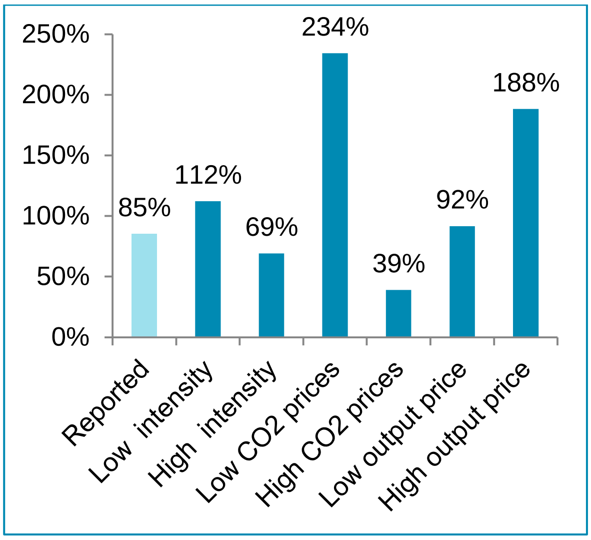
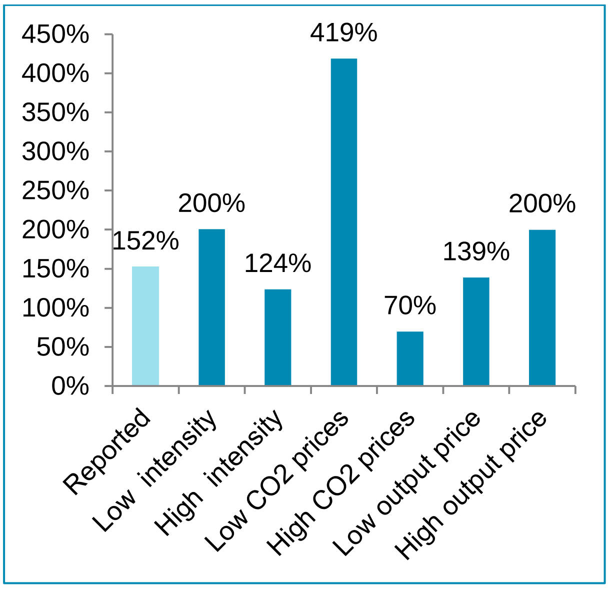
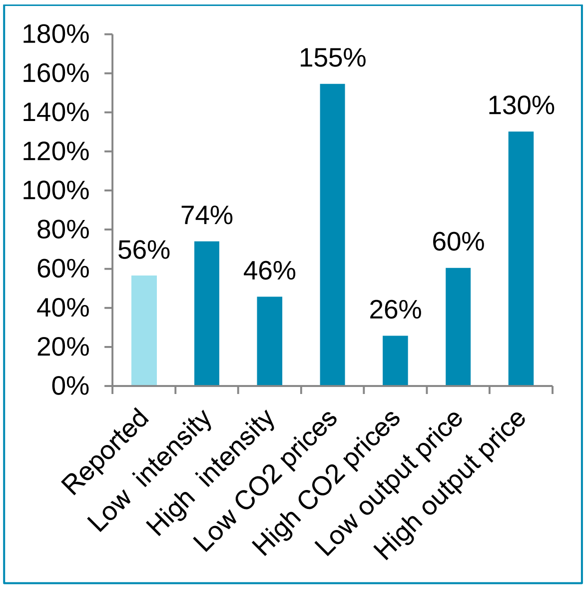


Figure 6: Cost pass-through rates, sensitivity analysis

b) HRC – Southern Europe (b) CRC – Southern Europe





[63] Marginal differences in the reported figures arise from rounding in the cost share of carbon

[64] The values presented in Figure 5 and Figure 6 correspond to a change in a single parameter

2.2.2.3. The arbitrary choice of sample period reduces dramatically the sample size and limits the possibility to generalize results

The final sample period considered by the authors is limited to August 2008 – December 2014:

"However, it turned out that the price hike up to mid-2008 (see Figure 19 and Figure 20) was highly influencing the results. Therefore, it was finally decided that we tested the hypothesis of cost pass-through on the data after August 2008 when the overheated market had cooled down" [65]

The authors choose to dismiss the price hike between September 2007 and July 2008 because of a peculiar evolution of steel prices, but still include the subsequent major drop in output prices. In addition to be arbitrary, a reduction in the sample **period** seriously limits the sample **size**. The choice of restricting the time span of the study thus seriously limits the power of the econometric estimation as it **reduces the number of observations to 77,** even less when accounting for the inclusion of lagged variables. As comparison, Alexeeva-Taleebi (2011) acknowledges "*limitations*" implied by a small sample when estimating a similar model (VECM), with a sample consisting of weekly data from 16 September 2005 to 22 March 2007, i.e. roughly 80 observations.

More importantly, the ability to pass through carbon costs to consumers cannot be expected to be impervious to the economic conditions in which producers operate. **In a crisis period, where prices and profitability drop sharply, the ability of producers to pass-through costs could be dramatically impacted. This thus limits the possibility to generalize results to any subsequent period if not else demonstrated.**

Another crucial implication in the case of steel is that capacity utilization can drop dramatically during economic downturns (capacity utilization has dropped to roughly 60% during the economic crisis – see Figure 16). As consequence, the share of costs for each input is also affected through the fixed/quasi-fixed nature of some inputs. Fixed costs are an important fraction of total costs in steel production, and because production plants cannot easily be re-opened after closure, the cost structure of steelmaking is very sensitive to economic cycles.

The specificities of the steel industry are thus in fundamental contradiction with the assumptions underpinning the theoretical equation estimated, which does not allow cost shares to evolve through time, as it assumes them to be constant. Similarly, the cost share of carbon is considered as constant when the price of carbon in fact varied by a factor of seven within the period**.**

A final, minor issue is that the authors revert to applying an Auto Regressive Distributed Lag Approach in Levels (ARDL) because no unit root was found for the price of output:

> *"The fact that the output prices do not contain a unit root in the time series used for the estimation implies that we cannot estimate a VECM with the output price included in the endogenous relationship, since cointegration in this framework is only possible between endogenous variables where all contain a unit root."* [66]

[65] Ex-post investigation of cost pass-through in the EU ETS, CE Delft – Oeko-Institut 2015, page 90

[66] Ex-post investigation of cost pass-through in the EU ETS, CE Delft – Oeko-Institut 2015, page 90

However, this result could be caused by the choice of sample period. A glance at the evolution of steel prices on Figure 8 and Figure 9 suggests that the evolution of prices could be different when using different sample periods: the failure of the unit root test leads to question whether this could be caused by the arbitrary choice of sample period, which starts in mid-2008 right before a sharp drop in prices due the crisis, but after the 2007-2008 price hike. As consequence, the choice of final specification could be challenged.

2.2.2.4. The specification is inconsistent across product categories

The choice of input price variables in the estimated equations for each product category is inconsistent.

As an illustration, the price of iron ore is measured by iron ore exported **to the Netherlands from Brazil** in 3 out of 4 product categories, and **exports to China** for cold rolled coil in Northern Europe (see Table 16 of the report, p.91). While this certainly fits the purpose of finding robust results, this arbitrary choice still needs to be justified theoretically, in particular to understand why the price of Chinese imports of iron ore is a good proxy for the price faced by EU steel producers.

Similarly, the timing of the effect of the price of scrap and of carbon emissions is allowed to differ across product categories without theoretical/factual justification. Accordingly, the impact of an exogenous shock of scrap prices hits the price of steel with zero delay except in the case of hot rolled coil in Southern Europe. A change in the price of CO2 would impact the price of steel with a one-period lag for cold rolled coil in Southern Europe, a two-period lag for cold rolled coil in Northern Europe, and a three-period lag for hot rolled coil in Northern and Southern Europe. These differences in the timing of impacts would need further empirical investigation, or at least a robust theoretical/factual justification.. Given that most of the steps in the BOF production process are identical between cold and hot rolled coil, it is hard to imagine any justification for such a different time span in the impact of input prices.

This highlights that the final specification across product categories is inconsistent and ad-hoc, and is not justified by any theoretical/factual argument, which again challenges the robustness of the estimates.

2.2.2.5. The final specification could suffer from omitted variables bias

The ARDL model did not produce satisfactory results when using all the input data, so the authors chose to arbitrarily ignore labour costs and concentrate on “only the output price, prices for iron ore, coke, scrap and CO2” in the dynamic relationships despite what was suggested from their unit root test “*Due to the poor performance of the wage time series*”.[67,68]

The plausibility and relevance of a particular model needs to be assessed based on statistical evidence. The explanation above does not justify why excluding the price of labor is an appropriate approach, neither through statistical tests, nor through theoretical arguments. Labour costs are a significant input cost for steel production, which actually means that the model built is disconnected from the reality of steel economics.

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[67] The argument was also used to justify the specification used for the glass industry

[68] Ex-post investigation of cost pass-through in the EU ETS, CE Delft – Oeko-Institut 2015, page 90

Regarding the choice of input price variables, it should also be noted that the proxy used for capital costs to explain the price of steel products is **not specific to the steelmaking activity**, while capital requirements, financing conditions or costs of capital among others can vary substantially across industries. The use of a market-wide interest rate is at best a very imperfect methodology as it assumes that all sectors are homogeneous in terms of financing costs.

Finally, the model doesn't take into account the evolution of productivity, which is critical in understanding the dynamics of the steel market. Steelmakers must increase their productivity every year to remain competitive in normal times, however, when production suddenly drops, as happened at the onset of the crisis, productivity naturally declines (as neither capital nor labour can be adjusted as quickly as production): by assuming constant productivity the pass-through rates measured by the authors could in fact contain a productivity variation element. After a regular increase of 3% per annum on average since the beginning of the century, productivity had been sharply affected during the period 2008-2014. During the specific period 2008-2014, plant productivity first fell down drastically (sample study shows -25% of productivity loss between 2007 and 2010, and 20% productivity loss between 2008 and 2010, and a gain back in productivity up to 2014, but that do not compensate for the earlier loss). This should have translated into the results, but the missing information disclosure regarding the full results prevent the reader to acknowledge how it has been taken into account.

2.2.2.6. Conclusions on the CE Delft / Oeko Institut (2015) model

The authors of the study recognize that "the estimated cost pass-through rate in this research is only giving an indicative value and can by **no means be interpreted as 'absolute truth'**. It provides a conjectured estimate of the amount of costs that seem to be passed through in the product prices. It is by definition true that this amount is larger than 0% [*sic*], but **the exact amount of costs passed through is difficult to discern precisely**. This also implies that **it is difficult to base a decision regarding carbon leakage risk and the free allocation of emission allowances on estimated cost pass-through rates alone**."[69]

They also explain that "the cost pass-through rate cannot be determined precisely in such models due to different reasons. **First, there are confidence bounds associated with econometric estimations**. Second, there are various **data issues arising when determining the hypothetical cost share if all costs were passed through**. Third, **the estimator of the cost pass-through rate compares the marginal cost price increase with the average expected cost price increase. If marginal and average costs diverge, cost pass-through rates may be calculated at well above the 100%, which is difficult to explain"** [70]

Given their insights in the limitations of their own model, it is surprising the authors did not pay more attention to the quality of the data they used. For instance using the cost structure of a single Japanese coastal steel plant as a proxy for the cost structure of European plants is likely to yield an inaccurate estimate of the cost shares, which is compounded by the fact that the estimates correspond to March 2015, which is posterior to the estimated sample period.

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[69] Ex-post investigation of cost pass-through in the EU ETS, CE Delft – Oeko-Institut 2015, page 61

[70] Ex-post investigation of cost pass-through in the EU ETS, CE Delft – Oeko-Institut 2015, page 61

It is also surprising, that given the sensitivity of the model to simple assumptions (CO2 price, CO2 emissions factor), they have not provided a sensitivity analysis, which would have shown that under many circumstances the pass-through rates implied by their approach are implausible, nor provided all the relevant statistical tests indicating the robustness of the model.

The model's results could also have been more explicitly confronted with the current conditions faced by EU steel producers: finding a 150% cost pass-through rate in the context of the European steel sector's current inability to cover average production cost, given dumping behaviour from non EU producers, is difficult to reconcile with basic economic intuition. A simple sensitivity analysis based on CO2 prices, CO2 intensity and steel prices, which implies cost pass-through ratios of up to 420% would also have shown that the model is disconnected from real-world conditions.

As such, the CE Delft / Oeko Institut study cannot reasonably be used to frame the debate on cost pass-through as the results presented are unlikely to be representative of the actual degree to which carbon costs have influenced steel prices.

3. Overview of the steel industry

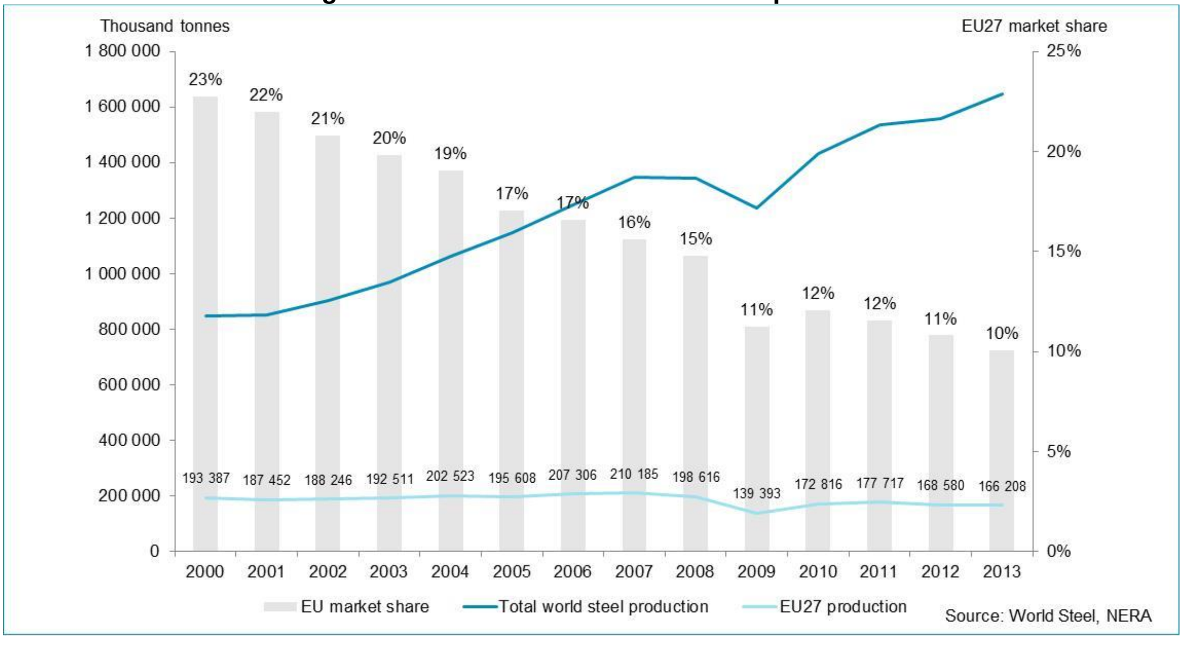
3.1. The steel industry has been facing headwinds in Europe over the past few years

Steel is a key input for many industries. Some of its main downstream markets are construction, engineering, automotive and transport. As such, steel is a critical step of the manufacturing value chain and widely regarded as a strategic industry.

To produce steel, the industry imports iron ore and coal, two key raw materials. As steel is entirely recyclable, and widely recycled in the EU, scrap metal is also used as a raw material for steel production. About 40% of European steel is produced from steel scrap[71] using the electric arc furnace technology and the rest from iron ore. Worldwide, only about 27% of steel is produced from recycled steel. Production of steel using scrap metal is much less emission intensive than producing it using iron ore and using the classical basic oxygen furnace process.

Europe has historically been a leader in steel production. In 1980, EU27 countries accounted for 29% of worldwide crude steel production but its share of the world production has decreased dramatically since. While the EU27 still accounted for 23% of the market in 2000, this was down to only 10% by 2013: over this period steel production in Europe declined by -14% while it increased by 94% worldwide.

Figure 7: EU27 and world crude steel production



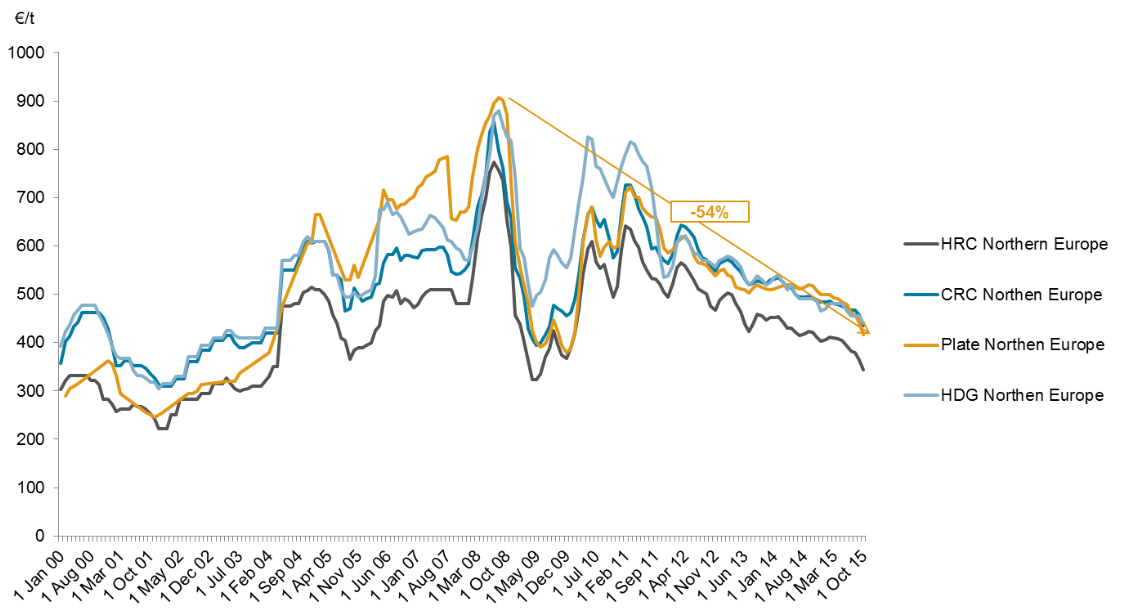
71 Steel statistical yearbook 2014

The EU steel industry currently employs around 330 000 employees (down from 440 000 in 2008) and has a turnover of between 180-200 billion Euros[72] (around 1.3% of EU28 GDP).

The financial crisis has deeply affected the industry, with prices declining steeply in 2009 and still far below their peak level (2015 prices are around 50% lower than 2008 prices).

Increases and decreases in steel prices, and more generally their volatility, reflects the equilibrium between demand and supply rather than just the underlying costs of production. One of the main drivers of steel prices is capacity utilization: when there is a supply shortage, prices increase; in situations with large idle capacity, prices decrease, sometimes even below the level necessary to cover variable costs (there is often political pressure not to close plants, notably when they are lossmaking in non EU countries).[73] The European steel industry is currently facing increasing competition from foreign producers and notably dumping from China and several other countries, as evidenced by the anti-dumping measures taken by the European Commission in 2015 (including Russia, Ukraine, Turkey, China, India and South Africa).[74]

Figure 8: Nominal flat steel prices – January 2000 to November 2015



Source: SBB Steel Prices

Steel demand in the EU fell by 35% in 2009 compared to the 2008 level and 39% compared to the 2007 peak. Demand increased in 2010 and 2011 but fell again due to the impact of the Eurozone crisis. 2014 demand still shows a 55 million tonnes gap with 2007 (28% reduction), and only a slight increase is expected for 2015 and 2016.

[72] Eurostat 2012 and 2011 figures in SBS

[73] OECD (2015), “Excess Capacity in the Global Steel Industry and the Implications of New Investment Projects”, OECD Science, Technology and Industry Policy Papers, No. 18, OECD Publishing

[74] See Anti-dumping and anti-subsidy measures list of EC Trade as of 31 October 2015

As a result of reduced demand from the main downstream markets and reduced prices, the industry's gross value added has declined by -50% between 2008 and 2012 (post-crisis GVA is down 41% compared to the average 2003-2008 level).

Figure 9: Nominal long steel prices – January 2000 to November 2015

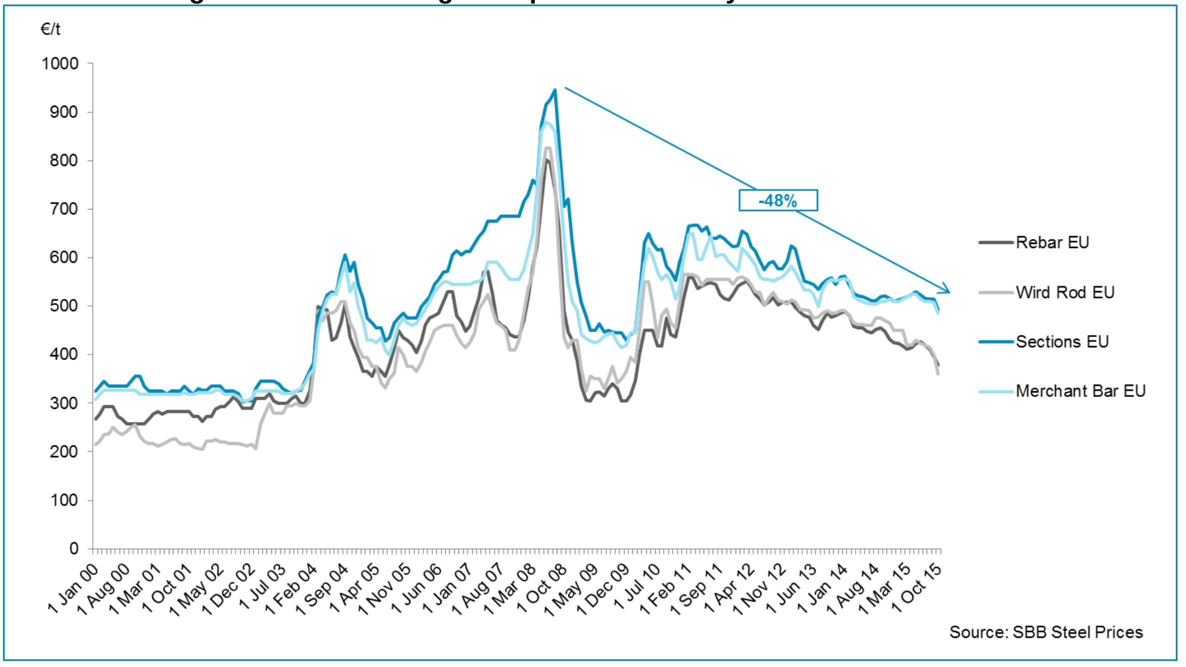
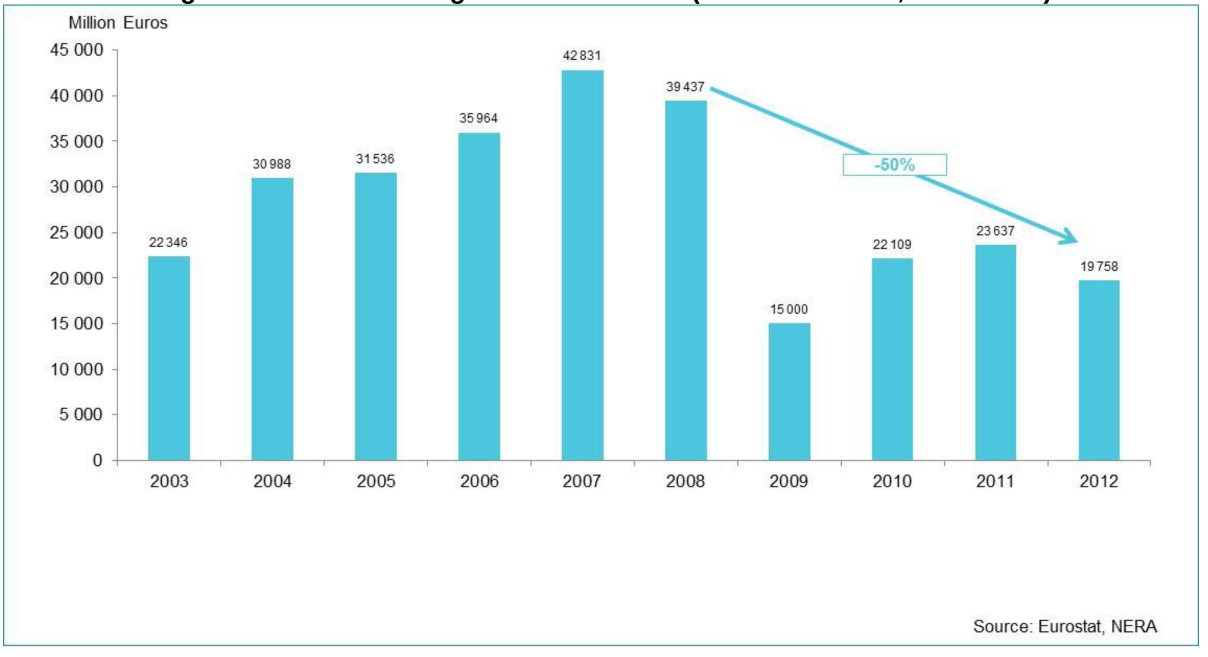


Figure 10: Steel sector gross value added (EU27 until 2010, EU28 after)



EU steel producers are also confronted by a regulatory environment which is more stringent and costly than those faced by steelmakers in some of Europe's most aggressive competitor countries – a point which was recognized in the EC assessment of the steel industry in 2009[75]: *"Compliance with environmental legislation represents a growing proportion of production costs."*

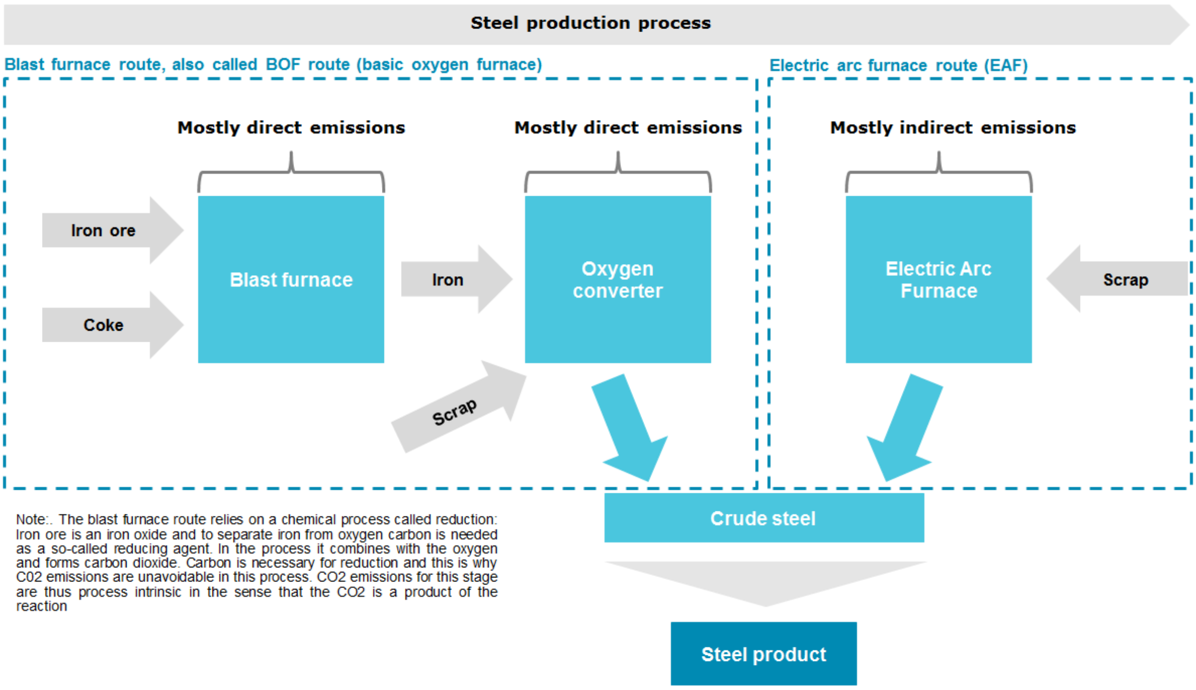
3.2. The steel industry is identified by the EC as being at risk of carbon leakage

Steelmaking is a very energy intensive process and is thus a major emitter of CO2 emissions.

However, not all emissions are a result of the use of energy: the blast furnace route relies on a chemical process called reduction: iron ore is an iron oxide and to separate iron from oxygen, carbon is needed as a so-called reducing agent. In the process it combines with the oxygen and forms carbon dioxide. Carbon is necessary for reduction and this is why CO2 emissions are unavoidable in this process. CO2 emissions for this stage are thus process intrinsic in the sense that the CO2 is a by-product of the reaction.

As a result, there is little ability to reduce non energy related CO2 emissions because of the thermodynamic limits of the process.

Figure 11: Steel sector production processs



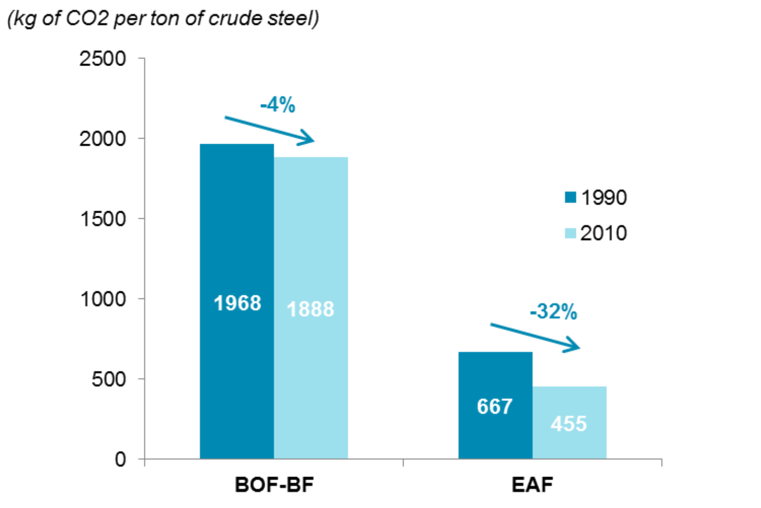
The electric arc furnace route, which relies on scrap metal as an input instead of iron ore, emits around a fourth less CO2 emissions than the BOF route. The EU produces a very high share of its

[75] European Industry in a changing world – Commission Staff Working Document, Updated sectoral review 2009

steel using the EAF process (40% vs. 26% for the rest of the world in 2013), but its growth is constrained by the availability of scrap materials used as inputs, quality requirements and electricity prices. Most BOF emissions are direct, while most EAF emissions are indirect (i.e. included in the electricity consumed).

As a very energy intensive industry in a very competitive market, steel plants have a natural incentive to increase their energy efficiency and thus reduce CO2 emissions. However, steelmaking is a very mature process and, in the current technological environment, there is little scope for much CO2 intensity reduction: for the BOF process, carbon intensity has decreased by only 4% between 1990 and 2010.

Figure 12: CO2 intensity by process



Source: A Steel Roadmap for a Low Carbon Europe 2050 (2013)

The electric arc furnace technology was less mature and improvements in energy efficiency have decreased the carbon intensity of producing a ton of steel by 32% between 1990 and 2010 (with decreased CO2 intensity of electricity generation accounting for 10% of total improvement), but further improvement is now mostly dependent on how the power sector improves its CO2 efficiency.

In 2009, the EC recognized that there was limited abatement potential for the steel industry:[76]

> *"Compliance might pose problems because the production process is at a mature stage, and there is only limited potential for improving energy efficiency in the short term while no major breakthrough technology can be expected in the near future".*

In this context, an asymmetric increase in CO2 costs for European producers is unlikely to significantly translate in a direct reduction of CO2 emissions via the use of more energy efficient technologies.

[76] European Industry in a changing world – Commission Staff Working Document, Updated sectoral review 2009

3.3. Trade of products containing steel means its trade exposure is greater than indicated by analysing only trade of steel products

In contrast with other types of industries at risk of carbon leakage, there is an important volume of trade in indirect steel, i.e. of products containing steel. As such, to assess the risk of carbon leakage regarding the steel industry as specified in the EC impact assessment, the indirect trade of steel (i.e. trade of products made of steel) should be taken into account.

Indeed, if European consumption of crude steel shrinks, it may also be the sign that downstream industries relocate outside the EU and imports of final steel made products increase. In such case, a larger part of the value chain is at risk of carbon leakage. Local increases of steel prices, in case cost pass-through is significant (or even the possibility of such an increase in the future) can trigger relocation of steel intensive production outside of Europe as a result of investment decisions. The European Commission has recognized the strategic nature of a competitive steel industry for all of European industry and in particular due to the large variety of steel uses

The increase in indirect trade in steel products has been analyzed recently by the World Steel Association. Indirect trade in steel, calculated as the difference between apparent steel use[77] and true steel use[78], has increased in EU28 from 2.6 million of tonnes of finished steel equivalent in 2006 to 15 million in 2013. Thus more than 10 percent of the steel in steel-containing products that are consumed in the EU or incorporated into EU production has actually been incorporated into those products *outside* of the EU.

[77] Apparent steel use measures direct steel demand (steel industry goods), and is calculated as deliveries minus net exports of steel industry goods, in volumes

[78] True steel use accounts for indirect trade in steel, and is calculated by deducting net indirect exports from apparent steel use

4. Three potential drivers of cost pass-through: trade exposure, market structure, and elasticities of the steel sector

4.1. CO2 Costs pass-through without significant loss of market share: the key to assess exposure to carbon leakage risk

The cost pass-through capacity refers to whether it is possible for a sector to pass on the direct costs of the required allowances and the indirect costs from higher electricity prices into product prices without significant loss of market share.

As such, it is an indicator of the carbon leakage exposure of a sector and it is at the center of discussions on how to deal with trade-exposed sectors under domestic and international climate policies.

Cost pass-through is a result of several factors, including the competitive nature of the market, the amount of production cost increase, and product substitutability.

Further, a domestic sector's ability to pass-through additional costs that foreign competitors do not bear is dynamic as elements driving competition change with time (e.g. transport costs, production costs, production availability, product specifications, etc.) and as the competitive environment adjusts.

"The compliance costs borne by sectors are ultimately dependent on their ability to pass through carbon costs to their customers. The ETS Directive already recognizes this fact suggesting that the level of carbon leakage risk possibly faced by sectors depends on the extent to which it is possible for these sectors to pass through their costs without losing market share." (Impact Assessment, p. 45)

When climate policy entails a substantial increase in costs for a sector in one region, as is the case with the ETS Directive, two cases can occur – at the heart of both is the pass-through of those additional costs:

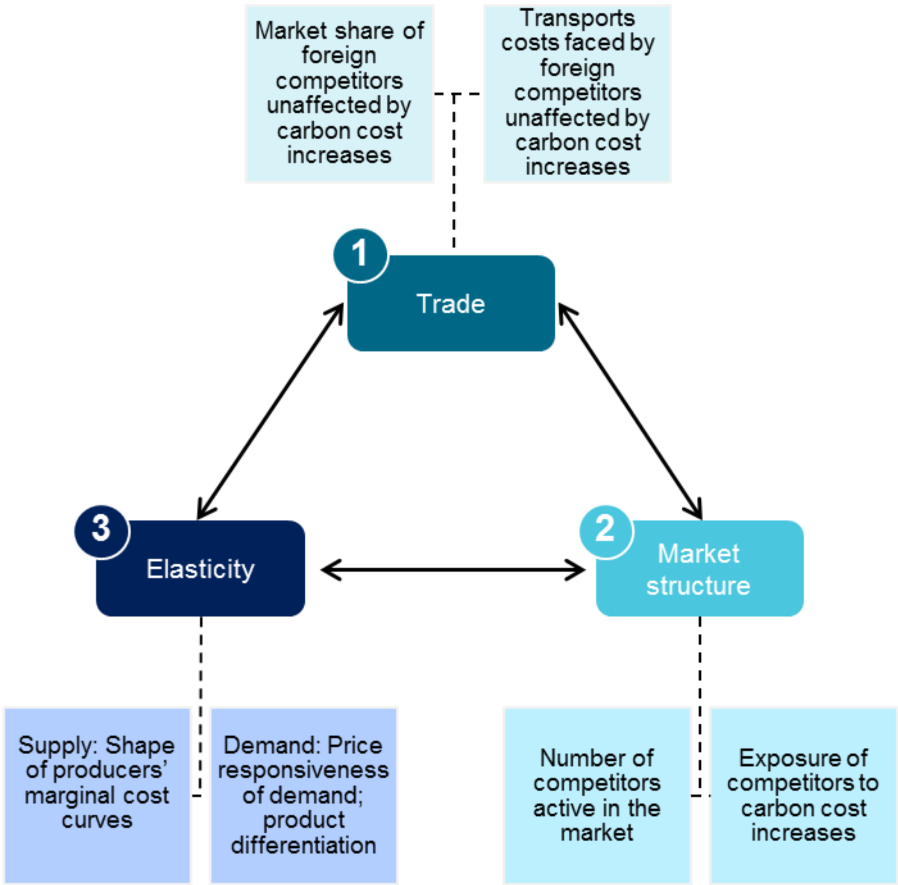
- In the case of limited international competition there can be greater pass-through of costs into product prices (all else being equal) – at least in the short run but, the overall size of the market can decline as a result of the price signal, depending on the degree of product substitutability.

- In the second case, where a sector is vulnerable to international competition, it will be either less likely to pass through cost increases onto its prices, and this will erode its profits, or be able to pass-through a share of its costs, but at the expense of its market share.

Over the medium- to long-run, if significant cost differences remain, this can affect utilization of existing capacity, the return on investments in new capacity, and investment decisions about the location of new investments (which are more likely to favor less stringent climate jurisdictions).

This medium- to long-term leakage ultimately can have a far greater impact than more immediate short-run effects.

The EC has identified three elements to assess the ability to pass-through costs without loss of market share:



This report reviews in detail the three factors that the European Commission's Impact Assessment identifies as affecting carbon cost pass-through.

The following pages are structured around the three factors identified by the European Commission:

- Trade exposure
- Market structure
- Supply and demand elasticity

It must however be noted that the three factors are interrelated[79] and must be analyzed together. In the following pages, each section thus draws on the findings of the others.

[79] For instance, high trade exposure for the steel sector suggests the international competition limits the ability to pass through cost, but to draw specific conclusion one must consider substitutability between domestic products and extra EU products (Armington elasticities) as well as the ability of extra EU operators to effectively serve the EU market (market structure).

The report will discuss each axis separately, first from a theoretical point of view based on the economic literature and second by assessing the European steel industry characteristics to answer the main questions. The conclusion synthesizes the findings in a global assessment.

In the first section, we will review the steel sector's exposure to trade and how this relates to the ability to pass-through an asymmetric cost increase in an open market. We will also focus on analyzing the main import and export flows and the current dumping of steel products by Asian producers, which demonstrate that in the current environment, steel is being priced below its long term cost and sometimes even below its marginal cost.

In the second section, we will analyze how steel producers, which face upstream concentration but have themselves little to no market power, can pass-through costs without losing market share in a business environment characterized by overcapacity, declining prices, low margins and competition based on scale and capacity utilization.

In the third section, we discuss how the relative inelastic demand for steel product in the short term does not necessarily imply an ability to pass-through costs without loss of market share when domestic steel products can be substituted by foreign imports (Armington elasticities) and how the asymmetrical supply elasticity of the steel sector compounds this effect in the current market environment.

4.2. The steel sector's exposure to trade suggests that the risk loss of market share is very high in case of attempt to pass-through asymmetric costs

4.2.1. The EC's assessment correctly identifies trade intensity as a relevant element of the ability to pass-through costs, which is true even for plants with indirect exposure to foreign competition

According to the EC Impact Assessment, *"**Exposure to international trade may also influence the ability of a firm to pass-through additional CO2 costs** (Varma et al., 2012). For example, if the exposure of a firm to international trade is low, higher product prices due to passing through additional costs may not impact the competitiveness of the firm. However, the trade exposure might actually differ within the EU, as for production located in the centre of the EU demand might exclusively be within the EU while for production located at the periphery competition with less expensive production units outside the EU is much stronger*."

Exposure to international trade means that European steel producers compete directly with non-European producers, who operate outside the EU ETS and are therefore unaffected by its carbon price. The Commission's Impact Assessment states that high exposure to international trade will be associated with low ability to increase prices to reflect carbon costs.

The Commission's thinking on this point is sound: if a cost increase does not affect all suppliers in the market, those affected by the cost increase (i.e., the European producers) will pass through less of it than if the cost increase was common to all suppliers.

The same holds if markets are not perfectly competitive: If competition is price-based (often corresponding to the short-term), the presence of unaffected producers in the market puts a check on European producers' ability to raise prices. In this case, indeed, the unaffected producers do not face an increase in their costs and hence have no incentive of their own to raise prices, which makes it harder for European producers to do so.

If producers instead compete by committing to sales volumes, the presence of unaffected competitors makes it less attractive for European producers to reduce their output in response to an increase in their costs. In effect, unaffected producers will expand their output more following a reduction in output by European producers than if they were themselves facing higher costs. The fact that more of their previous sales will be captured by competitors makes it less attractive for European producers to reduce output, which implies lower prices and less pass-through.

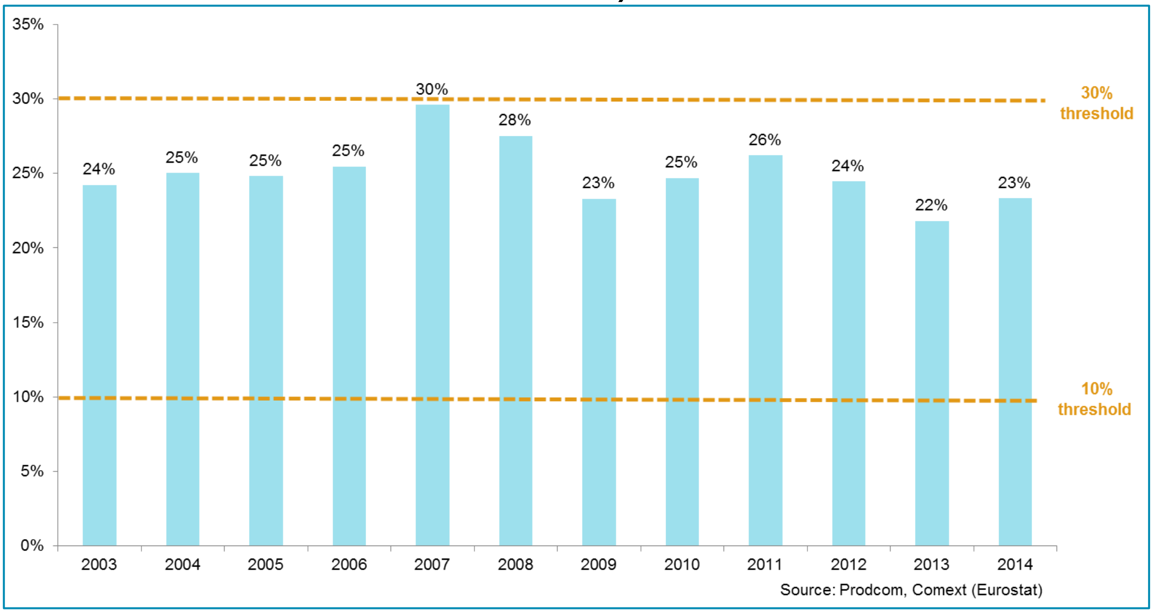
4.2.2. The steel industry has high exposure to trade

4.2.2.1. Evolution of steel trade intensity and main trade partners

Exposure to trade is a unique determinant of cost pass-through in that it unambiguously affects the ability of domestic producers to pass through cost increases when these costs affect domestic and foreign producers non-homogeneously. This contrasts with conclusions from the economic literature on factors for which the direction of the effect on cost pass-through depends on the level and nature of competition in the sector (perfect competition, price- and quantity-based oligopoly).

The EU market is highly connected to global markets as evidenced by its high level of trade intensity: trade intensity for basic iron and steel was 23% in 2014, well above the 10% threshold used by the EC for the definition of risk of carbon leakage for heavily carbon intensive industries.

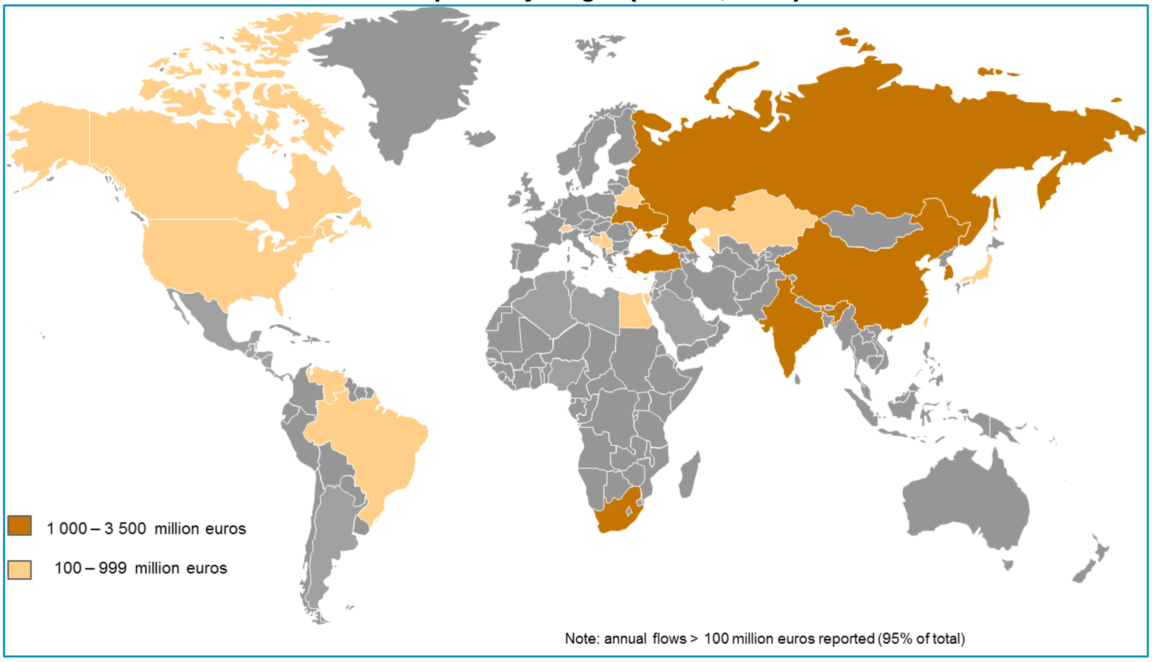
Figure 13: EU28 trade intensity in value (excluding trade with Norway, Liechtenstein and Iceland)



Despite large fluctuations in production (EU28 production dropped by 41% in 2009), trade intensity remained largely stable during the period considered, as imports and exports have largely followed fluctuations in production.

The fact that since 2012 exports have been declining faster than production or imports indicates that EU28 producers are losing market share, despite very low utilization rates, which should normally translate in higher exports. This can however be explained by the overcapacity plaguing the other main markets, limiting the ability to regulate the capacity utilization rates of the European market through exports.

Figure 14: Manufacture of basic iron and steel and of ferro-alloys (NACE 24.10) – Largest EU imports by origin (values, 2013)



Extra-EU producers of basic iron and steel supplying the EU market are mostly concentrated in Russia, China, Ukraine, Turkey, India, South Korea and South Africa.

On the exports side, EU28 production is directed towards markets where large domestic producers are active, such as China, India, Russia, Turkey and the United States. This two-way trade highlights that EU producers compete with sizeable competitors in their export market as well.

4.2.2.2. Capacity utilization in main trade partners is at a historically low level, inducing foreign producers to sell products at a discounted price on export markets

A look at the evolution of capacity utilization rates and spare capacity outside the EU28 suggests that international competition is unlikely to abate soon. World crude steel capacity more than doubled between 2000 and 2014, without a proportional increase in demand. As a consequence, world crude steel nominal capacity in 2014 exceeds demand by 700 million tonnes, up from 300 million in 2000.

Furthermore, capacity is still forecasted to expand in most markets in the near future. According to the OECD, capacity in Asia will increase by 10% between 2013 and 2017, by 50.5% in the Middle East and by 10.6% in Latin America.[80]

Major foreign competitors for the EU28 domestic market are the main contributors to the spare capacity plaguing the industry: they have seen their utilization rates decline since 2002, with an average decrease of 13 percentage points between 2011 and 2014.[81]

Low capacity utilization creates an incentive for producers to reduce their proposed prices because of the inherent features of steel production, with as a result a decline in market prices. Steelmaking is a high fixed cost production process. In a context of low capacity utilization, producers can increase output significantly without investing in new production plants. The total cost of producing extra units is low, as it is limited to marginal costs, such as labour, material and energy. In such a context, there is a high incentive for foreign producers to sell output at a price lower than average costs. Prices of flat products on the EU28 market have decreased by 40% since 2011.

This decrease in price could limit the ability of EU producers to pass through carbon costs, as they operate in an economic context in which competitors currently sell products at a discounted price on the market, as evidenced by the current antidumping measures and investigations from the EC (see table below).

The decision of the EC regarding dumping behaviour highlights the complex competitive environment in which EU steel producers are evolving. As foreign producers sell output at a discounted price on the EU market – price of cold rolled products decreased by 50% since its peak in 2008 – domestic

[80] OECD (2015), "Excess Capacity in the Global Steel Industry and the Implications of New Investment Projects", OECD Science, Technology and Industry Policy Papers, No. 18, OECD Publishing

[81] South Korea, Turkey and the United States are missing due to missing capacity data

producers could be unable to absorb an additional cost disadvantage due to carbon policy, increasing the risk of carbon leakage.[82]

Figure 15: World steel capacity and demand (2002-2014)

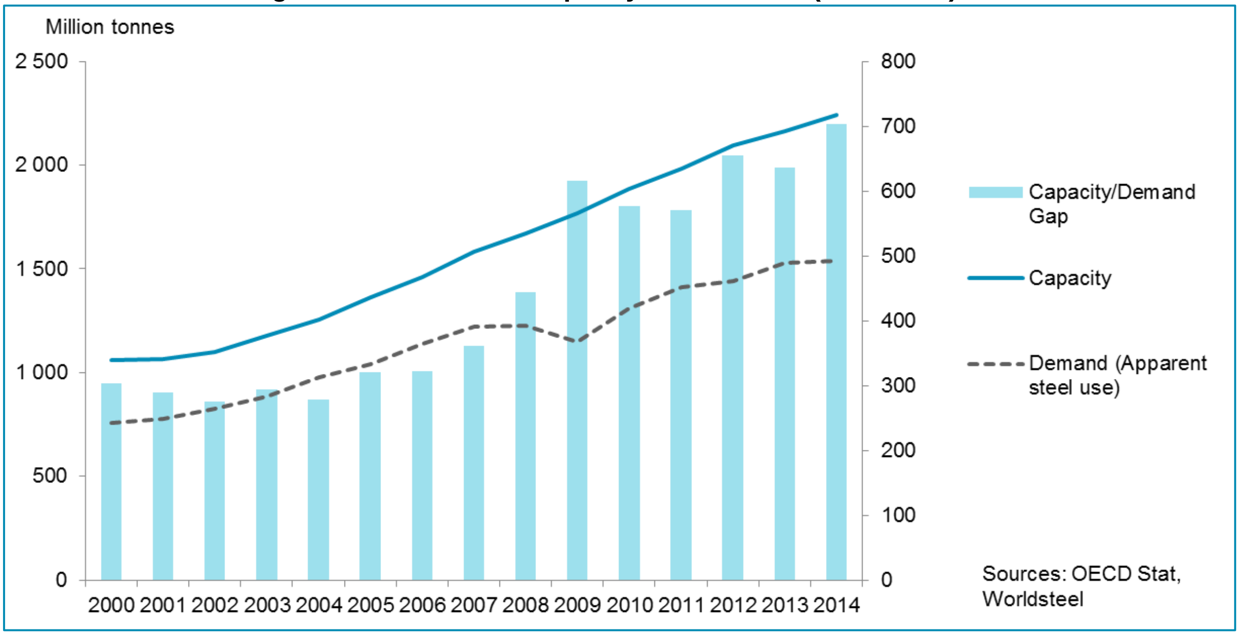
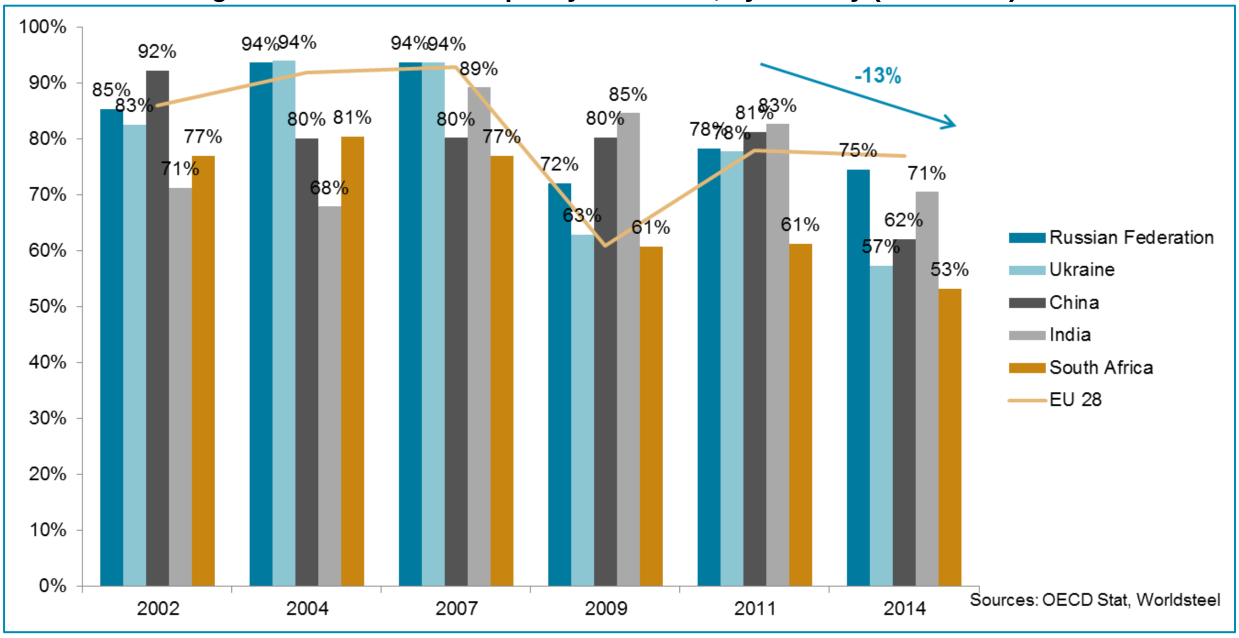


Figure 16: Crude steel capacity utilization, by country (2002-2014)



[82] Operating cost of EU producers in the BOF process is 40% above Brazil and Russia, and 20% for India and China (Hourcade et al., 2007)

Figure 17: Antidumping measures and investigations for steel products as of December 2015

Anti-dumping measures status	Steel products	Exporting countries
Ongoing investigation	Carbon/other alloy Cold Rolled Sheets	China, Russia
	High Fatigue Performance Rebar	China
Anti-dumping measures currently enforced	Stainless Steel Cold-Rolled Sheets	China, Taiwan
	Grain Oriented	Japan, South Korea, USA, Russia, China
	Organic Coated Sheets	China
	Wire Rod	China
	Stainless Steel Bright Bars	India
	Stainless Drawn Wire	India

This highlights that the ability to pass-through carbon costs is highly sensitive to market conditions. In a context of low capacity utilization and thus the incentive for foreign exporters to sell on the EU market at a discounted price, the ability of EU producers to pass-through carbon costs might even be negative, i.e. producers might be forced to sell at a price lower than total costs.

This salient feature of today's steel market conditions has been recognized by the report of CE Delft and Oeko-Institut in their investigation of cost pass-through in the EU-ETS of November 2015, though it is not reflected in the pass-through estimates for the steel industry.[83]

While the overcapacity and dumping behaviour is not specific to one country, Chinese steel can nonetheless be seen as one of the main threats given the overcapacity in crude steel, as illustrated in the chart below. It has been growing sharply and continuously over the last decade: total unused capacity has increased by 2400% between 2002 and 2014, with most of the increase occurring within the last five years (see Figure 18). Extra capacity available in 2014 represents a potential production of 379 million tonnes, which would be large enough to substitute the entire EU28 output for the corresponding year (169 million tonnes) (see Figure 19).

[83] Ex-post investigation of cost pass-through in the EU ETS, CE Delft and Oeko-Institut, November 2015

Figure 18: Chinese crude steel idle capacity (2012–2014)

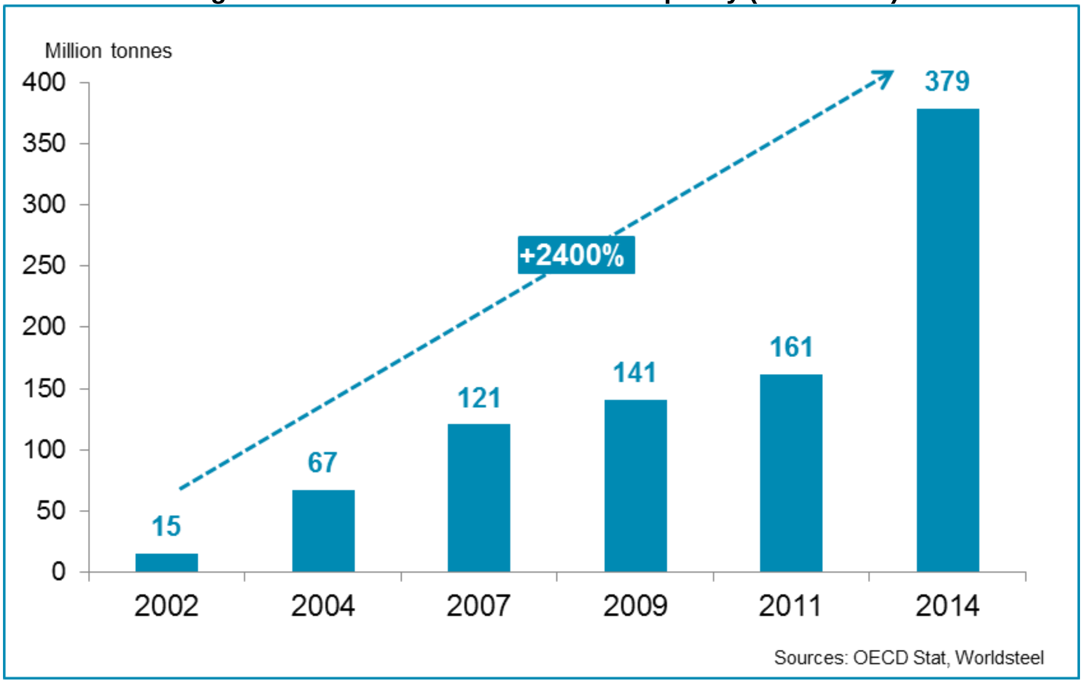
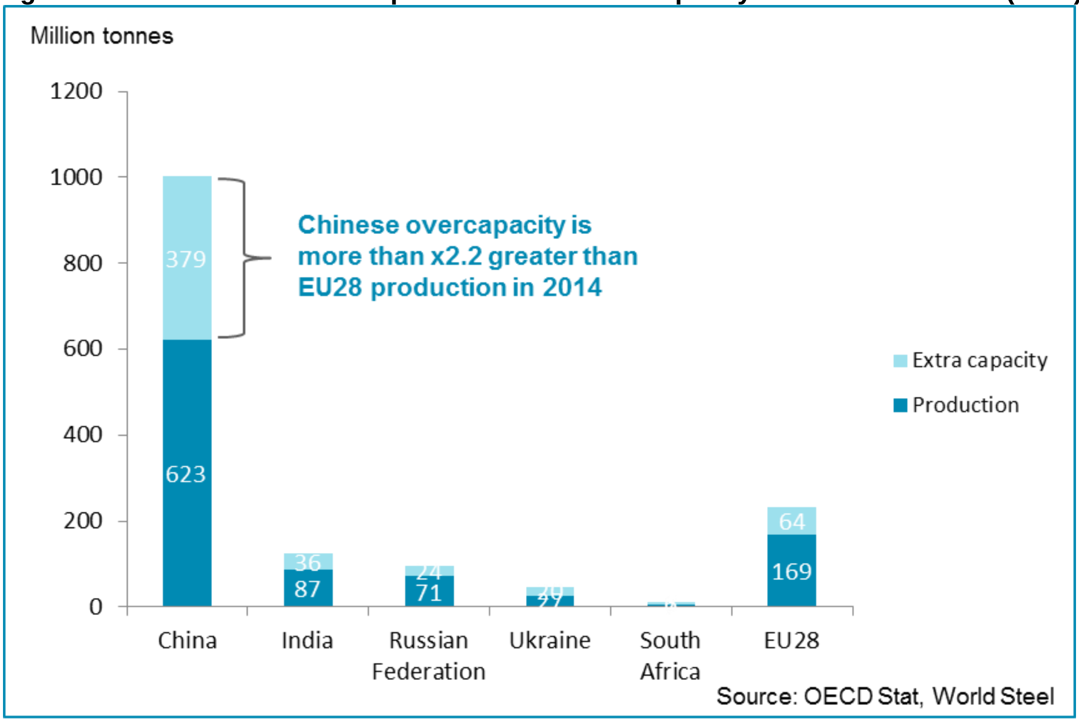


Figure 19: Chinese crude steel production and idle capacity vs. other countries (2014)



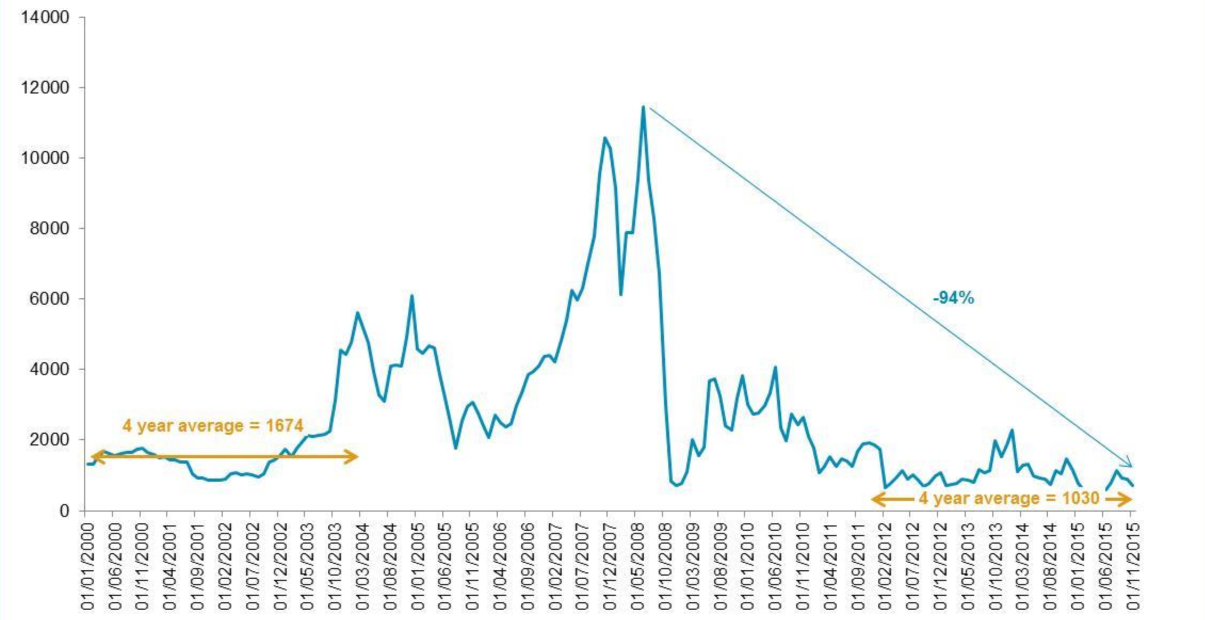
4.2.2.3. Shipping costs and localization of plants affect exposure to trade

Transport costs determine which non-European producers, in which foreign market, can compete for European sales. As such, transport costs are a key factor to identify the exposure to international trade, as well as the shape of the supply curve when carbon costs rise.

Under the hypothetical assumption that non-EU producers can already provide competitive global prices to EU clients, the ability to pass through CO_2 costs by European producers would depend on the relative size of extra carbon costs in comparison with the evolution of the cost of transporting steel products from each source country.

Since the 2008 and the peak of the commodity boom, shipping prices have decreased by 94%. Over the past 4 years, the Baltic Dry Index[84] has reverted to pre-commodity boom levels, even reaching an historic all-time low of 498 in November 2015, meaning that it is easier for foreign competitors to serve the domestic market and vice-versa.

Figure 20: Baltic Exchange Dry Index (BDI) – price index of shipping



Source: Datastream, NERA

The decline in shipping costs could explain why European imports have remained at a relatively high level despite idle capacity in Europe: while the incentive of European producers to regulate overcapacity via increasing their market share of the EU market has increased, the competitive pressure has also increased as a result of lower transport costs.

The Impact Assessment also notes that there may be heterogeneity of exposure within Europe, as producers on the periphery may be more exposed than those in the interior. Although interior producers may compete less *directly* with foreign production, interior EU producers do compete with EU producers on the periphery. If peripheral producers are under pressure not to raise prices, this will lead to more intensive competition with interior producers. Interior producers therefore are still affected by foreign competitors. Furthermore, a significant part of the steel production plants in the

[84] The Baltic Dry index is an indicator issued by the Baltic Exchange. It provides "an assessment of the price of moving the major raw materials by sea. Taking in 23 shipping routes measured on a timecharter basis, the index covers Handysize, Supramax, Panamax, and Capesize dry bulk carriers carrying a range of commodities" and we have accessed through the dataprovider Datastream.

EU are located close to the coast to allow access to the imports of key inputs (coke, iron ore, etc.). Thus, the infrastructure is already in place for competition by imports, so the discussion of geographical heterogeneity seems less relevant.

4.2.2.4. European steel producers are faced with a competitive international environment limiting their ability to pass-through CO2 costs

The high exposure to trade of the EU steel industry, associated with declining transport costs, and low capacity utilization in main competing countries, seriously limit the ability of EU producers to pass-through costs without significant loss of market share.

Exposure to international trade means that European steel producers compete directly with non-European producers, who operate outside the EU ETS and are therefore unaffected by its carbon price: if a cost increase does not affect *all* suppliers in the market, those affected by the cost increase (i.e., the European producers) will pass through less of it than if the cost increase was common to all suppliers.

This exposure is leading to an even larger pressure of steel prices over the last years. The European Commission recognizes the actual dumping behavior form Chinese steel producers in Europe. Facing competition with operators that implement dumping completely withdraw any consideration to tie prices to costs evolution.

Exposure to foreign competition is also unlikely to abate in the near future, since despite a glut of worldwide capacity, capacity is still being expanded in all markets (except the EU28).Given the high exposure to trade of the steel industry, passing-through costs would likely result in significant loss of market shares.

4.3. What does market structure of the steel industry tells us about the ability to pass through costs?

4.3.1. Cost-pass through depends to some extent on market structure, but the EC's analysis has shortcomings

The EC's impact assessment explains that *"market structure refers to the number of firms in the market and the level of state intervention either by regulation or direct ownership. The structure of the market determines the level of competition between firms and influences the ability of firms to pass on additional CO2 costs without losing market share. Sijm et al. (2009) derive the result that in general cost pass-through in competitive markets can be higher than in monopolistic markets. The monopolist aims to maximize profits and is therefore willing to sacrifice output. On oligopolistic markets the ability to pass-through the costs will depend on the pricing strategy and the utilization rates (CE Delft, 2010b). If capacity is fully utilized, full cost pass-through is likely. It is also conceivable that price increases are not immediately passed over to the customers, but price decreases of inputs are then used as balancing mechanism (Conforti, 2004)".*

The EC considers the following market features to be significant to assess the ability to pass through cost:

(i) The level of competition, assessed by the number of players or market power;

(ii) The nature of competition and the capacity utilization.

The following section of our report aims at underlining the fact that EC's impact assessment draws conclusions based on an analysis with some shortcomings. We will thus also point out relevant material which is necessary to consider the impact of market structure on the ability to pass-through costs.

The level of competition (i) has several impacts on the financial and pricing conduct of an industry. A low level of competition (monopolistic, or with largely differentiated products) enables the operators to achieve high profits. On the contrary a high level of competition induces competitive pricing, with no surplus profit being extracted (in such a scenario, EBIT = ROCE). This is the reason why, ***for a symmetric cost shock***, a high level of competition implies higher cost pass through rates. But in the context of an *asymmetric* cost shock, like an increase in carbon costs for EU producers but not for others, a high level of competition (from those who do not face the cost shock) increases significantly the risk of carbon leakage, as the logical result is a loss of market share in case of full pass-through. By increasing prices to cover their costs, European producers would abandon the share of the market for which they cannot compete with foreign imports. The loss of market share then depends on the shape of the cost curve, and on foreign producers' spare capacity (or ability to ramp up capacity quickly) as well as on the substitutability of domestic and foreign production. Therefore, while cost pass-through is possible in the case of a competitive market, this can be done only at the expense of market share if the price shock is asymmetric. Thus, a highly competitive industry does not guarantee high cost pass-through – in other words, the Sijm et al. result that the IA refers to is not true "in general", but only in the specific case where cost shocks are symmetric.

In contrast, monopolistic or oligopolistic industries that bear an *asymmetric* cost shock are likely to be more protected from competition, and therefore may be more likely to pass through a larger proportion of an asymmetric cost increase than they would if they faced large numbers of unaffected competitors.

Looking only at the structure of competition therefore does not provide enough information to understand how much a sector is likely to pass through cost increases. This must be analyzed in conjunction with exposure to foreign trade and elasticities, and must take into account the specific asymmetric nature of the cost increase as well as its extent (as the impact is not necessarily linear).

Moreover, (ii) as stated by the EC, for capital intensive industries capacity utilization can be an indicator of the ability of pass through costs. Indeed operating at full capacity may give some producers market power (if supply elasticity is low). But in cases where there is market power, producers consider both the potential change in price and its impact on demand, which may dampen incentives to fully pass costs through. Moreover, the marginal EU producer may exert market power when capacity utilization is high only if these capacity constraints are also faced by non-EU producers, otherwise foreign competitors can step in to supply the market. Such an analysis must thus take into account capacity utilization both within the EU28 and the rest of the world. While such considerations seem to be recognized to some extent by the IA, it is not reflected in its conclusions for the steel industry.

4.3.2. The steel industry's market structure indicates that a high CO2 cost pass-through would translate in a significant loss of market share

Competition in the steel market is driven to a large extent by the search for economies of scale. This shared incentive to increase capacities has led to a lasting overcapacity situation worldwide: capacity utilization in Europe is on average 10 points lower over the past five years compared to the 2000-2008 period. World overcapacity is estimated at 704 million tonnes of crude steel in 2014, which is more than four times the entire EU production estimated at 166 million tonnes[85].

This glut of idle capacity, has led producers to decrease prices since steel price strategies are driven to a large extent by the willingness to maintain capacity utilization sufficiently high to remain competitive. Especially since steel producers do not have the option of shutting down a plant and reactivating it a few months or years later to drive up utilization at other units, since blast furnaces cannot be shut down temporarily (i.e. any capacity taken out of the market equals full loss of the sunk investment).

The current low margins in the EU steel industry are proof of a very limited ability to pass-through any costs, let alone asymmetric costs. Indeed, low margins are associated with investment leakage: new capacity investments are realized outside of the EU, while plant closures affect EU producers. This is borne out by facts: the OECD expects the EU to be the only market in which capacity decreases between 2013 and 2017, while it is increasing in nearly every other market. An asymmetric increase in prices for EU producers would thus only amplify the phenomenon.

Downstream, steel producers are in no position to enforce asymmetric cost pass-through, especially for highly commoditized products such as semi-finished steel products and hot rolled products, since many clients various have a worldwide sourcing organization, which means that the diversity of steel uses does not shield it from a high level of competition for each use, resulting in highly contested markets.

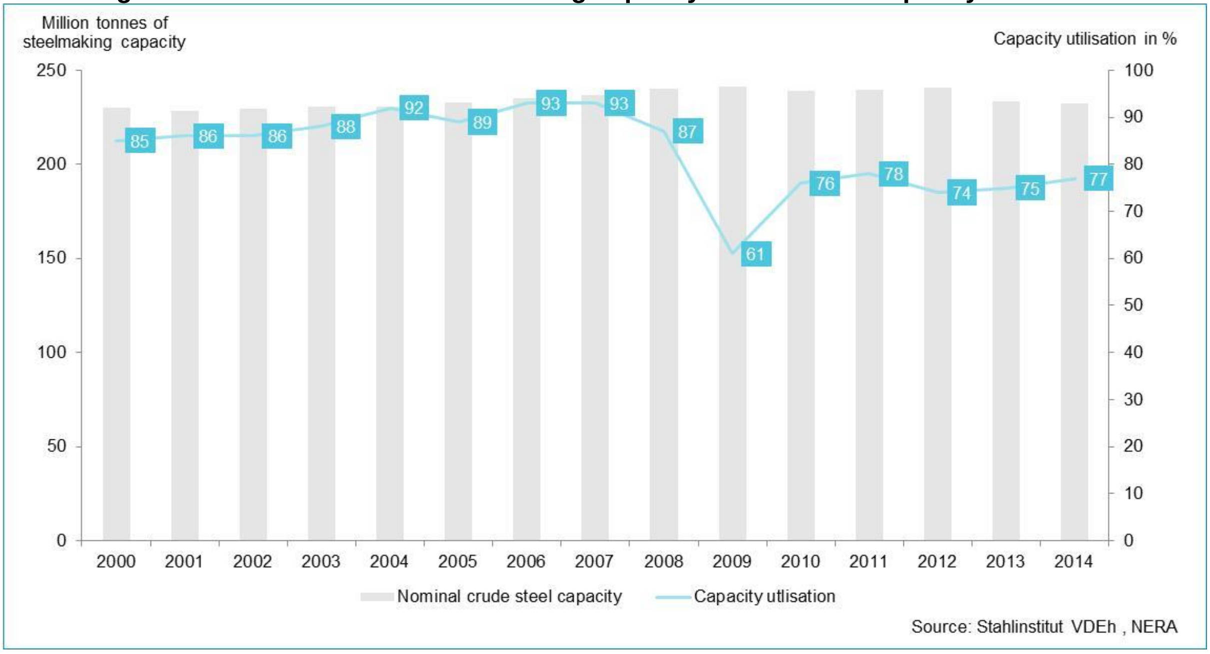
85

Upstream, faced with very concentrated players (4 companies account for 71% of the iron ore shipments in 2014)[86]), the steel industry has seen its share of the steel value chain reduced significantly over the years, indicating a progressive but significant decrease in its bargaining power.

4.3.2.1. The steel industry is driven by the search for economies of scale associated with necessary high capacity utilization

In the steel industry, production costs per unit fall as capacity increases, notably as a result of the so-called square-cube law, which means that the volume of steelmaking facilities grows faster than their surface, i.e. capacity grows faster than investment costs.

Figure 21: Evolution of EU steelmaking capacity and nominal capacity utilisation

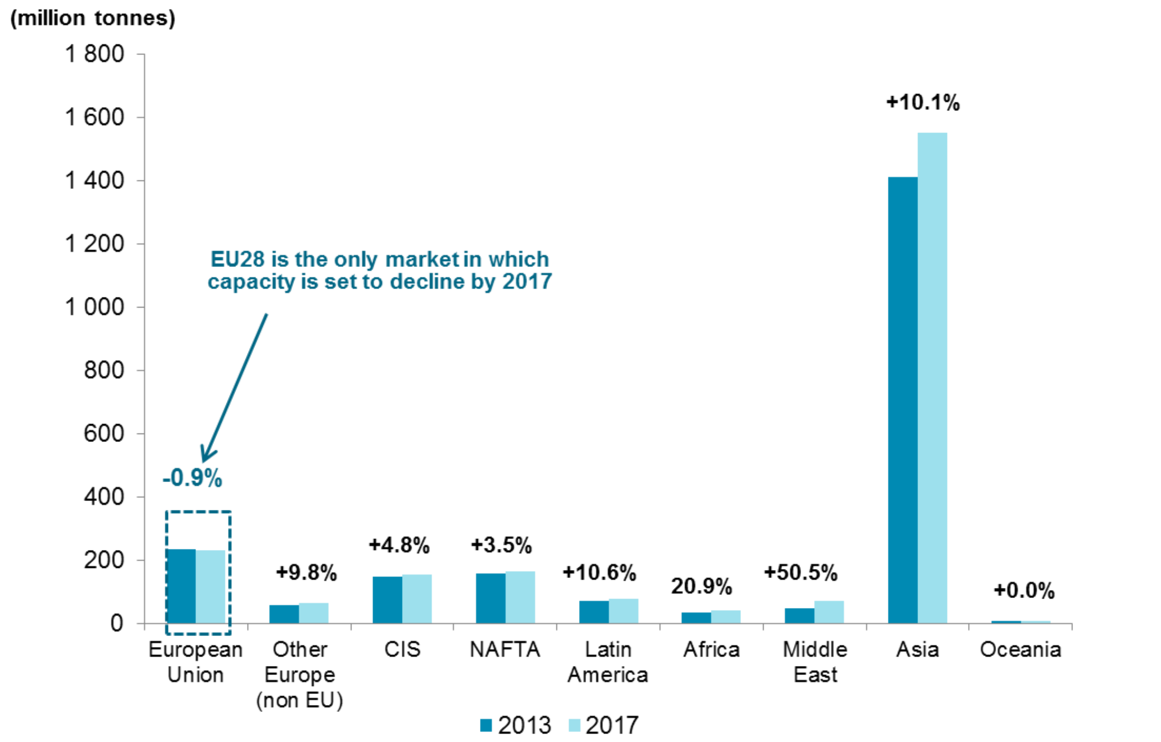


The decreasing unit costs per unit are also a result of the efficiencies that scale brings through the integration of processes: lower energy consumption can be achieved when all stages of production are concentrated on a single production plant.

Saturation of the installed capacity enables spreading fixed costs over a larger quantity of output, thus cutting total costs per ton as production grows. There is thus a definite advantage for producers with very large plants and high capacity utilization. Hence maintaining high capacity utilization is a common strategy, which make sense for each plant since it is rational for producers to have a preference for volumes over price, but which at the macro level can result in significant oversupply. It is important to recall that expected capacity utilization in steel factories is generally higher than in other European industries, such as cement for example. However, it doesn't make sense to compare capacity utilization rates of different industries, as CE Delft / Oeko-Institut does in its 2015 ex-post assessment of ETS, since breakeven points vary across industries: this means that under the same economic environment capacity utilization varies from industry to industry since they have different structural characteristics

86 Mining Giants' Push for Iron Ore Tests Mettle of Smaller Miners, Wall Street Journal, July 22nd 2015

Figure 22: Steelmaking capacity



Source: NERA analysis, OECD (2015), "Excess Capacity in the Global Steel Industry and the Implications of New Investment Projects", OECD Science, Technology and Industry Policy Papers, No. 18, OECD Publishing

4.3.2.2. EU and worldwide capacity utilization drives the steel prices

Steel prices have been facing a downward pressure since the beginning of the crisis as a result of a glut of spare capacity, both in the EU28 and in the rest of the world, which is not expected to disappear in the coming years: global capacity is expected to continue growing in most markets, except in Europe (see Figure 22: Steelmaking capacity). European capacity utilization, which was relatively high before the crisis[87], is experiencing a very slow recovery after 2009, reaching only 77% in 2014.

Even if capacity utilization rates were to recover in the EU, the European steel industry would still have difficulties in passing through costs without losing market share as long as the overcapacity in third countries persists. As demonstrated by the expected continued increase in global capacity despite low capacity utilization, steel supply is not as responsive as economic theory would anticipate.

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[87] Before the financial crisis, capacity utilization ranged between 86% and 93%. It has been recovering slowly since the crisis, reaching 77% in 2014 (from a low of 61% in 2009). Furthermore, it should be noted that these numbers understate capacity utilization, as nominal capacity does not take into account potential up- or downstream bottlenecks and is thus not effective capacity but maximum potential capacity. Also, given that the discussion of cost-pass through is relevant for the industry over the coming decade, the economic environment during the financial crisis should not be considered representative of the usual operating conditions of the steel industry, especially post-2020.

The reason behind the continued lack of adjustment of global steelmaking capacity is driven by two factors. The first one, explained above in details, is that scale and capacity utilization are key for competitiveness. The second factor results from high exit barriers (cost of dismantling mills, potential environmental clean-up, labour related costs, etc.) and inability to close some plants temporarily because of a technical specificity of blast furnaces: a blast furnace must remain almost continuously active, at very high temperatures. This means that once production at a blast furnace is stopped, it will be nearly impossible to resume without significant investments. So the steel industry does not have the option, as other industries do, to temporarily reduce capacity before bringing it back on line if market conditions improve (i.e. supply elasticity is not symmetric): reducing core capacity in the steel industry translates into a direct and final loss. As a consequence, even in a context of overcapacity, there is limited or no downward capacity adjustment, and growing pressure on prices. The natural consequence is an industry in which margins can remain low or negative for some time.

As consequence, foreign producers could ramp up production without requiring substantial investments, and thus easily substitute EU production, in response to an asymmetric cost shock on EU producers.

4.3.2.3. Negative profits are borne as a consequence of low price and low capacity utilization: a clear indicator that all costs are not passed through

The graph below shows the EBIT margin (Earnings before Interests and Taxes) evolution for all EU based steel companies with data available from 2006 through 2014.

The trend is apparent both for geographically and functionally diversified groups, as well as for the smallest European steelmakers. So while it is impossible to reconstruct, based on published financial accounts, a “pure steel EBIT”, the fact that the trend for small non-diversified companies and conglomerates active in steelmaking is exactly the same shows that the analysis stands for the sector as a whole, whatever the data limitations.

It also shows that small local producers face much more adverse conditions than their larger peers and would likely be the first to be impacted by an asymmetrical cost shock: the consistently negative EBIT margin over the past five years demonstrates an inability to cover the full cost of producing steel and thus of passing through their costs to customers.

These numbers are also consistent with the decline of gross operating surplus, as measured by Eurostat, which shows a decrease from on average more than 10% during the crisis to a low of 2% in 2012 (data for gross operating surplus of the steel industry at the European level is note available for the 2009 *annus horribilis* year in Eurostat).

It should also be noted that EBIT margin and gross operating surplus margin measure two different things and are thus complementary, but cannot be directly compared: while EBIT correspond to earnings after operational expenditures and after depreciation and amortization of capital costs, gross operating surplus is before accounting for depreciation and amortization costs [88] and is thus structurally higher.

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[88] Eurostat gross operating surplus definition: “*GOS differs from profits shown in company accounts for several reasons. Only a subset of total costs are subtracted from gross output to calculate the GOS. Essentially GOS is gross output less the cost of intermediate goods and services to give gross value added, and less*

Figure 23: EBIT of EU28 steel companies with NACE 2410 as their primary activity in Orbis

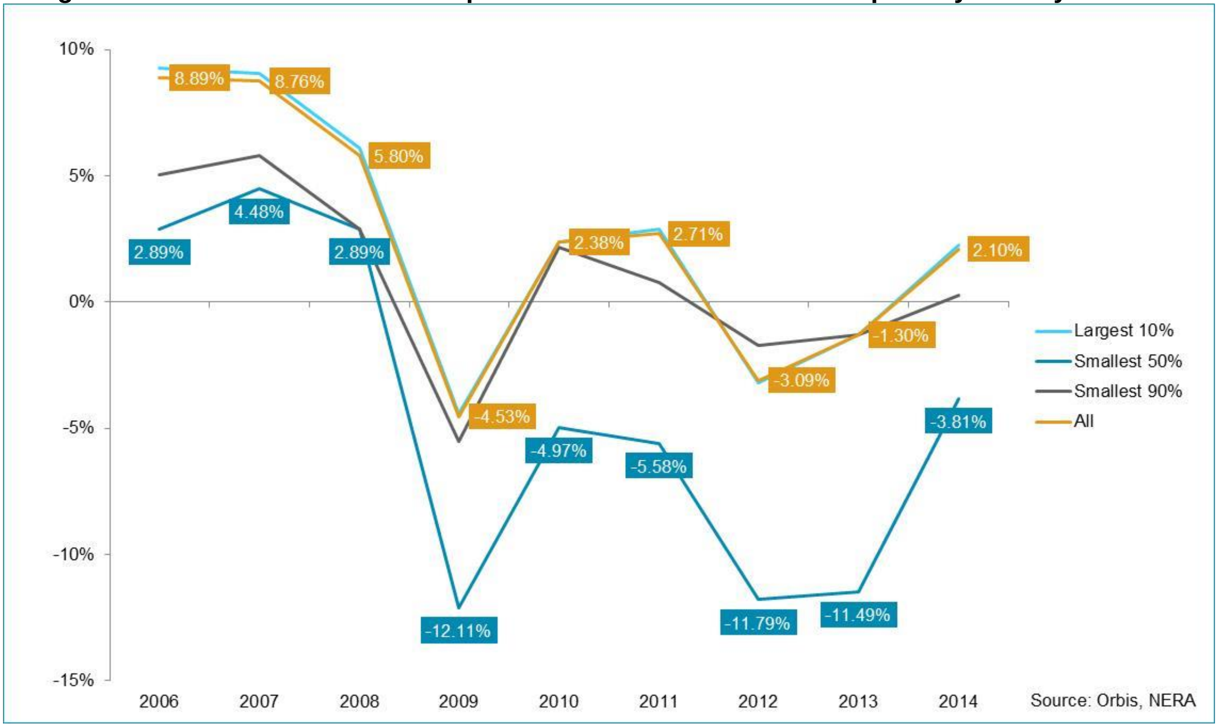
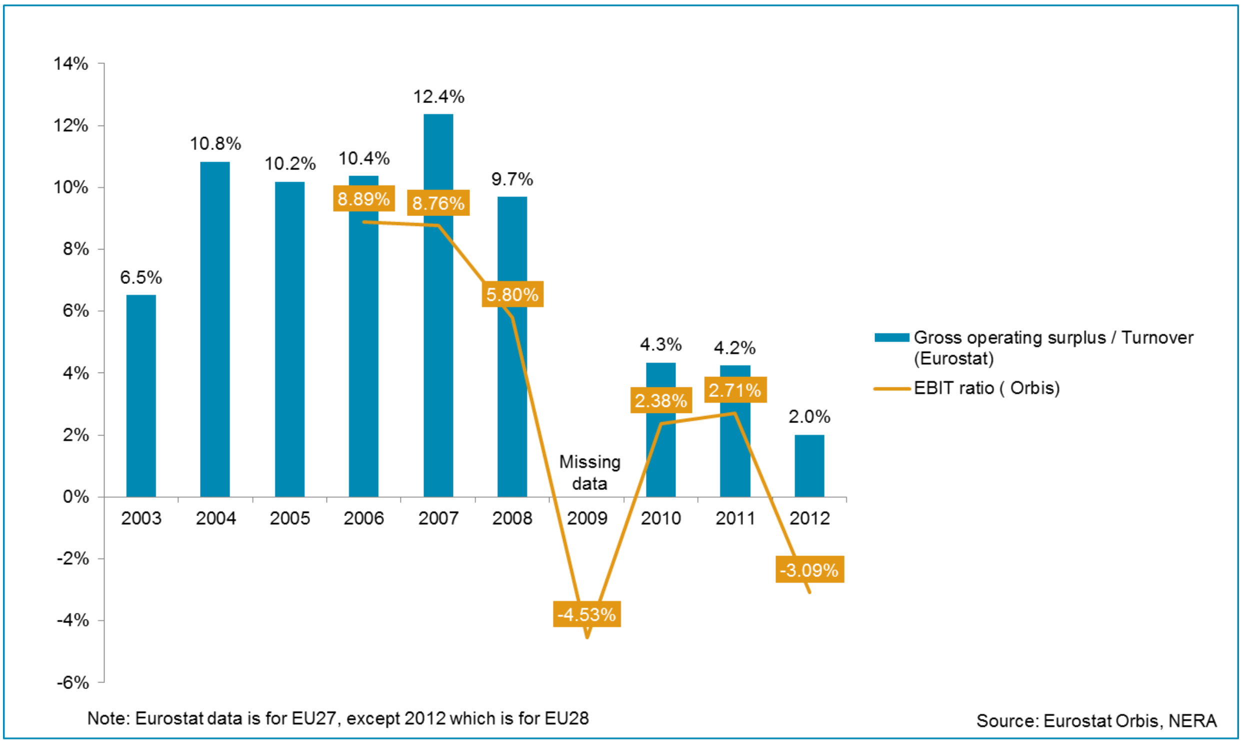


Figure 24: EBIT from Orbis and Gross Operating Surplus from Eurostat of EU steel companies for NACE 2410



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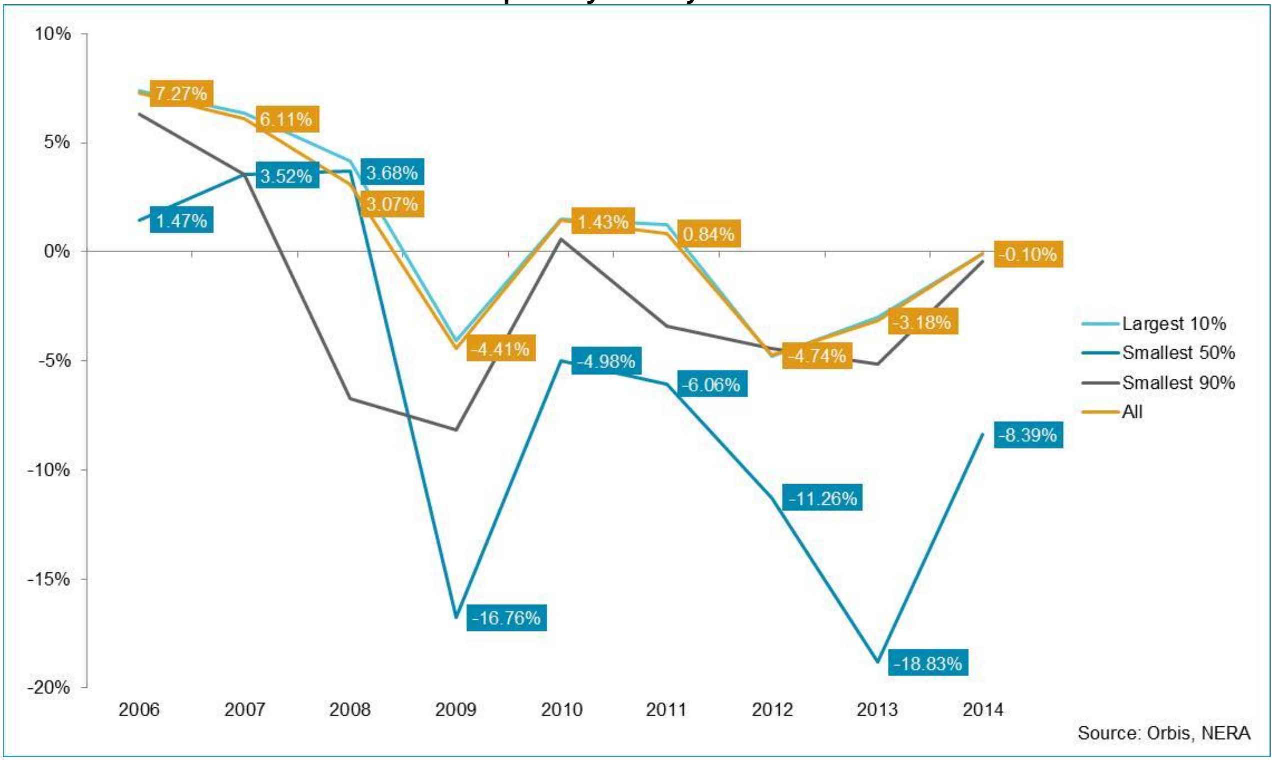
compensation of employees. It is gross because it makes no allowance for consumption of fixed capital (CFC). By deducting CFC from GOS one calculates net operating surplus (NOS).”

Whatever the data source or the observed indicator, the steel industry's post-crisis low margins are beyond doubt and indicate a difficulty to pass-through costs in a difficult economic environment, in an industry plagued by overcapacity.

In a highly capital intensive industry, it is obvious that a 2% gross operating surplus margin, as was the case in 2012, is not enough to cover the costs of past investments through depreciation and amortization (D&A), as evidenced by the fact that EBIT margin (after D&A) is negative for that year.

The industry as a whole has been experiencing losses in 2012 and 2014, and with the smallest active companies in the steel industry experiencing for their part losses of a significant magnitude for the past 6 years. The fact that smaller companies are more exposed to the adverse economic conditions is to be expected as steelmaking is an industry where scale is a key element of competitiveness.

Figure 25: Profit or loss as a share of turnover of EU28 steel companies with NACE code 2410 as their primary activity in Orbis



4.3.2.4. The steel industry lost its rank in the value chain

The steel industry is only moderately concentrated with the top 10 producers in the world accounting for just 26.7% of production in 2014 and the top 50 accounting for only 59% of total world production[89].

[89] World Steel Association, World Steel in Figure 2014

By contrast, the steel industry faces a very concentrated upstream market for iron ore, one of the key inputs for steel production, as iron ore production is one of the most concentrated industries in the world, with just 4 players accounting for over 90% of production. This results in the steel industry being a pure price taker for one of its key inputs, given its comparatively low market power.

The evolution of the profit pool[90] of the steel value chain (i.e. where profits are located along the entire value chain, from mining to finished steel products) has changed drastically over the last 20 years, with steelmakers seeing their global share of the profit pool of the steel value chain being captured by iron ore producers, showing that the loss of bargaining power of the steel industry is due not only to economic cycles, but to structural shifts. While steel producers managed to capture 80% of the profits of the steel value chain in the 1990's, their share has decreased to a third of that level, and even lower during crisis years [91].

Steel has many uses, ranging from engineering, construction, shipbuilding, electric appliances, etc. The downstream markets for steel products vary considerably in their level of concentration.

Some of the downstream markets for steel such as the car making industry (top ten players account for over 90% of production), are particularly concentrated sectors with an ability to keep supplier's costs down given their clout. Notwithstanding the various concentration levels of the downstream industries, they all share a common pattern that is a large exposure to international sourcing and international competition. The European steel market can be characterized as a contestable market: even though European industrialists source their steel in Europe for their main part of demand, they can easily source it on the international markets, and accordingly discuss their purchasing price.

4.3.3. Our market structure analysis suggests that high CO2 cost pass-through would translate in important loss of market share

EU producers, facing low utilization rates and overcapacity in the rest of the world, have seen the price of steel decline steeply.

Steel makers have lost their bargaining power and rank within the steel value chain, and are now capturing a lower share of industry profits than ever before: profits along the steel value chain are now mainly captured by companies active in iron ore mining and raw materials trading. The moderate concentration of steel producers does not limit the contestability of the steel market, to the benefit of downstream industries that can source easily outside Europe and refer to worldwide steel market prices.

Furthermore, the industry characteristics (constant search for economies of scale and maximum capacity utilisation) results in a rational preference for volumes over prices.

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[90] Profit pool is a strategy concept used to assess an industry based on where profits (margins and volume of profits) are located along the value chain. It is relevant to analyze industries since patterns of profit concentration in an industry will often differ from the patterns of revenue concentration. (see "Profit Pools: A Fresh Look at Strategy" - HBR, May 1, 1998)

[91] Competitiveness and challenges in the steel industry, McKinsey for the OECD Steel committee, 74th session, July 2013

These characteristics suggest that a high cost pass through of asymmetric costs would translate in an important loss of market share: European steelmakers are plagued by domestic and foreign overcapacity, translating into falling prices and EBIT margins. The fact that margins are decreasing and even negative is a good indicator that steel producers have a difficult time passing-through costs.

4.4. The analysis of supply and demand elasticities to an asymmetric cost increase does not suggest high rates of cost pass-through without significant loss of market share for the steel industry

The second axis of analysis is the supply and demand elasticities that provide elements to capture the dynamic effect on prices and markets shares following a cost increase. In the context of the ETS Directive, we must consider an asymmetric cost increase, meaning that we can consider that the CO2 cost increase won't be borne by extra EU producers. We explain the importance of such assumptions in Appendix D, which the Impact Assessment seems to ignore for it assumes that inelastic demand implies full pass through costs. It does not comment on the relation between supply elasticity and cost pass-through.

To understand whether cost-pass through without loss of market share is possible, one must consider three kinds of elasticities:

(i) Demand elasticity – to understand how final demand reacts to a price increase. If demand is inelastic, the size of the market does not vary much with a price increase, i.e. consumers neither use substitutes nor reduce their overall consumption. An inelastic demand usually translates in a high ability to pass through costs in a competitive environment, but the opposite can be true for an asymmetric price increase, as we will show.

(ii) Armington elasticities – to understand the elasticity of substitution between products of different countries. It is one of the best tool to appreciate the extent to which domestic production can be substituted by imports in case of a price increase. High Armington elasticities for a sector translate in a significant loss of market shares in the event of any asymmetric price increase.

(iii) Supply elasticity – to understand how the offer on the market reacts toward any change in prices. The impact of the supply elasticity on cost pass through depends on the dynamic effects that can occur in the market and specifically on the substitutability of domestic and foreign products.

To assess the ability to pass through cost with no significant loss of market shares, one must consider these elasticities ***in combination*** and not as purely isolated elements, but also in conjunction with market structure.

The Impact Assessment misses the combination of the different elasticities, and particularly does not take into account sufficiently the Armington elasticities on the one hand, and the dynamic impact of asymmetric costs on the supply elasticity on the other hand, leading to a too simplistic approach that leads to conclusions which cannot be considered definitive.

The economic literature for the steel industry shows consensus on, if not absolute values, at least qualitative assessment of each type of elasticities (demand, Armington and supply). We will review these in the following pages.

4.4.1. The EC's analysis of supply and demand elasticities with regards to cost pass-through is simplistic and incomplete

In its Impact Assessment, the EC explains that *"supply and demand elasticities refer to the degree to which supply or demand of a product responds to a change in price. If the demand elasticity of a product is zero (i.e. rigid demand) then additional CO2 costs can be passed through with no risk of a firm losing market share*".

However, the discussion of the significance of supply and demand elasticities in the Impact Assessment is simplistic and incomplete.

In perfectly competitive markets, pass-through of a cost increase that is **common to all producers** is determined by the relationship between the slopes of the supply and demand curves. In the special cases of perfectly elastic supply (horizontal supply curve) or inelastic demand (vertical demand curve), "full" cost pass-through occurs, where the impact on price is equal to the cost increase. Apart from these two polar cases, however, the price increase is less than the cost increase.

Focusing only on inelastic demand in a perfectly competitive market in which an industry-wide cost shock occurs (as the IA does) is too restrictive. In the context of the EU ETS, what is most relevant is **an asymmetric cost increase affecting European producers only**. Even maintaining the assumption of perfect competition and rigid demand, but moving from an industry-wide to an asymmetric cost increase, results in significantly less than full cost pass-through and loss of market share by European producers.

Put differently, the Impact Assessment confuses aggregate market elasticity with the cross-price elasticity of demand (which is what is relevant for market shares). EU firms that raise prices above those of foreign competitors may be forced out of the market completely, even if there is no change in the size of the market.

Things become even less clear-cut if competition is less than perfect. In oligopolistic markets, if producers face an increase in their marginal cost, their best response is to raise prices or, equivalently, reduce production up to a point where the cost saving associated with the last unit of forgone production equals the amount of lost revenue from that unit (i.e., marginal revenue equals marginal cost). The resulting pass-through rate is high if it takes a relatively large reduction in output for marginal revenue to equal marginal cost (flat marginal cost curve) and if that reduction in output also has a large impact on price (steep demand curve).

Thus, when markets are not perfectly competitive, the demand-side influence on pass-through cannot be approximated by the elasticity of demand alone. What increasingly matters in this case is the **curvature of the demand curve (see Appendix C)**, which expresses by how much consumers' price sensitivity varies with the price level they face.

Overall, therefore, the Commission's discussion of elasticities is simplistic as far as demand is concerned. Moreover, it is incomplete because it omits the impact of the non-domestic substitution and supply side. In what follows, we take a closer look at demand elasticity and its combination with non-domestic substitutability. We also provide an analysis of the supply-side impact on cost pass-through, with specific elements on the steel industry.

4.4.2. Short term and long term demand elasticity for steel products in Europe

Steel is serving other industrial sectors, for which the use of steel per unit of output is rather rigid in the short term. Although substitutability with other materials (aluminum, fiberglass plastic materials…) is possible in the long run for instance in motor vehicles and appliance production, switching costs might be high due to the changes required in the downstream production process.

As a consequence, steel has been usually characterized as inelastic in the short term, but not necessarily much more so than other industrial inputs, and somewhat more elastic in the long run (a prolonged period of low steel prices would likely result in growing demand, as industries might change their processes to integrate a higher proportion of steel and vice-versa).

Elasticity is also a function of the degree of differentiation, as differentiation means less products are perfect substitutes. In the case of steel, excluding highly specialized finished products, steel is a commodity complying with global standards, and demand can be characterized as served largely by undifferentiated producers.

Steel elasticities are thus the subject of varying interpretations. Economic literature on steel elasticities is mostly based on a nearly universally quoted source, Barnett and Crandall [92]. They described the US steel industry demand elasticity as inelastic, assuming this elasticity to lie between -0.2 and -0.3.

The International Energy Agency[93] instead proxies demand elasticity of the steel industry at -1, for the reason that steel is an internationally traded commodity with different uses. This is probably more of cross-price elasticity among domestic and foreign steel producers.

Demand elasticity by itself has little to say about the risk of carbon leakage[94]: A significant market size decrease following an increase of price (hence a high demand elasticity) does not affect neither relate specifically with the direct risk of carbon leakage, as long as the consumption of the product is diverted to more efficient products for the same final use, or that the final consumption is just reduced because it is constrained by clients' budget.

In addition, aggregate demand elasticity is not a good indicator of pass-through if not all suppliers are exposed to carbon cost increases.

Indeed, contrary to what is claimed in the Impact Assessment, even if overall market demand is completely inelastic, consumers may switch between individual suppliers in response to price differences when cost increases are asymmetric. For instance, if overall demand does not react to the price signal, but the level of imports vs. domestic production does, the market share of foreign producers mechanically increases if the carbon costs are passed on to consumers by EU producers.

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[92] Barnett and Crandall , *Commodities industries: steel* in, Industry studies by Larry Duetsch, 2002

[93] IEA, 2005, Information Paper, Industrial Competitiveness under the European Emissions Trading Scheme

[94] It should be noted that the market size decrease, following an increase of price, does not affect neither relate specifically with the risk of carbon leakage, as long as the consumption of the product is diverted to more efficient products for the same final use, or that the final consumption is just reduced because it is constrained by clients' budget

Finally, even in the case of a symmetric cost increase, inelastic demand in the short run does not systematically allow full cost pass through. Indeed, what is even more important for CO2 cost impact on the steel industry is not only the elasticity of demand, but the curvature of the demand: how the elasticity of demand evolves with price shift. There is little knowledge of the exact demand curves of any industry, but it is reasonable to state that choice to substitute steel with other material or to adapt production based on steel price may follow a nonlinear pattern, with hysteresis effects.

4.4.3. An asymmetric increase in costs would translate in substitution of EU production by foreign production given the near perfect substitutability of foreign and domestic steel as shown by Armington elasticities

Armington elasticities measure the degree of substitution of domestic supply by imports for a given price increase. It measures how higher domestic prices, as a result of an asymmetric cost increase, will lead to a decrease in domestic market shares. This elasticity is a key element of ETS impact assessment, as it reflects the whole phenomenon: both price increase and market share decrease. Hence there is a natural link between cost pass through as defined in the ETS Directive and Armington elasticities. As a general rule, the higher the Armington elasticity, the lower the ability to pass-through additional CO2 costs without loss of market share.

Armington elasticities are not commonly estimated in the economic literature and values differ depending on the geography studied, as well as on the reference years and scope of the studies. Nonetheless, theoretically, a consensus has been drawn that considers that (1) long-run estimates are higher than short-run estimates, (2) more disaggregated analyses find higher elasticities, and (3) reduced-form time series analyses generally find lower elasticities relative to cross-sectional studies that include a consideration of the supply conditions[95].

In the context of cost pass through study and ETS impact assessment, Armington elasticities taken into account should be based on long-run estimates and supply conditions: when considering ex-post estimates of cost pass through in particular, it is important to take into account the ability to abate extra CO2 cost, that is a long run strategy, and the ability to adapt supply. Because the ETS implementation is also based on a detailed, by product benchmarking of performances, it makes sense to target the most appropriate Armington elasticity per type of product.

High Armington elasticities imply that consumers view domestic and foreign **goods as close substitutes**, so carbon leakage effects are also high.

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[95] Impacts of the EU Emissions Trading Scheme on the industrial competitiveness in Germany, page 30

> "The results described above suggest that using estimates of Armington elasticities to assess the impact of the EU ETS for the relevant industry sectors in Germany, or using estimates from other regions instead may easily be challenged. Based on the multitude of different results, it seems little surprising that computable general equilibrium (CGE) modellers tend to rely on "guesstimates" when it comes to selecting the parameter values for Armington (and other) elasticities. Similar to McDaniel and Balistreri (2003), the findings presented in this section suggest that (1) stronger disaggregation of sectors results in higher Armington elasticities, (2) long-term elasticities are higher than short-term ones and (3) time series analyses result in lower elasticities than cross-cutting studies, and (4) Armington elasticities are higher for more homogenous products. In particular, the wide range of estimates cast doubts on the usefulness of most empirical estimates of Armington elasticities for policy recommendations."

When considering the empirical economic literature, a large set of values can be read as evidenced in Figure 26: Armington elasticities for the steel products in the economic literature. As Graichen et al. showed[96] empirical studies are often not applicable to inform the analysis of specific regulations, because they vary largely depending on the period, geographies and above all methodologies and assumptions used. The following table recalls the main results of the literature search regarding the steel sectors.

A conclusion one can draw on the steel industry Armington elasticity and other proxies is that, whatever the author, its references in terms on time series data, geography and global methodology of assessment, the steel Armington elasticity is systematically the highest value compared to other industrial sectors. It means that any asymmetrical price increase from the EU producer would lead to a significant loss of market share.

As cost pass through is a combination of elasticity of demand and Armington elasticity, it is very surprising that the EC impact assessment states that the EU steel industry has cost pass-through ratio which is high, and higher than other compared sectors, especially since high exposure to import substitution is not recent[97].

Very high Armington elasticities once combined with even an inelastic demand elasticity leads to significant domestic loss of market shares in case the domestic producer pass on their extra CO2 costs. This can be illustrated by the results of the Vivid study on the CO2 costs in the steel industry: it found that a partial pass-through cost results (3% price increase assumption for a 4% price shock for a 15€/tCO2 increase), just for the UK flat steel industry, results in a decrease in the UK steel industry profit of 18%[98].

Similarly the IEA[99] uses an estimate to assess global demand elasticity to EU steel producers: the demand reduction with the constraint of a constant profitability margin. It can be considered as the combination of both global demand elasticity and specific demand elasticity addressed to European producers. As the results in the table below show, the global demand elasticity for steel is high compared to other industries.

Table ES-2: **Demand reductions with product prices assuming constant profitability margins (EUR 10/tCO_2)**

	Steel BOF	Steel EAF	Cement	Newsprint	Aluminium
Price elasticity:	**-1.56**	**-1.56**	**-0.27**	**-1.88**	**-0.86**
Scenario					
2% allowance needs	-0.8%	-0.5%	-0.4%	-1.8%	-2.9%
10% allowance needs	-1.6%	-1.2%	-0.7%	-2.3%	-2.9%

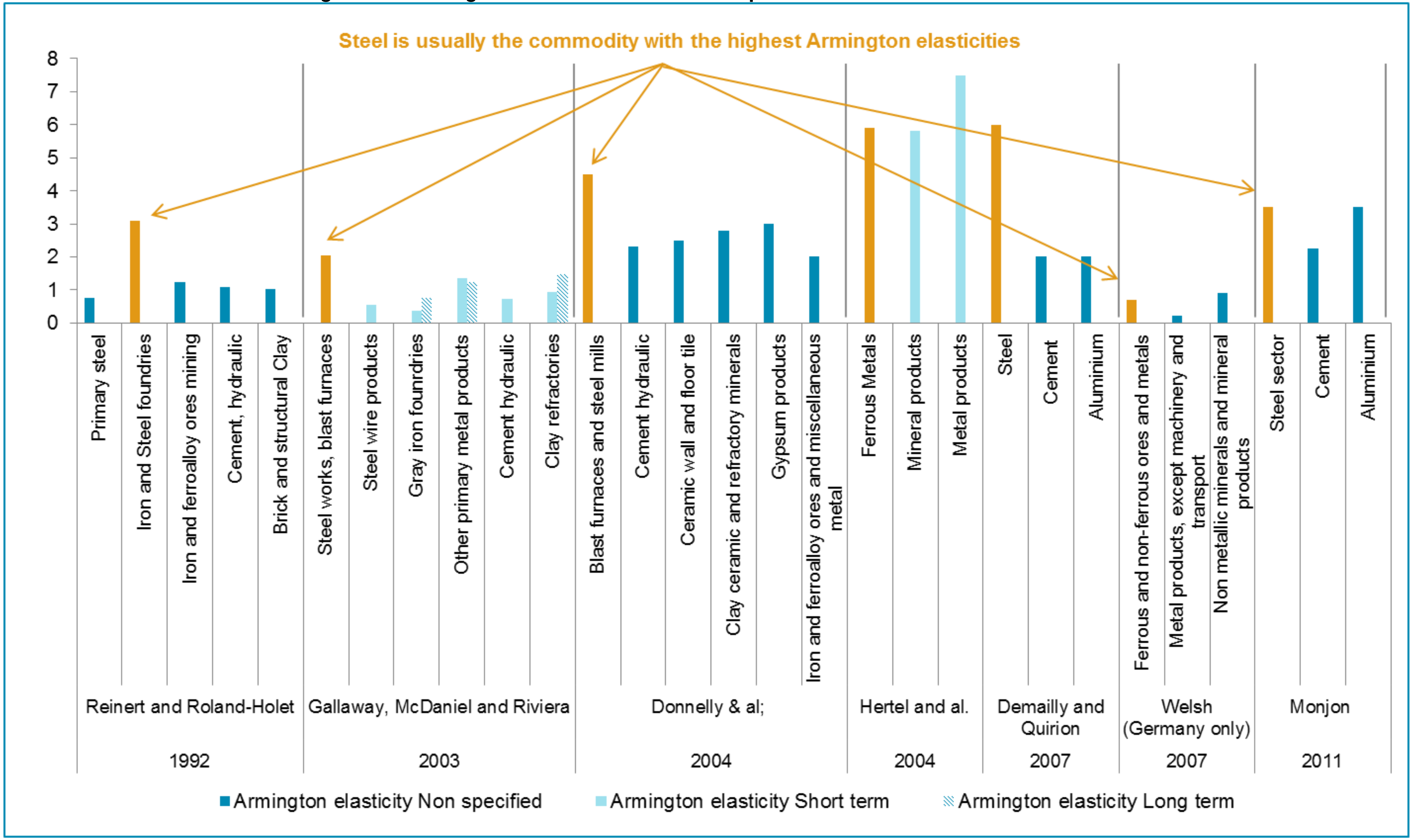
96 Ibidem note 18.

97 Back in the nineties Quirion already noted that "the linear demand curve case is not presented only for illustration: econometric studies presented by Goldberg and Knetter (1997) show that following a variation in marginal production cost due for example to exchange rates swaps, exporters do not pass on to foreign consumers the totality of the change in marginal production costs. In the iron and steel sector, it seems that about 50% of the change in marginal cost increase is passed through to consumers. In a monopolistic setting, this corresponds to a linear demand curve."

98 Vivid Economics, 2014, Case studies, report prepared for DECC

99 IEA, 2005, Information Paper, Industrial Competitiveness under the European Emissions Trading Scheme

Figure 26: Armington elasticities for the steel products in the economic literature

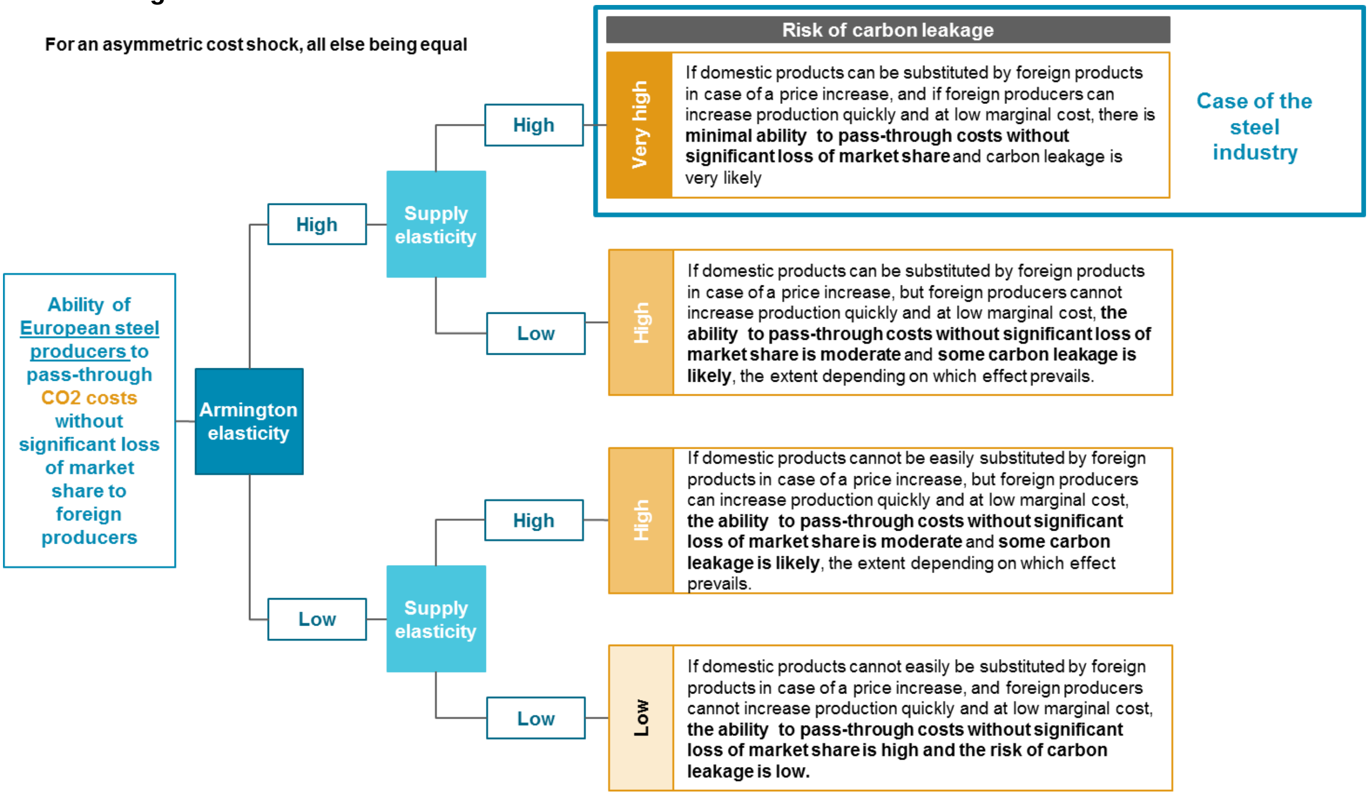


4.4.4. Supply elasticity and the ability to pass through asymmetric costs

Supply elasticity refers to the shape of producers' marginal cost curves (the aggregate of which is the supply curve in perfectly competitive markets). High supply elasticity corresponds to relatively flat marginal cost curves, which indicate that marginal production costs do not change much with quantity produced (for more detailed analysis of how cost curves interact with ability to pass-through costs without loss of market share, see Appendix D). From a static perspective and aggregate supply vision, the higher the elasticity of supply, the higher the ability to pass-through costs. The result is the opposite as soon as one considers the dynamic effects that occur as a response to an asymmetric cost shock.

Again a combined analysis of supply and Armington elasticities provides useful framework for the assessment of the risk of carbon leakage, as shown in Figure 27 below.

Figure 27: Elasticities and ability to pass-through extra CO2 costs for European producers without a significant loss of market share



The steel case fits with our analysis. Barnett and Crandall[100] estimate the steel supply elasticity at a level of 1.2. Their study is based on time series related to US "mini mills" using only scrap between the 1950's and the 1970's[101]. While this figure is probably outdated, the current market environment for steel suggests a high supply elasticity: the steel industry is characterized by standard efficiency

[100] Barnett and Crandall , *Commodities industries: steel* in, Industry studies by Larry Duetsch, 2002

[101] It is remarkable that this value is generally quoted, even indirectly and taken as an assumption of the global steel industry by economic literature: see Vivid assumptions (indirect quote), IEA, etc.

levels (reduced differentiation of marginal costs) among worldwide competitors and by significant overcapacity, as the EU's steel nominal utilization rate is currently more than 10 points lower than pre-crisis levels and **foreign spare capacity represents more than three times the entire EU28 total capacity**: **in 2014, while the entire EU28 crude steel production was 169 million tons, world nominal idle capacity stood at nearly 650 million tonnes**.[102]

Thus, the supply of steel can easily be increased by simply increasing capacity utilization of existing plants: little or no new investments would be required. Hence the European steel industry can be described as facing high supply elasticity **and** low ability to pass-through an asymmetrical cost increase. Furthermore, given that much of the spare capacity is located outside the EU28, an asymmetric cost-shock could be fully absorbed by these capacities.

4.4.5. Conclusion on the steel industry's ability to pass-through an asymmetric cost increase without significant loss of market share given supply and demand elasticity

With rather inelastic short term demand and high supply elasticity, the steel market is considered with a high ability to pass through costs by the impact assessment as well as the biased CE Delft / Oeko-Institut approach. The main reason is that they both neglect the importance of considering asymmetric cost shock related to CO2 extra costs, as well as combined demand and supply elasticities with the ability to substitute foreign products to EU products. The theoretical and factual analysis turns into completely reverse conclusions: with the highest Armington elasticities, the steel market is very sensitive to asymmetric cost-shock, and it derives into limited cost pass through ability. This is especially true in the current context, in which overcapacity in China alone is greater than the entire European production, meaning that there is near perfect supply elasticity and that foreign producers are in a strong position to benefit from any asymmetric cost increase by displacing European producers.

[102] Source: OECD Stat, worldsteel association

5. Conclusions on the steel industry’s ability to pass through costs without significant loss of market share

When analyzing the steel sector along the three dimensions identified by the EC to assess ability to pass-through costs without loss of market share (market structure, supply and demand elasticities, exposure to international trade), we conclude that a high level of cost pass-through would likely translate in significant loss of market shares, given that steel products have a high trade intensity, are substitutable by foreign products, and that spare capacity outside of the EU would enable producers not exposed to carbon costs to ramp up production and capture market share in case of cost pass-through. Alternatively, without cost pass-through, in the context of low margins experienced by the industry, the risk of carbon leakage through investment leakage is high.

The very limited existing literature (only 4 studies, two of which from the same consultants, none of which disclose their data or are peer reviewed) to which the EC refers for the most part does not address cost pass-through and market shares together, so it is not relevant when trying to assess ability to pass-through costs without loss of market share. The exception is the Vivid study, which does conclude that pass-through would result in significant loss of market share.

Applying a wrong estimated rate of cost pass-through without loss of market share to determine the free allocations of industries exposed to the risk of carbon leakage based on a misreading of the existing literature, as the EC does in its impact assessment, would result in removing the intended protection against the risk of carbon leakage. While a qualitative analysis can conclude that high pass-through costs for the steel industry would likely translate in significant loss of market share, a more detailed quantitative analysis would be necessary to determine the rate of cost pass-through without loss of market share, which would itself be dependent on the size of the carbon cost increase relative to the price of steel.

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Appendix B. Detailed review of the CE Delft / Oeko-Institut 2015 study

Summary of the methodology

The aim of the CE Delft/ Oeko Institute study is to provide an estimate of the carbon cost pass-through for flat steel products (hot, cold rolled) in Northern and Southern Europe, using a BOF production route. The carbon cost pass-through is defined as (p. 29):

"The extent to which carbon costs can be passed through is defined by Sijm and Chen (2009) as the cost pass-through rate: the increase in the final price of the product divided by the additional (opportunity) carbon costs in production."

The strategy presented by the authors involves two broad steps. First, the authors provide an estimate of the impact of carbon costs on the price of output for four different product categories. Second, the authors calculate a (theoretical) cost share of carbon. These two numbers are then compared to determine the pass-through rate: if numbers are equal, in other words if the increase in the output price caused by carbon costs is exactly equal to the theoretical (opportunity) cost of carbon, then the pass-through rate is equal to 100%.

The **first step** is based on a model developed by Alexeeva-Talebi (2011),[103] which aims at estimating a Vector Error Correction Model (VECM). In the case of steel, the conditions to implement this methodology are not met, such that the authors apply an Auto Regressive Distributed Lag Approach (ARDL) in levels. The output is an estimate of **the impact of a 1% change in carbon prices on the price of output**. The authors interpret this value as the cost share of carbon in percentage, which assumes that the nexus between profits and costs (i.e. the intensity of competition) is constant through time (see page 54 of the report). The estimated figures range from **3.1% for Cold rolled coil** (Southern Europe) to **8.4% for Hot rolled coil** (Southern Europe).

The **second step** provides an estimate of the theoretical cost share of carbon. In this exercise, the authors start from an average price of carbon of 10.31 € /t CO_2, which is then multiplied by a carbon intensity benchmark of 2 t CO_2 / ton of crude steel, corresponding to the benchmark value from the European Commission. This number is then compared with a reference cost structure from Steelonthenet, and results in an estimated **cost share of carbon of 5.5%**.

The carbon pass-through rates are then calculated as the ratio of carbon cost shares in both steps, and amount to **55%, 75%, 85%** and **155%**.

In the following paragraphs we scrutinize these results by assessing:

- Whether they are plausible
- Whether they are robust

[103] Alexeeva-Talebi, V. (2011), "Cost pass-through of the EU emissions allowances: Examining the European petroleum markets", Energy Economics, Vol. 33, Suppl. 1

– Whether they can be extrapolated to the 2020-2030 period

We are limited in our assessment of the study by the fact that, surprisingly, the authors did not present any sensitivity analysis nor do they present all the standard statistical tests of robustness and relevance.

It should furthermore be noted that we did not have access to the underlying data and did not replicate the model, as this was beyond our scope.

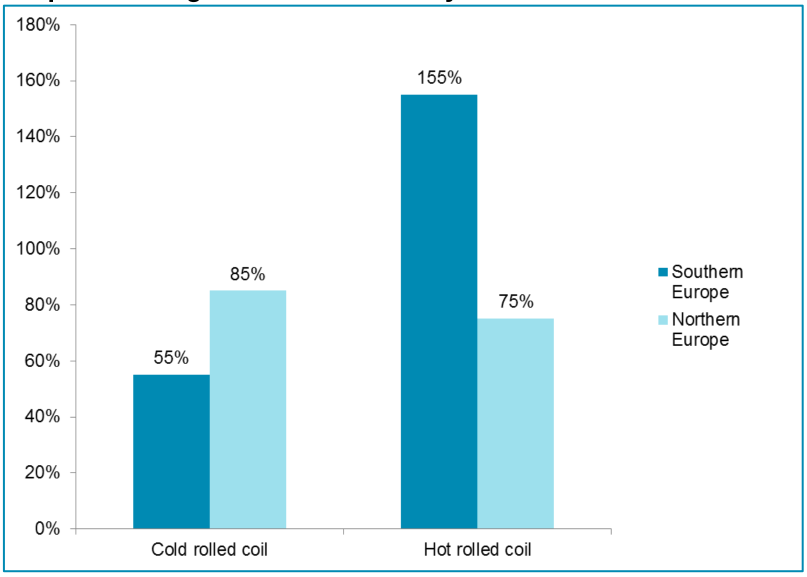
As a result, the following assessment should not be considered exhaustive.

Detailed review of the model

1. The results are implausible

In the report the authors indicate that “[…] indicative CO2 cost pass-through rates in North Europe range from 75% for hot rolled coil to 85% for cold rolled coil. In Southern Europe a larger differential can be found where the cost pass-through of hot rolled coil would surpass 100% and for cold rolled coil would equate to 55% »[104]**.** The actual figure for hot rolled coil in Southern Europe, which the authors refer to as surpassing 100%, is in fact 155%.

Figure 28 Cost pass-through rates estimated by the 2015 CE Delft / Oeko-Institut study



These results are very counterintuitive given that, during the period of observation (2008-2014), margins of steel makers have declined to a historical low, even reaching negative levels (see below and Figure 23, Figure 24 and Figure 25), which is indicative of an inability to pass-through costs.

[104] Ex-post investigation of cost pass-through in the EU ETS, CE Delft – Oeko-Institut 2015, page 92

Figure 29: EBIT margin of European steel producers in Orbis

	2006	2007	2008	2009	2010	2011	2012	2013	2014
EBIT margin	8.89%	8.76%	5.8%	-4.53%	2.38%	2.71%	-3.09%	1.30%	2.10%

These results are also counterintuitive given that the sector has suffered from dumping behaviour, which means by definition selling below production cost, i.e. not passing through all costs (and not just asymmetric costs), a fact that is recognized by the European Commission, as evidenced by the anti-dumping measures which have recently been introduced or are currently being discussed (see Figure 17).

So a 155% pass-through for an asymmetric opportunity cost seems implausible in this context. Especially since a simple sensitivity analysis based on the CO2 intensity (assumed at 2t CO2 per tonne of steel by the authors) gives widely varying results: for instance a with a C02 intensity of 1.5 t CO2/t steel, the cost pass-through for hot rolled products in Southern Europe would reach 200% .

A further counterintuitive, but not necessarily wrong result, is the fact that pass-through rates are very different between Southern and Northern Europe for a given product and that cost pass-through rates for the CO2 opportunity costs vary so significantly between products. At the very least, this shows the difficulty of coming to a conclusion regarding the steel sector as a whole (cold and hot rolled coils being just two among many steel products).

The implausibility of the results is compounded by the fact that the cost pass-through ratios found for other inputs also seems implausible. It is also possible, using the methodology suggested by the CE Delft / Oeko report, to calculate a purported "pass-through rate" for the other three inputs used by the authors, This would be a natural "sense-check" to have performed on the estimation results, to test the plausibility of the models that they have estimated. But conducting this sense check reveals equally implausible results. For example, the implied "pass-through rate" for iron ore (which, according to the CE Delft / Oeko report, accounts for approximately 30% of steel production costs), applying their suggested methodology, ranges between just 13% and 52%, depending on the European region considered. It is extremely difficult to see how steelmaking could possibly remain profitable if it were not able to pass through most or all of the costs of iron ore. Similarly, the pass-through rates for coke (around 20% of steel costs, according to CE Delft/Oeko Institut's data) range from just 14% to 80%. Again, given the importance of these inputs it is difficult to see how their rates of pass-through could be so low. And for scrap steel, we find the opposite: the pass-through rates using the CE Delft/Oeko methodology range from 364% to 681%. Thus, when the wider set of results reported by CE Delft and Oeko are analysed, their plausibility becomes even more suspect.

In the next sections we investigate the robustness of the modelling and of the assumptions, before assessing whether these results could be extrapolated to the steel industry for the 2020-2030 period.

2. The results are not robust

2.1. Major issues with the calculation of the cost pass-through ratio

The authors of the report are very transparent about the fact that the model is very sensitive to the input data and that any problem with the data used for the model would invalidate the results they present in the study:

“Empirical estimations of cost pass-through are made on the basis of analysing price data, where the price of outputs (products) is tested for the significance of the price of inputs (including CO2) used in production. **As CO2 costs are relatively small, the results are very sensitive against the quality of the data**, especially regarding the price of outputs**.** »[105]

Furthermore, the results (coefficients β1) of the complex econometric modelling undertaken by the authors are converted through a simple computation in into a cost pass-through rate[106].

$$\text{Cost pass through ratio} = \frac{Estimated\ coefficient\ \beta 1}{\frac{Emission\ factor * CO2\ price}{Product\ price}}$$

For this computation to be meaningful, even if coefficient β1 is correct, the assumptions taken for the carbon emission factor, the product price and the carbon price must be correct, otherwise the result is irrelevant.

Regarding the product price

The methodological section of the report suggests using the product price to compute the cost pass-through (Equation c2, p.53 of the report). Implicitly, CE Delft /O.I. thus equates product price with the total costs of production, which in itself is wrong given that CE Delft/O.I. doesn’t consider the possible deviation between the product cost and the product price. One doesn’t understand why they didn’t just use the product price on the market, which is available, instead of using this convoluted approach.

Far more importantly, the costs of production chosen by the authors to reflect the product price do not relate to plausible production costs. The assumption taken by the authors from *steelonthenet* are only 342.9€/t, representing, in March 2015 “*the cost is for a notional producer - a typical size integrated BOF plant, 3m t/yr, at a* ***Japanese coastal site*** *with its own coke and sinter plant, using imported ore and coal purchased at international prices with third party transport. The blast furnace is assumed to have PCI. The steel plant is assumed to make* ***commodity grade carbon steel*** *for flat products with average labour productivity*”.

The fact that this is from a Japanese coastal plant and not a European plant is a first and obvious reason why this is of course an inadequate figure. It introduces a temporal mismatch between the data used in the econometric model (2008-2014) and calculation of the cost pass-through ratio given that the data for the Japanese steel plant is from 2015. It is also not consistent with the price of CO2

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[105] Ex-post investigation of cost pass-through in the EU ETS, CE Delft – Oeko-Institut 2015, page 60

[106] Ex-post investigation of cost pass-through in the EU ETS, CE Delft – Oeko-Institut 2015, page 53

taken (averaged over the observation period instead of taking an end of period point estimate) and does not capture the variance of the price of the products over the period (which have decreased by around 50%-60% since 2008 (see Figure 8 and Figure 9). It also assumes the same product price for hot and cold rolled coils and across both Southern and Northern Europe, which defeats the purpose of modelling two products across two different geographies. If we consider European production costs, specifically for the BOF route, and during the period estimated, publicly reported figures are very different from the ones used by CE Delft / Oeko-Institut in 2015. In the steel roadmap 2050, BCG & VDEh present cost of production for 2010 that vary between 599€/t **crude steel** (with retrofit BOF plant) and 871€/t of **crude steel** for greenfield BOF plant[107]. **As a result, the CE Delft / Oeko Institut study cannot reasonably be used to frame the debate on cost pass-through as the results presented are unlikely to be an accurate reflection of actual cost pass-through of the steel industry in any way**

Regarding the emission factor

Despite recognizing the sensitivity of the model to input data, the authors do not present a sensitivity analysis, even when they acknowledge that they are uncertain about the data, as is the case for the CO2 intensity of the steel products: they consider that it can range from 1.5 to 2.5t per tonne of steel[108] and simply use 2t of CO2 per tonne of steel (for all products tested, across all geographies). As shown by the simple equation above, the estimated values for the carbon cost pass-through are very sensitive to the level of the emission factor. A deeper and more thorough analysis would have been essential to translate the impact of a change in carbon prices on output prices into a measure of carbon cost pass-through. The authors recognize this fact as they explain that "*uncertainty about the emission factor can result in biased estimates on the cost pass-through rate*"[109]. Indeed, the emission factor is subject to (i) the perimeter of the products studied, (ii) the date (it is not correct to assume it is constant over the period), (iii) the regions (the emission factor vary largely within the actors). **The level of uncertainty on the emission factor translates directly on the uncertainty related to pass-through costs: in the steel case, the results are thus uncertain within a range larger than 50% (- 25%/+25%). Accordingly, estimates for the cost pass-through range between 46% and 200%.**

Regarding the price of CO2

Furthermore, regarding the cost of CO2, the reference price of carbon is chosen at **10.31 € /t CO2**, a simple average over the sample period (and then rounded at 10€/t, which is inexplicable given that either values are not rounded to the full Euro). This reference value provides a very crude estimate, as the variance of the price of carbon has been large over the period. In addition, there is no a priori reason to assume that carbon pass-through is a linear function of carbon prices. An appropriate methodology would account for the variance of carbon prices, for example simply by calculating cost pass-through estimates with lower/upper bound of carbon prices over the period. As an illustration, the price of carbon was at **23.09 € /t CO2** at the beginning of the sample period (August 2008)[110]**,** and at **6.97 € /t CO2** at the end of the sample period (December 2014). **Overall,** the carbon price taken into account by CE Delft / Oeko-Institut (spot prices) vary between **3.51 and 23.52 €/t** over the

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[107] A steel roadmap for a low carbon Europe 2050, Eurofer, 2013, pp36-37.

[108] Ex-post investigation of cost pass-through in the EU ETS, CE Delft – Oeko-Institut 2015, page 81

[109] Ex-post investigation of cost pass-through in the EU ETS, CE Delft – Oeko-Institut 2015, page 53

[110] Source : SendeCO2 EUA spot price (URL : http://www.sendeco2.com/it/prezzi-co2)

sample period. **Interestingly, for other products studied, CE Delft** / Oeko-Institut **estimated the share of carbon cost among total costs for different carbon prices, but omits this for the steel sector**.[111] **Modifying CO2 prices translates into a very wide of estimates for cost pass-through, with lower and upper bounds at 34% and 420% respectively.**

Conclusion on the flawed cost pass-through computation

Correcting the CE Delft data, one can find results of carbon cost share estimate varying largely from the reported 5.5%. By only correcting the cost of production it falls to **between 2.3% and 3.3% and down to 1.5% if variations of carbon intensity are taken into account. As the authors acknowledge, for a carbon cost below 5%, the econometric approach may be irrelevant**:

> *"The formal test for our econometric study is therefore if this β coefficient is statistically significantly different from zero. If carbon costs are reasonably high (e.g. above 5% of total costs), it is clear that this is a good test. However, if carbon costs are very small (e.g. 1% of total costs) or if not all costs have been passed through into product prices, it becomes more difficult to discern whether this variable is statistically significantly from zero given the typical noise in the data."*[112]

Furthermore, the range of estimates obtained by modifying simple assumptions on parameter values is too large to be accurate, as cost pass-through estimates can vary **from 26 to 419% by changing a unique parameter value.** As an illustration, Figure 30 presents a sensitivity analysis of cost pass-through for each category of steel product by changing sequentially carbon intensity, carbon prices and output prices.

For Hot rolled coil in Northern Europe, for instance, the cost pass-through reported by CE Delft is 75%. When using the upper value for carbon intensity and keeping all other parameters constant, the implied pass-through is **60%**. By using the upper value, the estimated cost pass-through increases to **98%**. For carbon prices, by taking the highest/lowest values of carbon spot prices over the period under consideration and keeping all parameters equal, and using the same reference as reported in CE Delft / Oeko-Institut [113], the estimates are **34 and 204%.** For output prices, when using the price of output to calculate the cost share of carbon as suggested by Equation (c2) on page 53 of the report, the new estimates vary between **87 and 125%.**

When **combining** the different parameter values presented above, cost pass-through estimates overall vary between **26%** (Hot rolled coil, Southern Europe, High carbon prices) and **570%** (Hot rolled coil, low carbon intensity, low carbon price and cost share calculated on output price): **the range of estimates obtained by using different parameter values from the same references as used in the CE Delft / Oeko-Institut report, is thus too large to be considered accurate.**

Given the unreliable data used by the authors to calculate the cost pass-through for the steel industry, the reported figures cannot be taken at face value. In fact, even if these were corrected, the results would still be irrelevant as they would become statistically insignificant. And in the case not all costs are passed-through; the results are also statistically insignificant according to the authors. This is precisely the case for the steel industry over the last few years as a result of the dumping behavior

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[111] See for example the computation for fertilizers on p. 108 of the report

[112] Ex-post investigation of cost pass-through in the EU ETS, CE Delft – Oeko-Institut 2015, page 51

[113] Source : SendeCO2 EUA spot price (URL : http://www.sendeco2.com/it/prezzi-co2)

from third countries, which means that if the authors had first looked at the economics of the sector before building their model, they would have not used the modelling approach that they ended up using for the steel industry.

Figure 30: Sensitivity of Cost pass-through estimates to parameter values (unique changes and combinations)

	Estimated coefficient	Carbon intensity (t CO2 per ton steel)	Carbon price (€ per t CO2)	Carbon costs (intensity * price)	Steel output price (€ per t steel)	Total production costs, excl. CO2 (€ per t steel)	Implied carbon cost share	Cost pass-through estimates
Hot Rolled Coil, Northern Europe								
Reported figures	0.041	2	10	20		342.9	5.5%	**74%**
Low carbon intensity	0.041	1.5	10	15		342.9	4.2%	**98%**
High carbon intensity	0.041	2.5	10	25		342.9	6.8%	**60%**
Low carbon prices	0.041	2	3.51	7.02		342.9	2.0%	**204%**
High carbon prices	0.041	2	23.52	47.04		342.9	12.1%	**34%**
Low output price	0.041	1.5	10	15	319		4.7%	**87%**
High output price	0.041	2.5	10	25	762		3.3%	**125%**
Lower bound	0.041	2.5	23.52	47.04		342.9	12.1%	**34%**
Upper bound	0.041	1.5	3.51	7.02	762		0.9%	**445%**
Cold Rolled Coil, Northern Europe								
Reported figures	0.047	2	10	20		342.9	5.5%	**85%**
Low carbon intensity	0.047	1.5	10	15		342.9	4.2%	**112%**
High carbon intensity	0.047	2.5	10	25		342.9	6.8%	**69%**
Low carbon prices	0.047	2	3.51	7.02		342.9	2.0%	**234%**
High carbon prices	0.047	2	23.52	47.04		342.9	12.1%	**39%**
Low output price	0.047	1.5	10	15	390		3.8%	**122%**
High output price	0.047	2.5	10	25	801		3.1%	**151%**
Lower bound	0.047	2.5	23.52	47.04		342.9	12.1%	**39%**
Upper bound	0.047	1.5	3.51	7.02	801		0.9%	**536%**
Hot Rolled Coil, Southern Europe								
Reported figures	0.084	2	10	20		342.9	5.5%	**152%**
Low carbon intensity	0.084	1.5	10	15		342.9	4.2%	**200%**
High carbon intensity	0.084	2.5	10	25		342.9	6.8%	**124%**
Low carbon prices	0.084	2	3.51	7.02		342.9	2.0%	**419%**
High carbon prices	0.084	2	23.52	47.04		342.9	12.1%	**70%**
Low output price	0.084	1.5	10	15	330		4.5%	**185%**
High output price	0.084	2.5	10	25	476		5.3%	**160%**
Lower bound	0.084	2.5	23.52	47.04		342.9	12.1%	**70%**
Upper bound	0.084	1.5	3.51	7.02	476		1.5%	**570%**
Hot Rolled Coil, Southern Europe								
Reported figures	0.031	2	10	20		342.9	5.5%	**56%**
Low carbon intensity	0.031	1.5	10	15		342.9	4.2%	**74%**
High carbon intensity	0.031	2.5	10	25		342.9	6.8%	**46%**
Low carbon prices	0.031	2	3.51	7.02		342.9	2.0%	**155%**
High carbon prices	0.031	2	23.52	47.04		342.9	12.1%	**26%**
Low output price	0.031	1.5	10	15	390		3.8%	**81%**
High output price	0.031	2.5	10	25	840		3.0%	**104%**
Lower bound	0.031	2.5	23.52	47.04		342.9	12.1%	**26%**
Upper bound	0.031	1.5	3.51	7.02	840		0.8%	**371%**

Note: For each product, the various cost pass-through rates are obtained by changing one parameter value at a time, except for the Lower bound and Upper bound categories, which present the maximum/minimum value of cost pass-through achievable by combining different parameter values

2.2. Other issues affecting the model's robustness

2.2.1. The choice of sample period reduces dramatically the sample period, is inconsistent with the assumptions of the theoretical model and affects the choice of specification

The authors choose to dismiss the price hike between September 2007 and July 2008 because of a peculiar evolution of steel prices, but still include the subsequent major drop in output prices. In addition to be arbitrary, a reduction in the sample **period** seriously limits the sample **size**. The choice of restricting the time span of the study thus seriously limits the power of the econometric estimation as it **reduces the number of observations to 77,** even less when accounting for the inclusion of lagged variables. As comparison, Alexeeva-Taleebi (2011) acknowledges "*limitations*" implied by a small sample when estimating a similar model (VECM), with a sample consisting of weekly data from 16 September 2005 to 22 March 2007, i.e. roughly 80 observations.

Another crucial implication of the particular sample period in the case of steel is that capacity utilization can drop dramatically during economic downturns (capacity utilization has dropped to roughly 60% during the economic crisis – see Figure 16). As consequence, the share of costs for each input is also affected through the fixed/quasi-fixed nature of some inputs. This is enhanced by the intrinsic nature of steel production, where factories cannot easily be re-opened after closure, which creates an incentive to maintain production sites during temporary downturns. As amortization of fixed assets is not a choice variable, by definition, the share of variable costs will be impacted.

These specificities of the steel industry imply that cost shares can vary significantly with the economic cycles, and are thus in fundamental contradiction with the very nature of the theoretical equation estimated, which require the assumption that shares are constant through time. Similarly, the cost share of carbon is considered as constant when the price of carbon varies by a factor of seven within the period**.**

Another minor implication concerns the choice of specification and the test of unit root. Unit root tests are used to determine whether data series follow a trend, upward or downward (non-stationarity). If variables follow a non-stationary trend, then a simple, traditional linear regression could yield a positive and statistically significant coefficient estimate, which would be interpreted as a causal impact, while in fact variables are simply following the same trend, i.e. there is no causal relationship between them ("spurious correlation"). In case of unit root, the statistical techniques thus need to be adapted. A widely used model is the VECM, which has been used for the steel industry in CE Delft (2010).

The results from the unit root tests in the current study suggest that the dependent variable does not contain a unit root, such that the authors estimate an ARDL (Autoregressive Distributed Lag approach) using variables in levels. **However, the reason why the unit root fails could lie in the choice of sample period: there is a sharp drop in prices due to the crisis, followed by a bounce back period, such that there is not a clear trend (upward or downward) in the data.** The arbitrary choice of the sample period is justified as follows:

"However, it turned out that the price hike up to mid-2008 (see Figure 19 and Figure 20) was highly influencing the results. Therefore, it was finally decided that we tested the hypothesis of cost pass-through on the data after August 2008 when the overheated market had cooled down."[114]

The choice to restrict the sample period is not backed by hard evidence or by any statistical test. A first implication is that it would be necessary to explore other specifications, for example by *detrending,* or by *first-differencing* variables, to check the robustness of the results.

2.2.2. The choice of input price variables in the estimated equations for each product category is inconsistent

The choice of input price variables in the estimated equations for each product category is inconsistent. As an illustration, the price of iron ore is measured by iron ore exported **to the Netherlands from Brazil** in 3 out of 4 product categories, and **exports to China** for cold rolled coil in Northern Europe (see Table 16 of the report, p.91). While this certainly fits the purpose of the estimation, this arbitrary choice still needs to be justified theoretically, in particular to understand why the price of Chinese iron ore is a good proxy for the price faced by EU steel producers.

Similarly, **the timing of the effect of the price of scrap and of carbon emissions is allowed to differ across product categories** without any theoretical justification. Accordingly, the impact of an exogenous shock of scrap prices hits the price of steel with zero delay except in the case of hot rolled coil in Southern Europe. A change in the price of CO2 would impact the price of steel output with one-period lag for cold rolled coil in Southern Europe, two-periods for cold rolled coil in Northern Europe, and three-periods for hot rolled coil in Northern and Southern Europe. This differentiated timing of impacts would need further investigation, or at least a robust theoretical justification, as this is an important result from the estimation, in particular given that most of the steps in the BOF production process are identical between cold and hot rolled coil.

This highlights that the final specification across product categories is inconsistent and ad-hoc in terms of price variables chosen, and is not justified by any theoretical/factual argument, which again challenges the robustness of the estimates.

2.2.3. The statistical tool (p-value) used to determine the statistical significance of cost pass-through is inappropriate

The common procedure in the econometric literature to determine the statistical significance of parameters is to use a "t-test" to assess whether a coefficient is **different from zero** (i.e. there is an impact of an explanatory variable on an explained variable).[115] The corresponding t-test is a two-tailed test. However, the authors opt for a one-sided test, which increases the reported significance of the estimated parameters:

[114] Ex-post investigation of cost pass-through in the EU ETS, CE Delft – Oeko-Institut 2015, page 90

[115] The p-value approach is an alternative measure to the confidence interval to observe the statistical significance of a parameter, but they always lead to the same conclusions: if the confidence interval does not include zero, then the p-value will be small, and thus the parameter will be statistically significant.

"In our tests of significance of $\beta 1$, we have used one-sided confidence intervals. We only allow for positive values of $\beta 1$, for a negative value would imply a negative cost share as well as that product prices would decrease with the CO2 costs. This does not make sense."[116]

T-statistics for the coefficients on cost pass-through rates reported in Table 51 (Appendix D) are [**1.56, 2.04, 2.66 and 4.1**]. The direct implication of taking a two-sided test instead of a one-sided test is that the p-values are then multiplied by a factor of 2.

Based on one-sided t-tests, the authors find p-values of [0.00, 0.01, 0.02 and 0.06], i.e. all parameters are significant at a 10% threshold. Based on a two-sided test, and considering a large sample (larger than 200-300 observations), yields p-values of [< 0.01, 0.02, 0.04 and 0.12]. In consequence, we find **statistical insignificance** for cold rolled coil (Southern Europe), and results that are less significant for other products, though still under commonly accepted thresholds.

2.2.4. The chosen modelling method results from inconclusive results from the standard approach and introduces significant omitted variables bias

The ARDL approach did not produce satisfactory results when using all the input data, so the authors chose to arbitrarily ignore labour costs and concentrate on "only the output price, prices for iron ore, coke, scrap and CO2" in the dynamic relationships despite what was suggested from their unit root test "*Due to the poor performance of the wage time series*".[117,118]

The plausibility and relevance of a particular model needs to be assessed based on statistical evidence. The explanation above does not justify why excluding the price of labor is an appropriate approach, neither through statistical tests, nor through theoretical arguments. Labour costs are a significant input cost for steel production, which actually means that the model built is disconnected from the reality of steel economics.

More importantly, ignoring relevant variables creates the risk of the model suffering from **omitted variable bias, and seriously undermines the reliability of the results. The risk of omitted variables bias is present as long as the correlation of the various input prices with CO2 prices has not been ruled out.**

Regarding the choice of input price variables, it should also be noted that the proxy used for capital costs to explain the price of steel products is **not specific to the steelmaking activity**, while capital requirements, financing conditions or costs of capital among others can vary substantially across industries. The use of a market-wide interest rate is at best a very imperfect methodology as it assumes that all sectors are homogeneous in terms of capital costs.

Finally, the model doesn't take into account the evolution of productivity, which is critical in understanding the dynamics of the steel market. Steelmakers must increase their productivity every year to remain competitive in normal times, however, when production suddenly drops, as happened

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[116] Ex-post investigation of cost pass-through in the EU ETS, CE Delft – Oeko-Institut 2015, page 52

[117] The argument was also used to justify the specification used for the glass industry

[118] Ex-post investigation of cost pass-through in the EU ETS, CE Delft – Oeko-Institut 2015, page 90

at the onset of the crisis, productivity naturally declines (as neither capital nor labour can be adjusted as quickly as production): by assuming constant productivity the pass-through rates measured by the authors could in fact contain a productivity variation element.

3. Even if they were correct, the results could not be extrapolated for the 2020-2030 period

The selected sample period (August 2008 – December 2014) is very specific as it includes the economic crisis. The ability to pass through carbon costs to consumers cannot be expected to be impervious to the economic conditions in which producers operate. In crises period, where prices and profitability drop sharply, the ability of producers to pass through costs could be dramatically impacted. In consequence, even if the methodology presented is sound, results are likely to differ when considering a "normal" period. In other words, this limits the **"external validity" of the study, i.e. the possibility to generalize results to any subsequent period if not else demonstrated.** Establishing more robust estimates of carbon pass-through levels would require testing the robustness of the results by using **other sample periods**.

Furthermore, there are two strikingly different phases in the time period covered in the study. The first (Sept. 2008 – Apr. 2009) is a context of decreasing output prices, decreasing profitability and decreasing carbon costs. The second period (May 2009 – May 2011) is a period of increasing output price and stable carbon costs, and the last period (June 2011 – Sept. 2014) of decreasing output and carbon prices.

In such a context, the price of carbon and the price of output are likely to be correlated, but a positive correlation in crises periods, where producers are faced with a **drop in demand and need to adjust prices**, is **not equivalent** to a positive correlation in a price increase period where producers would potentially **factor-in the (opportunity) costs of carbon**. In other words, a positive correlation when both variables trend downwards does not imply the same behavioral assumption than cases in which both variables trend upwards.

In other words, the positive coefficient observed might as much reflect a pass-through of carbon costs to consumers than a drop in profitability with simultaneous decrease in carbon prices caused by any third factor.

This means such results cannot be extrapolated to the 2020-2030 period, in which the economic conditions faced by the steel industry are likely to be very different from the ones faced between 2008 and 2014, which corresponds to the most difficult economic environment since the 1930's.

Conclusion on the model

The authors of the study recognize that "the estimated cost pass-through rate in this research is only giving an indicative value and can by **no means be interpreted as 'absolute truth'**. It provides a conjectured estimate of the amount of costs that seem to be passed through in the product prices. It is by definition true that this amount is larger than 0% [*sic*], but **the exact amount of costs passed**

through is difficult to discern precisely. This also implies that **it is difficult to base a decision regarding carbon leakage risk and the free allocation of emission allowances on estimated cost pass-through rates alone**."[119]

They also explain that "the cost pass-through rate cannot be determined precisely in such models due to different reasons. **First, there are confidence bounds associated with econometric estimations**. Second, there are various **data issues arising when determining the hypothetical cost share if all costs were passed through**. Third, **the estimator of the cost pass-through rate compares the marginal cost price increase with the average expected cost price increase. If marginal and average costs diverge, cost pass-through rates may be calculated at well above the 100%, which is difficult to explain"** [120]

Given their insights in the limitations of their own model, it is surprising the authors did not pay more attention to the quality of the data they used. For instance using the cost structure of a single Japanese coastal steel plant as a proxy for the cost structure of European plants is likely to yield an inaccurate estimate of the cost shares.

It is also surprising, that given the sensitivity of the model to simple assumptions (CO2 price, CO2 emissions factor), they have not provided a sensitivity analysis, which would have shown that under many circumstances the model's results are implausible, nor provided all the relevant statistical tests indicating the robustness of the model.

The model's result could also have been more directly confronted with the current conditions faced by EU steel producers: finding a 150% cost pass-through rate in the context of the European steel sector's current inability to cover average production cost, given dumping behaviour from non EU producers, is difficult to reconcile with basic economic intuition. A simple sensitivity analysis based on CO2 prices, CO2 intensity and steel prices, which shows cost pass-through ratios of up to 420% would also have shown that the model is disconnected from empirical evidence.

As such, the CE Delft / Oeko Institut study cannot reasonably be used to frame the debate on cost pass-through as the results presented are unlikely to be representative of the actual degree to which carbon costs have influenced steel prices.

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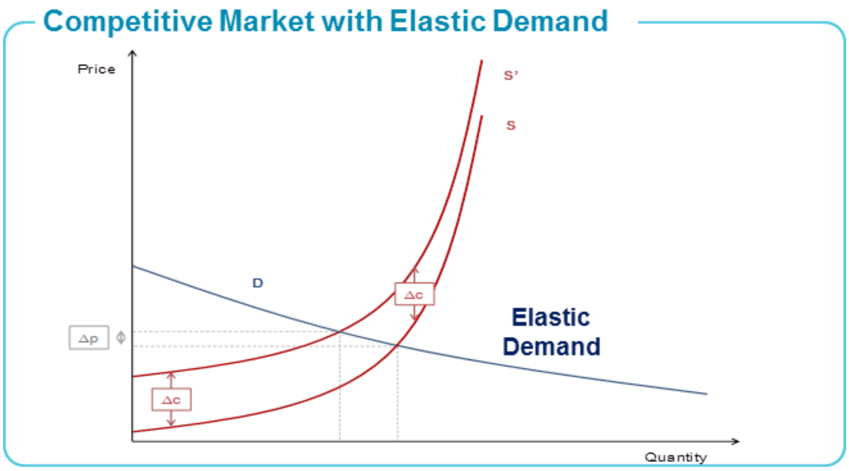
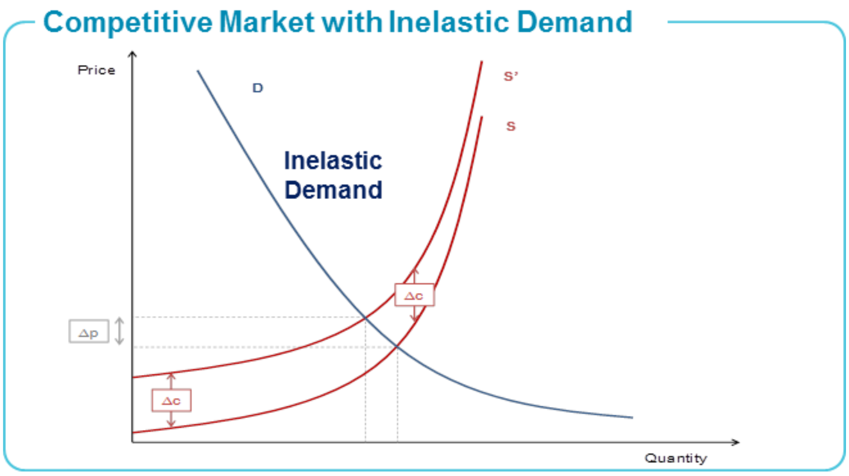
[119] Ex-post investigation of cost pass-through in the EU ETS, CE Delft – Oeko-Institut 2015, page 61

[120] Ex-post investigation of cost pass-through in the EU ETS, CE Delft – Oeko-Institut 2015, page 61

Appendix C. In a perfectly competitive market, a symmetric increase in price translates in high cost pass-through when demand is inelastic





Demand elasticity measures the degree to which sales are reduced by an increase in price. Low demand elasticity means that demand is relatively insensitive to price, corresponding to a steep demand curve.

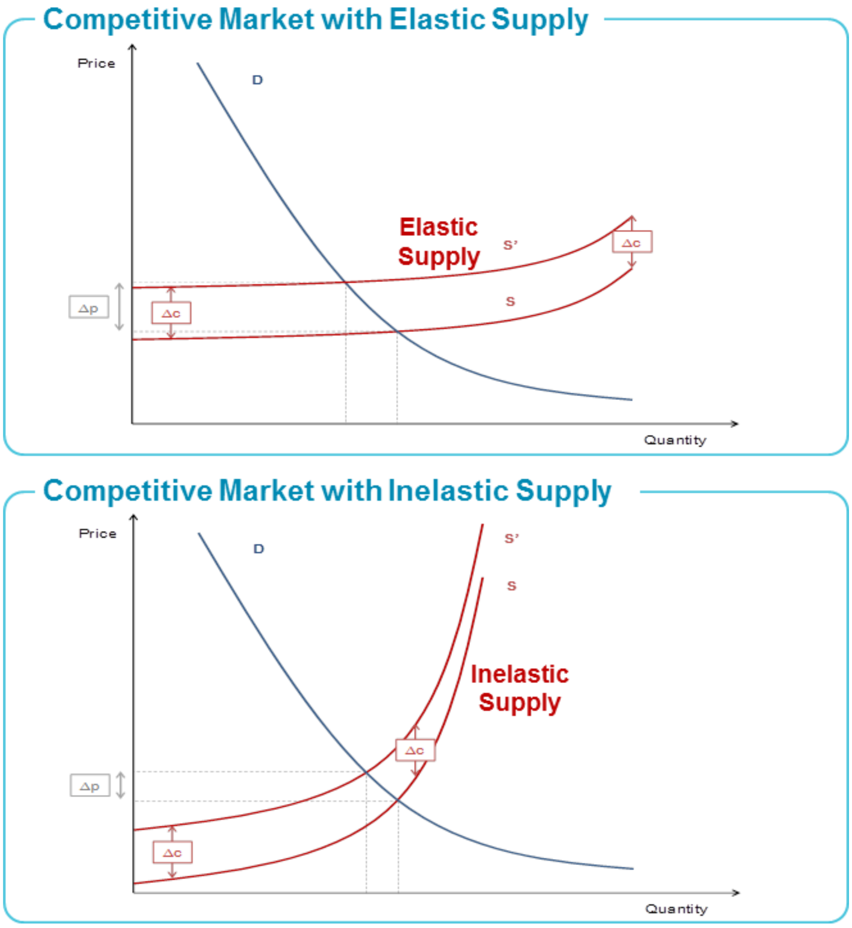
In perfectly competitive markets, pass-through of a cost increase common to all suppliers (which we consider as a starting point to present the basics of the analysis) is negatively correlated with demand elasticity: that is, when consumers are less responsive to price increases, we can expect greater cost pass-through.

The scenario of an industry-wide cost increase (assuming that all producers face the same increase in cost of magnitude Δc) is illustrated in the figures at the left. The supply curve shifts upward from S to S' due to carbon costs. Demand is relatively elastic in the top panel, while it is relatively inelastic in the bottom panel. For the same cost increase, the price increase is larger in the bottom panel, illustrating increased pass-through when demand is less elastic.

The analysis is more complex in markets that are not perfectly competitive. What matters to pass-through in these cases is not only demand elasticity, but also demand curvature (by how much the price responsiveness of demand varies with price). If consumers become less responsive to prices as prices increase (i.e., if demand is convex), pass-through can be higher with fewer competitors.

In most industries, little is known about the precise shape of the demand curve, including its curvature. The market for steel products is generally considered to exhibit relatively inelastic demand, at least in the short run. In the longer term, demand is somewhat more responsive to price, as there are greater opportunities to either reduce consumption or adjust downstream production processes in some industries, for instance by using aluminium or fiberglass instead of steel.

Appendix D. In a perfectly competitive market, a symmetric increase in price translates in high cost pass-through when supply is highly elastic



Supply elasticity refers to the shape of producers' marginal cost curves (the aggregate of which is the supply curve in perfectly competitive markets**).** High supply elasticity corresponds to relatively flat marginal cost curves, which indicate that marginal production costs do not change much with quantity produced (for more detailed analysis of how cost curves interact with ability to pass-through costs without loss of market share, see Appendix D).

All else being equal, cost pass-through is higher with higher supply elasticity, i.e., the less the cost of producing individual units of production changes with the production level, as shown in figures above. For the same absolute cost increase, the absolute price increase (Δp) is larger in the top panel, indicating **a higher rate of pass-through when supply is more elastic**.

Appendix E. Carbon leakage outcome will depend on combined assumptions on elasticities and capacity of foreign firms to serve the EU market

The outcome of EU ETS regarding carbon leakage and cost pass-through is sensitive to assumptions on market conditions, i.e. on supply and demand. In this section, we present potential outcomes from a hypothetical EU steel market. The market is assumed to be **perfectly competitive** and **without product differentiation**. The examples presented are for illustration only. To estimate actual impacts would require access to information about actual supply costs for both foreign and domestic producers.

The first hypothetical scenario would consider a **homogeneous cost increase**, which would result in **a 100% cost pass-through, without loss of market share**. In this case, all industries serving the EU domestic markets are covered by the increases in carbon costs. This could be the case if all producers are domestic producers, or if additional carbon policies raise carbon costs for producers in third party countries as well. Although this assumption does not necessarily apply to the steel industry, it serves as a reference case, as this is the situation apparently envisaged by the Impact Assessment's discussion of demand elasticity.

Figure E1 presents the market situation before the implementation of EU ETS (t_0). Domestic and foreign producers are indicated by the light blue and dark grey bars respectively. In this scenario, at t_0, the market share of foreign producers is approximately 10%, which is consistent with the descriptive statistics observed for the EU steel industry. Market price is determined by the interaction of supply and demand, and indicated by a dark blue dotted line.

The height of each bar corresponds to the cost of producing incremental output from each production unit, while the number of bars represents the quantities on the market. The implied aggregate supply curve is illustrated by the red line, and demand by the grey line. To match the case considered by the IA, **demand is almost perfectly inelastic**, so almost the same quantity is demanded at all price levels. This case matches a short term situation, where consumers of steel are not able to adjust consumption and switch towards product substitutes, or only at a high cost.

In all these scenarios, for simplicity, we observe the elasticity of demand faced by all producers irrespective of their source countries. That is, we abstract from potential differences in elasticities between EU and non EU producers and put aside the Armington dimension of elasticities. Allowing for Armington elasticities could change the composition of producers on the market, by facilitating or hindering the entry of foreign suppliers.

Figure E1: Homogeneous cost scenario pre-ETS (t_0)

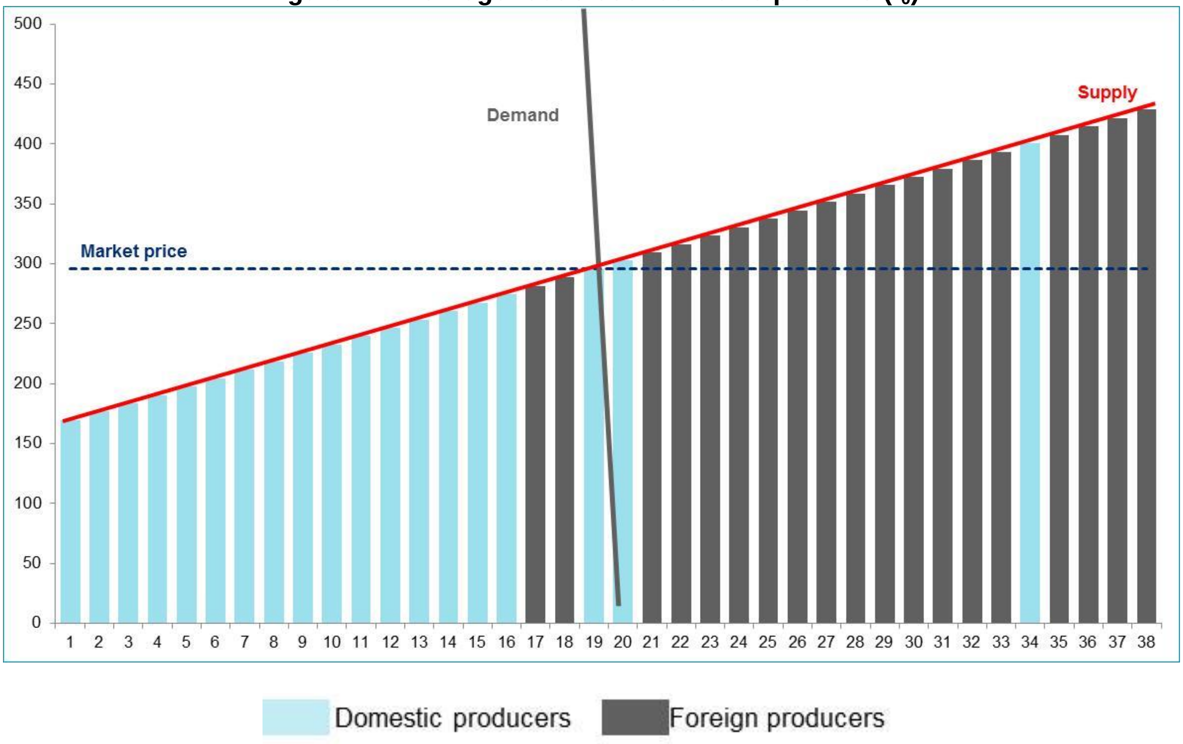


Figure E2: Homogeneous cost scenario post ETS (t+1)

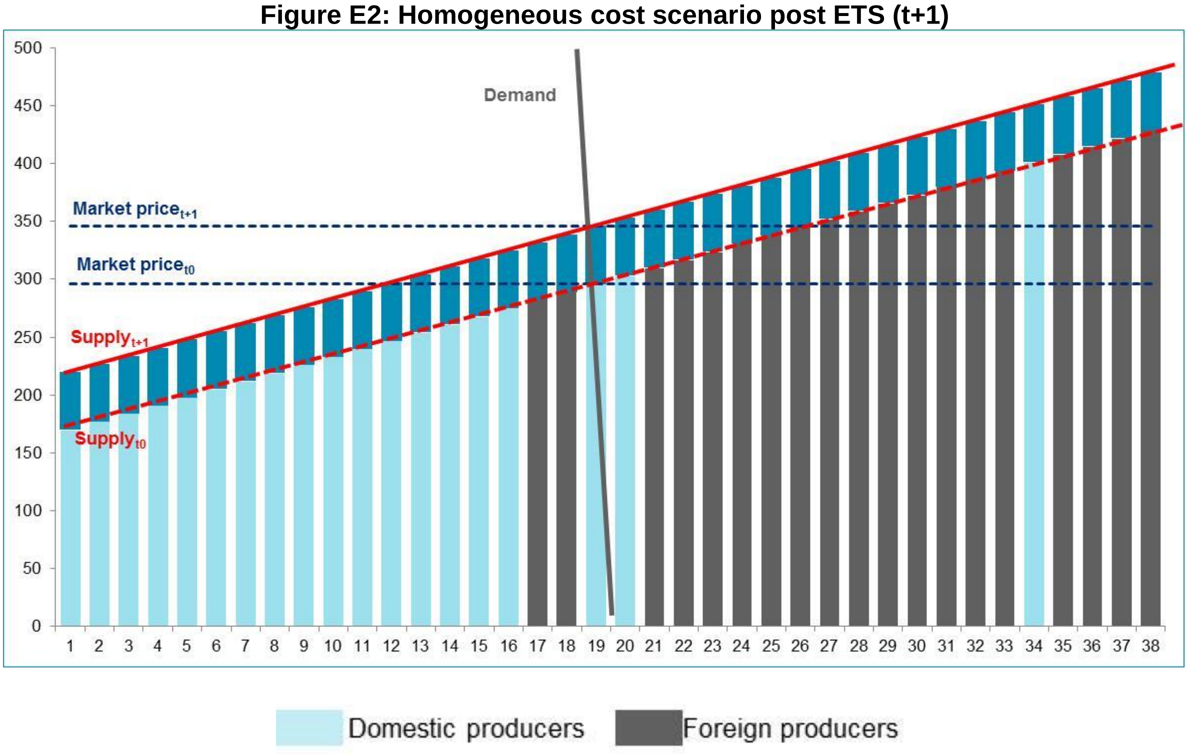
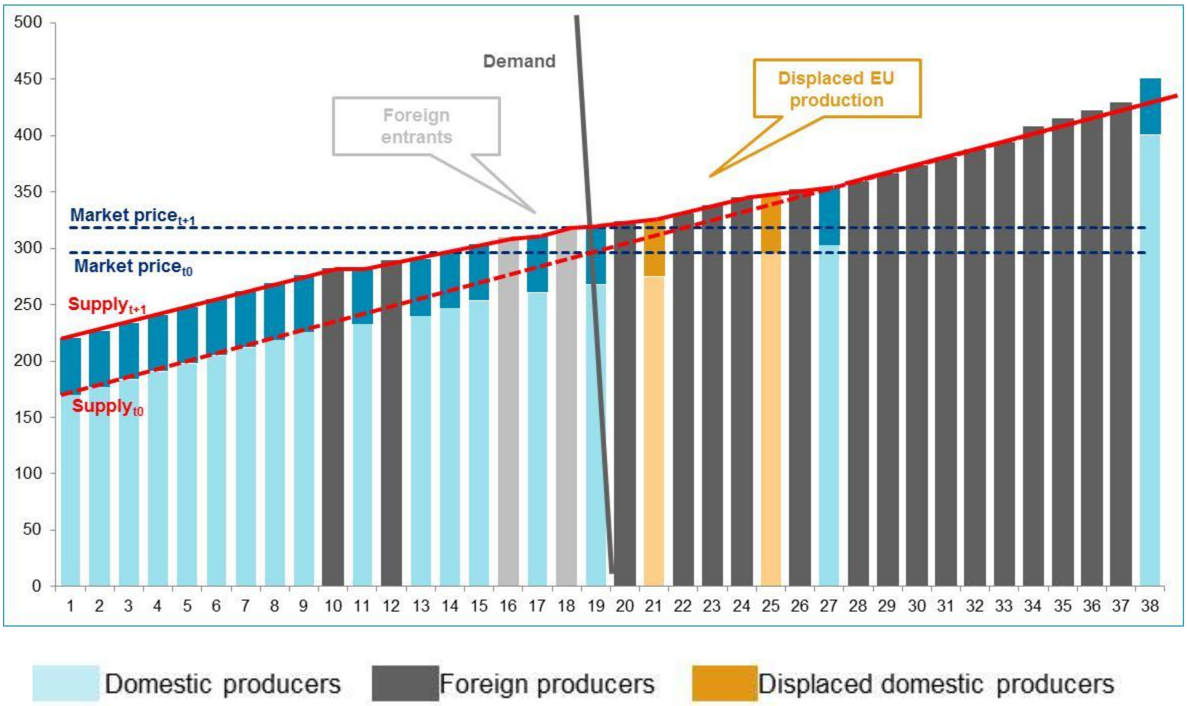


Figure E2 presents the same case after the introduction of the ETS scheme (throughout this discussion, we assume for simplicity that all EU producers are homogeneous w.r.t. carbon costs, i.e. face the same EU ETS costs, indicated by Δc, and represented by the dark blue bars). The new supply curve is indicated as Supply$_{t+1}$, whereas the old supply curve is retained for reference and indicated by a dotted line (Supply$_{t0}$).

Inspection reveals that the change in the market price from Market price$_{t0}$ to Market price$_{t+1}$ (Δp,), is very close to the size of the cost increase Δc, because the demand curve shown here is very inelastic. In other words, this suggests a **carbon cost pass-through close to 100 percent**. Furthermore, because all producers on the market are subject to the cost increase by assumption in this hypothetical scenario, there is **no loss of market share** from EU producers, and imports still represent roughly 10% of total consumption.

Figure E3 shows the impact of an illustrative carbon cost increase that only affects European steel producers, and shows that in this case the **pass-through is lower than 100%**, and **some carbon leakage takes place (after the introduction of the ETS scheme some European producers, illustrated by the two orange bars, are replaced by foreign producers, illustrated by the two dark grey bars)**.

Figure E3: Asymmetric cost scenario post ETS (t+1)



The new supply curve is again shown by the solid red line (the old supply curve is reproduced as a dotted line for reference). Pass-through is again illustrated by the difference between the market price at t_0 and a t+1 (Δ*p*), which is now only a third of the cost increase Δ*c*. This illustrates a cost pass-through of around 30%. Also, some output previously supplied by EU producers have become more expensive than non-EU supply that was not previously competitive, resulting in a loss of European market share of around 10-15 percentage points (the two bars shaded orange) and a corresponding gain for foreign suppliers (light grey bars).

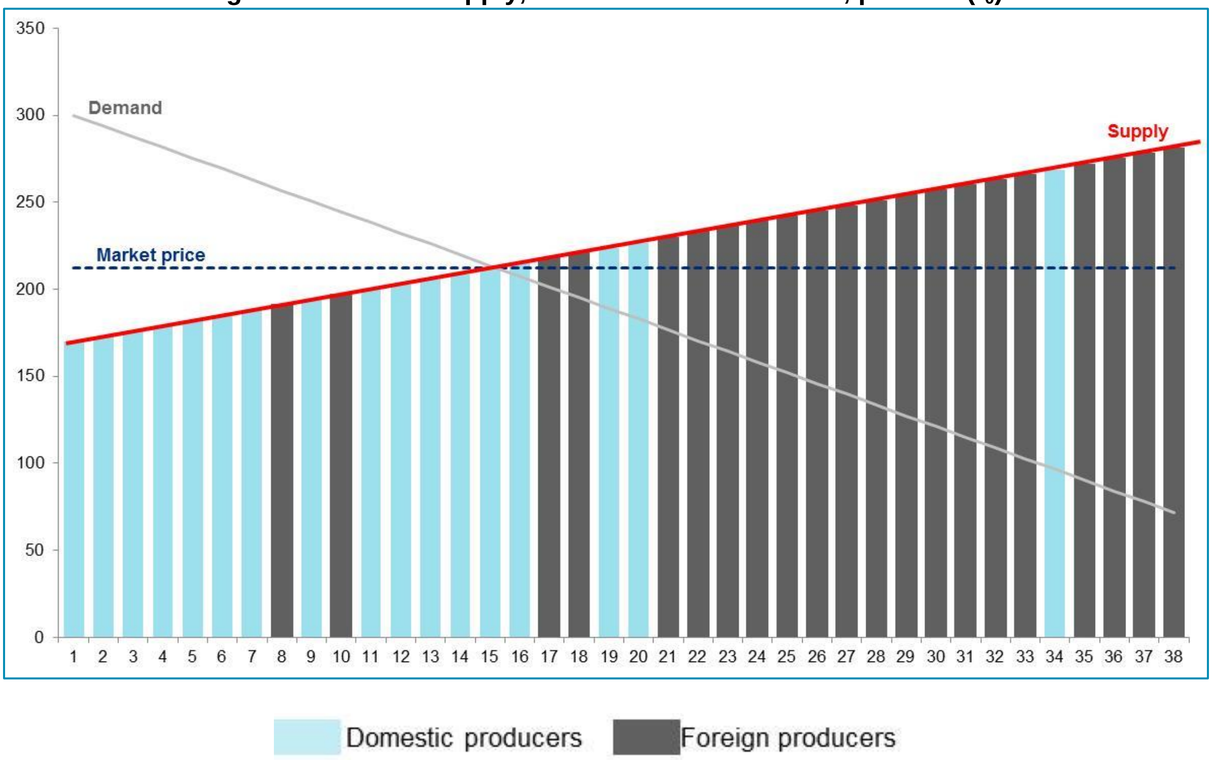
Thus, despite an almost **completely inelastic demand** and **perfect competition in the market**, cost pass-through is significantly **below 100 per cent**. The example also shows how inelastic demand does not imply anything about the degree to which *individual firms* can expect to retain market share. If there is a sufficient number of competitors that do not face carbon costs, an individual firm seeking to pass through its carbon costs may simply be displaced by suppliers who do not seek to raise prices. Thus, contrary to what the Impact Assessment suggests, low aggregate demand elasticity *in no way* guarantees that firms will retain market share if they seek to pass through cost increases not faced by all competitors.

It is also useful to consider the impact of the asymmetric cost increase on the shape of the aggregate supply curve. Compared to the original (dotted line), the new supply curve is more elastic (flatter).

Below, Figure E4 and E5 present a hypothetical illustration where the cost disadvantage of foreign producers is small.[121] That is, **market supply is more elastic**, and foreign producers can increase production to serve the EU market at a low cost. This could correspond to a long term setting, where the persistence of asymmetric carbon costs may result in new investment in foreign capacity that can supply EU markets at competitive prices, or even to a short term setting when **extra capacity is large**.

On the demand side, customers are expected to be more able to shift consumption of steel for technological substitutes, i.e. switching costs are lower. As a result, the elasticity of demand is higher as well.

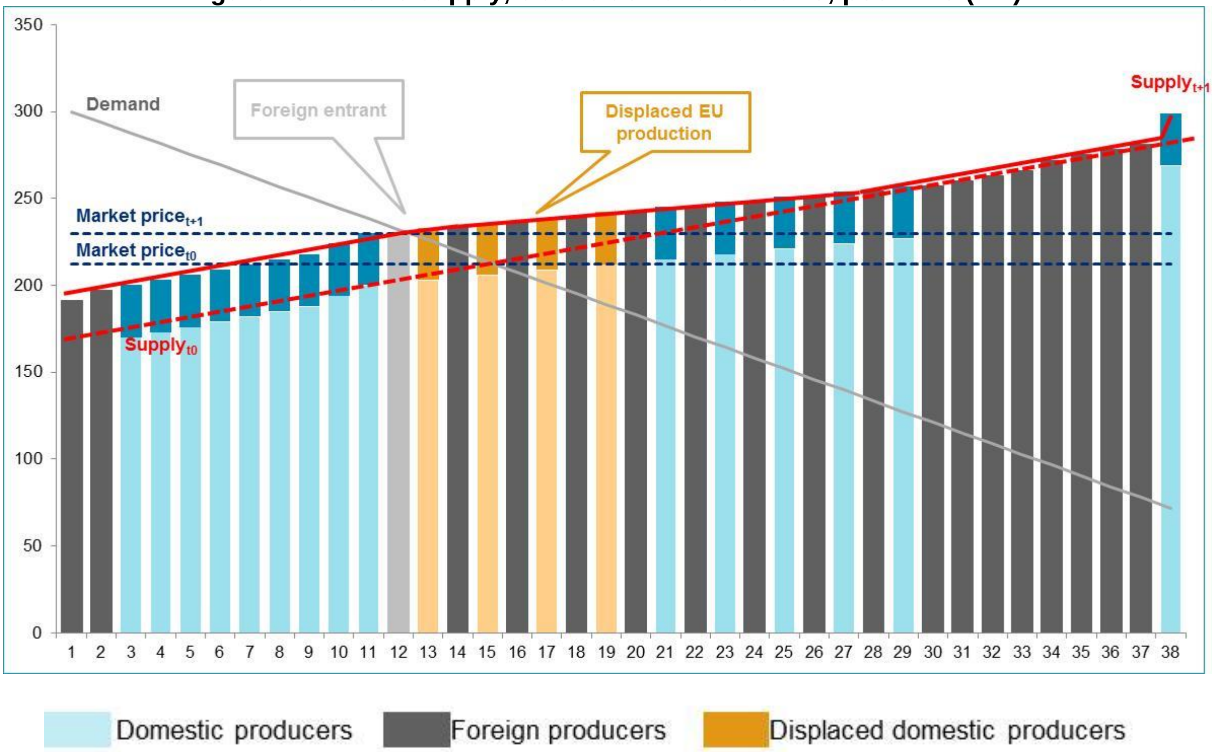
Figure E4: Elastic supply, elastic demand scenario, pre ETS (t_0)



As can be seen in Figure E5, the **total market equilibrium quantity is lower** compared to a situation where demand is more inelastic. In consequence, **more EU producers are evicted** from the market as can be observed by the number of orange bars), even if there is only one single foreign producer entering the EU market. Here, the large impact on EU producers here is not only caused by foreign entrants, but also by the reaction of consumers to the increase in prices. In such as setting, EU producers would **not be able to pass through** a high proportion of their costs without **an important loss of market share** caused by the **demand response of consumers**, irrespective of entry of foreign competitors.

[121] In fact, the cost advantage in the steel industry is even opposite. The EC recognizes that the operating costs of EU Steel producers in BOF technologies is 40% larger that producers located in Brazil and Russia, and 20% larger than those of producers in China and India ("Ex-post investigation of cost pass through in the EU ETS, An analysis for six sectors", CE Delft and Oeko Institut, November 2015).

Figure E5: Elastic supply, elastic demand scenario, post ETS (t+1)



The last hypothetical scenario presents an extreme case where the cost disadvantage of foreign producers is marginal and foreign capacity is large enough to satisfy all EU demand. Nonetheless, this corresponds to market conditions observed in the steel industry. As we have seen, foreign installed capacity is very large, as most firms operate at roughly 80% of capacity utilization as of today. In addition, the size of extra EU production is large: excess capacity in China alone could be sufficient to serve the entire demand.

Under this scenario, all **EU producers could exit the market**. The new domestic price would equal the market price without the carbon costs, as all producers still on the market are non EU ETS, i.e. there would be no carbon cost to pass-through.

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